THE TOWN OF COLEBROOK
OFFICE OF THE SUPERINTENDENT

HVAC UPGRADES

AT

COLEBROOK CONSOLIDATED SCHOOL

452 SMITH HILL ROAD

COLEBROOK CONNECTICUT 06021

STATE PROJECT # CV 29-003 HVAC

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SECTION 03 10 00 CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
   1. Formwork for cast-in place concrete, with shoring, bracing and anchorage.
   2. Openings for other work.
   3. Form accessories.
   4. Form stripping.

B. Related Documents: Additional requirements and information necessary to complete the Work of this Section may be found in other documents.

C. Related Sections:
   1. Section 032000 - Concrete Reinforcement: Coordination between formwork and reinforcement.
   2. Section 033000 - Cast-in-Place Concrete: Supply of concrete accessories for placement by this section.

1.2 REFERENCES

A. American Concrete Institute (ACI) Codes and Standards latest editions:
   1. ACI 301 - Structural Concrete for Buildings.
   2. ACI 318 - Building Code Requirements for Reinforced Concrete.
   3. ACI 347 - Recommended Practice For Concrete Formwork.

1.3 SUBMITTALS

A. Section 013300 - Submittal Procedures: Procedures for submittals.
   1. Product Data: Provide data on void form materials and installation requirements. Submit data on form-coating materials.
   2. Shop Drawings: Indicate pertinent dimensions, materials, required installation and removal of bracing, shoring and arrangement of joints and ties.

B. LEED Submittals:
   1. Product data and statements for credits being considered.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 347.

B. Where necessary, design formwork, shoring Funder direct supervision of a Professional Engineer experienced in design of formwork and licensed in State where Project is located.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver void forms and installation instructions in manufacturer's packaging.

B. Store off ground in ventilated and protected manner to prevent deterioration from moisture.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Environmental Impact:
   1. Formwork: Reuse forms to greatest extent possible without damaging structural integrity of concrete and without damaging aesthetics of exposed concrete.

PART 2 - PRODUCTS

2.1 WOOD FORMS

A. Forms for Exposed Finish Concrete: Plywood panels, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.
   1. Plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood," Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.

C. Lumber: Construction grade; with grade stamp clearly visible.

2.2 PREFABRICATED FORMS

A. Preformed Steel Forms: Minimum 16 gage, well matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

B. Void Forms (Carton Forms): Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete mix until initial set. Thickness indicated on drawings.

C. Tubular Column Type: Metal or fiberglass-reinforced plastic. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.

D. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration to match Architect's control sample. Provide solid backing and form supports to ensure stability of textured form liners.

2.3 ACCESSORIES

A. Form Ties: Factory-fabricated, removable or snap-off type, metal, of fixed or adjustable length as applicable, with cone ends. Designed to prevent form deflection and to prevent spalling concrete upon removal. Back break dimension, 1-1/2 inch from exposed concrete surface. Provide ties that, when removed, will leave holes not larger than 1 inch diameter in concrete surface.

B. Form Release Agent: 100 percent biodegradable colorless agent which will not stain concrete, or absorb moisture, or impair natural bonding or color characteristics of subsequent coatings intended for use on concrete surfaces. Zero VOC.
   1. Envirolux by Conspec, Kansas City, KS, (800) 348-7351 or (913) 287-1700.
   2. SMD-10 Soy Form Release by Strategic Market Development (800) 959-1071 or (815) 935-0863.
   3. Bio-Form by Leahy-Wolf, Franklin Park, IL, (888) 873-5327 or (847) 455-5710.
   4. Section 016000 - Product Requirements: Product options and substitutions. Substitutions: Permitted.

C. Corners: Chamfered, wood strip 3/4 x 3/4 inch size; maximum possible lengths.

D. Dovetail Anchor Slot: Galvanized steel, 22 gage thick, foam filled, release tape sealed slots, anchors for securing to concrete formwork.

E. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required, of sufficient strength and character to maintain formwork in place while placing concrete.

F. Waterstops (Rubber/PVC): Rubber or Polyvinyl chloride, minimum 1,750 tensile strength, minimum 50 degrees F to plus 175 degrees F working temperature range, width as indicated on Drawings, maximum possible lengths, ribbed profile, preformed corner sections, heat welded jointing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Verify that field measurements, surfaces, and conditions are as required, and ready to receive Work.
   1. Verify lines, levels and centers before proceeding with formwork. Ensure that dimensions agree with Drawings.

B. Report in writing to Contracting Officer prevailing conditions that will adversely affect satisfactory execution of the Work of this Section. Do not proceed with Work until unsatisfactory conditions have been corrected.

C. By beginning Work, Contractor accepts conditions and assumes responsibility for correcting unsuitable conditions encountered at no additional cost to the owner.

3.2 EARTH FORMS

A. Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.

3.3 FORMWORK INSTALLATION

A. Install formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 347R.

B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.

C. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores upon approval by the Professional Engineer responsible for their design.

D. Align joints and make watertight. Furnish in largest available sizes to minimize number of joints and to conform to joint system indicated on Drawings.

E. Obtain approval from the Engineer or Architect before framing openings in structural members which are not indicated on Drawings.

F. Provide chamfer strips on external corners of concrete members, to produce uniform, smooth lines and tight edge joints.

G. Install void forms in accordance with manufacturer's published instructions. Protect forms from moisture or crushing.

3.4 FORM RELEASE AGENT APPLICATION

A. Apply form release agent on formwork in accordance with manufacturer's published instructions.

B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

C. Do not apply form release agent where concrete surfaces will receive special finishes or applied coverings which are effected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.

3.5 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for items to be embedded in passing through concrete work.

B. Locate and set in place items which will be cast directly into concrete.

C. Coordinate with work of other sections in forming and placing openings, slots, recesses, sleeves, bolts, anchors, other inserts, and components of other Work.

D. Install accessories in accordance with manufacturer's published instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.

E. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

F. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

G. Install waterstops in accordance with manufacturer's published instructions continuous without displacing reinforcement. Seal joints watertight.

3.6 FORM CLEANING

A. Clean forms as erection proceeds, to remove foreign matter within forms.

B. Clean formed cavities of debris prior to placing concrete.

C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.

3.7 CONSTRUCTION

A. Site Tolerances:
   1. Construct formwork to maintain tolerances required by ACI 301 and ACI 347.
   2. Camber slabs and beams 1/4 inch per 10 feet in accordance with ACI 301.

3.8 FIELD QUALITY CONTROL

A. Section 014000 - Quality Requirements: Field inspection and testing.

B. Inspect erected formwork, shoring [, and reshoring], and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

3.9 FORM REMOVAL

A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads.
B. Do not remove shoring without approval from the Professional Engineer responsible for their design.

C. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.

D. Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.

END OF SECTION 03 10 00

SECTION 03 20 00 CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Reinforcing steel bars.
2. Steel wire mesh.
3. Reinforcement accessories.

B. Related Documents: Additional requirements and information necessary to complete the Work of this Section may be found in other documents.

C. Related Sections:
1. Section 031000 - Concrete Forming and Accessories: Coordination between formwork and reinforcing.
2. Section 033000 - Cast-in-Place Concrete: Coordination between concrete placement and reinforcing.

1.2 REFERENCES

A. American Concrete Institute (ACI):
1. ACI 301 - Structural Concrete for Buildings.
2. ACI 318 - Building Code Requirements For Reinforced Concrete.
3. ACI SP-66 - American Concrete Institute - Detailing Manual.

B. American Society for Testing and Materials (ASTM):
1. ASTM A 184 - Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
2. ASTM A 615 - Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
3. ASTM A 704 - Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.

C. American Welding Society (AWS):
1. AWS D1.4 - Structural Welding Code for Reinforcing Steel.

D. Concrete Reinforcing Steel Institute (CRSI):
1. CRSI - Manual of Practice.
2. CRSI 63 - Recommended Practice For Placing Reinforcing Bars.
3. CRSI 65 - Recommended Practice For Placing Bar Supports, Specifications and Nomenclature.

1.3 SUBMITTALS

A. Section 013300 – Submittal Procedures: Procedures for submittals.
   1. Shop Drawings: Indicate bar sizes, spacings, locations, and quantities of reinforcing steel [and wire fabric, bending and cutting schedules, and supporting and spacing device. Include special reinforcement required for openings through concrete structures.
   2. Assurance/Control Submittals;
      a. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
      b. Submit certified copies of mill test report of reinforcement materials analysis.
      c. Welder's Certificates.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with CRSI 63, 65 and Manual of Practice ACI 301, ACI SP-66, ACI 318, and ASTM A 184.

B. Design reinforcement under direct supervision of a Professional Structural Engineer experienced in design of this work and licensed in the State where the Project is located.

C. Welders' Certificates: Submit certificate, certifying welders employed on the Work, verifying AWS qualification within the previous 12 months.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Reinforcing Steel: ASTM A 615, 60 ksi yield grade; deformed billet steel bars, unfinished.

B. Reinforcing Steel Mat: ASTM A 704, ASTM A 615, 60 ksi yield grade; steel bars or rods, unfinished.

C. Reinforcing Steel Mesh: ASTM A185; 6X6, w 1.4 X w 1.4.

D. Dowels at Construction Joints: 1/4" x 4.5" Diamond Dowels by PNA Construction Technologies or approved equal.

2.2 ACCESSORIES

A. Tie Wire: Minimum 16 gage annealed type.

B. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for strength and support of reinforcement during concrete placement conditions including load bearing pad on bottom to prevent vapor barrier puncture.

C. Special Chairs, Bolsters, Bar Supports, Spacers Adjacent to Weather Exposed Concrete Surfaces: Plastic coated steel type(CRSI, Class 1) or stainless steel protected(CRSI, Class 2); size and shape as required.

2.3 FABRICATION

A. Fabricate concrete reinforcing in accordance with ACI SP-66 and ACI 318.

B. Weld reinforcement in accordance with AWS D1.4.

C. Locate reinforcing splices not indicated on drawings, at point of minimum stress. Review location of splices with Contracting Officer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Verify that field measurements, surfaces, and conditions are as required, and ready to receive Work.

B. Report in writing to Contracting Officer prevailing conditions that will adversely affect satisfactory execution of the Work of this Section. Do not proceed with Work until unsatisfactory conditions have been corrected.

C. By beginning Work, Contractor accepts conditions and assumes responsibility for correcting unsuitable conditions encountered at no additional cost to the owner.

3.2 PLACEMENT

A. Place, support and secure reinforcement against displacement. Do not deviate from required position.

B. Do not displace or damage vapor barrier.

C. Accommodate placement of formed openings.

D. Maintain concrete cover around reinforcing in accordance with ACI 318.

3.3 FIELD QUALITY CONTROL

A. Inspect reinforcing locations, bar types and sizes, wire ties, and welding.

END OF SECTION 03 20 00

SECTION 033000 – CAST IN PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Includes all labor, materials and appliances, and perform all operations in connection with the installation of Concrete Work, and all related work incidental to the completion thereof, as shown on the drawings, complete, in strict accordance with the drawings and as specified herein. Section Includes:

1. Cast-in-place (CIP) concrete in building slabs-on-grade, and mechanical equipment pads.
2. Finishing of concrete floor slabs and toppings. Concrete liquid surface treatment, sealer, and slip-resistant coatings.
3. Expansion and contraction, control joints in CIP concrete.
4. Concrete curing and protection.
5. Non-shrink grout including installation and forming.
6. Testing related services.

B. Related Documents: Additional requirements and information necessary to complete the Work of this Section may be found in other Documents and References in Section 1.2.

C. Related Sections: Related work specified elsewhere includes but may not be limited to
1. Section 031000: Concrete Forming and Accessories
2. Section 032000: Concrete Reinforcement

1.2 REFERENCES

A. American Concrete Institute (ACI) Codes and Standards latest editions:
1. ACI 117, “Standard Specification for Tolerances for Concrete Construction and Materials.”
2. ACI 301, “Specification for Structure /Concrete.”
3. ACI 302.1R, “Guide for Concrete Floor and Slab Construction.”
4. ACI 304R, “Guide for Measuring, Mixing, Transporting, and Placing Concrete.”
5. ACI 305, “Hot Weather Concreting.”
6. ACI 306, “Cold Weather Concreting.”
7. ACI 311, “Recommended Practice for Concrete Inspection.”
8. ACI 315, “Details and Detailing of Concrete Reinforcement.”
9. ACI 318, “Building Code Requirements for Structural Concrete.”
10. ACI 347, “Guide to Formwork for Concrete.”

B. American Welding Society (AWS)
1. AWS D1.4, "Structural Welding Code Reinforcing."

C. American Society for Testing and Materials (ASTM).
1. ASTM A615, "Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement."
2. ASTM C33, "Standard Specification for Concrete Aggregates."
3. ASTM C94, "Standard Specification for Ready-Mixed Concrete."
4. ASTM C150, "Standard Specification for Portland Cement."
5. ASTM C260, "Standard Specification for Air Entraining Admixtures for Concrete."
6. ASTM C309, "Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete."
7. ASTM C494, "Standard Specification for Chemical Admixtures for Concrete."
8. ASTM C618, "Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete."
9. ASTM C989, "Standard Specification for Ground Granulated Blast-Furnace Slag for Use in

D. Concrete Reinforcing Steel Institute (CRSI),
1. CRSI "Manual of Standard Practice."

1.3 SUBMITTALS

A. Section 013300 - Submittal Procedures: Procedures for submittals.
1. Product Data: Provide data technical, testing, and source for mix design materials and additives, steel reinforcement, joint sealant.

2. Shop Drawings: Provide shop drawings for reinforcement, layout, detailing, and placing prior to fabrication, site delivery, and installation.
   a. Mix design submittals.
   b. Rebar placing drawings (ACI 315, "Detailing Manual SP-66-(04)" or CRSI "Manual of Standard PracticeMSP-2-81"): Show bar sizes, bending, placing, spacing, locations, and quantities of reinforcing and wire fabric and supporting and spacing accessories. Provide steel order lists including bending and cutting details for all reinforcement shown on the structural design drawings.
   c. Form construction details, including jointing, special formed joints or reveals, location and pattern of form tie placement, and other items that affect exposed concrete visually.
   d. Calculations and layout drawings for formwork, shoring and/or reshoring, and other submittals indicated on the drawings. Work shall be prepared and signed and sealed by a Professional Engineer.

3. Assurance/Control Submittals:
   a. Test Reports: Prepare reports in conformance with Section 014000 - Quality Requirements:
   b. Submit laboratory test reports for concrete materials and mix designs for each strength and type of concrete proposed for use.
   c. Certificates: Manufacturer's certificate that Products meet or exceed specified requirements.

4. Delivery Tickets:
   a. Copies of delivery tickets for each load of concrete delivered to site.
   b. Indicate on each ticket the exact time that the mix is batched.
   c. Mix identification number on ticket shall match number on submitted and approved mix design
   d. Submit copies to Testing Laboratory for verification of compliance with placing time.

B. LEED submittals:
   1. Product data and statements for credits being considered.

1.4 QUALITY ASSURANCE

A. Perform work in accordance with the Codes and Standards referenced in section 1.2 of this specification.
   1. Provide qualification data for manufacturers and installers.

B. Pre-Installation Conference:
   1. Conduct a pre-installation conference prior to commencing Work of this Section.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in unopened containers with labels identifying contents.

B. Store powdered materials in dry area and in manner to prevent damage. Protect liquid materials from freezing or exceeding maximum storage temperatures set by product manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with project requirements, manufacturers offering Products which may be incorporated in the Work include the following:

   1. Applied Concrete Technology, Inc., Post Office Box 548, Grayslake, IL 60030, Toll Free: 800-228-6694, Phone: 847-548-2444, Fax: 847-548-2555. www.protecrete.com
   2. The Euclid Chemical Company, 19218 Redwood Road, Cleveland, OH 44110, Phone: 216-1-9222, Toll Free: (800) 321-7628, Fax: 216-531-9596 www.euclidchemical.
   3. Fortifiber Corporation, 419 W. Plumb Lane, Reno, NV 89509, Toll Free: 800-773-4777, Fax: 775-333-6411, Website: www.fortifiber.com.
   4. ChemRex Inc., Shakopee, Minnesota 55379, Toll Free: 800-433-9517, Fax: 800-496-6067.

5. BASF Construction Chemicals North America (former Master Builders), 23700 Chagrin Boulevard, Cleveland, OH 44122, Phone: 216-839-7500, Fax: 216-839-8821.
6. W.R. Meadows, Inc., PO Box 338, Hampshire, Illinois 60140-0338, Toll Free: 800-342-5976, Phone: 847-683-4500.
7. Reef Industries, 9209 Almeda Genoa, Houston, Texas 77075, Phone: 713-507-4251, Toll Free: 800-231-6074, Fax: 713-507-4295.
8. Stego Industries LLC, 27442 Calle Arroyo Suite A, San Juan, Capistrano, CA 92675, Phone: 877-464-7834, Fax: 949-493-5165, www.stegoindustries.com.
9. L & M Construction Chemicals, Inc. 14851 Calhoun Rd., Omaha, NE 68152-1140; Phone: 402-453-6600, Fax: 402-453-0244.
10. Curecrete Chemical Company, Inc., 1203 W. Spring Creek Pl., Springville, UT Phone: 801- 489-5663.
11. Midwest Floor Care Inc., 17202 Princeton Rd, Adams, NE 68301, Phone: 402-788-2820.
12. General Resource Technology, Inc., 2978 Center Court, Eagan, MN 55121, Phone: 800-324-8154, Fax: 651-454-4252, www.grtinc.com.

2.2 CONCRETE MATERIALS

A. Portland Cement: ASTM C150.

B. Liquid admixtures: The following admixtures are permitted when approved in writing prior to use or are required as specified herein and shall be used in strict accordance with the manufacturer's specifications or recommendations:

1. Calcium chloride: Conform to ACI 301. The water solble chloride ion level shall not exceed 0.3 percent by weight of cement.

2. Air-entraining admixtures: ASTM C260 For steel hard trowel interior slab finish, do not use air entrainment admixtures.
3. Water-reducing admixtures: Conform to ASTM C494, Type A.

4. Water-reducing/accelerating admixtures: Conform to ASTM C494, Type C or E.

5. Water-reducing/retarding admixtures: Conform to ASTM C494, Type D.
   a. High-range/water-reducing (HRWR) admixtures: Conform to ASTM C494, Type F or G super plasticizers. HRWR admixture shall be used in concrete with a maximum water/ cement ratio of 0.50 or less.

C. Aggregates:
1. Normal-weight concrete - ASTM C33.
2. Light-weight concrete – ASTM C330.
3. Aggregates shall be from a single source.

D. Water:
1. Clean, potable, and free of injurious amounts of oil, acid, alkali, organic or other deleterious matter not detrimental to concrete; drinkable.

2.3 GROUT/MORTARS

A. Cement grout: Conform to ASTM C387 "Dry packaged mixtures".

2.4 CURING/SEALING/HARDENERS

A. Dissipating liquid membrane-forming compounds for curing concrete; Conform to ASTM C309, Type 1. Curing compound shall be compatible with floor sealer or finish used. Low VOC.

B. Method of curing shall be approved by the finish flooring applicator where finishes are indicated.

C. Exterior Sealers: applied to horizontal concrete surfaces permanently exposed to salts, deicer chemicals and moisture, including parking decks. The manufacturer shall provide a five year labor and materials warranty on performance of the sealer. Sealer shall be compatible with the curing compound used.

D. Liquid Densifier/Sealer/Hardener: to be applied on exposed concrete floors cured with dissipating membrane forming curing compound to harden and densify concrete surfaces. Sealers are to be clear, chemically reactive, a waterborne solution of silicate or siliconate materials and proprietary components, odorless, and colorless.

2.5 JOINTS AND EMBEDDED ITEMS:

A. Construction and Contraction Joints: Sealant shall be two-part semi- rigid epoxy, and shall have minimum Shore A Hardness of 80 when measured with ASTM D2240.

B. Isolation Joints: Fillers shall consist of 1/8 inch width strips of neoprene, synthetic rubber, or approved substitute, extending the full depth of the slab. Sealant shall be two-part elastomeric type, polyurethane base.

2.6 VAPOR BARRIER/RETARDER

A. Provide cover over prepared soil, above aggregate subbase material at slabs-on-grade, where shown on the plans.. Use only materials which are resistant to decay.

2.7 PROPORTIONING

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If laboratory trial batch method is used, use

an independent testing facility acceptable to Contracting Officer for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing and inspection unless otherwise acceptable to Contracting Officer.

B. Submit written reports to the testing laboratory of each proposed mix for each class of concrete. Do not begin concrete production until mixes have been reviewed and approved.

C. Concrete types and strengths: Minimum 28 Day Compressive Strength shall be per design requirements but not less than:
   1. Slab-on-grade:4,000 psi.
   2. Tilt-up: 4,000 psi.
   3. All concrete exposed to weather shall be air entrained (ASTM C260).

D. Durability: Conform to ACI 301.
   1. All concrete exposed to potentially destructive weathering, such as freezing and thawing, or to de-icer chemicals is to be air-entrained, $\pm$1percent.,
   2. Water-cement ratio: For concrete subject to freezing and thawing or deicer chemicals, the water-cement ratio shall not exceed 0.53 by weight including any water added.

E. Slump: Conform to ACI 301 and to specific project mix requirements.

F. Production of concrete: Conform to ACI 301:
   1. Cast-in-place concrete used in the work shall be produced at a single off-site batching plant or may be produced at an on-site batch plant.
   2. All concrete shall be proportioned conforming to the approved mix designs and of the materials contained in those approved mixes.
   3. Prior to adding a high-range water reducer (super plasticizer), slump shall not exceed the working limit.
   4. Ready-mixed and on-site batched concrete shall be batched, mixed, and transported in accordance with ASTM C94.
      a. The concrete producer shall furnish duplicate delivery tickets, one for the Contractor and one given to the Owner's Representative for each batch of concrete. The information provided on the delivery ticket shall include the quantity of materials batched including the amount of free water in the aggregate and any water added onsite. Show the date, time of day batched, and if ready-mixed the time of discharge from the truck. The quantity of water that can be added at the site without exceeding the maximum water-cementitious ratio specified shall be noted on the delivery ticket.
   5. For concrete produced on site with a central batch plant, mixing shall be done in an approved batch mixer concrete shall be batched, mixed, and transported in accordance with ASTM C94.
   6. Variations in consistency during the discharge of a single batch shall not exceed 1 inch of slump, except that a greater variation will be permitted if the slump of the concrete decreases and no water is added.
   7. All other concrete: Conform to ACI 301
   8. When improved workability, pumpability, lower water-cement ratio, or high ultimate and/or early strength is required, the HRWR admixture (super plasticizer) may be used.

9. Ensure air content for slabs with steel trowel finish is less than 3.0 percent.
10. No water shall be added to concrete except under the direct awareness of the project inspector.
11. Adjustments to concrete mixes: Mix design adjustments may be requested by Contractor for approval by the Engineer at no additional cost to Contracting Officer. Laboratory test data for revised mix design and strength results must be submitted and accepted before using in work.

2.8 FORMWORK

A. Section 031000: Concrete Forming and Accessories

2.9 REINFORCING MATERIALS

A. Section 032000: Concrete Reinforcement

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Verify that field measurements, surfaces, substrates and conditions are as required, and ready to receive Work.

B. Report in writing to Contracting Officer prevailing conditions that will adversely affect satisfactory execution of the Work of this Section. Do not proceed with Work until unsatisfactory conditions have been corrected.

C. By beginning Work, Contractor accepts conditions and assumes responsibility for correcting unsuitable conditions encountered at no additional cost to the owner.

3.2 INSTALLATION - GENERAL

A. Install all cast-in-place concrete work in accordance with ACI 301 except as herein specified.

B. All bearing materials shall be inspected by the Geotechnical Engineer prior to placing concrete. The Geotechnical Engineer specify site preparation requirements and provide recommendations to the Architect/Engineer prior to placing concrete.

C. Immediately before placing concrete, spaces to be occupied by concrete shall be free from standing water, ice, mud, and debris.

D. Concrete shall not be deposited under water or where water in motion may injure the surface finish of the concrete.

E. Forms and the reinforcement shall be thoroughly cleaned of ice and other coatings. Remove surplus form releasing agent from the contact face of forms.

F. Notify all trades concerned and the Owner's Representative sufficiently in advance of the scheduled time for concrete placement to permit installation of all required work by other trades.

G. Before placing concrete, all required embedded items, including dovetail anchor slots, anchors, inserts, curb angles, metal frames, fixtures, sleeves, drains, stair nosings, accessory devices for Mechanical and Electrical installations shall be properly located, accurately positioned and built into the construction, and maintained securely in place.

H. Build into construction all items furnished by the Owner and other trades. Provide all offsets, pockets, slabs, chases and recesses as job conditions require.

I. Place and properly support reinforcing steel and anchor bolts.

J. The alignment, orientation, spacing, and embedment length of mechanical load transfer devices in slab-on-grade and pavements shall conform to dimensions and tolerances shown on the drawings.

3.3 INSTALLATION - FORMWORK

A. Section 031000 Concrete Forming and Accessories

B. Construction and Contraction Joints: Conform to ACI 301 and recommendations of ACI 302.1R.

3.4 REINFORCEMENT

A. Placement: Section 032000 Concrete Reinforcement

3.5 METHODS OF PLACEMENT AND PLACING CONCRETE

A. Placement: Conform to ACI 301:
   1. Concrete shall be placed within 90 minutes after the water has been added to the cement and aggregates. Concrete shall be placed prior to initial concrete set.
   2. Placing of concrete will not be permitted during rainfall or when rain appears imminent. If rain should fall subsequent to placement, the concrete shall be completely protected until curing is complete.
   3. Cold-Weather Placement: Comply with provisions of ACI 306.1 "Standard Specifications for Cold-Weather Concreting" for placement at temperatures below 40 deg F (4 deg C).

a. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
b. Concrete shall not be placed on frozen ground or placed when the ambient temperature is 40 deg F or less and dropping.
c. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures using vented heaters and insulating blankets.
d. Concrete temperatures shall be maintained above 50 degrees F for the first 7 days of curing.

4. Hot-Weather Placement: When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305R "Standard Specification for Hot-Weather Concreting" for placement at temperatures above 90 deg F (32 deg C).
   a. Reject any concrete that has a temperature at the point of placement above 90 deg F unless approved otherwise by the Engineer. When air temperatures are between 80 and 90 deg F the maximum mixing and delivery time is reduced to 75 minutes. When air temperatures exceed 90 deg F, the maximum mixing and delivery time is reduced to 60 minutes.
   b. Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to the Engineer.

B. Depositing Concrete
1. Deposit concrete as near its final position as possible to avoid segregation due to rehandling or flowing.
2. The number, type, position, and design of joints shall be approved by the Engineer prior to concrete placement.
3. The concreting shall be carried on at such a rate that the concrete is plastic at all times and flows readily into the spaces between reinforcing bars. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the work
4. When concreting is started, it shall be carried on as a continuous operation until the placing of the section is completed.
5. Except as intercepted by joints, concrete shall be placed in continuous layers.
6. Field records shall be kept of the time and date of the placing of each concrete pour. Locations where concrete test cylinders are made shall also be recorded. Records shall be kept on file at the job until its completion and shall be subject to the inspection of the Owner's Representative at all times.

C. Joints
1. Joints shall be horizontal in slabs.
2. Dowel bars and tie bars shall be inspected.
3. Control joints for controlling concrete shrinkage shall be provided in floor slabs, walls, decks, conduits, and channels as shown on the plans or approved by the Engineer.
4. Joint spacing and sawcut depth for slab-on-grade and concrete pavement shall conform to that shown on the pour sequencing plan and/or drawings.
   a. Sawed control (contraction) joints for pavements and slab-on-grade shall be installed as soon as practical so as not to ravel the concrete but less than 12 hours.
   b. Joint spacing shall in feet shall not exceed 2-1/2 times the slab thickness in inches unless otherwise approved by the Engineer.

5. Joints in slabs shall align with joints in adjoining walls unless otherwise approved by the Architect/Engineer.. Joints shall also line up with architectural reveals and form lines. All corners shall be relieved by cutting joint to adjacent control joint.
6. If there is a delay in casting but prior to concrete initial set, the concrete placed after the delay shall be thoroughly spaded and consolidated at the edge of that previously placed to avoid cold joints.
7. Where placing concrete is interrupted long enough for the concrete to take its initial set, the working face shall be made a construction joint.
   a. Preparation and disposition of unplanned cold joints in walls shall be approved by the Engineer.
   b. For slab-on-grade, pavements, sidewalk, and curb and gutter, concrete shall be removed back to the nearest planned joint and a construction joint installed.
8. Unless otherwise noted on the drawings, where concrete is to be placed against existing concrete, except in the case of expansion joints, the joint face of the existing concrete shall be roughened.
9. Corner sections of walls shall not be placed until the adjoining wall sections have cured at least 14 days.

D. Consolidation
   1. All concrete shall be thoroughly consolidated by internal mechanical vibrators during the placing operation and shall be thoroughly worked around the reinforcement and embedded fixtures and into corners of the forms.
   2. Consolidation shall be carried on continuously with the placing of concrete.
   3. The vibrator shall be kept in nearly a vertical position as practible. The use of vibrators to shift or drag concrete after deposition will not be permitted. Vibrators shall not be laid horizontally or laid over.
   4. Concrete shall not be placed until the previous layer has been vibrated.

E. Protection of cast concrete: Conform to ACI 301.

F. Repair of surface defects: Conform to ACI 301.

3.6 FINISHING

A. Finishing of formed surfaces: ACI 301:
   1. Tops of forms:
      a. Strike concrete smooth at tops of forms.
      b. Float to texture comparable to formed surfaces.
   2. Formed surfaces:
      a. Finished formed surfaces shall conform accurately to the shape, alignment, grades, and sections shown on the drawings or prescribed by the Engineer.
      b. Surfaces shall be free from fins, bulges, ridges, honeycombing, or roughness of any kind and shall present a finished, smooth, continuous hard surface.
      c. Rough form finish at unfinished areas unexposed to public view. Smooth form finish at surfaces exposed to public view.

B. Slabs: Minimum slab surface tolerance must satisfy ACI 301 and ACI 302.1R.
   1. Slabs-on-grade:
      a. For exposed slabs, install semi-rigid epoxy sealant in construction and contraction joints after slab has a minimum of 60 days or otherwise approved by the Engineer..
      b. Allowable tolerance for slab on grade surfaces, measured in accordance with ACI 117 shall meet or exceed an overall value of FF35/Fl25, with minimum local value of FF24/FL17.
   2. Concrete Finishes:
      a. Floor Slabs: Steel trowel finish.
      b. Exposed concrete slabs sealed or sealed and hardened using a liquid compound compatible with the curing method used.
      c. A heavy broom finish shall be provided on disabled person ramps, utility ramps, and around exterior loading docks.

3.7 CURING, PROTECTION, LIQUID HARDNERS AND SEALERS

A. Temperature, Wind, and Humidity
   1. When concrete slabs and other unformed concrete is placed in warm, dry, dusty, or windy conditions, concrete surfaces shall be protected from rapid drying by use of windbreaks, shading, fogging with properly designed nozzles, or a combination of these measures. Hot weather concreting procedures provided in ACI 305R shall be used when ambient conditions dictate.
   2. Cold weather concreting procedures provided in ACI 306R shall be used when ambient conditions dictate.

B. Curing Compound
   1. All curing methods shall be placed within two hours after final finishing. All exposed surfaces of concrete including floor slabs, whether or not they receive a finish flooring, shall be protected from premature drying for a minimum of seven days.
   2. Apply the specified curing compound in accordance with manufacturer’s written instructions.
   3. When used on an unformed concrete surface, application of the first coat of curing compound shall commence immediately after finishing operations have been completed. When curing compound is used on a formed concrete surface, the surface shall first be moistened with a fine spray of water immediately after the forms have been removed.
      a. Surfaces shall be sprayed uniformly with 2 coats of curing compound. As soon as the first coat has become dry, a second coat shall be applied in the same manner. The direction of application of the second coat shall be perpendicular to the first coat.
   4. Curing compound shall not be used on any concrete surface specified to receive additional concrete, coatings, grout, and chemical treatment

C. Protection
   1. Freshly placed concrete shall be protected against wash by rain.
   2. Dust control shall be provided in the surrounding areas during placement.

3. During the first 2 day period of curing, no traffic on or loading of the floors will be permitted.
4. The contractor shall allow no traffic and take precautions to avoid damage to the membrane of the curing compound for a period of not less than 28 days. Damage shall be repaired immediately.
5. Self-supporting structures shall not be loaded in such a way to overstress the concrete.

D. All floor slabs shall be cured using products and methods compatible with selected floor adhesives, toppings, and other finish materials.

E. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

F. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete according to manufacturer's written instruction.

3.8 PATCHING AND REPAIR

A. All repairs of defective areas shall conform to ACI 301. On areas requiring treatment of defects and until such repairs have been completed, only water cure will be permitted

B. At any time prior to final acceptance, concrete found to be defective, damaged, or not in accordance with the specifications shall be repaired or removed and replaced with acceptable concrete.

C. Repair or replace concrete with excessive honeycombing due to improper placement.
1. If approved, a bonding admixture, bonding compound, or epoxy adhesive may be used in accordance with the manufacturer's preparation and application recommendations. Comply with ACI 301 and ACI 503.2 for standard specifications for bonding plastic concrete to hardened concrete with a multiple component epoxy adhesive.
2. The repair concrete shall be thoroughly consolidated in place and struck off so as to leave the patch slightly higher than the surrounding surface. The concrete shall be left undisturbed for at least 1 hour to permit initial shrinkage then finished.
3. The patched area shall be kept damp for 7 days.
4. The color of the patch material shall match the color of the surrounding concrete. Repairs shall be made promptly while the base concrete is less than 28 days old

D. Areas showing excessive defects as determined by the Architect/Engineer shall be removed and replaced.

E. High spots identified in the floor flatness and levelness survey may be removed with bump grinding. Areas to be ground shall not exceed more than 10 percent of any one slab nor more than 5 percent of the total slab-on-grade area.

F. Interior slab-on-grade subjected to lift truck traffic shall be routed and sealed with a semi-rigid epoxy sealant. Exterior slabs may be routed and sealed with the flexible joint sealant to be installed in pavement joints.

3.9 GROUTING

A. After steel columns have been installed and leveled, grout the space between the bottom of the plate and concrete, using cement grout completely filling the space and forming solid bearing for the column base plate.

3.10 EVALUATION AND ACCEPTANCE OF CONCRETE

A. Comply with ACI 301, ACI 318-Chapter 5 and ACI 311 for compressive strength, slump, and frequency of testing.

B. The frequency of testing indicated in the aforementioned codes and standards shall be increased if concrete fails to meet the acceptance criteria or if deemed by the Engineer to be too variable.

3.11 ACCEPTANCE OF STRUCTURE

A. Comply with ACI 301 and modifications in this section.

B. Completed concrete work, which meets all applicable requirements, will be accepted without qualification.

C. Completed concrete work which fails to meet one or more requirements but which has been repaired to bring it into compliance will be accepted without qualification.

D. Completed concrete work which fails to meet one or more requirements and which cannot be brought into compliance may be accepted or rejected by the Contracting officer. In this event, modifications may be required to assure that remaining work complies with the requirements.

E. The costs of any additional tests or analysis, including additional architectural and engineering services, performed to prove the adequacy of the concrete work, shall be borne by the Contractor without extension of contract time.

3.12 MISCELLANEOUS CONCRETE

A. Curbs: Provide monolithic finish to interior surface of curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

B. Equipment bases and foundations: Provide machine and equipment bases and foundations as shown on drawings. Set anchor bolts for machines and equipment with template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

3.13 FIELD QUALITY CONTROL

A. Requirements:

1. Provide and maintain an adequate program of quality control for the materials, production methods, and workmanship to assure conformance of all work to the project contract documents.
2. Testing and Evaluation:
   a. Furnish and pay for the services of an independent Testing Laboratory satisfactory to the Contracting Officer. The testing laboratory shall have prime responsibility for review, verification inspection, and testing of the concrete producer's materials, operations, facilities, and quality control procedures and evaluating the results for conformance with these specifications.
   b. In addition to the requirements and duties in ACI 301 the testing laboratory shall provide the following:
      a. One or more additional test cylinders shall be taken during cold weather concrete placement and cured on the job site under conditions of concrete represented to determine safe form-stripping period.
      b. Inspect concrete batching, mixing, and delivery operations periodically or as directed by the Contracting Officer.
      c. Submit to the Contracting Officer and concrete producer, during construction, the results of concrete tests.
   c. The Testing Laboratory shall assess and report floor flatness and levelness in accordance with the requirements of this specification.
   d. Field and concrete plant inspections are to be made by a competent representative of the Testing Laboratory during all structural concreting operations including periodic audit and spot check of the Producer's and/or Contractor's quality control procedures to assure proper and adequate control. When it appears that any material furnished fails to fulfill specification requirements, the Testing Laboratory is to report such deficiency immediately to the Contracting Officer and appropriately record it in his report.

END OF SECTION 03 30 00

SECTION 220500 – COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 22.

B. Related sections, Division 23 ‘Common Work Results for HVAC’.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for plumbing installations.
   1. Codes & standards.
   2. Submittals.
   3. Quality control.
   4. Permits, fees, and inspections.
   5. Schedule and sequence.
   6. Project and site conditions.
   7. Delivery, storage, and handling.
   8. Record documents.
   9. Operation and Maintenance manuals.
   10. Warranties and guaranties.
   11. Rough-ins.
   12. Plumbing installations.
   13. Cutting, patching, and firestopping.
   14. Plumbing indentification.
   15. Training.

1.3 SUBMITTALS

A. Increase, by the quantity listed below, the number of plumbing related shop drawings, product data, and samples submitted, to allow for required distribution.

   1. Shop Drawings: Initial Submittal: 1 additional blue- prints.
   2. Product Data: 1 additional copy of each item.
   3. Samples: 1 addition as set.

B. Additional copies may be required by individual sections of these Specifications.

C. Shop Drawings:
   1. Submit for review, detailed shop drawings and product data of all the equipment and material required to complete the work. No material or equipment may be delivered to the jobsite or installed until accepted shop drawings for the particular material or equipment have been approved by the Owner or his authorized representative.
   2. Failure to submit shop drawings in ample time for checking will not entitle Contractor to claim extension of Contract time, or increase in contract cost.
   3. Pproposed piping layout for water distribution piping.
   4. Pproposed piping layout for sanitary waste and vent piping.

D. Tests & Certificates:
   1. As specified in other sections.

1.4 QUALITY ASSURANCE

A. Drawings:
   1. Drawings are diagrammatic. They indicate the general arrangement of systems and work included in the contract. Drawings are not to be scaled. Site and Architectural drawings and details shall be examined for exact location of fixtures and equipment. Where they are not definitely located, this information shall be obtained from the Owner or authorized representative.
   2. Surveys and Measurements:
      a. Before submitting bid, visit site, become familiar with conditions under which work will be installed. Contractor will be held responsible for assumptions, omissions, and errors made as a result of failure to become familiar with site and contract documents.
      b. Base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with established lines and levels. Verify all measurements at site and check the correctness of same.
      c. Notify the Engineer promptly of discrepancies between actual measurements and those indicated, which prevents following good practice or intent of drawings and specifications. Do not proceed with work until Contractor has received instructions from Engineer.

B. Labor:
   1. Coordinate with all other Trades:
      a. Give full cooperation to other trades; furnish in writing to General Contractor, with copies to the Engineer, information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
      b. Where work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If directed by the Engineer, prepare composite working drawings and sections at a suitable scale not less than 1/4" = 1'0",

clearly showing how work is to be installed in relation to the work of other trades. If work under this division is installed before coordinating with other trades, or to cause any interference with work of other trades, make necessary changes to correct the condition without additional cost.

c. Furnish to other trades all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

2. Materials & Workmanship:
   a. Materials and apparatus required for the work shall be new and of first class quality. Furnished, delivered, erected, connected and finished in every detail. Select and arrange to fit properly into the building spaces. Where no specific kind or quality of material is given, furnish first class standard article as accepted by Engineer.
   b. Furnish the services of an experienced superintendent who shall be in constant charge of the work, together with skilled craftsmen and labor required to unload, transfer, erect, connect-up, adjust, start, operate, and test each system.
   c. All equipment and materials to be installed with the acceptance of the Engineer in accordance with the recommendations of the manufacturer. This includes the performance of such test as the manufacturer recommends.

3. Protection of Materials:
   a. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

   b. Welding: Before any welding is performed, submit a copy of the Welding Procedure Specification (WPS) together with the Procedure Qualification Record a required by Section IX of the ASME Boiler and Pressure Vessel Code.
      1) Before any welder performs any welding, submit a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests as required by Section IX of the ASME Boiler and Pressure Vessel Code. The letter or symbol (as shown on the qualification test form) shall be used to identify the work of that welder and shall be affixed, in accordance with appropriate construction code, to each completed weld.
      2) The types and extent of non-destructive examinations required for pipe welds are shown in Table 136.4 of the Code for Pressure Piping, ASNI/ASME B31.1.

   c. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of

the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Engineer prior to the installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.5 CODES AND STANDARDS

A. Except as modified by governing codes, comply with applicable provisions and recommendations of the following:
   1. ANSI Standards.
   2. Owner's Insurance Company.
   3. Current Adopted Connecticut Codes, Laws and Statutes.

1.6 PERMITS, FEES, & INSPECTIONS

A. Give all necessary notices, obtain and pay for all permits, and pay all government sales taxes, fees, and other costs, including utility connections or extensions in connection with work. File necessary approvals of governmental departments having jurisdiction. Obtain required certificates of inspection for work and deliver a copy to the Owner or his authorized representative before requesting acceptance for final payment.

1.7 SCHEDULE & SEQUENCE

A. Temporary Services:
   1. Refer to the General Conditions and Special Conditions for a full description of the temporary services to be provided.

B. Temporary Openings:
   1. Ascertain from examination of the drawings any special temporary openings in the building required for the admission of apparatus provided under this Division. Notify the Owner accordingly. Contractor shall assume all costs of providing such openings thereafter.

C. Sequencing:
   1. Contractor shall coordinate sequence of work with owner's representative.

1.8 PROJECT & SITE CONDITIONS

A. Cutting, Patching, and Firestopping:
   1. Furnish all cutting, drilling and patching. Furnish sketches showing the locations and sizes of openings, chases, etc., required for the installation of

work. Furnish the Contractor with an approximation of the number and size of openings, chases, etc., required.

B. Waterproofing:
   1. Where any work pierces existing waterproofing, re-waterproof. The method of installation to be reviewed by Owner or his authorized representative before work is done. Furnish all sleeves, caulking, and flashing required to make openings watertight.

C. Fireproofing:
   1. Where any work penetrates a fire rated assembly, provide UL listed, firestopping with hourly rating equal to that of the penetrated assembly. Fireproofing shall be compatible with the pipe or equipment doing the penetration so that fire rating of the assembly is maintained.

1.9 DELIVERY, STORAGE, & HANDLING

A. Delivery & Receipt:
   1. Contractor is responsible for the delivery and storage of all materials, parts, equipment, etc. required for this project.

B. Storage:
   1. The Contractor shall store all material, parts, and equipment required for this project in accordance with supplier's and manufacturer's recommendations, and Owner's requirements.

C. Handling, Hoisting, Rigging, & Scaffolding:
   1. Furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1. 10 RECORD DOCUMENTS

A. Maintain at the job site a record set of drawings on which any changes in location of equipment, piping, valves, cleanouts, panels, ducts and major conduits shall be recorded. These shall be clearly marked on a clean set of prints at the completion of work for record drawings and turned over to the Owner.

B. Prepare record documents in accordance with the requirements below:
   1. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, tanks, etc.). Valve location diagrams, complete with valve tag chart.
   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
4. Contract Modifications, actual equipment and materials installed.

1.11 OPERATION & MAINTENANCE MANUALS FOR PLUMBING SYSTEMS

A. Bind Operation & Maintenance Manual for Plumbing System in a hard-backed binder.
   1. Provide a master index at beginning of Manual showing items included. Use plastic tab indexes for sections of Manual.
   2. First section shall consist of name, address, and phone number of Architect, Plumbing, Mechanical & Electrical Engineers, General Contractor and Mechanical, Plumbing, Sheet Metal, Refrigeration, Temperature Control & Electrical Contractors. Also include a complete list of equipment installed with name, address, and phone number of vendor.
   3. Provide section for each type of item of equipment.
   4. Submit three copies of Operation & Maintenance Manual to Engineer for his approval. Use one of these approved copies during final inspection and leave with building maintenance personnel.

B. Include descriptive literature (Manufacturer's catalog data) of each manufactured item. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.

1.12 WARRANTIES AND GUARANTIES

A. Guarantee all material and workmanship under this Division for a period of one year, from the date of final acceptance by the Owner.

B. During guarantee period, all defects developing through materials and/or workmanship shall be replaced immediately without expense to the owner. Make such repairs or replacements to the satisfaction of the Owner.

PART 2 - PRODUCTS

13. ACCEPTABLE MANUFACTURERS

A. As specified under other related sections.

B. As specified on drawings.

14. MATERIALS

A. As specified under other related sections.

B. As specified on drawings.

15. EQUIPMENT DEVIATIONS

A. Where the Contractor proposed to use an item of equipment or fixture other than that specified or detailed on the drawings which requires the redesign of the structure, partitions, foundations, piping, wiring or any other part of the original design layout, all such redesign, and all new drawings and detailing required therefore, shall be prepared at the Contractor's expense and are subject to the review and approval of the Engineer. Owner reserves the right to have the Engineer prepare any redesign work.

B. Where such accepted deviation requires a different quantity and arrangement of materials or equipment from that specified or indicated on the drawings, the Contractor will provide additional equipment and materials required at no additional cost to the Owner.

C. When equipment or methods deviate from original plans or specifications, the Contractor must submit a written request to deviate to the Engineer. At a minimum the request will address the following:

- equipment which is different than specified
- name and data related to the proposed deviation
- reason for deviation
- advantageous or disadvantageous to the Owner
- credit or increase in cost to the Owner
- guarantees or warranties offered (if any)
- acceptance of liability for equivalent performance.

1.16 FIRESTOPPING

A. Firestopping shall be UL listed, and tested in accordance with ASTM E814, E119, and E84.

B. Hourly rating shall be equal to or greater than that of the assembly being penetrated.

C. Firestopping shall be compatible with pipe or equipment penetrating the assembly. Fire rating of the assembly must be maintained.

D. Refer to firestopping specifications and details for additional requirements.

PART 3 - EXECUTION

1.17 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications for rough-in requirements.

1.18 PIPING SYSTEMS INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of plumbing systems, materials, and equipment. Comply with the following requirements:

4. Coordinate plumbing systems, equipment, and materials installation with other building components.
5. Verify all dimensions by field measurements.
6. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for plumbing installations.
7. Coordinate the installation of required supporting devices and sleeves to be set in structural components, as they are constructed.
8. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of the Work.
9. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
10. Coordinate connection of plumbing systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
11. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
12. Install piping behind finished surfaces unless other wise indicated. Piping within mechanical spaces/rooms shall be exposed.
13. Exposed piping shall be installed at right angle or parallel to building walls.
11. Install piping tight to walls, columns, beams, joists and other building elements.
12. Piping installed above accessible ceilings shall be installed with sufficient space to allow for the removal of respective ceiling panels.
13. Groups of piping shall be installed parallel to each other with sufficient spacing to allow for valve servicing and replacement.
14. Piping shall be installed at indicated slopes. Where slopes are not indicated, piping shall be installed as required by current adopted Code.
15. Install piping in such a manner as to eliminate any sags or bends.
16. Install respective fittings for all changes in direction and for branch connections.
17. Install piping to allow for installation of respective insulation plus one (1) additional inch of clearance all the wayt around the insulation.
18. System components shall have a pressure rating equal to or greater than maximum system pressure.

19. Provide escutcheons for all wall, ceiling and floor penetrations.
20. Provide sleeves for all piping passing through concrete/masonry walls, concrete floors and roof slabs as well as gypsum wallboard partitions.
21. Maintain fire rating of all walls, partitions, ceilings, flooring at pipe penetrations. Refer to Division 07.
22. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

1.19 PIPING JOINTS

A. General: Join piping components as indicated in other Divion 22 specification sections and drawings. Comply with the following requirements as well:
   1. Ream all ends of piping and remove burrs.
   2. Remove dirt, debris, scale and slag from the inside as well as the outside of all piping and fittings prior to assembly.
   3. Apply ASTM B 813 water flushable flux, unless otherwise indicated, to pipe ends and fittings of solder joints. Joints shall be constructed in accordance with ASTM B 828 using lead-free solder alloy complying with ASTM B 32.
   4. Brazed joints shall be constructed as per AW'S "Brazing Handbook – Pipe and Tube Chapter". Utilize copper-phosphorus brazing filler metal comply with AWS A5.8.
   5. Threaded joints shall be constructed utilizing threaded pipe with tapered pipe threads in accordance with ASME B1.20.1. Threads shall be cut full and clean utilizing sharp cutting dies. Ream threaded pipe ends to remove burrs and restore full I.D. Pipe fittings and valves shall be joined as follows:
      a. Apply appropriate thread tape or compound to exterior threads, unless dry seal thearing is specified.
      b. Pipe and pipe fitting with damage or corrded trheads shall not be utilized.
      c. Pipe sections with cracked or open welds shall not be utilized.

   6. Provide appropriate gasket material, size, type and thickness for flange joint for respective service application. Gasket shall be concentrically positioned. Utilize appropriate lubricant for bolt threads.
   7. Plastic piping solvent-cement joints shall comply with the following:
      a. Clean and dry joining surfaces.
      b. Comply with ASTM F 402 for safe handling practices of cleaners, primers and solvents.
      c. ABS piping shall be joined per ASTM D 2235 and ASTM D 2261 appendixes.
      d. CPVC piping shall be joined per ASTM D 2846 and ASTM D 2846M appendix.
      e. PVC pressure piping shall be joined per ASTM D 1785. PVC pipe and PVC socket fittings according to ASTM D 2672. Other than schedule number PVC pipe and socket fittings shall be joined in accordance with ASTM D 2855.
      f. PVC non-pressure piping shall be joined per ASTM D2855.

g. PVC to ABS non-pressure transition fittings shall be joined per ASTM D 3138 appendix.

8. Plastic pressure piping gasketed joints shall be joined per ASTM D 3139.
9. Plastic non-pressure piping gasketed joints shall be joined per ASTM D 3212.
10. PE Piping Heat-Fusion joints shall be cleaned, dried and joined in accordance with ASTM D 2657. Utilize butt fisuion for plain end pipe and fittings and socket fusion for plain end pipe and socket fittings.

1.20 PIPING CONNECTIONS

A. Comply with the following requirements unless otherwise noted.
   a. Piping NPS 2" or smaller: Provide unions adjacent to each valve and at final connection to each piece of equipment.
   b. Piping NPS 2-1/2" or larger: Provide flanges adjacent to flanged valves and at final connection to each piece of equipment.
   c. Dry piping systems: Provide dielectric unions and flanges for connection of piping utilizing dissimilar metals.
   d. Wet piping systems: Provide dielectric coupling and nipple fittings for connection of piping utilizing dissimilar metals.

1.21 EQUIPMENT INSTALLATION

A. Install equipment to provide maximum amount of headroom possible unless mounting heights are indicated.

B. Install equipment in accordance with manufacturers installation instructions and requirements.

C. Equipment shall be installed level and plumb as well as parallel and/or perdendicular to other building systems unless otherwise indicated.

D. Plumbing equipment shall be installed in such a manner as to facilitate the service, maintenance, repair and replacement of components.

E. Provide connections to equipment for ease of disconnection with minimum interference to other installations. Grease fittings shall be extended to an accessible area.

F. Installation of equipment shall give right of way to piping required to be installed at a slope.

1.22 FIELD QUALITY CONTROL

A. Perform field tests as specified under other sections.

B. Arrange for local inspection authorities to inspect work performed prior to burial, closing-in behind wall and above ceiling or encase in concrete. Also arrange for final inspection of work and obtain Final Inspection Certificate before final inspection by Owner or his representative.

1.23 TRAINING

A. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the following systems and associated equipment including but not limited too:

- Hot water heaters, mixing valves and associated controls.
- Plumbing fixtures, flush valves, faucets and associated controls.
- Grease interceptor.
- Natural gas system, valves and associated controls.

B. All training shall be video recored. Refer to Division 01 Specification 01 79 00 Demonstration and Training for further requirements.

END OF SECTION 220500

SECTION 22 05 23 – GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this section.

1.2 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.

1. Special purpose valves are specified in individual piping system specifications.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers:

1. Engineer approved equal

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems as indicated.

1. Nonrising stem valves may be used where indicated.

B. Pressure and Temperature Ratings: As required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.
2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.
2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
3. Solder-Joint: Comply with ANSI B16.18.
   a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze; with threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Teflon" impregnated packing, and two-piece backing gland assembly.

2.4 BALL VALVES

A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

B. Ball Valves, 1-1/4-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

2.5 PLUG VALVES

A. Plug Valves, 2-Inch and Smaller: Rated at 150 psi WOG; bronze body, with straightaway pattern, square head, and threaded ends.

B. Plug Valves, 2-1/2-Inch and Larger: MSS SP-78; rated at 175 psi WOG; lubricated plug type, with semisteel body, single gland, wrench operated, and flanged ends.

2.6 GLOBE VALVES

A. Globe Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing, and two-piece backing gland assembly.

2.7 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks.

2.8 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

B. Swing Check Valves, 2-1/2-Inch and Larger: MSS SP-71; Class 125 cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.2 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2-Inch and Smaller: threaded ends.
3. Steel Pipe Sizes 2-1/2 Inch and Larger: flanged ends.

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves as indicated.

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

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install valves in horizontal piping with stem at the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.

3.4 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to full open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.7 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.8 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.9 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES, 2-INCH AND SMALLER

SERVICE	GATE	GLOBE	BALL	CHECK
Domestic Hot and Cold Water	125	125	150	125

VALVES, 2-1/2-INCH AND LARGER

SERVICE	GATE	GLOBE	BUTTERFLY	CHECK
Domestic Hot and Cold Water	125	125	200	125

END OF SECTION 22 05 23

SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Identification devices specified in this section include the following:

1. Painted Identification Materials.
2. Plastic Pipe Markers.
3. Plastic Tape.
4. Underground-Type Plastic Line Marker.
5. Plastic Duct Markers.
6. Valve Tags.
7. Valve Schedule Frames.
8. Engraved Plastic-Laminate Signs.
9. Plastic Equipment Markers.
10. Plasticized Tags.

B. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division-23 sections.

C. Refer to Division-26 sections for identification requirements of electrical work; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves

which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 1.

D. Maintenance Data: Include product data and schedules in maintenance manuals; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering mechanical identification materials:

1. Engineer approved equal.

2.2 MECHANICAL IDENTIFICATION MATERIALS:

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-15 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS:

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.

B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.

2.4 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 degrees F (52 degrees 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 Owner/Owner’s Representative in cases of variance with names as shown or specified.

G. 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 a separate unit of plastic.

2.5 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", 2-1/2" wide tape for larger pipes.

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

2.6 UNDERGROUND-TYPE PLASTIC LINE MARKER:

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

1. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.7 VALVE TAGS:

A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved 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" diameter tags, except as otherwise indicated.
2. Provide size and shape as specified or scheduled for each piping system.
3. Fill tag engraving with black enamel.

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.
2. Provide size, shape and color combination as specified or scheduled for each piping system.

C. Plastic Valve Tags: Provide manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16" high letters and sequenced valve numbers approximately 3/8" high, and with 5/32" hole for fastener.

1. Provide 1-1/8" sq. white tags with black lettering.
2. Provide size, shape and color combination as specified or scheduled for each piping system.

D. 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.

E. 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.

2.8 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.

2.9 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. Thickness: 1/16", except as otherwise indicated.

C. Thickness: 1/8", except as otherwise indicated.

D. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

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

2.10 PLASTIC EQUIPMENT MARKERS:

A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers. Conform to the following color code:

1. Yellow: Heating equipment and components.
2. Blue: Equipment and components that do not meet any of the above criteria.
3. For hazardous equipment, use colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2" x 4" markers for control devices, dampers, and valves; and 4-1/2" x 6" for equipment.

2.11 PLASTICIZED TAGS:

A. General: Manufacturer's standard pre-printed or partially pre- printed accident-prevention tags, of plasticized card stock with matt 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).

2.12 LETTERING AND GRAPHICS:

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide

numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.

1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:

A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 PIPING SYSTEM IDENTIFICATION:

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

1. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2" beyond ends of lettering.
2. Stenciled markers, with lettering color complying with ANSI A13.1.
3. 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.
4. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.

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.

3.3 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.

3.4 VALVE IDENTIFICATION:

A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.

1. Tagging Schedule: Comply with requirements of "Valve Tagging Schedule" at end of this section.

B. Mount valve schedule frames and schedules in machine 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 valve 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.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION:

A. General: Install engraved plastic laminate sign or plastic equipment marker 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, gages, thermometers and similar units.
3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
4. Pumps, compressors, chillers, condensers and similar motor- driven units.
5. Fans, blowers, primary balancing dampers and mixing boxes.
6. Tanks and pressure vessels.
7. Strainers, filters, humidifiers, water treatment systems 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 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

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. Optional Use of Plasticized Tags: At Installer's option, where equipment to be identified is concealed above acoustical ceilings or similar concealment, plasticized tags may be installed within concealed space to reduce amount of text in exposed sign (outside concealment).

1. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at Installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

3.6 ADJUSTING AND CLEANING:

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.7 EXTRA STOCK:

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

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

END OF SECTION 22 05 53

SECTION 22 07 19 – PLUMBING PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-23 ‘Common Work Results for HVAC’ sections apply to work of this section.

1.2 DESCRIPTION OF WORK

A. Extent of mechanical insulation required by this section is indicated by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:

1. Plumbing Systems Insulation:
   a. Fiberglass.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 3 years.

B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.4 SUBMITTALS

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

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

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

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

B. Manufacturer: Subject to compliance with requirements, provide products of one of the following:

1. Engineered approved equal.

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. K-factor maximum of 0.25 at 75 degrees F.

B. Jackets for Piping Insulation: ASTM C 921, Type I (vapor barrier) for piping with temperatures below ambient, Type II for piping with temperatures above ambient.

1. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.

C. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

D. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

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

3.2 PLUMBING PIPING SYSTEM INSULATION

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, strainers, check valves, balance cocks, drainage piping buried piping, fire protection piping, and pre- insulated equipment.

B. Domestic Cold Piping:

1. Application Requirements: Insulate the following cold plumbing piping systems:
   a. Domestic cold water piping.
   b. Plumbing vents within 6 lineal feet of roof outlet.
   c. Waste Piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
   a. Fiberglass: thickness per most current IECC with vapor barrier.

C. Domestic Hot Supply and Return Piping:

1. Application Requirements: Insulate the following hot plumbing piping systems:
   a. Domestic hot water supply and return recirculating piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
   a. Fiberglass: Provide thickness as required per the following:
      3/8" diameter to 1/2" diameter = R-5
      5/8" diameter to 3/4" diameter = R-7
      7/8" diameter to 2" diameter = R-9
      2-1/2" diameter to 4" diameter = R-8

3.3 INSTALLATION OF PIPING INSULATION

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose. All proposed piping shall be insulated.

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

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

D. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

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

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

G. Butt pipe insulation against pipe hanger insulation inserts. 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.

3.5 PROTECTION AND REPLACEMENT

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

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 22 07 19

SECTION 22 11 13 - WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the following Division 23 Sections apply to this section:

1. "Common Work Results for HVAC."
2. "Hangers and Supports for HVAC Pipe and Equipment."

1.2 SUMMARY

A. This Section includes domestic cold water, hot water, fittings, and specialties within the building.

1.3 DEFINITIONS

A. Water Distribution Pipe: A pipe within the building or on the premises that conveys water from the water service pipe or meter to the points of usage.

B. Water Service Pipe: The pipe from the water main or other source of potable water supply to the water distributing system of the building served.

C. Pipe sizes used in this Specification are nominal pipe size (NPS).

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract.

1. Product data for each piping specialty meter and valve specified.
2. Test reports specified in Part 3 of this Section.
3. Maintenance data for each piping specialty and valve specified for inclusion in Maintenance Manual.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following codes:

1. ASME B31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pipe in a manner to prevent sagging and bending.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.8 EXTRA MATERIALS

A. Maintenance Stock: Furnish one valve key for each key-operated wall hydrant, fixture supply, or faucet installed.

PART 2 - PRODUCTS

2.1 PIPE AND TUBE MATERIALS, GENERAL

A. Pipe and Tube: Refer to Part 3, Article "Application, General," for identification of systems where the below materials are used.

B. Copper Tube: ASTM B 88, Type L Water Tube, drawn temper.

C. Copper Tube: ASTM B88, Type K water tube, annealed temper.

2.2 FITTINGS

A. Wrought Copper Solder-Joint Fittings: ANSI B16.22, streamlined pattern.

B. Wrought Copper and Bronze Grooved-End Fittings: ASTM B 75 Tube and ASTM B 584 Bronze Castings.

C. Bronze Flanges: ANSI B16.24, Class 150, raised ground face, bolt holes spot faced.

D. Unions: ASME B16.39, malleable iron, Class 150, hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces, female threaded ends. Threads shall conform to ASME B1.20.1.

E. Dielectric Unions: Threaded, solder, or grooved-end connections as required to suit application; constructed to isolate dissimilar metals, prevent galvanic action, and prevent corrosion.

2.3 JOINING MATERIALS

A. Solder Filler Metal: ASTM B 32, 95-5 Tin-Antimony.

B. Brazing Filler Metals: AWS A5.8, BCuP Series.

C. Gasket Material: Thickness, material, and type suitable for fluid to be handled and design temperatures and pressures.

2.4 GENERAL-DUTY VALVES

A. General-duty valves (i.e., gate, globe, check, and ball, valves) are specified in Division 23 Section "Valves." Special duty valves are specified below by their generic name; refer to Part 3 Article "Valve Application" for specific uses and applications for each valve specified.

2.5 SPECIAL DUTY VALVES

A. Balance Cocks: 400 psi WOG, 2 piece bronze, ball valve, handle, memory stop, with solder-end connections.

2.6 PIPING SPECIALTIES

A. Y-type Strainers: Cast-iron body, epoxy coated 125 psi flanges, removable cover with blow down tapping removable noncorrosive perforated strainer having 1/8 inch perforations.

B. Water mixing valves shall be of the thermostatic type with liquid filled thermal motor. It shall have bronze body construction with replaceable corrosion resistant components. Valve construction shall employ a sliding piston control mechanism. Sliding piston and liners shall be of stainless steel material. Valve shall come equipped with union end stop and check inlets with removable stainless steel strainers. Valve shall provide protection against hot or cold supply line failure and the thermostat failure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine rough-in requirements for plumbing fixtures and other equipment with water connections to verify actual locations of piping connections prior to installation.

3.2 PIPE APPLICATIONS

A. Install Type L, drawn copper tube with wrought copper fittings and solder joints for pipe sizes 4 inches and smaller, above ground, within building. Install Type K, annealed temper copper tube for pipe sizes 4 inches and smaller, with minimum number of brazed joints, below ground.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and branch connections.

C. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted unless expressly indicated.

D. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

E. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

F. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

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

H. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4-inch ball valve, and short 3/4-inch threaded nipple and cap.

I. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls with sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inches shall be galvanized steel pipe; pipe sleeves 6 inches and larger shall be galvanized steel sheet metal.

J. Fire Barrier Penetrations: Where pipes pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity. Refer to Division 7 for special sealers and materials.

K. Install piping level with no pitch.

L. Expansion loops shall be provided in hot water piping. Expansion joints are to be avoided.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, support, and anchor devices conforming to MSS SP-69 are specified in Division 23 Section "Hangers and Supports for HVAC Pipe and Equipment." Conform to the table below for maximum spacing of supports:

B. Pipe Attachments: Install the following:

1. Adjustable steel clevis hangers, MSS Type 1, for individual horizontal runs.
2. Riser Clamp to support vertical runs.

C. Install hangers for individual horizontal piping with the following maximum spacing and minimum rod sizes:

Nom. Pipe Size - In.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to 3/4	6	3/8
1	6	3/8
1-1/4	6	3/8
1-1/2	10	3/8
2	10	3/8
2-1/2	10	1/2
3	10	1/2
3-1/2	10	1/2
4	10	1/2

D. Support vertical copper tube at each floor.

3.5 PIPE AND TUBE JOINT CONSTRUCTION

A. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."

B. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

1. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts of piping specialties before soldering and brazing.
2. Fill the tubing and fittings during soldering and brazing with an inert gas (nitrogen or carbon dioxide) to prevent formation of scale.
3. Heat joints to proper and uniform temperature.

C. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.6 VALVE APPLICATIONS

A. General-Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shut-off duty: Use gate, ball, and butterfly valves.
2. Throttling duty: Use globe, ball, and butterfly valves.

3.7 INSTALLATION OF VALVES

A. Sectional Valves: Install sectional valves on each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections and elsewhere as indicated.

B. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, on each supply to each plumbing fixture, all branch lines and risers and elsewhere as indicated. For

shutoff valves 2 inches and smaller, use gate or ball valves; for shutoff valves 2-1/2 inches and larger, use gate valves.

C. Drain Valves: Install drain valves on each plumbing equipment item, located to drain equipment completely for service or repair. Install drain valves at the base of each riser, at low points of horizontal runs, and elsewhere as required to drain distribution piping system completely. For drain valves 2 inches and smaller, use gate or ball valves.

D. Check Valves: Install swing check valves on discharge side of each pump and elsewhere as indicated.

E. Balance Cocks: Install in each hot water recirculating loop, discharge side of each pump, and elsewhere as indicated.

3.8 INSTALLATION OF PIPING SPECIALTIES

A. Install backflow preventers at each connection to mechanical equipment and systems and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Install air gap fitting and pipe relief outlet drain without valves to nearest floor drain.

B. Install water hammer arrestors for each flush valve. Size in accordance with manufacturer's instructions.

3.9 EQUIPMENT CONNECTIONS

A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts to fixtures of sizes indicated, but in no case smaller than required by plumbing code.

B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection; provide drain valve on drain connection.

3.10 FIELD QUALITY CONTROL

A. Inspections: Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.
2. During the progress of the installation, notify the plumbing official having jurisdiction at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.
    a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed in after system is roughed in and prior to setting fixtures.
    b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to ensure compliance with the requirements of the plumbing code.

3. Reinspections: Whenever the plumbing official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the plumbing official.
4. Reports: Prepare inspection reports signed by the plumbing official.

B. Test water distribution piping as follows:

1. Test for leaks and defects all new water distribution piping systems and parts of existing systems that have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced water distribution piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.
3. Cap and subject the piping system to a static water pressure of 50 psig above the operating pressure without exceeding the pressure rating of the piping system materials. Isolate the test source and allow to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.
4. Repair all leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained.
5. Prepare reports for all tests and required corrective action.

3.11 ADJUSTING AND CLEANING

A. Clean and disinfect water distribution piping as follows:

1. Purge all new water distribution piping systems and parts of existing systems that have been altered, extended, or repaired prior to use.
2. Use the purging and disinfecting procedure proscribed by the authority having jurisdiction or, in case a method is not prescribed by that authority, the procedure described in the 2003 International Plumbing Code.
   a. Submit water samples in sterile bottles to the authority having jurisdiction. Repeat the procedure if the biological examination made by the authority shows evidence of contamination.

B. Prepare reports for all purging and disinfecting activities.

3.12 COMMISSIONING

A. Fill the system. Check that the system is completely full of water.

B. Before operating the system, perform these steps:
1. Close drain valve, hydrants, and hose bibs.
2. Open valves to full open position.
3. Remove and clean strainers.
4. Check pumps for proper direction of rotation. Correct improper wiring.
5. Lubricate pump motors and bearings.

END OF SECTION 22 11 13

SECTION 230500 – COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Materials and methods for performance of all mechanical work.

B. Provide complete and operational mechanical systems including, but not limited to, all required materials, parts, equipment, labor, tools, and accessories.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations.

1. Codes & standards.
2. Submittals.
3. Quality control.
4. Permits, fees, and inspections.
5. Schedule and sequence.
6. Project and site conditions.
7. Delivery, storage, and handling.
8. Record documents.
9. Operation and Maintenance manuals.
10. Warranties and guaranties.
11. Rough-ins.
12. Mechanical installations.
13. Cutting, patching, and firestopping.
14. Mechanical indentification.
15. Training.

1.3 CODES AND STANDARDS

A. Except as modified by governing codes, comply with applicable provisions and recommendations of the following:

1. ANSI Standards.
2. Owner's Insurance Company.
3. Current Connecticut Laws and Statutes.

1.4 SUBMITTALS

A. Increase, by the quantity listed below, the number of mechanical related shop drawings, product data, and samples submitted, to allow for required distribution.

1. Shop Drawings: Initial Submittal: 1 additional blue- prints.
2. Product Data: 1 additional copy of each item.
3. Samples: 1 addition as set.

B. Additional copies may be required by individual sections of these Specifications.

C. Shop Drawings:

1. Submit for review, detailed shop drawings and product data of all the equipment and material required to complete the work. No material or equipment may be delivered to the jobsite or installed until accepted shop drawings for the particular material or equipment have been approved by the Owner or his authorized representative.
2. Failure to submit shop drawings in ample time for checking will not entitle Contractor to claim extension of Contract time, or increase in contract cost.
3. The proposed piping layout for the Boiler system is required.
4. The proposed ductwork layout for the RTUs/AHUs is required.
5. The proposed piping layout of the VRF system is required.

D. Tests & Certificates:

1. As specified in other sections.

1.5 QUALITY ASSURANCE

A. Drawings:

1. Drawings are diagrammatic. They indicate the general arrangement of systems and work included in the contract. Drawings are not to be scaled. Site and Architectural drawings and details shall be examined for exact location of fixtures and equipment. Where they are not definitely located, this information shall be obtained from the Owner or authorized representative.
2. Surveys and Measurements:
   a. Before submitting bid, visit site, become familiar with conditions under which work will be installed. Contractor will be held responsible for assumptions, omissions, and errors made as a result of failure to become familiar with site and contract documents.
   b. Base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with established lines and levels. Verify all measurements at site and check the correctness of same.
   c. Notify the Engineer promptly of discrepancies between actual measurements and those indicated, which prevents following good practice

or intent of drawings and specifications. Do not proceed with work until Contractor has received instructions from Engineer.

B. Labor:

1. Cooperation with Other Trades:
   a. Give full cooperation to other trades; furnish in writing to General Contractor, with copies to the Engineer, information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
   b. Where work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If directed by the Engineer, prepare composite working drawings and sections at a suitable scale not less than 1/4" = 1'0", clearly showing how work is to be installed in relation to the work of other trades. If work under this division is installed before coordinating with other trades, or to cause any interference with work of other trades, make necessary changes to correct the condition without additional cost.
   c. Furnish to other trades all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

2. Materials & Workmanship:
   a. Materials and apparatus required for the work shall be new and of first class quality. Furnished, delivered, erected, connected and finished in every detail. Select and arrange to fit properly into the building spaces. Where no specific kind or quality of material is given, furnish first class standard article as accepted by Engineer.
   b. Furnish the services of an experienced superintendent who shall be in constant charge of the work, together with skilled craftsmen and labor required to unload, transfer, erect, connect-up, adjust, start, operate, and test each system.
   c. All equipment and materials to be installed with the acceptance of the Engineer in accordance with the recommendations of the manufacturer. This includes the performance of such test as the manufacturer recommends.

3. Protection of Materials:
   a. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

   b. Welding: Before any welding is performed, submit a copy of the Welding Procedure Specification (WPS) together with the Procedure Qualification

Record a required by Section IX of the ASME Boiler and Pressure Vessel Code.

1) Before any welder performs any welding, submit a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests as required by Section IX of the ASME Boiler and Pressure Vessel Code. The letter or symbol (as shown on the qualification test form) shall be used to identify the work of that welder and shall be affixed, in accordance with appropriate construction code, to each completed weld.
2) The types and extent of non-destructive examinations required for pipe welds are shown in Table 136.4 of the Code for Pressure Piping, ASNI/ASME B31.1.

c. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Engineer prior to the installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

C. High Performance Building Requirements:

1. Adhesives, sealants, paints or coatings used for work in this section for interior applications shall meet the requirements of Division 1, Section 018113: “Volatile Organic Compound (VOC) Limits for Adhesives, Sealants, Paints and Coatings”, where applicable.
2. Materials manufactured within a radius of 500 miles from the project site where all or a portion of the raw resources also originate within a radius of 500 miles shall be documented in accordance with the High Performance Building Requirements of this Section.
3. Materials that contain recycled content shall be documented in accordance with the High Performance Building Requirements of this Section.

1.6 PERMITS, FEES, & INSPECTIONS

A. Give all necessary notices, obtain and pay for all permits, and pay all government sales taxes, fees, and other costs, including utility connections or extensions in connection with work. File necessary approvals of governmental departments having jurisdiction. Obtain required certificates of inspection for work and deliver a copy to the Owner or his authorized representative before requesting acceptance for final payment.

1.7 SCHEDULE & SEQUENCE

A. Temporary Services:

1. Refer to the General Conditions and Special Conditions for a full description of the temporary services to be provided.

B. Temporary Openings:

1. Ascertain from examination of the drawings any special temporary openings in the building required for the admission of apparatus provided under this Division. Notify the Owner accordingly. Contractor shall assume all costs of providing such openings thereafter.

C. Sequencing:
1. Contractor shall coordinate sequence of work with owner's representative.

1.8 PROJECT & SITE CONDITIONS

A. Cutting, Patching, and Firestopping:

1. Furnish all cutting, drilling and patching. Furnish sketches showing the locations and sizes of openings, chases, etc., required for the installation of work. Furnish the Contractor with an approximation of the number and size of openings, chases, etc., required.

B. Waterproofing:

1. Where any work pierces existing waterproofing, re-waterproof. The method of installation to be reviewed by Owner or his authorized representative before work is done. Furnish all sleeves, caulking, and flashing required to make openings watertight.

C. Fireproofing:

1. Where any work penetrates a fire rated assembly, provide UL listed, firestopping with hourly rating equal to that of the penetrated assembly. Fireproofing shall be compatible with the pipe or equipment doing the penetration so that fire rating of the assembly is maintained.

1.9 DELIVERY, STORAGE, & HANDLING

A. Delivery & Receipt:

1. Contractor is responsible for the delivery and storage of all materials, parts, equipment, etc. required for this project.

B. Storage:

1. The Contractor shall store all material, parts, and equipment required for this project in accordance with supplier's and manufacturer's recommendations, and Owner's requirements.

C. Handling, Hoisting, Rigging, & Scaffolding:

1. Furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1.10 RECORD DOCUMENTS

A. Maintain at the job site a record set of drawings on which any changes in location of equipment, piping, ducts, valves, cleanouts, panels, and major conduits shall be recorded. These shall be clearly marked on a clean set of prints at the completion of work for record drawings and turned over to the Owner.

B. Prepare record documents in accordance with the requirements below:

1. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, tanks, etc.). Valve location diagrams, complete with valve tag chart.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
4. Contract Modifications, actual equipment and materials installed.

1.11 OPERATION & MAINTENANCE MANUALS FOR MECHANICAL SYSTEMS

A. Bind Operation & Maintenance Manual for Mechanical System in a hard-backed binder.
1. Provide a master index at beginning of Manual showing items included. Use plastic tab indexes for sections of Manual.
2. First section shall consist of name, address, and phone number of Architect, Mechanical & Electrical Engineers, General Contractor and Mechanical, Plumbing, Sheet Metal, Refrigeration, Temperature Control & Electrical Contractors. Also include a complete list of equipment installed with name, address, and phone number of vendor.
3. Provide section for each type of item of equipment.

4. Submit three copies of Operation & Maintenance Manual to Engineer for his approval. Use one of these approved copies during final inspection and leave with building maintenance personnel.

B. Include descriptive literature (Manufacturer's catalog data) of each manufactured item. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.

C. Operating instructions shall include:

1. General description of each mechanical system.
2. Step by step procedure to follow in putting each piece of mechanical equipment into operation.
3. Provide schematic control diagrams for each separate fan system, refrigeration system, heating system, control panel, etc. Each diagram shall show locations of start-stop switches, insertion thermostats, room thermostats, thermometers, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating setting for each control instrument on these diagrams.
4. Provide diagram for electrical control system showing wiring of related electrical control items such as firestats, fuses, interlock, electrical switches, and relays.
5. Provide drawing of each temperature control panel system.

D. Prepare maintenance manuals to include the following information for equipment items:

1. Manufacturer's maintenance equipment installed in Project. Instructions shall include name of vendor, installation instructions, parts numbers & lists, operation instructions of equipment and maintenance & lubrication instructions.
2. Summary list of mechanical equipment requiring lubrication showing name of equipment, location and type, and frequency of lubrication.
3. List of mechanical equipment used indicating name, model, serial number, and name plate data of each item together with number and name associated with each system item.
4. List spare parts and quantities to be maintained in ready inventory at project site.
5. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
6. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
7. Servicing instructions and lubrication charts and schedules.

E. Air Balance and Water Balance Test Run Reports

1.12 WARRANTIES AND GUARANTIES

A. Guarantee all material and workmanship under this Division for a period of one year, from the date of final acceptance by the Owner.

B. During guarantee period, all defects developing through materials and/or workmanship shall be replaced immediately without expense to the owner. Make such repairs or replacements to the satisfaction of the Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As specified under other related sections.

B. As specified on drawings.

2.2 MATERIALS

A. As specified under other related sections.

B. As specified on drawings.

2.3 EQUIPMENT DEVIATIONS

A. Where the Contractor proposed to use an item of equipment other than that specified or detailed on the drawings which requires the redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical layout, all such redesign, and all new drawings and detailing required therefore, shall be prepared at the Contractor's expense and are subject to the review and approval of the Engineer. Owner reserves the right to have the Engineer prepare any redesign work.

B. Where such accepted deviation requires a different quantity and arrangement of materials or equipment from that specified or indicated on the drawings, the Contractor will provide additional equipment and materials required at no additional cost to the Owner.

C. When equipment or methods deviate from original plans or specifications, the Contractor must submit a written request to deviate to the Engineer. At a minimum the request will address the following:

- equipment which is different than specified
- name and data related to the proposed deviation
- reason for deviation

- advantageous or disadvantageous to the Owner
- credit or increase in cost to the Owner
- guarantees or warranties offered (if any)
- acceptance of liability for equivalent performance.

2.4 MANUFACTURER'S IDENTIFICATION

A. Attach manufacturer's nameplate, name, trademark and address permanently to equipment and material furnished under this Division. Nameplate of a Contractor or Distributor is not acceptable.

2.5 ELECTRICAL REQUIREMENTS

A. Motors:

1. Electric motors furnished as a component part of equipment furnished under this Division shall conform to the requirements of IEEE, NEMA, UL, ANSI C50, and ANSI CI. Motors to be suitable for required load, duty voltage, phase, frequency, service and location.
2. Motors to be suitable for continuous duty at rated horsepower with temperature rise not to exceed 40oC for dripproof motors, 50oC for splashproof motors, and 55oC for totally enclosed motors. Motors to be capable of withstanding momentary overloads of 25 percent without injurious overheating.
3. Motors to have nameplates giving Manufacturer's name, serial number, horsepower, speed and current characteristics.
4. Motor leads shall be permanently identified and supplied with connectors.
5. Each motor to be selected for quiet operation in accordance with NEMA standards.

B. Motor Starters:

1. Electric motor starters shall conform to requirements of IEEE, NEMA, UL, ANSI, CI and shall be suitable for the required load, duty, voltage, phase, frequency, service, and location.
2. When interlocking or automatic control of single phase motors is required, motors to be furnished with full voltage, across-the-line starters.

C. Connections:

1. All wiring to be furnished and installed under Division 16.

2. Power wiring to be furnished and installed complete from power source to motor or equipment junction box, including power wiring through the starters. Starters not factory mounted on equipment shall be furnished and installed under Division 16.

2.6 MECHANICAL REQUIREMENTS

A. Bases & Supports:

1. Provide necessary foundations, supports, pads, bases and piers required for equipment, tanks, and other equipment furnished under this Division. Submit drawings to Engineer for review before purchase, fabrication, or construction.
2. Construction of foundations, supports, pads, bases, and piers where mounted on the floor to be of the same materials and same quality of finish as the adjacent surrounding flooring material.

B. Lubrication:

1. Lubricate all equipment having moving parts and requiring lubrication according to manufacturer's recommendations prior to testing and operation. Equipment discovered to have been operated before lubrication is subject to rejection and replacement at no cost to the Owner.

C. Accessibility:

1. Be responsible for the sufficiency of the size of shafts and chases, adequate clearance in double partitions and hung ceilings for proper installation of work. Cooperate with the Contractor and other contractors whose work is in the same space. Advise the Contractor of requirements. Such spaces and clearances shall be kept to the minimum size required.
2. Locate all equipment which requires servicing in fully accessible positions. Equipment shall include but not be limited to, valves, traps, clean-outs, motors, controllers, switchgear, and drain points. Any change shall be submitted to the Owner or his authorized representative for review.

D. Connection to Existing Structures:

1. Before cutting, drilling, attaching, or any work involving building elements, coordinate work with others and Owner to avoid damage to building elements.

2.7 FIRESTOPPING

A. Firestopping shall be UL listed, and tested in accordance with ASTM E814, E119, and E84.

B. Hourly rating shall be equal to that of the assembly being penetrated.

C. Firestopping shall be compatible with pipe or equipment penetrating the assembly fire rating of the assembly must be maintained.

D. Provide firestopping for all pipe/duct penetrations. Coordinate with architectural plans.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications for rough-in requirements.

3.2 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 CUTTING, PATCHING, AND FIRESTOPPING

A. General: Perform cutting and patching in accordance with the following requirements apply:

1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Remove and replace defective Work.
2. Remove and replace Work not conforming to requirements of the Contract Documents.
3. Remove samples of installed Work as specified for testing.
4. Install equipment and materials in existing structures.
5. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

1. Patch finished surfaces and building components using materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

E. Firestop all pipe/duct and equipment that penetrates fire rated assembly. Follow manufacturer's instructions to provide fire rating equal to that of the assembly.

F. Infill/patch all existing pipe/duct opening no longer in use.

3.4 FIELD QUALITY CONTROL

A. Perform field tests as specified under other sections.

B. Arrange for local inspection authorities to inspect work performed prior to burial, closing-in behind wall and above ceiling or encase in concrete. Also arrange for final inspection of work and obtain Final Inspection Certificate before final inspection by Owner or his representative.

3.5 PAINTING

A. Materials shipped to the job site under this Division to have prime coat and standard manufacturer's finish.

3.6 TESTING & BALANCING: See Section 230593

3.7 EQUIPMENT IDENTIFICATION

A. Valves charts and tags

1. All valves shall be provided with valve tags secured to the valve stems or handles with brass chains or S hooks. Tags shall be based on Seton Nameplate Co. (Numbers and letter identification shall indicate service where valve is located. Tags shall be 1-3/8" diameter.
2. Furnish two (2) valve charts, one framed under glass and one unframed copy for record files. Charts shall indicate system designation, valve number, service, and location of valve. Use actual room names on charts.

3.8 CLEANING

A. Any part of a system stopped by foreign matter after being placed in operation, to be disconnected, cleaned, and reconnected to locate and remove obstructions. Work damaged in the course of removing obstructions will be repaired or replaced at no additional cost to the Owner.

B. Cap all pipes to protect against entrance of foreign matter.

C. Remove rubbish, debris, and excess materials. Remove oil and grease stains on floor areas.

3.9 TRAINING

C. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the following systems and associated equipment including but not limited to:

- Hot water system, boilers, pumps, glycol, expansion tanks, radiation, cabinet unit heaters, unit heaters, convectors, valves and associated controls.

- Roof mounted dedicated outside air units (DOAS) and associated controls.
- Variable Refrigerant Flow (VRF) Heat Pump units, Indoor Air Conditioning units and associated controls.
- Ductless Split System Heat Pump units, Indoor Air Conditioning units and associated controls.
- Modular air handling units, coils, filters, valves and associated controls.
- Diffusers and grilles.
- Air cooled condensing units and associated controls.
- Packaged Rooftop units, duct mounted hot water coils, valves variable air volume (VAV) boxes with hot water reheat and associated controls.
- Kitchen: packaged rooftop unit, grease fan for hood, dishwasher fan and associated controls.
- Exhaust fans and associated controls.
- Radon system, fan and associated controls.
- Kiln exhaust system and associated controls.
- Variable frequency drives and associated controls.
- Building management system front end, programming, laptop, control panels and associated components.

B. All training systems shall be recorded. Refer to Division 01 Specification 01 79 00 Demonstration and Training for further requirements.

END OF SECTION 230500

SECTION 230523 – GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this section.

B. Requirements of the following Division 23 Sections apply to this section:

1. "Common Work Results for HVAC"

1.2 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.

1. Special purpose valves are specified in individual piping system specifications.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Comply with the requirements specified in Division 1 Section "MATERIALS AND EQUIPMENT."

B. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation For Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.
2. Protect valve ends against damage to threads, flange faces, and weld-end preps.
3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers:

1. Engineer approved equal

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems as indicated.

1. Nonrising stem valves may be used where indicated.

B. Pressure and Temperature Ratings: As required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.
2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.
2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
3. Solder-Joint: Comply with ANSI B16.18.
   a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze; with threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Teflon" impregnated packing, and two-piece backing gland assembly.

2.4 BALL VALVES

A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

B. Ball Valves, 1-1/4-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

2.5 PLUG VALVES

A. Plug Valves, 2-Inch and Smaller: Rated at 150 psi WOG; bronze body, with straightaway pattern, square head, and threaded ends.

B. Plug Valves, 2-1/2-Inch and Larger: MSS SP-78; rated at 175 psi WOG; lubricated plug type, with semisteel body, single gland, wrench operated, and flanged ends.

2.6 GLOBE VALVES

A. Globe Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing, and two-piece backing gland assembly.

2.7 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks.

2.8 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

B. Swing Check Valves, 2-1/2-Inch and Larger: MSS SP-71; Class 125 cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.2 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2-Inch and Smaller: threaded ends.
3. Steel Pipe Sizes 2-1/2 Inch and Larger: flanged ends.

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves as indicated.

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

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install valves in horizontal piping with stem at the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.

3.4 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to full open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.7 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.8 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.9 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES, 2-INCH AND SMALLER

SERVICE	GATE	GLOBE	BALL	CHECK
Heating Hot Water	150	150	150	150

VALVES, 2-1/2-INCH AND LARGER

SERVICE	GATE	GLOBE	BUTTERFLY	CHECK
Heating Hot Water	125	125	200	125

END OF SECTION 230523

SECTION 230529 – HANGERS AND SUPPORTS FOR HVAC PIPE AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 23 Sections apply to this section:

1. "Common Work Results for HVAC."

1.2 SUMMARY

A. This section includes the following:

1. Horizontal-piping hangers and supports.
2. Vertical-piping clamps.
3. Hanger-rod attachments.
4. Building attachments.
5. Saddles and shields.
6. Spring hangers and supports.
7. Miscellaneous materials.
8. Equipment supports.

B. Related sections: The following sections contain requirements that relate to this section:

1. Division 23 Section "HVAC Piping Insulation"

1.3 DEFINITIONS

A. Terminology used in this section is defined in MSS SP-90.

1.4 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division specification sections.

1. Product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

2. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.
3. Assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

1.5 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Regulatory Requirements: Comply with applicable plumbing code pertaining to product materials and installation of supports and anchors.

C. High Performance Building Requirements:

1. Adhesives, sealants, paints or coatings used for work in this section for interior applications shall meet the requirements of Division 1, Section 018113: “Volatile Organic Compound (VOC) Limits for Adhesives, Sealants, Paints and Coatings”, where applicable.
2. Materials manufactured within a radius of 500 miles from the project site where all or a portion of the raw resources also originate within a radius of 500 miles shall be documented in accordance with the High Performance Building Requirements of this Section.
3. Materials that contain recycled content shall be documented in accordance with the High Performance Building Requirements of this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58 and MSS SP-69.

1. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

2.2 MISCELLANEOUS MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substates and conditions under which supports and anchors are to be installed. Do not proceed with installing until unsatisfactory conditions have been corrected.

3.2 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 and SP-89. Install supports with maximum spacings complying with Boca Plumbing and Mechanical Codes. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

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

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

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

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

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

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

1. Shields: Install protective shields MSS Type 40 on cold water piping that has vapor barrier. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
1/4 THROUGH 3-1/2	12	0.048
4	12	0.060

2. Insert material shall be at least as long as the protective shield.
3. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.3 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

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

C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours welded surfaces to match adjacent contours.

3.4 ADJUSTING

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

END OF SECTION 230529

SECTION 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Identification devices specified in this section include the following:

1. Painted Identification Materials.
2. Plastic Pipe Markers.
3. Plastic Tape.
4. Underground-Type Plastic Line Marker.
5. Plastic Duct Markers.
6. Valve Tags.
7. Valve Schedule Frames.
8. Engraved Plastic-Laminate Signs.
9. Plastic Equipment Markers.
10. Plasticized Tags.

B. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division-23 sections.

C. Refer to other Division-23 sections for identification requirements at central-station mechanical control center; not work of this section.

D. Refer to Division-26 sections for identification requirements of electrical work; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

C. High Performance Building Requirements:

1. Adhesives, sealants, paints or coatings used for work in this section for interior applications shall meet the requirements of Division 1, Section 018113: “Volatile Organic Compound (VOC) Limits for Adhesives, Sealants, Paints and Coatings”, where applicable.
2. Materials manufactured within a radius of 500 miles from the project site where all or a portion of the raw resources also originate within a radius of 500 miles shall be documented in accordance with the High Performance Building Requirements of this Section.

3. Materials that contain recycled content shall be documented in accordance with the High Performance Building Requirements of this Section.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 1.

D. Maintenance Data: Include product data and schedules in maintenance manuals; in accordance with requirements of Division 1.

E. High Performance Building Submittal Requirements: The contractor or subcontractor shall submit the following High Performance Building certification items:

1. A Connecticut High Performance Building Compliance letter shall be provided verifying agreement with relevant High Performance requirements. Information to be supplied includes, but is not limited to:

   a. The percentage by weight of recycled content in the product(s). Identify post-consumer and/or pre-consumer recycled content.
   b. The manufacturing location for the product(s); and the location (source) of the raw materials used to manufacture the product(s).
   c. Provide material costs for the materials included in the contractor’s or subcontractor’s work. Material cost does not include costs associated with labor and equipment.

2. Letters of Certification, provided from the product manufacturer on the manufacturer’s letterhead, to verify the amount of recycled content.
3. Product Cut Sheets for all materials of this Section that meet High Performance Building Requirements.
4. Material Safety Data Sheets (MSDS), for all applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings applied on the interior of the building. MSDS shall indicate the Volatile Organic Compound (VOC) limits of products submitted (If an MSDS does not include a product’s VOC content, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC content)

1.4 HIGH PERFORMANCE BUILDING GENERAL REQUIREMENTS

A. Implement practices and procedures to meet the project's environmental goals, which include complying with Connecticut Standard Guidelines Compliance Manual for High Performance Buildings, September 2011 with additional mandatory building project requirements for schools. Specific project goals which may impact this and the other sections of this specification include: use of recycled-content materials; use of locally-manufactured materials; use of low-emitting materials; use of certified wood products; construction waste recycling; and the implementation of a construction indoor air quality management plan. Ensure that the requirements related to these goals, as defined in this Section and other Sections of the contract documents, are implemented to the fullest extent. Substitutions or other changes to the work shall not be allowed if such changes substantially com-promise the stated High Performance Building criteria.

B. Comply with Connecticut Standard Guidelines Compliance Manual for High Performance Buildings, September 2011 with additional mandatory building project requirements for schools and the Department of Administrative Services / Office of School Construction Grants & Review High Performance School Construction Bulletin, June 2017.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering mechanical identification materials:

1. Engineer approved equal.

2.2 MECHANICAL IDENTIFICATION MATERIALS:

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-15 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS:

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.

B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.

2.4 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 degrees F (52 degrees 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 Owner/Owner’s Representative in cases of variance with names as shown or specified.

G. 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 a separate unit of plastic.

2.5 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", 2-1/2" wide tape for larger pipes.

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

2.6 UNDERGROUND-TYPE PLASTIC LINE MARKER:

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

1. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.7 VALVE TAGS:

A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved 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" diameter tags, except as otherwise indicated.
2. Provide size and shape as specified or scheduled for each piping system.
3. Fill tag engraving with black enamel.

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.
2. Provide size, shape and color combination as specified or scheduled for each piping system.

C. Plastic Valve Tags: Provide manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16" high letters and sequenced valve numbers approximately 3/8" high, and with 5/32" hole for fastener.

1. Provide 1-1/8" sq. white tags with black lettering.
2. Provide size, shape and color combination as specified or scheduled for each piping system.

D. 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.

E. 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.

2.8 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.

2.9 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. Thickness: 1/16", except as otherwise indicated.

C. Thickness: 1/8", except as otherwise indicated.

D. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

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

2.10 PLASTIC EQUIPMENT MARKERS:

A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers. Conform to the following color code:

1. Yellow: Heating equipment and components.
2. Blue: Equipment and components that do not meet any of the above criteria.
3. For hazardous equipment, use colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2" x 4" markers for control devices, dampers, and valves; and 4-1/2" x 6" for equipment.

2.11 PLASTICIZED TAGS:

A. General: Manufacturer's standard pre-printed or partially pre- printed accident-prevention tags, of plasticized card stock with matt 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).

2.12 LETTERING AND GRAPHICS:

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:

A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION:

A. General: Identify air supply, return, exhaust, intake and relief ductwork with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color).

B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacings along exposed runs.

C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 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. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2" beyond ends of lettering.
   2. Stenciled markers, with lettering color complying with ANSI A13.1.

3. 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.
4. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.
5. All natural gas piping shall be painted yellow.

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.

3.4 VALVE IDENTIFICATION:

B. 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, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.

1. Tagging Schedule: Comply with requirements of "Valve Tagging Schedule" at end of this section.

C. Mount valve schedule frames and schedules in machine 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 valve 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.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION:

A. General: Install engraved plastic laminate sign or plastic equipment marker 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, gages, thermometers and similar units.
3 Fans, blowers, primary balancing dampers.
4 trainers, 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 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

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. Optional Use of Plasticized Tags: At Installer's option, where equipment to be identified is concealed above acoustical ceilings or similar concealment, plasticized tags may be installed within concealed space to reduce amount of text in exposed sign (outside concealment).

1. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at Installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

3.4 ADJUSTING AND CLEANING:

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.5 EXTRA STOCK:

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

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

END OF SECTION 230553

SECTION 230593 – TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 SUMMARY:

A. This Section specifies the requirements and procedures total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

B. Test, adjust, and balance the following mechanical systems:

1. Supply, return and outside air systems;
2. Exhaust air systems;
3. Hydronic systems;
4. Verify temperature control system operation.

1.3 DEFINITIONS:

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. the balance of water/air distribution;
2. adjustment of total system to provide design quantities;
3. electrical measurement;
4. verification of performance of all equipment and automatic controls;
5. sound and vibration measurement.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: pipe containing the system's major or entire fluid flow.

I. Submain: pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: pipe serving two or more terminals.

K. Branch: pipe serving a single terminal.

1.4 SUBMITTALS:

A. Agency Data:

1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below.

B. Engineer and Technicians Data:

1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.

C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.

D. Maintenance Data: Submit maintenance and operating data that include how to test, adjust, and balance the building systems. Include this information in maintenance data specified in Section 230500.

E. Sample Forms: Submit sample forms, if other than those standard forms prepared by the NEBB are proposed.

F. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:

1. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports.
3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
   a. General Information and Summary
   b. Air Systems
   c. Temperature Control Systems
4. Report Contents: Provide the following minimum information, forms and data:
   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.
   b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC and NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.

G. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.5 QUALITY ASSURANCE:

A. Agency Qualifications:

1. Employ the services of an independent testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives.Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.
2. The independent testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by NEBB as a Test and Balance Engineer.

B. Codes and Standards:

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
2. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

1.6 PROJECT CONDITIONS:

A. Systems Operation: Systems shall be fully operational prior to beginning procedures. Verify with engineer prior to commencing of testing.

1.7 SEQUENCING AND SCHEDULING:

A. Test, adjust and balance hydronic systems at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING:

A. Before operating the system, perform these steps:

1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
2. Obtain copies of approved shop drawings of hydronic system layout, outlets (supply and return) and temperature control diagrams.
3. Compare design to installed equipment and field installations.
4. Adjust circuit setters.
5. Calibrate inline pumps.
6. Prepare schematic diagrams of system "as-built" piping layouts to facilitate reporting.

3.2 MEASUREMENTS:

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

G. Take all reading with the eye at the level of the indicated value to prevent parallax.

H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

I. Take measurements in the system where best suited to the task.

3.3 PERFORMING TESTING, ADJUSTING, AND BALANCING:

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

B. Cut insulation and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

C. Patch insulation and housings, using materials identical to those removed.

D. Seal piping, and test for and repair leaks.

E. Seal insulation to re-establish integrity of the vapor barrier.

F. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

G. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.4 RECORD AND REPORT DATA:

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.5 DEMONSTRATION:

A. Training:

1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures. Review with the Owner's personnel, the information contained in the Operating and Maintenance Data specified in Section 230500.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

END OF SECTION 230593

SECTION 230700 – DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-23 sections, apply to work of this section.

1.2 DESCRIPTION OF WORK

A. Extent of mechanical insulation required by this section is indicated by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:

1. HVAC Duct Systems Insulation:
   a. Fiberglass.

C. Refer to Division-23 section "Supports and Anchors" for protection saddles, protection shields, and thermal hanger shields; not work of this section.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 3 years.

B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.4 SUBMITTALS

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

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

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

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

B. Manufacturer: Subject to compliance with requirements, provide products of one of the following:

1. Ownes Corning
2. Johns Manville
3. Knauf

2.2 DUCTWORK INSULATION MATERIALS:

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1.

B. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, Class B-4.

C. Jackets for Ductwork Insulation: ASTM C 921, Type I.

D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

E. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

F. Provide thickness as required per most current IECC standards.

PART 3 - EXECUTION

3.1 INSPECTION

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

3.2 INSTALLATION OF HVAC DUCT 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. All proposed ductwork shall be insulated.

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

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

D. Maintain integrity of vapor-barrier jackets on duct insulation, and protect to prevent puncture or other damage.

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

3.3 PROTECTION AND REPLACEMENT

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

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 230700

SECTION 230719 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-23 sections, apply to work of this section..

1.2 DESCRIPTION OF WORK

A. Extent of mechanical insulation required by this section is indicated by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:

1. HVAC Piping Systems Insulation:
   a. Fiberglass.

C. Refer to Division-23 section "Supports and Anchors" for protection saddles, protection shields, and thermal hanger shields; not work of this section.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 3 years.

B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.4 SUBMITTALS

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

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

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

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

B. Manufacturer: Subject to compliance with requirements, provide products of one of the following:

1. Ownes Corning
2. Johns Manville
3. Knauf

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. K-factor maximum of 0.25 at 75 degrees F.

B. Jackets for Piping Insulation: ASTM C 921, Type I (vapor barrier) for piping with temperatures below ambient, Type II for piping with temperatures above ambient.

1. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.

C. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

D. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

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

3.2 HVAC PIPING SYSTEM INSULATION

A. Cold Piping (40 degrees F (4.4 degrees C) to ambient):

1. Application Requirements: Insulate the following cold HVAC piping systems:

a. Air conditioner condensate drain piping.

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

a. Fiberglass: Provide thickness as required per most current IECC standards.

B. Hot Low Pressure Piping (to 250 degrees F (121 degrees C)):

1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi, water piping up to 250 degrees F (121 degrees C).

a. HVAC hot water supply and return piping.
b. Refrigerant piping.

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

a. Fiberglass: Provide thickness as required per most current IECC standards.

3.4 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. All proposed piping shall be insulated.

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

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

D. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

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

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

G. Butt pipe insulation against pipe hanger insulation inserts. 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.

3.5 PROTECTION AND REPLACEMENT

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

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 230719

SECTION 23 09 00 BAS INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 13, BAS Instrumentation and Control Devices

B. SECTION 23 09 13.13, BAS Actuators and Operators

C. SECTION 23 09 13.23, BAS Sensors and Transmitters

D. SECTION 23 09 13.33, BAS Control Valves

E. SECTION 23 09 13.43, BAS Control Dampers

F. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI/ISA 5.5-1985 Graphic Symbols for Process Displays.

2. ANSI/IEEE 260.1 2004, Standard Letter Symbols for SI and Certain Other Units of Measurements (SI Units, Customary Inch Pound Units and Certain Other Units).

1.3 ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

A. Acronyms used in BAS.

1. BAS – Building Automation System

2. EMCS – Energy Management and Control System

3. GUI – Graphical User Interface

4. HVAC - Heating, Ventilation, Air Conditioning

5. I/O - Input/output

6. ISA - Industry Standard Architecture

7. O&M - Operation and Maintenance

1.4 PERMITS AND FEES

A. In accordance with General Conditions of Contract.

B. Submit certificate of acceptance from authority having jurisdiction to Owner.

1.5 GENERAL DESCRIPTION

A. Refer to control schematics for general system architecture.

B. Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:

1. Control devices as listed in I/O Summaries.

2. Peripheral devices.

3. Complete operating and maintenance manuals and field training of operators, programmers and maintenance personnel.

4. Acceptance tests, technical support during commissioning, full documentation.

5. Wiring interface co-ordination of equipment supplied by others.

6. Miscellaneous work as specified in these sections and as indicated.

1.6 US CUSTOMARY MEASUREMENT REFERENCES

A. Conform to NIST Handbook 44 - 2014 Edition Appendix C “General Tables of Units of Measurement”

B. {USC}Provide required adapters between US Customary and Metric components.

1.7 STANDARDS COMPLIANCE

A. All equipment and material to be from manufacturer's regular production, UL and/or ULC or CSA certified, manufactured to standard quoted plus additional specified requirements.

B. Where UL and/or ULC or CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.

C. Submit proof of compliance to specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.

D. In lieu of such evidence, submit certificate from testing organization, approved by Owner, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.

E. For materials whose compliance with organizational standards/codes/specifications is not regulated by an organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

1.8 WORK INCLUDED

A. Provide a new building system to control and monitor the building’s mechanical and electrical systems.

B. Provide control valves, control dampers (gravity, fire and smoke control dampers by others), flow switches, thermal wells for temperature control, and air flow stations as necessary.

C. Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry, pneumatic (as required) and electrical installation, programming, start up, test and validation acceptance documentation, as-built documentation, maintenance manuals and system warranties.

D. All labor, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.

E. The work covered by this specification and related sections consists of providing shop drawings, equipment, labor, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

1. The preparation of submittals and provision of all related services.

2. Furnish and install all to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

3. Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.

4. Perform acceptance tests and commissioning as indicated.

5. Provide full documentation for all applications and equipment.

6. Miscellaneous work as indicated in these specifications.

1.9 WORK BY OTHERS

A. Setting in place of valves and dampers, access doors, flow meters, water pressure and differential taps, flow switches, thermal wells, fire and smoke control dampers, and air flow stations, shall be by others.

B. Duct smoke detectors, fire alarm system relays, modules and monitoring devices shall be provided by Division 26. Connection of auxiliary terminals of duct smoke detectors, fire alarm system relays, modules and monitoring devices shall be wired to the BAS for monitoring purposes only by this section.

C. High and low temperature thermostats shall be provided by this section.

D. Switches, and power wiring to motors, starters, thermal overload switches, and contactors, is specified in Division 26. This Section includes the furnishing and installation of controls and wiring for automatic controls, electric damper and valve operators, terminal control units, interlocks, starting circuits, and wiring to power consuming control devices.

1.10 BAS CONTRACTOR QUALIFICATIONS

A. Within 14 days of award of the contract the BAS contractor is to:

1. Provide proof of having a local office within 50 miles of project for at least 5 years, staffed by trained personnel capable of providing instruction, routine maintenance, emergency service on systems,

2. Provide record of successful installations of similar size, performed by Contractor submitting the tender, showing successful experience with similar computer based systems.

3. Provide proof of having in-house staff with expertise in pneumatic controls where applicable.

4. Provide Profiles for each employee who will be involved in this project.

PART 2 - PRODUCTS

2.1 QUALITY ASSURANCE

A. All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:2008 manufacturer, for a minimum duration of 5 years, at time of bid.

B. The Building Automation System shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be Factory Authorized in good standing with the Manufacturer. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

1. Upon request, installer shall present records of successful completion of factory training courses including course outlines.

2. Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.

PART 3 - EXECUTION

3.1 CO-ORDINATION

A. All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer / Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.

B. Organize all your sub-contractors and ensure that they maintain the schedule.

C. Contractor shall work in harmony with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.

D. Notify Engineer/Construction Manager, in writing, of any changes to the schedule. Send any schedule changes and weekly progress reports to Engineer/Construction Manager.

E. Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference.

F. When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

3.2 SUPERVISION OF PERSONNEL

A. Maintain qualified personnel and supporting staff at this project with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.

B. Supervisory personnel and their qualifications are subject to the approval of the Owner.

C. All personnel working on-site shall sign in as required by the Owner.

D. When requested and for whatever reason, remove personnel and/or support staff from project. Take immediate action.

3.3 SYSTEM DESIGN AND RESPONSIBILITY

A. The BAS contractor is responsible for designing wire type to link the various elements in view of the present and future capabilities.

B. The Contractor is responsible for supplying sufficient Controllers of all types to meet the intent of the specification.

C. The quantity and point content of the Controllers must be approved by the Engineer prior to point installation.

3.4 PRODUCTS

A. Materials and equipment shall be essentially the catalogued products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest standard design that complies with the specification requirements.

B. Where two units of the same class of equipment are required, these units shall be products of a single manufacturer, and the component parts of the system shall be the products of a single manufacturer.

C. Each major component of equipment shall have the manufacturer's name and address and the model and serial number on a nameplate securely attached in a conspicuous place.

3.5 ELECTRICAL WORK, WIRING AND SAFETY

A. Electrical work shall be in accordance ANSI/NFPA 70 and the local Electrical Code.

B. Based on project location, Regional Regulation Compliance Certifications (CSA C22.1) will be required.

C. Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel.

D. All wiring shall conform to the most stringent requirements of the local electrical authority having jurisdiction. Refer to Division 26 00 00 for electrical requirements, codes and regulations.

E. All wiring associated with and required by the BAS shall be the responsibility of this contractor.

1. The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system.

2. If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.

3.

3.6 LABELING

A. Labels shall be provided for all control items listed or shown in the submittal and approved control diagrams.

B. Each inscription shall identify its function, such as "mixed air controller", "cold deck sensor" in official languages etc. and when applicable, its position.

1. Size of labels shall be 1 inch by 3 inches minimum.

2. Lettering shall be minimum ¼ inch high normal black lettering.

3.7 PRELIMINARY DESIGN REVIEW

A. The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information:

1. Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.

2. Provide product data sheets and a technical description of all direct digital controller hardware required to meet specifications listed herein.

3. Provide an overview of the BAS contractor’s local/branch organization, local staff, recent related project experience with references, and local service capabilities.

4. Provide information on the BAS contractor’s project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

3.8 SUBMITTALS

A. Within 45 days of award of contract and before start of construction, submit copies of manufacturer's information and shop drawings per owners direction.

1. Drawings to be in AutoCAD or VISIO and Sequence of Operations and Points List (Input/output Summary) shall be in Word and Excel format (latest versions) structured using menu format for easy loading and retrieval on the OWS.

B. Provide in completely coordinated and indexed package to assure full compliance with the contract requirements.

1. Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work.

2. Arrange the submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended.

C. Submittals for each manufactured item shall be manufacturer's descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalog cuts, and shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

D. Control System Shop Drawings

1. Schematic diagram of each controlled system. Label control points with point names.

2. Bill of Material for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

3. Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.

4. Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.

5. Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.

3.9 AS-BUILT DOCUMENTATION (OPERATING AND MAINTENANCE (O&M) MANUALS)

A. As-built documentation shall include the following information and submitted per the owners direction.

B. The final documentation package shall include:

1. Hard and soft copies of all control drawings.

2. Manufacturer's technical data sheets for all hardware and software.

3. Factory operating and maintenance manuals with any customization required.

4. Soft copies of programming and front-end software and each controller's database. Hard copy output of programming is not necessary.

5. Provide clear, concise, printed and soft copy descriptions of all control sequences in the working language.

6. Soft copy text files shall be in Microsoft Word format.

7. Copy of all graphics files.

C. All hard copies of instruction and reference manuals shall be bound in hardback, 3 ring, binders or an approved equivalent shall be provided.

1. Binders to be no more than 2/3 full.

2. Each binder to contain index to full volume.

3. One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance.

4. The identification of each manual's contents shall be inscribed on the cover and spine.

5. The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system.

6. The manuals shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject.

7. Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph.

8. Manuals and specifications shall be furnished which provide full and complete coverage of the following subjects:

   a. Operational Requirements: This document shall describe in concise terms, all the functional and operational requirements for the system and its functions that have been implemented. It shall be written using common terminology for building operation staff and shall not presume knowledge of digital computers, electronics or in-depth control theory.
   b. System Operation: Complete step by step procedures for operation of the system,

including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.

c. Maintenance: Documentation of all maintenance procedures for all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module. This shall include calibration, maintenance, and repair or replacement of all system hardware.

d. Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures. A provision for the measurement or observation of results, based on the published test specification, forms the test reports. The procedures record and the results of these exercises shall be conveniently bound and documented together.

e. Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system. This shall include all information required to ensure necessary coordination of hardware and software changes, data link or message format/content changes, and sensor or control changes in the event system modification are required, and to fully document such new system configurations.

3.10 MAINTENANCE CONTRACT

A. The BAS Contractor shall present a two year maintenance contract for the Owner's acceptance within sixty days after installation of the system begins. Show the price for each year with all payment terms and conditions.

B. The Maintenance Contract shall include the following provisions:

1. On-line Service - Provide diagnostic and trouble-shooting services via remote communications capabilities. Response time to Owner requests for this type of corrective maintenance is within four (4) hours.

2. Software Maintenance and Consultation - The BAS Contractor reviews the need for software modifications to the existing database quarterly, and implement modification.

3. Backup of the database will be made quarterly and retained by the BAS Contractor and a copy shall be provided to the owner.

4. Software Maintenance - Provide software revisions as they become available. All costs associated with updating software shall be included with the maintenance contract

5. Repair and Replacement - The BAS Contractor provides materials and labor for repair or replacement of failed equipment and components with new equipment or components. Reconditioned equipments and components are at the discretion of the O

6. Emergency Service - The BAS Contractor provides emergency service, between scheduled preventive maintenance calls, including overtime, necessary to keep equipment and components in proper operation. Overtime costs shall be in addition to the maintenance agreement

7. The BAS Contractor guarantees future availability of continuous, twenty-four hour, seven days a seek service for the systems through available maintenance contracts.

8. Emergency Response Time - When a site visit is required to complete troubleshooting procedures, the System Contractor will be on-site within four (4) hours.

9. Factory trained and employed service representatives of the BAS Manufacturer contractor will perform service.

10. Perform preventive Maintenance in accordance within a program of standardized maintenance routines supplied to the Owner's equipment.

11. Each schedule lists the equipment name, location, and appropriate preventive maintenance functions to be performed during that inspection.

C. Maintenance Routines include, but are not be limited to the following:

1. Checking performance of equipment and components.

2. Diagnostic test, examination, cleaning, lubrication, adjustment and calibration of equipment and their components. Such components include but are not limited to: Central Processing Unit, disk memory, monitors, displays, printer, remote units, printed circuit boards, and associated sensors and controllers.

D. The Maintenance Contract shall be renewable at the Owner’s option and include provision for increased charges due to expansion of the system, changes in service coverage, and/or inflation.

END OF SECTION 230900

SECTION 23 09 13 BAS INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00, BAS Instrumentation and Control

B. SECTION 23 09 13.13, BAS Actuators and Operators

C. SECTION 23 09 13.23, BAS Sensors and Transmitters

D. SECTION 23 09 13.33, BAS Control Valves

E. SECTION 23 09 13.43, BAS Control Dampers

F. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 COMPUTER HARDWARE

A. General Description:

1. The computer shall consist of commercially available general-purpose equipment manufactured by a recognized manufacturer with factory authorized service centers within 75 miles of the job site.

2. The server shall be provided for centralized system control, information management, alarm management and data base management functions.

3. All real time control functions shall be resident in the standalone Network Control Unit (NCU) and local controllers (LCUs and TCUs).

B. Provide a server(s) as detailed herein complete with software, as described in Section 23 09 13.

C. Provide Operator workstations as detailed herein complete with software, as described in Section 23 09 13

D. The system shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users. The BAS shall be provided with a minimum of 32 user licenses.

E. Provide three copies of all Programming Software required for programming LCUs and TCUs as described herein.

F. Any computer with access to the BAS LAN shall display the systems in a graphical and dynamic format utilizing a standard web browser and HTTP protocol. Screen refresh shall be automatic. Manual refresh is not acceptable.

2.2 SERVER HARDWARE REQUIREMENTS

A. The Server shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB 3.0 ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

B. The server operating system

1. shall be one of:

a. Windows 10 Pro 64bit

b. Windows 10 Enterprise 64bit

2. With VM support

3. With the most recent service packs and system updates.

4. Selected based on availability and project requirements.

5. Latest version of Symantec Antivirus Software that includes a 3 year subscription service to the Symantec software.

C. Acceptable Manufacturers are:

1. Dell

2. Lenovo

3. HP (Hewlett Packard)

D. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

E. The server location will be corrdianted through the RFI process.

F. The server shall support all Network Control Units (NCU), OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.

2.3 WORKSTATION HARDWARE REQUIREMENTS

A. The workstation shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

B. The operating system

1. shall be one of:

a. Windows 10 Pro 64bit

b. Windows 10 Enterprise 64bit

2. With the most recent service packs and system updates.

3. Selected based on availability and project requirements.

C. Acceptable Manufacturers are:

1. Dell

2. Lenovo

3. HP (Hewlett Packard)

D. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

E. Provide _1__ Workstations.

F. Location of workstation shall be coordinated the RFI process.

G. Workstation(s) should be loaded with TCU/LCU and all Programming Tools necessary to operate and make modification to the BMS.

2.4 NOTEBOOK WORKSTATION REQUIREMENTS

A. The Notebook Workstation shall be a minimum Intel Core i3 Dual core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6Gb/s transfer rate. It shall include a minimum 32X CD-ROM drive, and 3-USB ports, minimum 15" LED display capable of as a minimum 1024 x 768 resolution.

B. The operating system

1. shall be one of:

    a. Windows 10 Pro 64bit

    b. Windows 10 Enterprise 64bit

2. With the most recent service packs and system updates.

3. Selected based on availability and project requirements.

C. Acceptable Manufacturers are:

1. Dell

2. Lenovo

3. HP (Hewlett Packard)

D. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

E. Provide 1 Notebook Workstations. Turn over the notebook workstations to the owner at time of training.

2.5 PRINTERS

A. Provide a report printer connected to each Operator Workstation and one alarm printer. Printer location to be coordinated through the RFI process.

B. The alarm printer(s) shall be a 24 pin head dot matrix printer, parallel interface, capable of 360x360 dpi, 132 characters per line, 192 cps in draft mode, NLQ mode, with spare ribbon, fan fold paper and 5000 sheets of paper.

C. The report/graphics printer shall be a color inkjet printer, 1440 x1440 dpi photo quality color resolution, internal 1MB buffer memory, minimum 8 pages per minute in black and 4 pages per minute in color, 100 sheet 8.5"x11" cassette feed, 100 sheet output cassette, with separate dedicated color and black and white cartridges. Supply one spare set of ink cartridges and 5000 sheets of pape

2.6 UNINTERRUPTABLE POWER SUPPLIES

A. Provide the OWS, Server, and each NCU with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration. UPS to include remote alrming capabilities upon a low battery condition

B. Acceptable Manufacturers

1. APC.

2. Functional Devices

2.7 OPERATOR SOFTWARE

A. Operating System: See Sections 2.2 and 2.3 for specific OSs.

B. The software shall employ browser-like functionality for ease of navigation.

1. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database.

2. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills.

a. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

C. Real-Time Displays.

1. Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.

a. Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.

b. The graphic shall provide for the ability to command each point, including both timed and permanent overrides.

c. Provide for all information represented in the graphics in an associated graphical table with links to the equipment graphics and command-able points.

d. Sample graphics shall be provided as part of the submittals for approval by owner.

D. The Operator software, shall at a minimum, support the following graphical features and functions:

1. Graphic screens shall be developed using GIF, PNG, JPG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.

2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.

3. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.

E. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

F. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

G. Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.

H. System Configuration.

1. At a minimum, the Operator software shall permit the operator to perform the following tasks, with proper password access:

a. Create, delete or modify control strategies.

b. Add/delete objects to the system.

c. Tune control loops through the adjustment of control loop parameters.

d. Enable or disable control strategies.

e. Generate hard copy records or control strategies on a printer.

f. Select points to be alarm-able and define the alarm state.

g. Select points to be trended over a period of time and initiate the recording of values automatically.

I. On-Line Help.

1. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.

a. On-line help shall be available for all applications and shall provide the relevant data for that particular screen.

b. Additional help information shall be available through the use of hypertext.

c. All system documentation and help files shall be in HTML format.

J. Security.

1. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data.

2. System security shall be selectable for each operator.

3. The system administrator shall have the ability to set passwords and security levels for all other operators.

4. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.

5. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.

6. This auto log-off time shall be set per operator password.

7. All system security data shall be stored in an encrypted format.

K. System Diagnostics.

1. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.

2. The failure of any device shall be annunciate to the operator.

L. Alarm Console.

1. The system shall be provided with a dedicated alarm window or console.

a. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

b. The use of the Alarm Console can be enabled or disabled by the system administrator.

1. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

c. This window will notify the operator of new alarms and un-acknowledged alarms.

d. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

M. Operator's software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming.

1. This system shall provide the capability to configure controller binary and analog inputs/outputs.

N. The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.

1. Graphics generation shall be done using standard Windows packages.

2. No proprietary graphics generation software shall be needed.

O. Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

P. The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information.

1. All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console.

2. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection.

3. The facility shall be provided to permit the operator to perform the following tasks:

a. Automatic logging of digital alarms and change of status message.

b. Automatic logging of all analog alarms.

c. System changes (alarm limits, set-points, alarm lock-outs, etc.).

d. Display specific points as requested by the operator.

e. Provide reports as requested by the operator and on Scheduled basis where so required.

f. Display graphics as requested by the operator.

g. Display of help information.

h. Provide trend logs as required by the operator.

i. Provide manual control of digital and analog outputs as required by the operator.

j. Direct the hard copy output of information to the device selected by the operator.

k. Data displayed on monitor to cyclic update as appropriate.

Q. Online changes:

1. Alarm limits.

2. Setpoints.

3. Dead-bands

4. Changes/deletions/additions of points.

5. Control and change of state changes.

6. Time of day, day, month, year.

7. Control loop control description changes for NCU based CDM's.

8. Control loop tuning changes

9. Schedule changes

10. Changes/additions/deletions to system graphics

11. Changes/additions/deletions to total systems

R. It shall be possible for the operator to override automatic analog and digital output commands.

1. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.

2. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.

3. It shall be possible for the operator to place any computed system setpoint to a computed basis as and when required.

4. All above functions shall operate under the password protection system.

S. A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows: %, ˚C, KPA, KW, KWH, L/S, CFM, ˚F, and PSI.

T. The descriptions shall be alterable from the OWS console with the system on-line.

U. Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on printer or Monitor.

1. The output device shall be by operator's choice.

2. Analog values and status displayed on the Monitor shall be updated whenever new values are received.

3. Points in alarm shall be flagged by blinking, inverse video different color, bracketed, or by some other means to differentiate them from points not in alarm.

V. Error Messages

1. Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of BAS.

2. Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

W. Password Protection

1. Provide security system that prevents unauthorized use unless operator is logged on.

   a. Access shall be limited to operator's terminal functions unless user is logged on, including displays as outlined above.

2. Each operator's workstation shall provide security for 100 users minimum.

   a. Each user shall have an individual User ID, User Name and Password.

   b. Entries are alphanumeric characters only and are case sensitive (except for User ID).

   c. User ID shall be 8 characters,

   d. User Name shall be a maximum of 29 characters, and Password shall be a maximum of 8 characters long.

   e. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access.

   f. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal.

   g. Each user shall also have a set security level, which defines access to displays and individual objects the user may control.

   h. System shall include 10 separate and distinct security levels for assignment to users.

X. Trend Data

1. System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk.

   a. Archived files shall be appended with new sample data, allowing samples to be accumulated over 3 years.

   b. Systems that write over archived data shall not be allowed, unless limited file size is specified.

   c. Samples may be viewed at the operator's terminal in a trend log.

d. Logged data shall be stored in spreadsheet format.

e. Operator shall be able to scroll through all trend log data.

f. System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically.

g. All trend log information shall be displayed in standard engineering units.

2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colors and these Graphs shall show object type value relative to time.

3. Operator shall be able to change trend log setup information.

   a. This includes the information to be logged as well as the interval at which it is to be logged.

   b. Minimum interval of 1 minute.

   c. All input, output, and value object types in the system may be logged.

   d. All operations shall be password protected.

   e. Setup and viewing may be accessed directly from any and all graphics object is displayed on.

4. System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk.

   a. Archive files shall be appended with the new data, allowing data to be accumulated over several years.

   b. Systems that write over archived data shall not be allowed unless limited file size is specified.

   c. System shall automatically open archive files as needed to display archived data when operator scrolls through the data.

   d. Display all energy log information in standard engineering units.

5. System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time.

   a. All data shall be stored in spreadsheet format for direct use by third-party spreadsheet or other database programs.

   b. Operation of system shall not be affected by this operation.

6. Operator shall be able to change the energy log setup information.

a. Including the meters to be logged, meter pulse value, and the type of energy units to be logged.

b. All meters monitored by the system may be logged.

c. All operations shall be password protected.

Y. Graphics

1. The operator's workstation shall display all data associated with the project.

   a. The operator's terminal software shall accept, GIF, PNG, JPG and ICO format graphic files for display purposes.

   b. Graphic files shall be created using scanned, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.

   c. Operator's workstation shall display all data using 3-D graphic representations of all mechanical equipment.

   d. Displays can be used as templates to produce other displays

2. System shall be capable of displaying graphic file, text, and dynamic object data together on each display.

   a. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.

   b. All information on any display shall be dynamically updated without any action by the user.

   c. Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.

   d. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

3. All displays shall be generated and customized in such a manner by the local DDC system supplier that they fit the project as specified.

   a. Canned displays shall not be acceptable.

   b. Displays shall use Standard English for labelling and readout.

   c. Systems requiring factory programming for graphics are specifically prohibited.

   d. The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.

4. Binary objects shall be displayed as ON/OFF/NULL or with customized text.

a. Text shall be justified left, right or centre as selected by the user.

b. Allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic.

c. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm.

d. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp).

e. Additionally, allow binary objects to be displayed as an animated graphic.

5. Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

a. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation.

b. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF.

c. Allow operator to change bitmap file assignment and also create new and original bitmaps online.

d. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator.

e. Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.

6. Analog objects shall be displayed with operator modifiable units.

a. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic.

b. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps.

c. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint.

d. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box.

e. Selection for display type shall be individual for each object.

f. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad.

7. Analog objects may also be assigned to an area of a system graphic, where the color of the defined area would change based on the analog objects value.

   a. For example, an area of a floor-plan graphic served by a single control zone would change color with respect to the temperature of the zone or its deviation from set-point.

   b. All editing and area assignment shall be created or modified online using simple icon tools.

8. A customized menu label (push-button) shall be used for display selection.

   a. Menu items on a display shall allow penetration to lower level displays or additional menus.

   b. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item.

   c. Each display may be protected from viewing unless operator has appropriate security level.

   d. A separate security level may be assigned to each display and system object.

9. A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

10. Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.

    a. The presentation will contain displays for:

       1. Site Overview

       2. Specific Building(s)

       3. Floor plates within Building(s)

       4. Each controlled Zone

       5. Each controlled System or Sub-System

    b. All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)

       1. Clicking on a building in the Site Overview displays the specific building display.

       2. Clicking on a floor, displays the floor plate display

3. Clicking on a zone, displays the specific control system for that zone.

4. Clicking on a specific system or sub-system coarse representation at the floor plate display level displays a detailed presentation of the system or sub-system.

11. Displays are stored on the server and may be modified on site or via remote communications.

12. Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

Z. Alarms

1. Operator’s terminal shall provide audible, visual, electronic and printed means of alarm indication.

2. Any alarm may be handled based on its individual or assigned class actions.

a. Actions are, but not limited to

1. Displayed on the Alarm console.

a. The system shall be provided with a dedicated alarm window or console.

b. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

c. The use of the Alarm Console can be enabled or disabled by the system administrator.

d. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

e. This window will notify the operator of new alarms and un-acknowledged alarms.

f. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

g. Printout of alarms shall be sent to the assigned terminal and port.

2. Delivery by electronic mail (e-mail).

a. Sent via e-mail to one or more recipients.

3. Printed.

a. Printed on local or network printer

3. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal.

a. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

4. Alarm messages shall be in user-definable text English or other specified language) and shall be entered either at the operator's terminal or via remote communication.

AA. Scheduling

1. Operator's terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

a. This includes all ON/OFF times (to the minute) for each day's events.

2. Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

a. These speciality schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, again allowing easy data entry.

b. Exception schedule data is entered by the following methods:

1. date entries (one day entries)

2. date-to-date (a range or span of days)

3. by weekday (for example, a given day of a given week each month)

c. User shall be able to scroll easily through the months for each year as a minimum.

3. At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

BB. Archiving

1. Store back-up copies of all controller databases in at least one OWS and the server.

2. Provide continuous supervision of integrity of all controller databases.

a. Data base back up and downloading to occur over LAN without operator intervention.

3. Operator to be able to manually download entire controller database or parts thereof.

CC. Reports

1. Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.

a. If display output (Monitor) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report.

b. Output to be sorted by area, system point.

2. Periodic/Automatic Report:

   a. Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.

   b. The software will allow the operator to modify the periodic/automatic reporting profile at any time.

3. As a minimum, the following reports shall be configured on the system:

   a. Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency and it shall be possible to select points on the following basis:

      1. All points in all areas

      2. Area (all points in area)

      3. Area system (all points in system)

      4. Area system point (individual point)

      5. System (all points by system and point type)

      6. System point (all points by system and point type)

      7. Area point (all points by area and point type).

   b. Summary Report:

      1. To permit the display or printing of the dynamic values for the user specified points.

         a. Reports to be available on same basis as dynamic reports.

         b. Output will be to the user selected output device.

   c. Trend Reports:

      1. To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

   d. Historical Data Collection:

      1. Provision shall be made to ensure historical data is not lost.

         a. The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided.

b. Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.

e. Critical Alarm Summary:

1. Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.

f. Maintenance Alarm Summary:

1. Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.

g. Alarm Summary:

1. Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

h. Disable Point Summary:

1. Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

i. Run Time Summary:

1. Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

j. Schedule Summary:

1. Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

k. User Record Summary:

1. Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

DD. LCU / TCU Programming Software

1. The Programming software must be able to be seamlessly launched from within the Niagara Framework as a wizard.

a. Connection methods (Tunneling or by building controller – not direct to controller).

2. Provide programming software for the Local Control Unit (LCU) and the Terminal Control Unit (TCU) that allows for the development of the LCU/TCU control logic and point management and Graphical User Interface screens.

    a. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens.

    b. Access to these functions shall be provided through Graphical User Interface software (GUI).

    c. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool.

    d. Completed applications may be stored in the library for future use.

    e. Graphical User Interface screens shall be created in the same fashion.

    f. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates.

    g. Any real-time data value or object property may be connected to display its current value on a user display.

    h. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

    i. Programming Methods:

        1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application.

        2. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another.

        3. Object links will support one-to-one, many-to-one, or one-to-many relationships.

        4. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.

    j. Object Configuration

        1. Each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons.

        2. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

    k. The software shall provide the ability to view the logic with values being inputted to and outputted from the graphical blocks in real time. (debug mode)

l. The system shall support object duplication within a client's database.

1. An application, once configured, can be copied and pasted for easy re-use and duplication.

2. All links, other than to the hardware, shall be maintained during duplication.

m. Provides function to compare and calculate from multiple values from networked controllers (NCU, TCU and/or LCU).

n. As a minimum, the function shall calculate and compared the values and return the average, sum, highest, lowest, 3 highest, 3 lowest values and multi-state value count.

o. Auto-linking of objects to graphics

p. [Can include] Auto-Encapsulate functionality (the automatic ability to group multiple programming objects into a new singular programming object).

q. Allow for uploading/downloading to/from multiple controllers

EE. Utility Software

1. Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.

2. Upon Engineers approval of record documents, Enter "Record" drawings on all OWS.

2.8 NATIVE WEB BROWSER INTERFACE

A. The contractor shall provide web-browser delivered graphical visualization software as part of the operator workstation, server, NAC(s), and/or IP-CTRL devices, as indicated on construction documents. The contractor shall configure the graphical visualization software in accordance with project requirements.

B. The graphical visualization software shall have two operating modes: Studio & Viewer, as described below. For both Studio & Viewer modes, the graphical user interface shall be delivered to the user by pointing a modern web browser to a project-specific URL and logging into the system. The software shall not require any software plugins to be installed in conjunction with the web browser.

C. When delivered to a modern web browser, the software shall implement web development standards, including but not limited to Hypertext Markup Language (HTML) v5, Cascading Style Sheets (CSS) v3, and JavaScript (in compliance with ECMAScript specifications).

2.9 BAS CONTROLLERS

A. Controllers –BACnet/IP Protocol

1. Provide BACnet Controllers that are BACnet Testing Laboratory listed (v12 or later) as specified herein:

a. BACnet Building Controller (B-BC)

b. {BIP}BACnet Advanced Application Controller (B-AAC)

c. {BIP}BACnet Application Specific Controller (B-ASC)

2. All BACnet/IP Controllers shall use the following communication specifications and achieve performance as specified herein:

   a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU).

      1. Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

   b. Performance

      1. Each BACnet controller shall have a minimum of 512KB of RAM and 4GB of non-volatile flash memory.

      2. {BIP}Each controller shall have a 32-bit microprocessor operating at 600 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2012 and the BACnet Device Profile supported.

   c. BACnet Controllers shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings.

      1. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.

   d. Control Unit (LCU) and Terminal Control Unit (TCU)

      1. Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

      2. All control sequences programmed into the LCU and TCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

      3. LCU and TCU controllers that are not fully programmable and/or cannot retain programming as outlined in .2 are not acceptable.

   e. BACnet Controllers shall communicate with the Network Control Unit (NCU) via a BACnet/IP connection at a baud rate of not less than 100 Mbps

   f. {BIP}BACnet TCU to have a communications port for connecting a matching room temperature and/or humidity sensor and does not utilize any of the I/O points of the Controller.

1. The TCU and all other devices on the BACnet bus shall be accessible from this communications port.

g. The Contractor supplying the BACnet Controllers shall provide documentation for each device, with the following information at a minimum:

1. BACnet Device; MAC address, name, type and instance number.

2. BACnet Objects; name, type and instance number

h. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each BACnet controller, as required by the Point List located in the POINTS LIST section of this specification.

B. Controllers – BACnet Protocol

1. Provide BACnet Controllers that BACnet Testing Laboratory listed (v12 or later) as specified herein:

a. BACnet Building Controller (B-BC)

b. BACnet Advanced Application Controller (B-AAC)

c. BACnet Application Specific Controller (B-ASC)

2. All BACnet Controllers shall use the following communication specifications and achieve performance as specified herein:

a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU).

1. Any controller on the MS/TP Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

b. Performance

1. Each BACnet MS/TP controller shall have a minimum of 64Kb of RAM and 384Kb of non-volatile flash memory.

2. Each controller shall have a 32-bit microprocessor operating at 68 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2012 and the BACnet Device Profile supported.

3. Each BACnet controller on the BACnet MS/TP communications trunk shall provide a loading characteristic of minimum 1/8th Load.

4. Manufacturers, who wish to supply LCU and TCU controllers with less than a 32-bit microprocessor and/or a MS/TP loading characteristic of greater than 1/8th Load, may do so as long as they only provide a maximum of 32 controllers on a single bus segment per NCU.

c. BACnet Controllers shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings.

1. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.

d. Control Unit (LCU) and Terminal Control Unit (TCU)

1. Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

2. All control sequences programmed into the LCU and TCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

3. LCU and TCU controllers that are not fully programmable and/or cannot retain programming as outlined in .2 are not acceptable.

e. BACnet Controllers shall communicate with the Network Control Unit (NCU) via a BACnet/IP connection at a baud rate of not less than 100 Mbps or via the RS485 MS/TP connection at a baud rate of not less than 76.8 kbps.

f. {MSTP}BACnet TCU to have a communications port for connecting a matching room temperature and/or humidity sensor and does not utilize any of the I/O points of the Controller.

1. The TCU and all other devices on the BACnet bus shall be accessible from this communications port.

g. The Contractor supplying the BACnet Controllers shall provide documentation for each device, with the following information at a minimum:

1. BACnet Device; MAC address, name, type and instance number

2. BACnet Objects; name, type and instance number

h. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each BACnet controller, as required by the Point List located in the POINTS LIST section of this specification.

C. Local Control Units (LCU) (Primary Systems such as AHU, MAU, Chiller, Boiler, Water System)

1. The Local Control Units (LCU) shall be 32 bit microprocessor-based.

a. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2. Each LCU shall have sufficient memory, to support its own operating system and data-bases, including:

   a. Control processes

   b. Energy management applications

   c. Alarm management applications

   d. Historical/trend data for points specified

   e. Maintenance support applications

   f. Custom processes

   g. Manual override monitoring

3. Each LCU shall support:

   a. Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

      1. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

      2. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

      3. Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

      4. Digital outputs (contact closure for motor starters up to size 4).

      5. Analog outputs of 4-20 mA and 0-10 Vdc.

4. The LCU analog or universal input shall use a 16 bit A/D converter.

   a. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

5. The LCU analog or universal output shall use a 10 bit D/A converter.

6. Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection.

   a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

   b. As a minimum, provide one of each type of point available on the controller.

7. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

8. The LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.

    a. The controller shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication.

9. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN OWS or Server.

    a. Controller requiring a local port to reload the controller software is not acceptable.

10. Provide an onboard network communication jack for connection to the BACnet Network (RJ-45 or equivalent quick connect)

11. Wireless port supporting a wireless transceiver for communication with wireless sensors/switches

12. Acceptable Products:

    a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) or BACnet Advanced Application Controller (B-AAC)

D. IP Plant Controller (IP-SYS-CTRL)

1. The IP-SYS-CTRL shall be 32 bit microprocessor-based operating at a minimum of 1 GHz.

    a. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

    b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2. Each IP-SYS-CTRL shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases, including:

    a. Control processes

    b. Energy management applications

    c. Alarm management applications

    d. Historical/trend data for points specified

    e. Maintenance support applications

f. Custom processes

g. Web Based interface via integral Web Server.

h. Support for up to a minimum of 256 I/O points which are added via Expansion I/O modules.

i. Shall have a graphical interface with a common library of HVAC system image and animation such as AHU, MAU, Boiler Plant, Chiller Plant, and Rooftop Unit.

3. The IP-SYS-CTRL shall have a Real Time clock.

4. The IP-SYS-CTRL will support the following communications protocols:

a. BACnet/IP

1. Supporting IPv4 addressing.

2. DHCP support and Auto DNS.

3. 2 - RJ45 ports each capable of supporting 10/100 Base-T.

a. Supporting controller daisy chaining on the Ethernet network via integral switch functionality.

4. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

b. BACnet MS/TP supporting up to minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.

1. Supporting 9600 to 115200 baud

c. Modbus RTU

1. Supporting 9600 to 115200 baud

d. Modbus TCP

e. 2 x USB 2.0 Expansion ports for:

1. 802.11 Wi-Fi Adapter enabling wireless connectivity including:

a. ‘Hot Spot’

b. Client

c. Access Point

2. If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

5. Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

6. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES

7. Acceptable Products:

    a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

E. IP-SYS-CTRL Communication Modules

1. Each IP-SYS-CTRL Communication module shall be capable of RS-485 communication with the following requirements, without the additional gateways/routers to enable RS-485 communication:

2. Include two separate RS-485 communication ports.

    a. Allow for either Modbus RTU or BACnet MS/TP communication on either of the ports

3. Allow for a minimum of 32 Modbus RTU communicating devices and/or a minimum of 50 BACnet MS/TP communicating devices to be connected on each RS-485 segment.

4. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES

F. IP-SYS-CTRL Expansion I/O modules:

1. Each IP-SYS-CTRL Expansion I/O module shall be capable of monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

    a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

    b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

        1. The analog or universal input shall use a 16 bit A/D converter.

            a. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

2. Each IP-SYS-CTRL Expansion I/O module shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

    a. Digital outputs.

        1. Optional Form C relay outputs.

        2. Optional Triac Outputs.

    b. Analog outputs of 4-20 mA and 0-10 Vdc.

1. The analog or universal output shall use a 10 bit D/A converter.

c. HOA (Hand, Off, Auto) support.

3. Each completed configuration of IP-SYS-CTRL and Expansion I/O modules shall have a minimum of 10% spare capacity for each point type for future point connection.

a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

b. As a minimum, provide one of each type of point available on the controller.

4. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

5. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

G. IP nLight ECLYPSE™ System Controller (IP-NE-CTRL)

1. The IP-NE-CTRL shall be 32 bit microprocessor-based operating at a minimum of 1 GHz.

a. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.

b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2. Each IP-NE-CTRL shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases, including:

a. Control processes

b. Alarm management applications

c. Maintenance support applications

d. Custom processes

e. Web Based interface via integral Web Server.

f. Shall have a graphical interface with a common library of nLight system

3. The IP-NE-CTRL shall have a Real Time clock.

4. The IP-NE-CTRL will support the following communications protocols:

a. BACnet/IP

1. Supporting IPv4 addressing.
2. DHCP support and Auto DNS.
3. 2 - RJ45 ports each capable of supporting 10/100 Base-T.
    a. Supporting controller daisy chaining on the Ethernet network via integral switch functionality.
4. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.
5. Network Lighting Control (NLC)
6. Supporting up to 1500 NLC devices.
7. 3 – RJ45 ports supporting NLC networks.
8. Refer to 26 09 43 for NLC devices.
9. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

b. BACnet MS/TP supporting up to minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.
    1. Supporting 9600 to 115200 baud

c. 2 x USB 2.0 Expansion ports for:
    1. 802.11 Wi-Fi Adapter enabling wireless connectivity including:
        a. ‘Hot Spot’
        b. Client
        c. Access Point.
        d. Spanning Tree Protocol
    2. If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

5. Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module.
6. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES.
7. Acceptable Products:
    a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

H. IP Equipment Controller (IP-EQUIP-CTRL)

1. The IP-EQUIP-CTRL shall be 32 bit microprocessor-based operating at a minimum of 600 MHz.

    a. They shall be multi-tasking, real-time digital control processor based supporting a fixed I/O point count.

2. Each IP-EQUIP-CTRL shall have minimum of 512MB memory, with a minimum of 4 GB non-volatile flash, to support its own operating system and databases, including:

    a. Control processes

    b. Maintenance support applications

    c. Custom processes

    d. Energy management applications

    e. Alarm management applications

    f. {BIP}Historical/trend data for points specified

    g. Embedded Web Server for local hosting of graphics

3. The IP-EQUIP-CTRL shall have a Real Time clock with rechargeable battery.

4. Power Requirements

    a. 24 VAC with local transformer power

5. The IP-EQUIP-CTRL will support the following communications protocols:

    a. BACnet/IP

        1. Supporting IPv4 addressing.

        2. DHCP support and Auto DNS.

        3. 2 - RJ45 ports each capable of supporting 10/100 Base-T.

            a. Supporting controller daisy-chain topology on the wired IP network via integrated switch functionality.

            b. Integrated fail-safe should allow for communication when the controller is powered down.

        4. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

    b. 2 x USB 2.0 Expansion ports for:

1. 802.11 Wi-Fi Adapter enabling wireless connectivity including:
    a. 'Hot Spot'
    b. Client
    c. Access Point
2. If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

6. The IP-EQUIP-CTRL controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

7. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

8. The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

9. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

10. Provide a minimum of 8 software configurable Universal Inputs capable of supporting the following input signal types:
    a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
    b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.
    c. The analog or universal input shall use a 16 bit A/D converter.
        1. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

11. Provide a minimum of 2 software configurable Universal Outputs capable of supporting the following output signal types:
    a. Digital outputs.
    b. Analog outputs of 4-20 mA and 0-10 Vdc.
        1. The analog or universal output shall use a 10 bit D/A converter.

12. Provide a minimum of 4 digital/Triac outputs.

13. Provide a minimum of 2 software configurable outputs that can either be utilized as additional digital/Triac outputs or as universal outputs.

14. Provide a minimum of 3 Modbus connected devices.

    a. Provide on-board RS-485 communication for Modbus RTU communication to a minimum of 3 connected devices on the RS-485 segment.

15. Provide connection to Intelligent Space Sensors (ISS) (see section 23 09 13 **Error! Reference source not found. Error! Reference source not found.**) via on-board RJ-45 subnetwork port.

16. Shall contain a "FIPS 140-2 Level 1 Compliant" cryptographic module

17. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

I. IP Terminal Unit Controller (IP-TU-CTRL).

1. The IP-TU-CTRL shall be 32 bit microprocessor-based operating at a minimum of 600 MHz.

    a. They shall be multi-tasking, real-time digital control processor based supporting a fixed I/O point count.

2. Each IP-TU-CTRL shall have minimum of 512MB memory, with a minimum of 4 GB non-volatile flash, to support its own operating system and databases, including: .

    a. Control processes

    b. Maintenance support applications

    c. Custom processes

    d. Energy management applications

    e. Alarm management applications

    f. Historical/trend data for points specified

    g. Embedded Web Server for local hosting of graphics.

3. The IP-TU-CTRL shall have a Real Time clock with rechargeable battery.

4. Power Requirements.

    a. 24 VAC with local transformer power.

5. The IP-TU-CTRL will support the following communications protocols: .

    a. BACnet/IP.

        1. Supporting IPv4 addressing.

        2. DHCP support and Auto DNS.

3. 2 - RJ45 ports each capable of supporting 10/100 Base-T.

    a. Supporting controller daisy-chain topology on the wired IP network via integrated switch functionality.

    b. Integrated fail-safe should allow for communication when the controller is powered down.

    c. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

b. 2 x USB 2.0 Expansion ports for:

    1. 802.11 Wi-Fi Adapter enabling wireless connectivity including: .

        a. 'Hot Spot'.

        b. Client

        c. Access Point.

    2. If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality. .

6. The IP-TU-CTRL controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

7. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

8. The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

9. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

10. Provide a minimum of 8 software configurable Universal Inputs capable of supporting the following input signal types:

    a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

    b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

        1. The analog or universal input shall use a 16 bit A/D converter.

        2. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

11. Provide a minimum of 2 software configurable Universal Outputs capable of supporting the following output signal types:

    a. Digital outputs.

    b. Analog outputs of 4-20 mA and 0-10 Vdc.

        1. The analog or universal output shall use a 10 bit D/A converter.

12. Provide a minimum of 4 digital/Triac outputs.

13. Provide a minimum of 2 software configurable outputs that can either be utilized as additional digital/Triac outputs or as universal outputs.

14. Provide connection to Intelligent Space Sensors (ISS) (see section 23 09 13 **Error! Reference source not found. Error! Reference source not found.**) via on-board RJ-45 subnetwork port.

15. Shall contain a "FIPS 140-2 Level 1 Compliant" cryptographic module

16. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

J. IP VAV Controller (IP-VAV-CTRL)

1. Refer to 23 09 13 2.11 Variable Air Volume (VAV) Terminal Control Units (TCU) for VAV related functionality requirements.

    a. In cases of conflict between this section (IP-VAV-CTRL) and the referenced section (VAV) this section (IP-VAV-CTRL) takes precedence.

2. The IP-VAV-CTRL shall be 32 bit microprocessor-based operating at a minimum of 400 MHz.

3. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

4. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

5. Each IP-VAV-CTRL shall have minimum of 512MB memory, with a minimum of 1GB non-volatile flash, to support its own operating system and databases, including:

    a. Control processes

    b. Maintenance support applications

    c. Custom processes

6. The IP-VAV-CTRL shall have a Real Time clock with rechargeable battery.

7. Power Requirements

    a. 24 VAC with local transformer power

    b. {BIP}50 VAC utilizing Power Over Ethernet (POE)

8. The IP-VAV-CTRL will support the following communications protocols:

    a. BACnet/IP

        1. Supporting IPv4 addressing.

        2. DHCP support and Auto DNS.

        3. 2 - RJ45 ports each capable of supporting 10/100 Base-T.

        4. If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

    b. 2 x USB 2.0 Expansion ports for:

        1. 802.11 Wi-Fi Adapter enabling wireless connectivity including:

            a. ‘Hot Spot’

            b. Client

            c. Access Point

        2. If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

9. Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

10. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

11. Acceptable Products:

    a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC)

K. Blinds Control Module (B-C-M)

1. Application

    a. To upgrade any ECLYPSE™ series TCU controllers to provide blinds control.

2. Refer to 23 09 13 Terminal Control Units (TCU) for TCU related functionality requirements.

a. In cases of conflict between this section (B-C-M) and the referenced section (TCU) this section (B-C-M) takes precedence.

3. They shall consist of modular hardware with communication controllers, power supplies and input/output point modules.

4. Blinds I/O to appear as extension to host HVAC controller.

5. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

   a. Support for up to 4 (24VDC or 100-220VAC) blinds actuators.

   b. Support for up to 4 Digital Inputs

6. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

7. Acceptable Products:

   a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC)

8. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

9. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

L. Integrated Lighting Control Unit (ILCU)

1. Provide a standalone microprocessor based integrated lighting control panel that utilizes the BACnet protocol and contains line and or low voltage relays for control of the lighting circuits along with the appropriate schedules and local user interface.

2. Integrated Lighting Control Unit that use proprietary protocols or require gateways to convert proprietary protocol into BACnet shall not be acceptable.

   a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) or BACnet Advanced Application Controller (B-AAC)

      1. {||MSTP,LONTALKPROGRAM}Analog outputs of 4-20 mA or 0-10 Vdc.

M. Variable Air Volume (VAV) Terminal Control Units (TCU)

1. The VAV TCU controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

2. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

3. The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

4. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

5. The VAV TCU shall include a built-in 'flow thru' differential pressure transducer.

    a. The controller shall convert this value to actual air flow.

    b. Single point differential pressure sensing device is not acceptable.

    c. Membrane based pressure differential transducer is not acceptable.

    d. The VAV TCU differential pressure transducer shall have a measurement range of 0 to 2 in. W.C. and measurement accuracy of ±4% at 0.05 to 2 in. W.C. and a minimum resolution of 0.0001 in. W.C., insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified minimum and maximum air flow parameters.

    e. VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable.

6. The BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.

7. The VAV TCU shall include provision for air flow balancing using a local air flow balancing interface.

8. An Intelligent Space Sensor (ISS) (see section 23 09 13 **Error! Reference source not found. Error! Reference source not found.**) shall be used for balancing air flow.

    a. In lieu of an ISS, a portable air flow balancing interface capable of balancing air flow is acceptable.

9. The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.

10. The VAV TCU shall also provide an air flow balancing tool.

11. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.

    a. The provision of these tools does not alleviate the contractors responsibility to support the balancer and maintain the project schedule.

12. Systems not able to provide a web based air balance tool or a portable air flow balancing interface or an Intelligent Space Sensor (ISS) (see section 23 09 13 **Error! Reference source not found. Error! Reference source not found.**) capable of balancing air flow as part of the VAV TCU controller shall provide an individual full time technician during the air flow balancing process to assure full balance compliance.

13. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5 ˚F of setpoint at the room sensor location.

14. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements.

    a. This algorithm shall function to signal the respective controller to perform the required discharge temperature reset in order to maintain space temperature setpoint.

15. It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.

16. Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE.

PART 3 - EXECUTION

3.1 MANUFACTURER'S RECOMMENDATIONS

A. Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.2 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.3 FIELD QUALITY CONTROL

A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Continually monitor field installation for code compliance and workmanship quality.

C. Contractor shall arrange for work inspection by authorities having jurisdiction over the work.

3.4 WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC

C. Low-voltage wiring shall meet NEC Class 2 requirements. Sub fuse low-voltage power circuits as required to meet Class 2 current limit.

D. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

E. Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. {USC}Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10 ft. intervals

I. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

J. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

K. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

1. Include one pull string in each raceway 1 in. or larger.

L. Use color-coded conductors throughout.

M. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

N. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 in. between raceway and high-temperature equipment such as steam pipes or flues.

O. Adhere to requirements in Division 16 where raceway crosses building expansion joints.

P. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

Q. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

R. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

S. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.5 COMMUNICATIONS WIRING

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

1. Runs that are longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.6 FIBER OPTIC CABLE

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

C. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

D. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

END OF SECTION 23 09 13

SECTION 23 09 13.23 BAS SENSORS AND TRANSMITTERS

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00, BAS Instrumentation and Control

B. SECTION 23 09 13, BAS Instrumentation and Control Devices

C. SECTION 23 09 13.13, BAS Sensors and Transmitters BAS Actuators and Operators

D. SECTION 23 09 13.33, BAS Control Valves

E. SECTION 23 09 13.43, BAS Control Dampers

F. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 SENSORS AND DEVICES

A. Input/output sensors and devices shall be closely matched to the requirements of the BAS controller for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

B. Sensors and transmitters shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.

C. Provide guards (plastic or wire) for sensors, thermostats, and transmitters that are installed in public areas such as gymnasiums, classrooms, corridors, and vestibules.

D. Temperature sensors shall have the following characteristics:

1. Sensors shall have +/- 1.0 ˚F accuracy between 32 ˚F and 212 ˚F.

2. Space temperature sensors

a. Shall consist of an element within a ventilated cover.

b. Space sensors located in mechanical rooms and public shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment).

c. Space sensors shall be provided in accordance with the drawings and specifications with the following options:

1. Sensor complete with Network Jack

2. Sensor complete with Network Jack, and Set Point Adjustment

3. Sensor complete with Network Jack, and illuminated Override switch

4. Sensor complete with Network Jack, Set Point Adjustment, and illuminated Override switch

5. Sensor complete with Network Jack, Set Point Adjustment, illuminated Override switch and Fan Speed Selection.

E. RTD Transmitter

1. Where reference is made on the drawings for a RTD transmitter, it shall be interpreted as follows:

2. Transmitters shall meet at minimum the following requirements.

a. Provide an RTD transmitter in configurations below meeting the following requirements:

1. 100 ohm or 1000 ohm PT RTD

2. 24V ac/dc power supply.

3. 4-20 mA, 0-10Vdc or 0-5Vdc outputs compatible with BMS.

4. Electronics accuracy of +/-0.1% of span.

5. Operating temperature range of 32˚F to 158˚F. OSA only - operating temperature range of -40˚F to 185˚F.

6. Optional LCD display

F. Temperature Sensor – Outside Air

1. Provide outside air temperature sensors as indicated within the field termination schedules and/or controls diagrams.

2. Temperature sensors shall meet, at minimum, the following requirements:

a. Aluminum LB with PVC sun and windscreen.

b. Wall mount weatherproof enclosure with conduit entrance.

c. Thermistor or RTD compatible with BMS

G. Temperature Sensor – Duct Mounted – Single Point

1. Provide duct mounted, single point, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows:

a. In ducts less than 10 ft² in cross-sectional area.

b. In ducts greater than 10 ft² in cross-sectional area if there is no heating coil and no cooling coil and no mixing of air flows of different temperature upstream.

2. Temperature sensors shall meet, at minimum, the following requirements:

a. 0.25” stainless steel probe of length between one-third and two-thirds of the duct width.

b. Thermistor or RTD compatible with BMS, sealed in probe with 3 part moisture protection system.

c. Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal, weather proof or no enclosure available)

H. Temperature Sensor – Duct Mounted – Averaging

1. Provide duct mounted, averaging, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows;

a. In ducts greater than 10ft² in cross-sectional area.

2. Temperature sensors shall meet, at minimum, the following requirements:

a. Probe length of 12 feet minimum or 1ft per ft² of duct cross-sectional area, whichever is greater.

b. Copper sheathed or plenum rated flexible construction.

c. Thermistor or RTD compatible with BMS.

d. BMS shall report the monitored temperature with an accuracy of 2.0°F

e. Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal or weather proof available)

f. Suitable supports at all bends and at intermediate points to prevent movement in the air systems.

I. Temperature Sensor – Wall Mounted – Lobby, Hallways Or Security Spaces

1. Provide wall mounted stainless plate temperature sensors for lobbies and lobby vestibule spaces as indicated within the field termination schedules and/or control diagrams as follows.

2. Temperature sensors shall meet, at minimum, the following requirements:

   a. Stainless plate sensors to fit 4" X 2" junction box, available with or without tamperproof screws.

   b. Thermistor or RTD compatible with BMS.

J. Temperature Sensor – Immersion - Thermowell Mounted

1. Provide thermowell mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams as follows.

2. Temperature sensors shall meet, at minimum, the following requirements:

   a. Rigid 0.25" stainless steel probe of length, which is, at minimum, 20% of the pipe width.

   b. Thermistor or RTD Compatible with BMS sealed in probe with three-part moisture protection system.

   c. BMS shall report the monitored temperature with an accuracy of 1.0°F

   d. ABS housing with conduit entrance. (Optional metal or weather proof available)

   e. Provide Brass or Stainless steel thermowell (316 or 304).

   f. Provide with thermal grease to aid temperature sensing.

K. Temperature Sensor – Strap-On

1. Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:

   a. 0.25" Stainless steel probe, 2"

   b. Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system

   c. ABS housing with conduit entrance. (Optional metal or weather proof available)

L. Temperature Sensor – Strap-On - Plate

1. Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:

   a. Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system

b. A single point strap-on temperature sensor to be precision bonded to a 1.5”x1.5” aluminum plate and adhered to a 1.5” x 1“compressible foam. A 10” S/S Pipe clamp to be provided to secure the assembly to various sizes of pipe.

c. ABS housing with conduit entrance. (Optional metal or weather proof available)

M. Relative Humidity Sensor – Wall Mounted

1. Provide wall mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:

a. White protective enclosure

b. Sensor to be laser trimmed thermoset polymer based capacitive type.

c. 24 Vac/dc power supply

d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

e. 2% accurate (5-95% RH). (3 & 5 % accurate units available)

f. Operating temperature range of 32˚F to 158˚F.

g. Reverse voltage protected and output limited.

h. Optional LCD display-SP and RH100A series

i. Optional set point adjustment-SP series

j. Optional push button override-RH100A series

N. Relative Humidity Sensor – Duct Mounted

1. Provide duct mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Duct mounted relative humidity sensors shall meet, at minimum, the following requirements:

a. ABS housing with conduit entrance.

b. Sensor to be laser trimmed thermoset polymer based capacitive type.

c. 24 Vac/dc power supply.

d. 4-20 mA two wires, 0-10 Vdc and/or 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

e. 2% accurate (5-95% RH). (3 & 5 % accurate units available)

f. 9” probe length.

g. Operating temperature range of 32˚F to 158˚F.

h. Reverse voltage protected and output limited.

i. 60 micron HDPE filter

O. Relative Humidity Sensor – Outside Air

1. Provide OSA relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:

a. ABS hinged weatherproof housing with conduit entrance.

b. Sensor to be laser trimmed thermoset polymer based capacitive type.

c. 24 Vac/dc power supply

d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

e. 2% accurate (5-95% RH).

f. Operating temperature range of 32˚F to 185˚F.

g. Reverse voltage protected and output limited.

P. Combination Relative Humidity And Temperature Sensors

1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.

Q. Static Pressure Sensor – Duct Mounted

1. Provide duct mounted static pressure sensors as indicated within the Field termination schedules and/or control diagrams. Static pressure sensors shall meet, at minimum, the following requirements:

a. Input range shall be appropriate for the application. Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior. Typically, for low pressure commercial duct consider using a range of 0 to 2” wc., for medium pressure duct use a range of 0 to 6” wc. and for high-pressure duct use a range of 0 to 10” wc.

b. 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.

c. 1% Full scale output accuracy

d. Operating temperature range of 32˚F to 140˚F.

e. Easily accessible, integral non-interacting zero adjustment.

f. Minimum over pressure input protection of two times rated input or 20 psi whichever is greater.

R. Differential Pressure Sensor – Air (Filter/Coil Monitoring)

1. Provide air differential pressure sensors as indicated in field termination schedules and/or control diagrams. Air differential pressure sensor shall meet, at minimum, the following requirements:

2. Sensors used for filter or coil differential pressures shall also have a display of the monitored differential pressure.

3. Output shall be 4-20mA, 0-10Vdc or 0-5Vdc output proportional to pressure input range compatible with BMS.

4. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0-2" wc range for low-pressure commercial duct.

5. Operating temperature range of 32˚F to 140˚F.

S. Differential Pressure Switch – Air

1. Provide air differential pressure switches as indicated in field termination schedules and/or control diagrams. Air differential pressure switches shall meet, at minimum, the following requirements:

a. An IP54 (NEMA 13) polycarbonate housing.

b. SPDT switch rated at 250 Vac at 1 amp.

c. Field adjustable range from 0.02" wc to max range of device. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2" wc range for low-pressure commercial duct.

d. Temperature range of -4˚F to 140˚F.

e. Set point adjustment knob with indication.

f. Automatic reset.

T. Air Flow Sensor

1. Provide airflow rate sensors and transducers as indicated in the Field termination schedules and/or control diagrams. Air flow rate sensors and transducer shall meet, at minimum, the following requirements:

a. Hot wire anemometer type.

b. Self-compensation for changes in air temperature.

c. Probe and transducer housing shall be constructed of durable PVC.

d. Probe shall be adjustable from 2" - 7.3".

e. Power supply shall be 24 Vac/dc.

f. Output signal of 4-20 mA or 0-10Vdc proportional to air flow speed equal to 3150 ft/min or 1575 ft/min jumper selectable.

g. Air temperature range of 14˚F to 140˚ F.

h. 5% accuracy of measured value.

U. Water Pressure Sensor

1. Provide water pressure sensors as indicated within the Field termination schedules and/or control diagrams. Pressure sensors shall meet the following requirements:

a. Operating range shall be suitable for the application. Select range such that it covers from zero pressure to twice the amount of pressure desired for control purposes or that could be encountered.

b. 4-20 mA output proportional to water pressure.

c. 0.25% accuracy of range.

d. Temperature range of -40˚F to 260˚F.

e. Over pressure input protection of a minimum two times rated input.

f. An optional ABS wiring housing is available for an interior application and weatherproof wiring housing is available for an exterior application.

g. 17-4PH stainless steel wetted parts.

h. Burst pressure of a minimum five times rated input.

V. Water Differential Pressure Sensor

1. Provide water differential or gage pressure sensors as indicated in the Field termination schedules and /or control diagrams. Water differential pressure sensors shall meet, at minimum, the following requirements:

a. Output of 4-20 mA, 0-10 or 0-5 Vdc proportional to the pressure sensed.

b. Momentary over pressure protection of five times the rated input.

c. Operating range shall be suitable for the application. Select range such that it covers from zero differential pressure up to a differential static pressure of 20% to 50% in excess of the maximum static pressure that could be encountered. Remember that if the sensor is used for the control of a chilled water bypass and is located across, for example, a chilled water AHU coil, the pressure drop of both the coil and the associated valve at full design flow have to be taken into account.

d. Accuracy of better than 1% of full-scale reading.

e. Valve tapping shall be furnished and installed by the Mechanical contractor. Coordinate with the Mechanical contractor.

W. Current Relay/Switch

1. Provide current sensing relays as indicated in the Field termination schedules and/or control diagrams. Current sensing relays shall meet, at minimum, the following specifications:

a. Rated for the applicable load.

b. The output relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.

c. Current relay shall have input and output isolation via current transformer.

d. Current relay shall be self-powered with no insertion loss.

e. Relay shall be in a dustproof housing.

f. Accuracy to be <2% of full-scale max.

g. Temperature rating of 5˚F to 140˚F.

h. Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay.

i. The BMS contractor shall provide current sensing relays at the MCC starters.

j. The BMS contractor shall provide the current sensing relays for motors with local starters and no MCC starter.

X. Current Sensor

1. Provide monitoring of the current as identified in Field termination sheets and/or control drawings. Current monitoring shall meet, at minimum, the following requirements:

a. 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw.

b. Reverse polarity protected and output limited.

c. 50/60 Hz operation.

d. Accuracy of better than 1%.

e. Operating temperature range of -20˚F to 120˚F.

Y. Air Quality Sensor - Wall Mounted

1. Provide wall mounted air quality sensors as indicated within the Field termination schedules and/or control diagrams. Sensors shall meet, at minimum, the following requirements:

a. Measurement of volatile organic compounds (VOC) that could contain, at minimum, the following gases:

1. Methane

2. Ethylene

3. Hydrogen

4. Carbon Monoxide

5. Propane

6. Ammonia

b. Microprocessor based using a semiconductor element based on the Taguchi gas principle.

c. White attractive ventilated cover.

d. 20-30 Vac/dc power supply, 100mA @24Vdc, 220mA @24Vac, 6VA max.

e. Analog stepped output standard 0-10 Vdc or optional 4-20mA and adjustable relay.

f. Programming and selection via internal push buttons and jumpers.

g. Temperature range of 32˚F to 104˚F.

Z. Air Quality Sensor - Duct Mounted

1. Provide duct mounted air quality sensors as indicated within the field termination schedules and/or control diagrams. Sensors shall meet, at minimum, the following requirements:

a. Measurement of air stream volatile organic compounds (VOC) that could contain, at minimum, the following gases:

1. Methane

2. Ethylene

3. Hydrogen

4. Carbon Monoxide
5. Propane
6. Ammonia

b. Microprocessor based using a semiconductor element based on the Taguchi gas principle.

c. 20-30 Vac/dc power supply, 100mA @24Vdc, 220mA @24Vac, 6VA max.

d. Analog stepped output standard 0-10 Vdc or optional 4-20mA and adjustable relay.

e. Programming and selection via internal push buttons and jumpers.

f. Temperature range of 32˚F to 104˚F.

g. 8" duct probe.

AA. Carbon Dioxide (CO2) Sensor

1. Provide a space or duct carbon dioxide gas detection sensor as indicated within the field termination schedules and/or control diagrams. Carbon dioxide detection sensors shall meet, at minimum, the following requirements:

a. Set-up to be fully microprocessor based c/w LCD.

b. 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to 0 to 2000 ppm of carbon dioxide concentration

c. Power supply to be 20-28Vac/dc @ 140 mA max for 24 Vac and 80 mA avg. @24 Vdc.

d. No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing the Automatic Calibration Logic Program (ACLP).

e. Standard accuracy to be 3% of reading or 75 ppm, whichever is greater.

f. Optional integral humidity and temperature transmitter or temperature sensor (thermistor or RTD)

g. BACnet communications

h. Optional setpoint adjustment, override switch and relay.

i. Operating temperature of 32˚F to 122˚F.

BB. Carbon Monoxide (CO) Sensor

1. Provide CO monitoring systems for the enclosed levels of the parking garage. Provide complete coverage of the enclosed levels of the parking garage and provide systems for each level. A CO monitoring system shall not cover an area on more than one level and the failure of any component shall not affect more than one level.

    a. Sensors shall be of the electrochemical type.

    b. Locate sensing points on walls and columns at 5-6ft above floor level. Locate one sensing point per 7500 ft². Do not locate sensing points closer than 6ft to traffic lanes.

    c. Sensor range shall be of 0 to 300 ppm for 5% accuracy cell

    d. Provide two (2) relay contacts, at minimum, per sensor, to indicate CO warning level (initially set at 50ppm) and CO alarm level (initially set at 200ppm) for each sensing point.

    e. Unit shall be complete with 85 db audible alarm and have visual output reading via an LCD display of the gas sensed.

    f. Provide 4-20mA, 0-10 or 0-5Vdc output of Carbon Monoxide sensed compatible with BAS system.

    g. The proposed sensor locations shall be submitted at the shop drawing stage and shall be amended as directed by the Owner and/or Engineer.

    h. Sensor shall be factory calibrated and will only require calibration after a minimum one (1) year service.

CC. Leak Detection Monitoring – Water

1. Provide water leak monitoring as identified within the Field termination schedules and/or control diagrams. Water leak detection monitors shall meet, at minimum, the following requirements:

    a. Corrosion and abrasion resistant.

    b. Adjustable height-single point model

    c. Configured for normally open or normally closed as required by the application.

    d. Form C output relay rated at 5 am/s @ 120 Vac / 30 Vdc.

    e. Operating temperature range of -40˚F to 185˚F.

    f. Optional remote mount probe and water sensing cable available in different lengths.

DD. Electrical Submeter

1. Powering

a. Meter shall be capable of powering from AC line voltage over complete range of 85 – 600 VAC.

b. Meter shall be capable of powering from USB port for ease of Meter Configuration without requiring line power.

c. Meter shall be fused protected.

d. Meter shall be capable of exporting power to 5VDC digital peripherals.

2. Mounting

a. Meter shall have means of permanent mounting.

b. Meter shall be capable of mounting inside electrical panel.

c. Meter shall be compatible with 35mm DIN rail mounting.

d. Meter shall use removable terminal blocks for wiring.

e. Meter shall be available with LCD display.

f. Meter shall detect CT wiring mistakes and alert user.

3. Communication

a. Meter shall be capable of field selecting BACnet IP, BACnet MS/TP, Modbus TCP, Modbus RTU and USB communications.

b. Meter shall support Modbus Baud Rates from 9600 to 115200 BPS.

c. Meter shall support BACnet Baud Rates from 9600 to 76800 BPS.

d. Meter shall support field selectable Ethernet, RS-485, USB and Pulse Outputs.

e. Meter shall use PC based configuration tools.

4. Metering

a. Meter shall meet ANSI 12.2 accuracy requirements.

b. Meter shall be capable of field selecting Rogowski Coils or mV CT's interchangeably.

EE. Branch Circuit Monitor

1. Powering

a. Meter shall be capable of powering from AC line voltage over complete range of 85 – 600 VAC.

b. Meter shall be capable of powering from USB port for ease of Meter Configuration without requiring line power.

c. Meter shall be fused protected.

d. Meter shall be capable of exporting power to 5VDC digital peripherals.

2. Mounting

a. Meter shall have means of permanent mounting.

b. Meter shall be capable of mounting inside electrical panel.

c. Meter shall be compatible with 35mm DIN rail mounting.

d. Meter shall use removable terminal blocks for wiring.

e. Meter shall be available with LCD display.

f. Meter shall detect CT wiring mistakes and alert user.

3. Communication

a. Meter shall be capable of field selecting BACnet IP, BACnet MS/TP, Modbus TCP, Modbus RTU and USB communications.

b. Meter shall support Modbus Baud Rates from 9600 to 115200 BPS.

c. Meter shall support BACnet Baud Rates from 9600 to 76800 BPS.

d. Meter shall support field selectable Ethernet, RS-485, USB and Pulse Outputs.

e. Meter shall use PC based configuration tools.

4. Metering

a. Meter shall meet ANSI 12.2 accuracy requirements.

b. Meter shall be capable of field selecting Rogowski Coils or mV CT's interchangeably.

FF. Insert-style Impeller Flow Sensor, Liquid, Single-Channel

1. Impeller flow sensor shall work in conjunction with impeller flow monitor or transmitter to calculate and/or collect readings of the rate of liquid flow and total accumulated flow. Nonmagnetic, spinning impeller is swept forward as liquid passes through the conduit; a low impedance square wave signal is transmitted with a frequency proportional to the flow rate. Sensor shall be suitable for applications in metallic or non-metallic pipes, and plastic versions are suitable for service in corrosive liquids. Power is provided on an analog current loop by receiving device. Impeller assembly is field-replaceable and sensors of similar type are interchangeable. Recalibration after servicing or replacement is not required. All sensor electrical components are self-contained.

2. Certifications

a. CE

b. CSA®

3. Flow Sensor

4. Primary Sensor shall be one of the following as required for project:

   a. Glass-filled, six bladed, nylon impeller design with a proprietary non-magnetic sensing mechanism.

   b. Glass-filled, six bladed, Tefzel® impeller design with a proprietary non-magnetic sensing mechanism.

5. Sensor sleeve shall be Polyvinyl Chlorine (PVC); and mounting adapter shall be 316 Stainless Steel.

6. Continuous operating temperature of standard versions shall be 221°F [105°C].

7. PVC sensor shall operate at line pressures up to 100 psi at 100°F [38°C].

8. Sensor will operate with pipe size/range 3 to 40".

9. Sensor housing shall be constructed from glass reinforced Polyphenylene Sulfide (PPS).

10. Internal Electronics

11. Enclosure shall be NEMA-6P [IP 68]v

12. Standard and CSA versions sensor electronics cable shall be 20' [6 m] of 2-conductor 20 AWG shielded wire provided for connection to display or analog transmitter unit. Rated to 211°F [105°C]. May be extended to a maximum of 2000' [610 m] with similar cable and insulation appropriate for application.

13. Outputs:

   a. Native

   b. Raw pulse

14. Sensor Performance

   a. Measuring range 0.5 to 30 ft/s.

   b. Accuracy shall be ±1% of full scale

   c. Repeatability shall be ±0.3% of full scale

   d. Linearity shall be ±0.2% of full scale

   e. Flow sensitivity (standard) is 0.15 to 9 ft/s

GG. Electromagnetic Flow Meter, Liquid, Single-Channel

1. Electromagnetic flow meter is intended for fluid metering in industries including water, wastewater, food and beverage, pharmaceutical and chemical. Measures fluid flow of water or fluids which are highly corrosive, very viscous, contain a moderate amount of solids, or require special handling. No moving parts are in the flow stream. Amplifier can be integrally mounted to the detector or can be remote-mounted. Unit is ideally suited for measuring dynamic, non-continuous flow. In applications where a minimum and/or maximum flow rate must be tracked and monitored, the unit provides pulse signals that can be fed to dedicated batch controllers, PLCs and other more specialized instrumentation.

2. System Components

   a. Metering Tube (Detector): Consists of stainless steel tube lined with a non-conductive material. Energized detector coils around tube create a magnetic field across the diameter of the pipe. As a conductive fluid flows through the magnetic field, a voltage is induced across two electrodes; this voltage is proportional to the average flow velocity of the fluid.

   b. Signal Amplifier: Consists of unit which receives, amplifies, and processes the detector's analog signal. Signal is converted to both analog and digital signals that are used to display rate of flow and totalization. Processor controls zero-flow stability, analog and frequency outputs, serial communications and a variety of other parameters. Integrated LCD display indicates rate of flow, forward and reverse totalizers and diagnostic messages. Display guides user through programmable routines.

3. Operational Requirements

   a. The flow meter system shall operate with a pulsed DC excitation frequency, and shall produce a signal output that is directly proportional and linear with the volumetric flow rate of the liquid flowing through the metering tube. The metering system shall include a metering sensor tube (detector), a signal amplifier, and the necessary connecting wiring. The metering system shall have the ability to incorporate a meter mounted or remote mounted amplifier.

4. Engineering Units:

   a. The signal amplifier shall be program selectable to display the following units of measure: U.S. gallons, imperial gallons, million gallons (U.S.), cubic feet, cubic meters, liters, hector-liters, oil barrels, pounds, ounces or acre feet.

5. Operating Principle: Electromagnetic Induction

6. Fluid Temperature Range

   a. Liner shall be selected according to project requirements with respect to operating temperature range.

7. Signal Amplifier

a. The signal amplifier shall include non-volatile memory capable of storing all programmable data and accumulated totalizer values in the event of a power interruption.

b. Automatic zero stability, low flow cut-off, empty pipe detection and bi-directional flow measurement shall be inherent capabilities of the signal amplifier.

8. Outputs: The signal amplifier shall provide a total of four digital outputs, one analog output and one digital input.

a. Up to four open collector digital outputs, program selectable from the following: Forward pulse, reverse pulse, AMR pulse, flow set point, empty pipe alarm, flow direction, reset output, error alarm and 24V supply.

b. Up to two active digital (24 Volt) outputs, program selectable from the following: Forward pulse, reverse pulse, AMR pulse, flow set point, empty pipe alarm, flow direction, preset output, error alarm and 24V supply.

c. Up to two AC solid-state relay outputs, program selectable from the following: Frequency output, flow set point, empty pipe alarm, flow direction, preset amount and error alarm.

d. One analog output programmable and scalable from the following: 0-10mA, 0-20mA, 2-10mA or 4-20mA. Voltage sourced and isolated. Max. loop resistance = 800 ohms.

9. One digital input, program selectable from the following: Remote reset, batch reset and positive return to zero.

10. Advanced protocol support using Modbus/RTU.

11. Control and Programming

a. The signal amplifier shall be programmed via three function buttons. The programming functions shall be available in a user-friendly, menu driven software through the four-line LCD interface. The signal amplifier shall accommodate the following languages: English, German, Czech, French or Spanish.

b. Programmable parameters of the amplifier include, but are not limited to: calibration factors, totalizer resets, unit of measure, analog and pulse output scaling, flow-alarm functions, language selection, low-flow cutoff, noise dampening factor and excitation frequency selection.

c. The signal amplifier shall have a programming option allowing entry of a selected numeric password value for tamper protection.

12. System Performance

a. The metering system shall operate over a flow range of 0.10 to 39.4 ft/s .

b. The metering system shall perform to an accuracy ± 0.25 percent of rate for velocities greater than 1.64 ft/s, ± 0.004 ft/s for velocities less than 1.64 ft/s.

c. The metering system shall be capable of measuring the volumetric flow rate of liquids having an electrical conductivity as low as 5.0 micromhos per centimeter.

d. The system measuring repeatability shall be <0.10% of full scale.

13. Indication

a. The signal amplifier shall include a four-line, 20-character, backlit LCD interface to display the following values:

b. Flow rate in selectable rate units

c. Forward totalizer in selectable volume units

d. Reverse totalizer in selectable volume units

e. Net totalizer in selectable volume units

f. Error or alarm messages

g. Software revision level

HH. Impeller Flow Sensor and Energy Meter, Liquid, Single-Channel

1. Energy measurement system is suitable for metering cold or hot systems. Integral flow sensor, energy calculator and temperature sensors compute energy using flow and temperature differential. BTU system incorporates impeller flow sensor and two temperature probes. One temperature probe is mounted directly in the flow sensor tee, the second temperature probe is installed either the supply or the return line depending on application.

2. System Components

a. Integral Hydronic Energy Calculators, Flow Sensor, & Temperature Sensors

b. Consists of a casting which houses the flow sensor mechanism, a calculator which integrates the flow and temperature data to compute flow/energy rate and total.

c. Temperature probes used to measure temperature by correlating the resistance of the RTD element with temperature. Set consists of one to measure liquid in the inlet pipe, and one to measure the liquid in the outlet pipe.

d. Standard 5-pin Mini USB Cable

e. Cable required to connect flow sensor system to PC for use of commissioning software.

f. 120 VAC/12V DC Power Supply

3. Operational Requirements

    a. The system shall be a microprocessor based digital unit, capable of calculating and outputting energy information. Energy information shall be either a scaled pulse output representing energy total or RS-485output providing complete information (standard feature). The RS-485 shall communicate using either BACnet, MSTP or Modbus RTU.

4. Certifications

    a. RTD meets IEC751 Class B

    b. Electrical Inputs meet RS-485

    c. Enclosure shall be NEMA 4X [IP 65]. Sensor housing shall be constructed of PEEK.

5. Complete information from RS485 output shall include energy rate, energy total, temperature one, temperature two, temperature differential, temperature mode, flow filter coefficient, temperature filter coefficient, specific heat coefficient, and fluid density coefficient.

6. Primary Sensor: Grade 316 stainless steel, non-magnetic impeller design.

7. The system shall operate with pipe size ranges 0.75 to 2".

8. Tee shall be constructed from cast bronze.

9. Type of process connection shall be NPT.

10. Hot liquid sensor shall have continuous operating temperature of 40° to 260°F.

11. Chilled liquid sensor shall have continuous operating temperature of -4° to 140°F.

12. One temperature probe shall be mounted directly in the flow sensor tee; the second shall be placed on either the supply or the return line depending on the application.

13. Scaled pulse output. Solid state switch. Maximum frequency of scaled pulse varies based upon pulse width selected. Pulse width available is 10, 50, 150, 200, 250, and 500mS. Resulting frequency range is 0.01 Hz min. to 100 Hz max.

14. Signal can travel up to 2000 feet between flow sensor and connected device depending on cable.

15. Industrial Communications (native):

    a. BACnet on MS/TP

    b. Modbus RTU

16. Standard flow measurement range shall be 1.97 to 19.69 ft/s

17. Low flow measurement range shall be 0.295 to 8.2 ft/s

18. Accuracy shall be ±2% of full scale

19. Repeatability shall be ±0.5% of full scale

20. Types of Liquids: Suitable for clean, homogenous, lower-viscosity liquids

II. Impeller Flow Sensor, Liquid

1. The flow sensor shall be an in line type with a nonmagnetic, spinning impeller (paddle wheel) as the only moving part. The impeller shall have a UHMWPE, Tefzel®, or Teflon® sleeve bearing. The shaft material shall be tungsten carbide, Zirconia Ceramic, or 316 Stainless Steel. The electronics housing shall have two ethylene-propylene, Nitrile rubber, or Viton® O-Rings and shall be easily removed from the meter body.

2. Certifications

   a. Device shall be certified by CSA®

   b. Enclosure shall be NEMA-6P [IP 68]

3. Flow Sensor shall be one of the following as required for project:

   a. Glass-filled, six bladed, nylon impeller design with a proprietary non-magnetic sensing mechanism.

   b. Glass-filled, six bladed, Tefzel® impeller design with a proprietary non-magnetic sensing mechanism.

4. Sensor Performance

   a. Measuring range 0.5 to 30 ft/s

   b. Accuracy shall be ±1% of full scale

   c. Repeatability shall be ±0.7% of full scale

   d. Linearity shall be ±0.7% of full scale

   e. Turndown shall be 60:1.

5. Continuous operating temperature of standard versions shall be 221°F.

6. Tee material shall be Valve Bronze, UNS C83600.

PART 3 - EXECUTION

3.1 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft2 of coil area.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.

5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

J. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

K. Flow Switch Installation

1. Use correct paddle for pipe diameter.

2. Adjust flow switch according to manufacturer's instructions.

L. Flow Sensors

1. Insert-style Impeller Flow Sensor, Liquid

   a. Follow manufacturer’s recommendation for installation and conform to the guidelines provided by the Installation & Operation Manual.

   b. Straight pipe requirement for mounting shall be 10 diameters up stream and 5 downstream.

   c. Sensor shall be located with the least possible circumferential displacement from top-center of pipe; any circumferential location in vertical pipes is acceptable.

   d. Sensor mounted in 2" NPT tap in either pipe saddle or weld on fitting.

   e. An insertion depth of 1 1/2" for pipe sizes 2.5" and larger is required for accurate flow monitoring.

   f. Sensor orientation shall be such that flow arrow on sensor is aligned with flow direction.

2. Electromagnetic Flow Meter, Liquid

   a. Follow manufacturer’s recommendation for installation. Installation will conform to the guidelines provided by the Installation & Operation Manual.

   b. Straight pipe requirement shall be an equivalent of three diameters on the inlet (upstream) side, and two diameters on the outlet (downstream) side.

   c. For best performance, place meter vertically, with liquid flowing upward and meter electrodes in a closed, full pipe.

3. Impeller Flow Sensor and Energy Meter, Liquid

   a. Follow manufacturer’s recommendation for installation.

   b. Straight pipe requirement shall be 10 diameters upstream and 5 diameters downstream. Pipe bends, valves, other fittings, pipe enlargements and reductions should not be present in this length of pipe.

   c. Apply pipe compound over the first 3 or 4 threads of the mating pipe.

   d. Thread the pipe into the sensor tee until hand tight, and then tighten the pipe an additional 1-1/2 turns, using a wrench.

   e. System requires isolated 12-24 V AC/DC power supply. To avoid ground fault conditions, power should not be shared with other devices.

f. The RS-485 requires three connections: RS-485+, RS-485- and REF. RS-485 is a high-speed connection and should be wired to meet TIA-EIA-485-A standards.

g. The pulse output is a simple solid state switch. The switch is not polarity sensitive, however, the maximum voltage and current ratings should not be exceeded.

4. Impeller Flow Sensor, Liquid

a. Follow manufacturer's recommendation for installation and conform to the guidelines provided by the Installation & Operation Manual.

b. Straight pipe requirement for mounting shall be 10 diameters up stream and 5 downstream.

c. Tee sensor shall be vertically upright in horizontal locations; any circumferential orientation in vertical installations is acceptable.

d. Sensor orientation shall be such that flow arrow on sensor is aligned with flow direction.

END OF SECTION 23 09 13

SECTION 23 09 13.43 BAS CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00, BAS Instrumentation and Control

B. SECTION 23 09 13, BAS Instrumentation and Control Devices

C. SECTION 23 09 13.13, BAS Actuators and Operators

D. SECTION 23 09 13.23, BAS Sensors and Transmitters

E. SECTION 23 09 13.33, BAS Control Valves

F. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 AUTOMATIC CONTROL DAMPERS

A. Manufacturer shall submit leakage data for all control dampers with the temperature con Dampers shall be minimum leakage type to conserve energy and the temperature control trol submittal.

B. Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.

C. Provide any automatic control dampers not specified to be integral with other equipment.

D. Provide automatic control dampers as specified herein:

1. Frame construction shall not be less than 14 gauge galvanized steel or extruded aluminum at a minimum 4-1/2” X 1” X 0.125” in thickness.

2. Blades shall be single skin and not less than 16-gauge galvanized steel roll formed or extruded aluminum. Blades shall not be over: 8” wide, 48” in length and 72” high.

3. All blade edges and top and bottom of frame shall be provided with compressible seals. Side seals shall be compressible stainless steel of the tight-seal spring type.

4. Blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5 inches of WC differential pressure. Dampers and seals shall be suitable for temperature ranges of -40 to 180 ˚F.

5. Bearings shall corrosion resistant, molded synthetic sleeve type turning in an extruded hole in the damper frame.

6. Axles shall be a minimum of ½" diameter and be welded to blade or riveted to blade

7. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6".

8. Where ultra-low leakage dampers are specified the blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 6 CFM per square foot for dampers in excess of sixteen inches square at 1 inch of WC.

9. Individual damper sections shall not be larger than 48" X 60". Provide a minimum of one damper actuator per section.

10. All proportional control dampers shall be opposed or parallel blade type as hereinafter specified and all two-position dampers shall be parallel blade types.

11. Combination automatic smoke control dampers, where indicated on the plans, shall conform to the UL555S Leakage Class specified.

PART 3 - EXECUTION

3.1 CO-ORDINATION

A. Coordinate delivery of dampers to site.

B. Clearly tag and mark dampers for their purpose and location.

C. Supervise Mechanical Contractor in the installation of the dampers ensuring proper dampers(s) are located and installed in proper location(s)

END OF SECTION 23 09 13.43

SECTION 23 09 23 BAS DIRECT DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00 BAS Instrumentation and Control

B. SECTION 23 09 13, BAS Instrumentation and Control Devices

C. SECTION 23 09 13.13, BAS Actuators and Operators

D. SECTION 23 09 13.23, BAS Sensors and Transmitters

E. SECTION 23 09 13.33, BAS Control Valves

F. SECTION 23 09 13.43, BAS Control Dampers

1.2 REFERENCES

A. Supplementing 23 09 00 1.2 References requirements.

1. ANSI/ASHRAE 135-2012, BACnet®[1] - A Data Communication Protocol for Building Automation and Control Networks.

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Supplementing 23 09 00 1.3 Acronyms, Abbreviations and Definitions requirements

1. Acronyms used in BAS.

a. AI - Analog Input

b. AO - Analog Output

c. BACnet® - Building Automation and Control Network

d. BAS - Building Automation System

e. CAD - Computer Aided Design

f. CDL - Control Description Logic

g. COSV - Change of State or Value

h. CPU - Central Processing Unit

i. DI - Digital Input

j. DO - Digital Output

k. ECU - Equipment Control Unit

l. IDE - Interface Device Equipment

m. LAN - Local Area Network

n. LCU - Local Control Unit

o. NCU - Network Control Unit

p. Niagara4 – Software framework for building device-to-enterprise applications and Internet-enabled products.

q. OS - Operating System

r. OWS - Operator Work Station

s. PC - Personal Computer

t. PCI - Peripheral Control Interface

u. PCMCIA - Personal Computer Micro Card Interface Adapter

v. RAM - Random Access Memory

w. ROM - Read Only Memory

x. TCU - Terminal Control Unit

y. USB - Universal Serial Bus

z. UPS - Uninterruptible Power Supply

B. Definitions:

1. Point: a point may be logical or physical. Logical points are values calculated by system such as totals, counts, derived corrections i.e. as result of and/or statements in CDL's. Physical points are inputs or outputs, which have hardware, wired to controllers which are measuring or providing status conditions of contacts or relays providing interaction with related equipment (stop, start) or valve or damper actuators.

C. Symbols and Engineering unit abbreviations utilized in displays: to ANSI/ISAS 5.5.

1. Printouts: to ANSI/IEEE 260.

1.4 BAS CONTRACTOR QUALIFICATIONS

A. Supplementing 23 09 00 1.12 BAS Contractor Qualifications.

1. The contractor must be regularly engaged in the service and installation of BACnet and Niagara4 as specified herein,

2. The Contractor shall have a minimum of 5 years' experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.

3. The Contractor must be an authorized factory direct representative in good standing of the manufacturer of the proposed hardware and software components. Provide a letter dated within the last 12 months, from the manufacturer certifying that the Contractor is an authorized factory direct representative.

4. The Contractor shall a minimum of three (3) technicians who have successfully completed the factory authorized training of the proposed manufactures hardware and software components and have successfully completed Niagara4 certification course(s).

    a. Contractor must provide proof of required training.

    b. The Contractor's capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubling shooting and service.

5. The contractor shall submit a list of no less than three (3) similar (in function, application and design) projects, which have similar Building Automation Systems as specified herein installed by the Contractor.

    a. These projects must be on-line and functional such that the Owner's/User's representative can observe the system in full operation.

1.5 GENERAL DESCRIPTION

A. Supplementing 23 09 00 1.5 General Description requirements.

1. System to be "Open Protocol".

    a. BACnet® communications protocol will be used for communications.

2. Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:

    a. Building Controllers NCU, LCU, TCU.

    b. OWSs.

    c. Data communications equipment necessary to achieve an BAS data transmission system including LAN hardware and software for a BACnet® system

    d. Software complete with full documentation for software and equipment.

1.6 WORK INCLUDED

A. Supplementing 23 09 00 1.10 Work Included requirements.

B. Provide a new building automation system to control and monitor the building's mechanical and electrical systems.

1. The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type, i.e. HVAC, lighting, and security devices should easily coexists on the same network channel without the need for gateways.

2. Components not supplied by the primary manufacturer shall be integrated to share common software for network communications, time scheduling, alarm handling, and history logging.

C. The Installer furnishing the BAS network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network.

1. The variable frequency drive (VFD) vendor shall furnish VFDs with an interface to the control and monitoring points specified utilizing:

   a. Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

   b. BACnet/IP network connection.

   c. BACnet MS/TP network connection

2. Energy and utility metering shall interface to the BAS system and provide the monitoring points specified herein utilizing:

   a. Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

   b. BACnet/IP network connection.

   c. BACnet MS/TP network connection

3. The lighting control vendor shall furnish lighting controls with an interface to the control and monitoring points specified utilizing:

   a. Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

   b. BACnet/IP network connection.

   c. BACnet MS/TP network connection

4. The Owner or his designated representative shall be present at this meeting.

5. Each Installer shall provide the Owner and all other Installers with details of the proposed interface, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories.

6. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the BAS network.

7. Submittals for these products shall not be approved prior to the completion of this meeting.

D. Provide new controllers of the latest revisions with input and output points as specified herein.

E. Operator workstations located as listed in the specifications.

F. Furnish and install all controllers to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

G. Furnish and load all software required to implement a complete and operational BAS.

1.7 SYSTEM DESIGN RESPONSIBILITY

A. Supplementing 23 09 00 1.13 System Design Responsibility requirements.

1. Supply sufficient programmable controllers of all types to meet project requirements. Quantity and points contents to be approved by Owner prior to installation.

a. Local Control Units (LCU) shall be utilized for primary mechanical and electrical systems such as Air handling equipment, Make-up Air Unit, Boiler System Control, and Chiller System Control type of applications.

b. Terminal Control Units (TCU) shall be utilized for terminal equipment, such as Variable Air Volume, Fan Coil, Heat Pump, Roof Top, and Chilled Ceiling type of applications.

c. Each LCU and TCU controller shall have a minimum of 10% spare capacity of each point type for future points. As a minimum, each controller shall have one spare of each point type available on the controller.

d. Each NCU and each LAN shall have the capability of accepting 20% additional LCU/TCU(s) without the necessity of adding additional LAN controllers or LAN wiring.

e. The LCU and TCU controller programming or configuration tools (see section 23 09 13) shall be fully accessible through the Operator Workstation and Web Browser Client.

f. All LCUs and TCUs shall be furnished with extended memory. No LCU/TCU shall be provided with less than 128 MB of RAM. The number of controllers attached to any NCU shall not exceed the following limits:

Combined Memory	Maximum Number of Controllers
128 MB SDRAM / 64 MB Serial Flash	25
256 MB DDR RAM / 128 MB Serial Flash	50
1 GB DDR2 RAM / 1 GB Serial Flash	125

2. Regardless of the maximum number of controllers indicated above, it is ultimately the exclusive responsibility of the systems integrator/building controls contractor to ensure that the NCU has adequate resources for the number of controllers attached to it.

3. Niagara4 Network Manager Server software shall be furnished and installed on a server grade PC for applications requiring two or more NCUs.

Note: Delete this section above if there is an existing Niagara4 Network Manager.

1.8 BUILDING AUTOMATION SYSTEM (BAS)

A. The contractor shall be responsible for the hardware and software for the enterprise framework and system integration required for the complete Building Automation System.

B. The BAS shall be comprised of Network Control Units (NCU) connected to the Building Automation System local area network (BAS LAN).

1. Access to the BAS, either through a Workstation on the BAS LAN, within the building or through a Wireless Application Protocol device, or remotely through the Internet, shall be accomplished through a standard Web browser.

2. Each NCU shall communicate to BTL Listed BACnet controllers provided under the Programmable Controllers section.

3. Each NCU shall communicate to LonMark Certified LonWorks controllers provided under the Programmable Controllers section.

C. The system includes software and programming of the NCU(s), Operator Workstation(s) (OWS) software and hardware, development of all graphical screens, setup of schedules, trends, logs and alarms, network management and connection of the NCU(s) to the local area network.

1.9 SYSTEM DESIGN

A. The system shall consist of a network of Network Control Units (NCUs), interoperable Local Control Units (LCUs) and Terminal Control Units (TCUs) (VAV Box Controllers, Fan Coil Unit Controllers, etc.). All controllers for terminal units, air handling units (AHU) and controllers shall communicate and share data, utilizing BACnet communications protocols only.

B. The intent of this specification is to provide a distributed and networked open Building Automation System, the capability to integrate ANSI/ASHRAE Standard 135, BACnet and ISO/IEC 14908-1: Open Data Communication in Building Automation, Controls and Building Management – Control Network Protocol into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.

C. The proposed system must maintain strict adherence to industry standards including ANSI/ASHRAE Standard 135, Annex L, and Device Profile to assure interoperability between all system components. BACnet system must be tested and listed on BACnet Testing Laboratory (BTL) web site. Systems based on vendor specific proprietary hardware or software will not be considered for this project.

D. Systems utilizing gateways to proprietary communication systems will not be considered for this project. A gateway is considered to be a device or controller where the sole function is mapping of data points from one protocol to another. A gateway device cannot perform higher-level energy management functions such as Outdoor Air Optimization, Electrical Demand Limiting and the like.

E. The supplied system software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE™ Standard 135, BACnet to assure interoperability between all system components is required.

F. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a flat single tiered architecture shall not be acceptable. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 10 seconds for network connected user interfaces. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

G. User Access

1. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs.

H. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system databases, all controller program graphics and network databases which shall be provided in a Niagara4 Framework format.

1. This data shall reside on a supplier-installed server for all database access.

2. Systems requiring proprietary database and user interface programs shall not be acceptable.

I. Software Tools

1. All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or his designated agent.

a. Any licensing required by the manufacturer now and to the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

b. Any such changes to the designated license holders shall be made by the manufacturer upon written request by the owner or his agent.

c. Any cost associated with the license changes shall be identified within the BAS submittals.

J. Software License Agreement

1. All needed licenses shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

a. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

b. In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project.

c. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NCU, Server, OWS and any related LAN/WAN/Intranet and Internet connected routers and devices.

d. Any and all required User IDs and passwords for access to any component or software program shall be provided to the owner.

1.10 DYNAMIC DATA ACCESS

A. All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

1.11 NETWORKS

A. The BAS network(s) must be based on Open Systems.

B. Niagara4 shall be used at the network levels as the manager(s).

C. High-speed data transfer rates for alarm reporting, quick report generation form multiple controllers and upload/download efficiency between network devices.

D. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

E. Detection and accommodation of single or multiple failures of workstations, controller panels and the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

F. Message and alarm buffering to prevent information from being lost.

G. Error detection, correction, and retransmission to guarantee data integrity.

H. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

I. Commonly available, multiple sourced, networking components shall be used to allow the system to coexist with other networking applications such as office automation. Ethernet to IEEE 802.3 standard is the only acceptable technology.

J. Synchronization of the real-time clocks in all NCU panels shall be provided.

K. The BAS LAN shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, SOAP, OBIX, SNMP and SMTP Protocols for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Control Units (NCUs), user workstations and where specified, a local server. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE standard 802.3

2. Cable; 100 Base-T, UTP-8 wire, category 5

3. Minimum throughput; 100 Mbps

4. Provide the ability for access to the BAS LAN via a Wireless Application Protocol (WAP) device. Through this connection the BAS LAN will provide authorized staff with the ability to monitor and control the BAS from any location within the through a web browser, or web enabled devices.

5. Provide the ability for access to the BAS LAN from a remote location, via the Intranet or Internet. The owner shall provide, at their discretion, a connection to the Internet to enable access via high-speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or access to an Internet Service Provider (ISP). If required, the owner will provide a switch/firewall between the building LAN and the BAS LAN. Through this connection the BAS LAN will provide authorized staff with the ability to monitor and control the BAS from a remote location through a web browser, or web enabled devices.

L. Controller Local Area Network (BAS sub LAN)

1. Provide a network of stand-alone, distributed direct digital controllers that operate on the following protocol using the specified physical layers:

a. The BAS sub LAN shall employ the BACnet protocol for communication between controllers. BACnet protocol implementation shall adhere to the ANSI/ASHRAE Standard 135. Communications between BACnet devices shall be 76.8 kbps over approved twisted shielded pair cabling utilizing Master/Slave Toke Passing BACnet protocol. BACnet defines a comprehensive set of object types and application services for communication requirements among all levels of control in a distributed, hierarchical Building Automation System. BACnet is intended to provide a single, uniform standard for the BAS to provide the required interoperability.

2. Strict adherence to industry standards including ANSI/ASHRAE Standard 135, BACnet, certified by BACnet Testing Laboratory (BTL listed) to assure interoperability between all system components. Controllers that are not BTL listed are unacceptable.

3. Provide BAS Controllers that conform to ANSI/ASHRAE Standard. 135, BACnet

   a. Controllers using proprietary protocols or protocols other than listed herein are unacceptable.

4. The design of the BAS sub LAN shall network Local Control Unit (LCU) and Terminal Control Unit (TCU) to a Network Control Unit (NCU).

5. This level of communication shall support a family of application specific controllers and shall communicate bi-directionally with the network through DDC Controllers for transmission of global data.

6. Terminal Control Unit (TCU) shall be arranged on the BAS sub LAN's in a functional relationship manner with Local Control Unit (LCU). Ensure that a Variable Air Volume (VAV) Terminal Control Unit (TCU) is logically on the same LAN or segment as the Local Control Unit (LCU) that is controlling its corresponding Air Handling Unit (AHU).

PART 2 - PRODUCTS

2.1 QUALITY ASSURANCE

A. Supplementing 23 09 00 2.1 Quality Assurance requirements.

1. The manufacturer of the Building Automation System digital controllers shall provide documentation supporting compliance with ISO 9001:2000 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing).

2. Provide a copy of the registration certificate that contains the ISO 9001:2000 Certification bearing the name of the registered auditor.

3. Control products such as direct digital controllers, control valves, actuators, sensors and transmitters shall be provided from a single manufacturer.

   a. Provide product literature that bears the name of the manufacturer on all direct digital controllers, control valves, actuators, sensors and transmitters.

4. Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

5. All controllers provided as part of this system and used for indoor applications shall operate under ambient environmental conditions of 32 ˚F to 122 ˚F dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

6. All controllers provided as part of this system and used for outdoor applications shall operate under ambient environmental conditions of -40 ˚F to 158 ˚F dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

2.2 ACCEPTABLE SYSTEM MANUFACTURERS

A. Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems. The BAS Manufacturer shall meet the following qualifications as a minimum:

1. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of building automation systems as specified herein, and must have been so for a minimum of five (5) years.

2. The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International.

3. At least 75% of the manufactured product line shall be produced under their own direction, including R&D and assembly. Rebranding of another manufacture product shall not qualify.

B. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

C. Acceptable Manufacturers with open protocol systems

1. Honeywell Controls

2. Distech Controls

3. Siemens Talon

PART 3 - EXECUTION

3.1 PRELIMINARY DESIGN REVIEW

A. Supplementing 23 09 00 3.8 Preliminary Design Review requirements.

1. The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information in addition to the requirements of 23 09 00:

a. Provide product brochures and a technical description of the Server, Operator Workstation, and Network Control Unit (NCU) software required to meet this specification. Provide a description of software programs included.

b. Open Protocols - For all direct digital controller hardware BACnet Protocol Implementation Conformance Statement PICS. Provide complete description and documentation of any proprietary services and/or objects where used in the system.

c. Submit the Niagara Compatibility Statement (NiCS) verifying that all aspects of the Niagara Framework as provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties.

1. Property	2. Value
3. Station Compatibility IN	4. All
5. Station Compatibility OUT	6. All
7. Tool Compatibility IN	8. All
9. Tool Compatibility OUT	10. All

2. Provide a description and samples of graphics and reports.

3. Provide a URL address for the engineer to view the proposed functionality via a web based BAS through a standard web browser.

3.2 SUBMITTALS

A. Supplementing 23 09 00 3.9 Submittals requirements.

1. Control System Shop Drawings

a. Detailed system architecture and points list showing all points associated with each controller, controller locations, and describing the spare points capacity at each controller and BAS LAN.

2. Direct Digital Control System Hardware

a. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of BACnet controller.

b. Bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

c. Manufacturer's description and technical data such including product specifications and installation and maintenance instructions for items listed herein:

1. Direct digital controllers (BACnet and LonWorks)

2. Sensors and Transmitters

3. Transducers
4. Actuators
5. Automatic Control Valves
6. Automatic Control Dampers
7. Air Flow Stations
8. Control panels
9. Operator interface equipment
10. Ancillary equipment such as relays, power supplies and wiring

d. Riser diagrams showing control network layout, communication protocol, and wire types.

3. Building Automation System Server and Operator Workstation (OWS)

a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.

b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

1. Central Processing Unit (CPU) or web server
2. Monitors
3. Keyboards
4. Uninterruptible Power supplies
5. Network switches, hubs and routers.
6. Interface equipment between CPU or server and control panels
7. Operating System software
8. Operator interface software
9. Color graphic software
10. Third-party software

c. Network diagram of control, communication, and power wiring for BAS Server and OWS installation.

END OF SECTION 23 09 23

SECTION 230993 – SEQUENCE OF OPERATION
PART 1 - GENERAL

1.1 SEQUENCES OF OPERATION

1. Single Zone Unit (Gym)

BMS contractor shall integrate to the RTU factory mounted controller. BMS contractor shall provide low voltage control wiring for RTU manufacturer provided sensors.

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
  - A 75°F (adj.) cooling setpoint
  - A 70°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  - A 85°F (adj.) cooling setpoint.
  - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status.

Supply Air Smoke Detection:
The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Zone Temperature Control:
The controller shall measure the zone temperature and shall modulate the supply fan VFD speed to maintain zone temperature setpoint. The fan speed shall increase as the zone temperature rises above cooling setpoint, or as the zone temperature drops below heating setpoint. The supply fan VFD speed shall not drop below 30% (adj.).

Return Fan:
The return fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Return Fan Failure: Commanded on, but the status is off.
- Return Fan in Hand: Commanded off, but the status is on.
- Return Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Cooling Stages:
The controller shall measure the zone temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.

- AND the supply fan status is on.
- AND the heating is not active.

Gas Heating Stages:
The controller shall measure the zone temperature and stage the heating to maintain its heating setpoint. To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.

Economizer:
The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air enthalpy is less than 22Btu/lb (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the outside air enthalpy is less than the return air enthalpy.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 45°F to 40°F (adj.).
- OR on loss of supply fan status.
- OR freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

Mixed Air Temperature:
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Carbon Dioxide (CO2) Concentration Monitoring:
The controller shall measure the return air CO2 concentration.

Alarms shall be provided as follows:

- High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration is greater than 1000ppm (adj.) when in the occupied mode.

Return Air Humidity:
The controller shall monitor the return air humidity and use as required for economizer control (if present) or humidity control (if present).

Alarms shall be provided as follows:

- High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- Low Return Air Humidity: If the return air humidity is less than 35% (adj.).

Return Air Temperature:
The controller shall monitor the return air temperature and use as required for economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).

- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Mixed Air Temp	x								x		x
Outside Air Humidity	x								x		x
Outside Air Temp	x								x		x
Return Air Carbon Dioxide PPM	x								x		x
Return Air Humidity	x								x		x
Return Air Temp	x								x		x
Zone Temp	x								x		x
Mixed Air Dampers		x							x		x
Supply Fan VFD Speed		x							x		x
Return Fan Status			x						x		x
Supply Air Smoke Detector			x						x	x	x
Supply Fan Status			x						x		x
Supply Fan VFD Fault			x						x		x
Cooling Stage 1				x					x		x
Cooling Stage 2				x					x		x
Cooling Stage 3				x					x		x
Heating Stage 1				x					x		x
Heating Stage 2				x					x		x
Return Fan Start/Stop				x					x		x
Supply Fan Start/Stop				x					x		x
Cooling Setpoint					x				x		x
Economizer Zone Temp Setpoint					x				x		x
Heating Setpoint					x				x		x
Schedule								x			
Compressor Runtime Exceeded										x	
High Mixed Air Temp										x	
High Return Air Carbon Dioxide Concentration										x	
High Return Air Humidity										x	

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
High Return Air Temp										x	
High Zone Temp										x	
Low Mixed Air Temp										x	
Low Return Air Humidity										x	
Low Return Air Temp										x	
Low Zone Temp										x	
Return Fan Failure										x	
Supply Fan Failure										x	

2. DOAS (typical of 2)

BMS contractor shall integrate to the DOAS factory mounted controller. BMS contractor shall provide low voltage control wiring for DOAS manufacturer provided sensors.

Run Conditions - Requested:
The unit shall run whenever:

- Any zone is occupied.
- OR a definable number of unoccupied zones need heating or cooling.

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status.

High Static Shutdown:
The unit shall shut down and generate an alarm upon receiving an high static shutdown signal.

Supply Air Smoke Detection:
The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Supply Air Duct Static Pressure Control:
The controller shall measure duct static pressure and shall modulate the supply fan VFD speed to maintain a duct static pressure setpoint of 1.5in H2O (adj.). The supply fan VFD speed shall not drop below 30% (adj.).

Alarms shall be provided as follows:

- High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
- Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint.
- Supply Fan VFD Fault.

Return Fan:
The return fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Return Fan Failure: Commanded on, but the status is off.
- Return Fan in Hand: Commanded off, but the status is on.
- Return Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
- Return Fan VFD Fault.

Return Fan Tracking:
The return fan VFD shall modulate in unison with the supply fan VFD. The return fan VFD shall track the supply fan VFD at 80% (adj.) of the supply fan VFD speed. The return fan VFD speed shall not drop below 20% (adj.).

Heat Recovery Wheel - Variable Speed:
The controller shall modulate the heat recovery wheel for energy recovery as follows.

Cooling Recovery Mode:
The controller shall measure the heat wheel discharge air temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) less than the unit supply air temperature setpoint. The heat wheel shall run for cool recovery whenever:

- The unit return air temperature is 5°F (adj.) or more below the outside air temperature.
- AND the unit is in a cooling mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

Heating Recovery Mode:
The controller shall measure the heat wheel discharge air temperature and modulate the heat wheel speed to

maintain a setpoint 2°F (adj.) greater than the unit supply air temperature setpoint. The heat wheel shall run for heat recovery whenever:

- The unit return air temperature is 5°F (adj.) or more above the outside air temperature.
- AND the unit is in a heating mode.
- AND the economizer (if present) is off.
- AND the supply fan is on.

Periodic Self-Cleaning:
The heat wheel shall run at 5% speed (adj.) for 10sec (adj.) every 4hr (adj.) the unit runs.

Frost Protection:
The heat wheel shall run at 5% speed (adj.) whenever:

- Outside air temperature drops below 15°F (adj.)
- OR the exhaust air temperature drops below 20°F (adj.).

The heat wheel bypass dampers will open whenever the heat wheel is disabled.

Alarms shall be provided as follows:

- Heat Wheel Rotation Failure: Commanded on, but the status is off.
- Heat Wheel in Hand: Commanded off, but the status is on.
- Heat Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
- Heat Wheel VFD Fault

Supply Air Temperature Setpoint - Optimized:
The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling and heating requirements

The supply air temperature setpoint shall be reset for cooling based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.) .

If more zones need heating than cooling, then the supply air temperature setpoint shall be reset for heating as follows:

- The initial supply air temperature setpoint shall be 82°F (adj.).
- As heating demand increases, the setpoint shall incrementally reset up to a maximum of 85°F (adj.).
- As heating demand decreases, the setpoint shall incrementally reset down to a minimum of 72°F (adj.).

Cooling Stage:
The controller shall measure the supply air temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.
- AND the heating (if present) is not active.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.

Gas Heating Stage:
The controller shall measure the supply air temperature and stage the heating to maintain its heating setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the supply fan status is on.
- AND the cooling (if present) is not active.

The heating stage shall run for freeze protection whenever:

- Supply air temperature drops from 40°F to 35°F (adj.).
- AND the supply fan status is on.

Alarms shall be provided as follows:

- Low Supply Air Temp: If the supply air temperature is 5°F (adj.) less than setpoint.

Economizer:
The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air enthalpy is less than 22Btu/lb (adj.)
- AND the outside air temperature is less than the return air temperature.
- AND the outside air enthalpy is less than the return air enthalpy.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 40°F to 35°F (adj.)
- OR the freezestat (if present) is on.
- OR on loss of supply fan status.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum adjustable position during building occupied hours and be closed during unoccupied hours.

Final Filter Status:
The controller shall monitor the final filter status.

Alarms shall be provided as follows:

- Final Filter Change Required: Final filter differential pressure exceeds a user definable limit (adj.).

Mixed Air Temperature:
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Carbon Dioxide (CO2) Concentration Monitoring:
The controller shall measure the return air CO2 concentration.

Alarms shall be provided as follows:

- High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration is greater than 1000ppm (adj.) when in the unit is running.

Return Air Humidity:
The controller shall monitor the return air humidity and use as required for economizer control (if present) or humidity control (if present).

Alarms shall be provided as follows:

- High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- Low Return Air Humidity: If the return air humidity is less than 35% (adj.).

Return Air Temperature:
The controller shall monitor the return air temperature and use as required for setpoint control or economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Supply Air Temperature:
The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Exhaust Air Temp	x								x		x
Heat Wheel Discharge Air Temp	x								x		x
Mixed Air Temp	x								x		x
Outside Air Temp	x								x		x
Return Air Carbon Dioxide PPM	x								x		x
Return Air Humidity	x								x		x
Return Air Temp	x								x		x
Supply Air Static Pressure	x								x	x	x
Supply Air Temp	x								x		x

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Heat Wheel VFD Speed		x							x		x
Mixed Air Dampers		x							x		x
Return Fan VFD Speed		x							x		x
Supply Fan VFD Speed		x							x		x
Final Filter Status			x						x		
Heat Wheel Status			x						x		x
Heat Wheel VFD Fault			x						x	x	x
High Static Shutdown			x						x	x	x
Return Fan Status			x						x		x
Return Fan VFD Fault			x							x	
Supply Air Smoke Detector			x						x	x	x
Supply Fan Status			x						x		x
Supply Fan VFD Fault			x							x	x
Cooling Stage 1				x					x		x
Heat Wheel Bypass Dampers				x					x		x
Heat Wheel Start/Stop				x					x		x
Heating Stage 1				x					x		x
Return Fan Start/Stop				x					x		x
Supply Fan Start/Stop				x					x		x
Economizer Mixed Air Temp Setpoint					x				x		x
Supply Air Static Pressure Set-point					x				x		x
Supply Air Temp Setpoint					x				x		x
Compressor Runtime Exceeded										x	
Final Filter Change Required										x	x
Heat Wheel in Hand										x	
Heat Wheel Rotation Failure										x	
Heat Wheel Runtime Exceeded										x	
High Mixed Air Temp										x	
High Return Air Carbon Dioxide										x	

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Concentration											
High Return Air Humidity										x	
High Return Air Temp										x	
High Supply Air Static Pressure										x	
High Supply Air Temp										x	
High Supply Air Temp										x	
Low Mixed Air Temp										x	
Low Return Air Humidity										x	
Low Return Air Temp										x	
Low Supply Air Static Pressure										x	
Low Supply Air Temp										x	
Low Supply Air Temp										x	
Return Fan Failure										x	
Return Fan in Hand										x	
Return Fan Runtime Exceeded										x	
Supply Fan Failure										x	

Automatic Transfer Switch Monitoring

The BMS will monitor the automatic transfer switch located in the electrical room. If the switch activates, the BMS will generate an alarm when the site is on emergency power.

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
ATS Switch Monitoring (Emergency Power)			x			x			x	x	x

Boiler System

Boiler System - Run Conditions:
The boiler system shall be enabled when space temperatures drop below 70 degrees (adj). BMS to monitor VRF zones and enable the boiler and the associated pumps.

To prevent short cycling, the boiler system shall run for and be off for minimum adjustable times (both user definable), unless shutdown on safeties or outside air conditions.

Each boiler shall run subject to its own internal safeties and controls.

The boiler system shall also run for freeze protection whenever outside air temperature is less than 40°F (adj.)

Boiler Safeties:
The following safeties shall be monitored:

- Boiler alarm.
- Low Water Level.

Alarms shall be provided as follows:

- Boiler alarm.
- Low Water Level alarm.

Hot Water Pumps:
The hot water pump shall run anytime the boiler is called to run and shall have a user definable delay (adj.) on stop.

Alarms shall be provided as follows:

- Hot Water Pump Failure: Commanded on, but the status is off.
- Hot Water Pump Running in Hand: Commanded off, but the status is on.
- Hot Water Pump Runtime Exceeded: Status runtime exceeds a user definable limit.

Circulation Pumps:
The circulation pump shall run anytime the boiler is called to run and shall have a user definable (adj.) delay on stop.

Alarms shall be provided as follows:

- Circulation Pump Failure: Commanded on, but the status is off.
- Circulation Pump Running in Hand: Commanded off, but the status is on.
- Circulation Pump Runtime Exceeded: Status runtime exceeds a user definable limit.

Boiler Enable:
The boiler shall be enabled when the boiler system is commanded on. The boiler shall be enabled after pump status is proven on and shall run subject to its own internal safeties and controls.

Alarms shall be provided as follows:

- Boiler Failure: Commanded on, but the status is off.
- Boiler Running in Hand: Commanded off, but the status is on.
- Boiler Runtime Exceeded: Status runtime exceeds a user definable limit.

Hot Water Supply Temperature Setpoint Reset:
The hot water supply temperature setpoint shall reset based on outside air temperature.

As outside air temperature rises from 0°F (adj.) to 70°F (adj.) the hot water supply temperature setpoint shall reset downwards by subtracting from 0°F (adj.) up to 20°F (adj.) from the current boiler setpoint.

Primary Hot Water Temperature Monitoring:
The following temperatures shall be monitored:

- Primary hot water supply.
- Primary hot water return.

Alarms shall be provided as follows:

- High Primary Hot Water Supply Temp: If greater than 200°F (adj.).

- Low Primary Hot Water Supply Temp: If less than 100°F (adj.).

	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Primary Hot Water Return Temp	x								x		x
Primary Hot Water Supply Temp	x								x		x
Boiler Hot Water Supply Temp Setpoint Reset		x							x		x
Boiler Alarm Status			x						x	x	x
Boiler Status			x						x		x
Circulation Pump Status			x						x		x
Hot Water Pump 1 and 2 Status			2x						x		x
Low Water Level			x						x	x	x
Boiler Enable				x							x
Circulation Pump Start/Stop				x					x		x
Hot Water Pump 1 and 2 Start/Stop				2x					x		x
Outside Air Temp					x						x
Boiler Failure										x	
Boiler Running in Hand										x	
Boiler Runtime Exceeded										x	
Circulation Pump Failure										x	
Circulation Pump Running in Hand										x	
Circulation Pump Runtime Exceeded										x	
High Primary Hot Water Supply Temp										x	
Hot Water Pump Failure										x	
Hot Water Pump Running in Hand										x	
Hot Water Pump Runtime Exceeded										x	
Low Primary Hot Water Supply Temp										x	

SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Extent of hydronic piping, fittings, valves and accessories is indicated on the drawings, in schedules and by the requirements of this Section.

B. Types: Types of hydronic piping systems specified in this Section include the following:

1. Heating water supply and return.

C. Related Sections: Refer to other Division 23 sections for the following:

1. Meters and Gauges.
2. Supports and Anchors.
3. Mechanical Insulation.
4. Firestopping.
5. Testing, Adjusting, and Balancing.
6. Valves

1.2 QUALITY ASSURANCE

A. Codes and Standards: Provide piping conforming to the requirements of the following:

1. American National Standards Institute (ANSI):
   a. B16.3 Malleable Iron Threaded Fittings
   b. B16.5 Pipe Flanges and Flanged Fittings
   c. B16.9 Factory-Made Wrought Steel Buttwelding Fittings
   d. B16.11 Forged Steel Fittings, Socket-Welding and Threaded
   e. B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
   f. B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
   g. B16.39 Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
   h. B31 Code for Pressure Piping
   i. B31.1 Power Piping

2. American Society of Mechanical Engineers (ASME): Installation of piping shall conform to the requirements of ANSI B31.1 "Power Piping."
3. American Society for Testing and Materials (ASTM):
   a. A 47 Standard Specification for Ferritic Malleable Iron Castings
   b. A 53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded Seamless
   c. A 106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
   d. A 126 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
   e. A 183 Standard Specification for Carbon Steel Track Bolts and Nuts
   f. A 193/

A 193M Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

g. A 194/ A 194M Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
h. A 307 Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
i. A 536 Standard Specifications for Ductile Iron Castings
j. B 16 Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
k. B 32 Standard Specification for Solder Metal
l. B 61 Standard Specification for Steam or Valve Bronze Castings
m. B 62 Standard Specification for Composition Bronze or Ounce Metal Castings
n. B 88 Standard Specification for Seamless Copper Water Tube
o. D 2000 Standard Classification System for Rubber Products in Automotive Applications

4. American Society of Testing Materials (ASTM) Standard Specification for Crosslinked Polyethylene (PEX) Tubing B Designation: F876
5. American Society of Testing Materials (ASTM) Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems B Designation: F877
6. National Sanitation Foundation (NSF) and American National Standards Institute (ANSI) Standard 14 B Plastic Piping System Components and Related Materials.
7. German Standard B Pipelines of Plastic Materials used in Warm Water Floor Heating Systems; General Requirements B Designation: DIN 4726.
8. Plastic Pipe Institute (PPI) Technical Report TR-3B Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.
9. Plastic Pipe Institute (PPI) Technical Report TR-4 B Recommended Hydrostatic Strength and Design Stresses for Thermoplastic Pipe and Fitting Compounds.

B. Qualification of Welders: Welders performing work under this Contract shall be certified and qualified in accordance with tests prescribed by the National Certified Welding Bureau (NCWB) or by other approved test procedures using methodology and procedures covered in the ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1. Submit for approval the names, identification, and welder's assigned number, letter or symbol of welders assigned to this project.
2. The assigned identification symbol shall be used to identify the work of each welder and shall be indelibly stamped immediately upon completion of each weld.
3. Welders shall be tested and certified for all positions.
4. Submit identifying stencilled test coupons made by each operator.
5. Any or all welders may be required to retake welding certification tests without additional expense.

6. When so requested, a welder shall not be permitted to work as a welder on this project until he has been recertified in accordance with NCWB.
7. Recertification of the welder shall be made after the welder has taken and passed the required tests.
8. Where piping 1-1/2 inches and smaller is butt or socket welded, submit 3 samples of test welds for approval.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's standard technical product data indicating conformance to the stipulated reference specifications, construction materials, construction details, and test and operating pressures. Submit manufacturer's product data on the following:

1. Pipe materials.
2. Unions and flanges.
3. Welding fittings.
4. Valves.
5. Strainers.
6. Equipment.

1.4 STORAGE AND PROTECTION

A. Storage: Store piping on the project site so as to preclude the entrance of construction dirt and debris into the open ends of piping. Do not install piping fouled with construction dirt.

B. Storage of Fittings: Store fittings under cover, protected from construction dirt and rain.

C. Storage of Valves: Store valves under cover with blind or protective wood flanges secured to valve openings. Valves fouled with construction dirt shall be removed from the project site and replaced with new.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operations and maintenance data, including manufacturer’s descriptive literature, installation instructions, operating instructions and maintenance and repair data.

1.6 WARRANTY

A. Brass fittings and accessories will have a 5 year warranty

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Pipe 2-1/2-inch Diameter and Smaller: Provide piping as follows:

1. Copper, Type K or L, conforming to ASTM B 88.

B. Pipe 3 inches Diameter and Larger: Provide piping as follows:

1. Schedule 40 black steel conforming ASTM A 53 or A 106.
2. Use A 53 or A 106 for expansion loops, expansion bends or stresses in excess of 12,000 psig.

2.2 PIPE FITTINGS: 125 PSIG MAXIMUM WORKING PRESSURE

A. Fittings 2-inch and Smaller: Pipe fittings for piping 2 inches and smaller shall be tested and permanently stamped for 125 psig water working pressure and conform to the following:

1. Provide threaded cast iron elbows, tees, caps and plugs conforming to ANSI B16.4, Class 125.
2. Threaded galvanized malleable iron elbows, tees, plugs and caps conforming to ANSI B16.3, Class 150.
3. Provide cast iron flanges conforming to ANSI B16.1, Class 125.
4. Provide galvanized malleable iron unions, with bronze facings conforming to ANSI B16.39.
5. Provide bolts and nuts conforming to ASTM A 307, Grade B up to 125 pounds per square inch working pressure.

B. Fittings 2-1/2-inch Diameter and Larger: For working pressures not exceeding 125 psig water pressure provide fittings as follows:

1. Provide butt welding tees long radius pattern, long radius elbows and caps conforming to ANSI B16.9, each stamped by the manufacturer for conformance and working pressure.
2. Provide steel flanges conforming to ANSI B16.5, standard or welding neck pattern.
3. Provide cast iron flanged tees, flanged long radius elbows, flanged reducers and blank flanges conforming to ANSI B16.1, 125 psig class.

C. Fittings for Copper Pipe: Provide fittings for copper piping 2-1/2-inch diameter and smaller as follows:

1. Provide cast or wrought copper solder joint fittings conforming to ANSI B16.18 or ANSI B16.22. Solder shall be composition ASTM B 32 Grade 95TA, Tin-Antimony or ASTM B 32 95TS Silver Solder.
2. The use of lead-tin solder is not permitted.

D. Fittings
1. Fittings will be constructed from brass.
2. Fittings will be selected from the BRHC Product Catalog.
3. All fittings will meet the dimensional requirements for copper sweat and pipe threads in accordance with ASME B16.22 and B1.20.
4. Sweat fittings will be made up with solder that meets the requirements of ASTM B32-95b
5. Installation accessories will not conflict with local building codes.

2.3 SHAPED NIPPLES

A. Welded Shaped Nipples: On hydronic piping systems operating at less than 125 pounds per square inch water working pressure, factory made shaped welding nipples may be used under the following conditions:
1. Thickness of the fitting at any point shall not be less than the thickness of adjacent piping.
2. Tapping holes shall be drilled or ground smooth and of a diameter to match nipple bell.
3. Branch pipe diameter does not exceed 50 percent of the diameter of the main.
4. Field cut pipe or standard threaded coupling will not be permitted.

2.4 STRAINERS

A. Types: Provide strainers of the "Y" or basket types as indicated on the drawings or required to suit the field conditions.

B. Strainers 1-1/2-Inch Diameter and Smaller: Provide strainers with bronze bodies conforming to ASTM B 62, Grade C or cast iron bodies conforming to ASTM A 126, Class B.
1. End connections shall be threaded.
2. Screens shall be 18-8 stainless steel with 1/32-inch diameter perforations or openings.

C. Strainers 2-Inch and Larger: Provide strainers with cast iron bodies conforming ASTM A 126, Class B with flanged end connections.

1. Screens shall be bronze, monel metal or 18-8 stainless steel.
2. Sizes 2-inch to 6-inch shall have 1/16-inch diameter perforations.
3. Sizes 8-inch to 12-inch shall have 1/8-inch diameter perforations.
4. Sizes larger than 12-inch shall have 5/32-inch diameter perforations.

D. Design Pressure: Provide strainers designed for 125 pounds per square inch working pressure on systems less than 125 pounds per square inch.

E. Strainer Free Area: The free area of each strainer screen shall be not less than three times the area of the strainer inlet pipe.

F. Drain Valves: For each strainer 1-1/2-inch diameter and larger, provide a plugged minimum 1/2-inch diameter gate or ball valve, bronze body, working pressure to match

the strainer, threaded with a plugged outlet.

2.5 BALANCING DEVICES

A. Types: Wherever "Balancing Valves", "Balancing Cocks", or similar words are used on the Contract Drawings, provide globe valves, resilient face eccentric plug valves, multi-purpose plug valves or butterfly valves for balancing purposes.

B. Butterfly Valves: Provide butterfly valves conforming to MSS SP 67 with single flange or lug type end connections which will anchor the valve body in place when either one or the adjacent flanged connection is unbolted.

C. Ball Valves: Provide ball valves conforming to MSS SP 72.

1. Provide one piece bodies on sizes 1-inch and smaller.
2. Provide top entry or split body type on sizes 1-1/2-inch and larger.

D. Locking Device: On each balancing valve size 1-1-2-inch and larger provide a locking device, with indicator, to secure the valve in the balanced position. If standard with the manufacturer, the locking device may be arranged so that the valve may be closed and then returned to its original balanced position.

E. Stems and Hand Operators: Design valves with stems and hand operators of sufficient length to project outside of 2-inch thick insulation. Indicators and locking devices shall be exposed.

F. Precision Plug Valve: In lieu of other balancing valves specified, at the Contractor's option precision all brass or bronze plug valves may be furnished.

1. Provide internal "O" ring or teflon seals to prevent leakage.
2. Machined orifice or low loss Venturi shall be calibrated and provided with four laminated pressure-flow charts for any valve position between fully opened and fully closed.
3. Provide a calibrated plate and pointer mounted on the valve to indicate the degree of valve opening.
4. Provide a quick disconnect gauge connection of bronze or stainless steel.

G. Balancing Fittings: On pipe sizes 3/4-inch diameter and smaller, provide balancing fittings on runouts to fan coil units, fin tube radiation, convectors and reheat coils.

1. Fittings shall be of the combination balancing and shut-off type with the balancing device positioned by an Allen set screw or other approved method which permits closing of the valves without disturbing its balanced position.
2. Bodies may be of the globe or "Y" type with contour flow plug or approved equivalent.
3. Provide a graduated dial or other device to indicate the valve setting.
4. Gland shall permit packing under pressure.
5. Materials and construction shall be as specified for water valves sizes 1-1/2-inch and smaller.

6. On sizes 3/4-inch and smaller ends may be sweat or compression type.

H. Circuit setters provide as required on drawings.

2.8 PIPE ANCHORS

A. General: Provide pipe anchors where indicated on the drawings or where required to restrain the movement of piping systems.

1. See Section,"Supports and Anchors"
2. Anchors shall be suitable for the location of installation and shall be designed to withstand all forces and movements acting on the anchor.
3. Design anchors with a safety factor of four.
4. Anchor vertical piping with steel clamps welded to the piping and secured to the wall or floor construction.

2.10 CONTROLS

A. Controls will be approved by local codes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sizes: Provide piping systems of sizes indicated on the drawings. Systems shall be installed complete.

B. Codes: Install piping systems in conformance with ANSI B31.

C. Expansion: Install piping to allow for expansion and contraction of the piping systems. Provide offsets and swing joint connections at coils, pumps and other equipment to eliminate undue strain to the equipment connections.

1. Connect flanges and tack weld piping systems in place before full circumferential welds are made.
2. Springing of piping at equipment connections will not be permitted.
3. The use of "cold-spring" is not permitted.

D. Branch Connections: Branch connections to up feed systems shall be made at the top or at a 45 degree angle above the centerline. Branch connections for down feed systems shall be made at the bottom or at a 45 degree angle below the centerline.

E. Pitch: Install water piping with a pitch or slope of not less than 1-inch in 40 feet.

1. Provide 3/4-inch diameter plugged drain valves at each low point in mechanical rooms.

F. High Points: At each high point of the piping system provide a 3/8-inch diameter plugged globe valve.

1. Where high points are located in an inaccessible position, provide a 3/8-inch diameter bleed line from the high point of the piping system and extend to an approved location, with access. Anchor bleed piping and provide 3/8-inch diameter globe valve.

G. Vibration and Flexibility: Support, anchor, and guide piping systems to preserve piping flexibility and the isolation effects of sound and vibration isolation hangers.

H. Welding: Conform to the welding and welder qualification requirements of "Quality Assurance" paragraph of this Section.

1. Perform welding in conformance with ANSI B31.1.
2. Perform welding in ambient temperatures above 0 degrees F.
3. Ream and clean ends of piping.
4. Support piping, align and tack weld making allowance for pipe pitch and insulation. Temporarily block piping at hangers.
5. Use welding pipe clamps on piping 4-inch diameter and larger, and verify alignment before welding.

3.2 CLEANING

A. Pipe Exterior: Wash and wipe pipe exterior to remove construction dirt, loose scale and flux.

B. Pipe Interior: Flush pipe interior with clean water. Continue flushing until the piping system runs clean. After flushing inspect strainer screens, refrigeration machine water boxes, piping low points, and tank drains to determine the presence of construction debris. If debris is found, disassemble equipment and remove debris. Reflush the system and re-inspect.

1. Do not operate pumps until system has been cleaned and flushed.

3.4 TESTING

A. 125-Pound Systems: Test hydronic piping systems at not less than 150 pounds per square inch gauge or 1-1/2 times the maximum working pressure of devices connected to the piping system, whichever is greater, measured at the low point of the system.

B. Test Procedures: Test system as follows:

1. Gauge safety valves during testing.
2. Fill the system and remove all air. Apply test pressure when water and ambient temperature are approximately equal and constant.
3. Maintain test pressure for one hour without adding any additional fluid to the system.

4. If the system shows loss in pressure, determine and repair leaks and retest the system. System shall show no loss in pressure for one hour.
5. Leaks in screw fittings shall be corrected by remaking the joints.
6. Leaks in welded joints shall be cut out and rewelded. Caulking will not be permitted.

END OF SECTION 232113

SECTION 232300 – REFRIGERANT PIPING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air conditioning applications. This Section includes:

1. Pipes, tubing, fittings, and specialties.
2. Special duty valves.
3. Refrigerants.

1.2 SUBMITTALS

A. Product data for the following products:

1. Each type valve specified.
2. Each type refrigerant piping specialty specified.

B. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment.

C. Brazer's Certificates signed by Design Builder certifying that brazers comply with requirements specified under "Quality Assurance" below.

D. Maintenance data for refrigerant valves and piping specialties, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23 Sections.

1.3 QUALITY ASSURANCE

A. Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications".

B. Regulatory Requirements: Comply with provisions of the following codes:

1. ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping.
2. ANSI/ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.
3. BOCA Basic National Mechanical Code.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate the installation of roof piping supports, and roof penetrations. Roof specialties are specified in Division 7.

1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:

1. Refrigerant Valves and Specialties:

a. Alco Controls Div, Emerson Electric.
b. Danfoss Electronics, Inc.
c. EATON Corporation, Control Div.
d. Henry Valve Company.
e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
f. Sporlan Valve Company.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3, Article "PIPE APPLICATION" for identification of systems where the below specified pipe and fitting materials are used.

B. Copper Tubing: ASTM B 280, Type ACR, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

C. Copper Tubing: ASTM B 88, Type L, hard-drawn straight lengths, and soft-annealed copper tubing.

2.3 FITTINGS

A. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

2.5 VALVES

A. General: Complete valve assembly shall be UL-listed and designed to conform to ARI 760.

B. Globe: 450 psig maximum operating pressure, 275 deg. F maximum operating temperature; cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections.

C. Check Valves - Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300 deg. F maximum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

D. Check Valves - 7/8 inch and Larger: 450 psig maximum operating pressure, 300 deg. F maximum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Valve shall be straight through or angle pattern, with solder-end connections.

E. Solenoid Valves: 250 deg. F temperature rating, 400 psig working pressure; forged brass, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter, and 24 volt, 60 Hz. normally closed holding coil.

F. Evaporator Pressure Regulating Valves: pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gage tappings, 24 volts DC, 50/60 Hz, standard coil; and wrought copper fittings for solder end connections.

G. Thermal Expansion Valves: thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections; complete with sensing bulb, a distributor having a side connection for hot gas bypass line, and an external equalizer line.

H. Hot Gas Bypass Valve: adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading; and wrought copper fittings for solder end connections.

2.6 REFRIGERANT PIPING SPECIALTIES

A. General: Complete refrigerant piping specialty assembly shall be UL-listed and designed to conform to ARI 760.

B. Strainers: 500 psig maximum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

C. Moisture/liquid Indicators: 500 psig maximum operation pressure, 200 deg. F maximum operating temperature; forged brass body, with replaceable polished optical viewing window, and solder end connections.

D. Filter-driers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

1. Standard capacity desiccant sieves to provide micronic filtration.
2. High capacity desiccant sieves to provide micronic filtration and extra drying capacity.

E. Suction Line Filter-Drier: 350 psig maximum operation pressure, 225 deg. F maximum operating temperature; steel shell, and wrought copper fittings for solder end connections.

Permanent filter element shall be molded felt core surrounded by a desiccant. for removal of acids and moisture for refrigerant vapor.

F. Suction Line Filters: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter core kit, including gaskets, as follows:

G. Flanged Unions: 400 psig maximum working pressure, 330 deg. F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions shall be forged steel, and for 2-1/8 inch through 3-1/8 inch shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory-applied rust-resistant coating.

H. Flexible Connectors: 500 psig maximum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

2.7 REFRIGERANT

A. Refrigerant No. 12, in accordance with ASHRAE Standard 34.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.2 PIPE APPLICATIONS

A. Use Type L, or Type ACR drawn copper tubing with wrought copper fittings and brazed joints above ground, within building. Use Type K, annealed temper copper tubing for 2 inch and smaller without joints, below ground and within slabs. Mechanical fittings (crimp or flair) are not permitted.

1. Install annealed temper tubing in pipe duct. Vent pipe duct to the outside.

B. If other than Type ACR tubing is used, clean and protect inside of tubing as specified in Article "CLEANING" below.

3.3 PIPING INSTALLATIONS

A. General: Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration."

B. Install piping in as short and direct arrangement as possible to minimize pressure drop.

C. Install piping for minimum number of joints using as few elbows and other fitting as possible.

D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

F. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

G. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

H. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

I. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2" per 10 feet downward slope away from the compressor.
2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.
4. Liquid lines may be install level.

J. Use fittings for all changes in direction and all branch connections.

K. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

L. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

M. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

N. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

O. Locate groups of piper parallel to each other, spaced to permit applying insulation and servicing of valves.

P. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

Q. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 7 for special sealers and materials.

R. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

S. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

T. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.

1. Install moisture/liquid indicators in lines larger than 2-1/8 inch OD, using a bypass line.

U. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

V. Install flexible connectors at the inlet and discharge connection of compressors.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors are specified in Division 23 Section "SUPPORTS AND ANCHORS." Conform to the table below for maximum spacing of supports:

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe rollers complete supports for multiple horizontal runs, 20 feet or longer supported by a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers in compliance with all Applicable Code Standards and Local Governing Authorities.

D. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.
2. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats, and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do no apply heat near the bulb of the expansion valve.

B. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.

C. Heat joints using oxy-acetylene torch. Heat to proper and uniform brazing temperature.

3.6 VALVE INSTALLATIONS

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

C. Install a full sized, 3-valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at the top.

1. Electrical wiring for solenoid valves is specified in Division 26. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.
2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.
3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.
4. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.7 EQUIPMENT CONNECTIONS

A. Install piping adjacent to machine to allow servicing and maintenance.

3.8 FIELD QUALITY CONTROL

A. Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI.

B. Repair leaking joints using new materials, and retest for leaks.

3.9 CLEANING

A. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.10 ADJUSTING AND CLEANING

A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Clean and inspect refrigerant piping systems in accordance with requirements of Division-15 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

C. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.11 COMMISSIONING

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.
2. Evacuate refrigerant system with vacuum pump; until temperature of 35 deg F is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.
6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

C. Review data in Operating and Maintenance Manuals. Refer to Division 1 section "Project Closeout."

D. Schedule training with Owner through the Owner/Owner's Representative, with at least 7 days advance notice.

END OF SECTION 23 23 00

SECTION 233100 – HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes rectangular and round ducts.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems," except as indicated otherwise.

1.4 SUBMITTALS

A. Duct Lining: Acoustical performance shall be established by ASTM C423-90 procedures. Sound absorption coefficients with Type “A” mounting per ASTM E795 shall be supplied that meets or exceeds requirements established later in this Specification.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized Sheet Steel: Lock-forming quality, ASTM A 527, Coating Designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.

2.2 FIRE-STOPPING

A. Refer to Division 7 Section "Firestopping" for fire-stopping.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4 inches thick.

B. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.

1. Straps and Rod Sizes: Conform with Table 4-1 in SMACNA HVAC Duct Construction Standards, 1985 Edition, for sheet steel width and gage and steel rod diameters.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.4 RECTANGULAR DUCT FABRICATION

A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.

1. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

2.5 RECTANGULAR DUCT FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 1985 Edition, Figures 2-1 through 2-10.

2.6 ROUND DUCT FABRICATION

A. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct that has a circumference equal to the perimeter of a given sized of flat oval duct.

B. Round Ducts: Fabricate round supply ducts with spiral lockseam construction to elbows being pleated. Comply with SMACNA "HVAC Duct Construction Standards," Table 3-2 for galvanized steel gages.

2.7 SOUND LININGS

A. Duct lining shall be roll form, 1” or 2” as called out in the drawings or specifications. It shall be installed on all interior surfaces of sheet metal ductwork where shown on the drawings or specifications.

B. Duct lining shall be adhered by 100% covering of a fire retardant adhesive. The black acrylic face shall face the air stream. When width of duct exceeds 12” and also on sides when height exceeds 24”, use non-ferrous mechanical fasteners in addition to 100% adhesive coverage. All transverse and longitudinal abutting edges of duct lining shall be sealed and lapped 3” with a heavy coat of adhesive, in accordance with the manufacturer’s recommendations.

C. Duct lining shall be fiberglass insulation with a surface acrylic EPA registered anti-microbial coating that will not support biological growth, and meets ASTM G21 and G22 specifications. This coating shall also guard against incursion of dust and dirt into the insulation. This coating shall be damage resistant, i.e. does not tear or abrade easily. Duct lining shall be capable of being cleaned per NAIMA Duct Cleaning Standards. Duct lining shall be black, minimum 1.5 lb/ft3 density meeting the requirements of NFPA 90A and 90B, FHC 25/50, and limited combustibility. Duct lining shall be suitable up to 5000 fpm. Duct lining and adhesives shall

comply with ASTM E-84 and shall have a maximum flame spread rating of 25 and smoke rating of 50. Duct lining adhesive shall conform to ASTM C916 “Specifications for Adhesives for Duct Thermal Insulation.” Fasteners shall comply with SMACNA HVAC Duct Construction Standards Article S2.11.

D. Metal nosings shall be securely installed over transversely-oriented liner edges facing the air stream at forward discharge and at any point where lined duct is preceded by unlined duct. When velocities exceed 4000 FPM, use metal nosings on every leading edge. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.

E. Duct lining shall conform to ASTM C1071 standard “Thermal and Acoustical Insulation” and have the following minimum sound absorption coefficients when tested in accordance with ASTM C423 and E795 procedures mounting Type A.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

A. Install ducts with the fewest possible joints.

B. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

C. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

D. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or in soffits.

3.2 HANGING AND SUPPORTING

A. Install rigid round, and rectangular metal duct with support systems indicated in SMACNA "HVAC Duct Construction Standards," Tables 4-1 through 4-3 and Figures 4-1 through 4-8.

B. Support horizontal ducts within 2 feet of each elbow.

C. Support vertical ducts at each floor.

D. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated.

E. Install powder actuated concrete fasteners after concrete is placed and completely cured.

3.3 CONNECTIONS

A. Equipment Connections: Connect equipment with flexible connectors.

B. Clean ducts systems prior to final acceptance to remove dust and debris.

END OF SECTION 233100

SECTION 233300 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Types of ductwork accessories required for project include the following:

1. Dampers.
   a. Low pressure manual dampers.
   b. Control dampers.
   c. Counterbalanced relief dampers.
2. Fire and smoke dampers.
3. Turning vanes.
4. Duct hardware.
5. Duct access doors.
6. Flexible connections.

B. Refer to other Division-23 sections for testing, adjusting, and balancing of ductwork accessories; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:

1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
3. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers".
4. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

C. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 DAMPERS:

A. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Control Dampers: Provide dampers with parallel blades for 2- position control, or opposed blades for modulating control. Construct blades of 16-ga steel, provide heavy-duty molded self-lubricating nylon 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-ga channel for face areas over 25 sq. ft. Provide galvanized steel finish with aluminum touch-up.

C. Control Dampers: Refer to Division-15 section "Control Systems" for control dampers; not work of this section.

D. Counterbalanced Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-ga 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-ga channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering dampers which may be incorporated in the work include, but are not limited to, the following:

1. Air Balance, Inc.
2. Airguide Corp.
3. American Warming & Ventilating, Inc.
4. Arrow Louver and Damper; Div. of Arrow United Industries, Inc. Louvers & Dampers, Inc.
5. Penn Ventilator Co.
6. Ruskin Mfg. Co.

2.2 FIRE AND SMOKE DAMPERS:

A. Fabricated Fire Dampers: Provide dampers constructed in accordance with SMACNA "Fire Dampers and Heat Stop Guide". Provide fire and smoke dampers at all rated assemblies.

B. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-ga galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide damper with positive lock in closed position, and with the following additional features:

1. Damper Blade Assembly: Single-blade type.
2. Damper Blade Assembly: Multi-blade type.
3. Damper Blade Assembly: Curtain type.
4. Blade Material: Steel, match casing.
5. Blade Material: Stainless steel.

C. Fire/Smoke Dampers: Provide fire/smoke dampers, of types and sizes indicated. Construct casings of 11-ga galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide additional frangible link containing explosive charge, connected in series with fusible link. Provide stainless steel spring loaded leakage seals in sides of casing, and 36" long wire leads for connecting smoke link to smoke detector, and the following additional features:

1. Damper Blade Assembly: Single-blade type.
2. Damper Blade Assembly: Multi-blade type.
3. Damper Blade Assembly: Curtain type.
4. Blade Material: Steel, matching casing.
5. Blade Material: Stainless steel.

D. Motor-Driven Fire/Smoke Dampers: Provide motor-driven fire/smoke dampers in types and sizes indicated, with casing constructed of 11-ga galvanized steel with bonded red acrylic enamel finish, fusible link 160 to 165 degrees F (71 to 74 degrees C), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32" long wire leads for connecting to smoke detector, and with the following construction features:

1. Unit Assembly: Motor mounted outside air stream.
2. Unit Assembly: Motor mounted inside air stream.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire and smoke dampers which may be incorporated in the work include, but are not limited to, the following:

1. Air Balance, Inc.
2. American Warming & Ventilating, Inc.
3. Arrow Louver and Damper; Div. of Arrow United Industries Inc.
4. Louvers and Dampers, Inc.
5. Penn Ventilator Co.
6. Phillips-Aire
7. Ruskin Mfg. Co.

2.3 TURNING VANES:

A. Fabricated Turning Vanes: Provide fabricated turning vanes and vane runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2" wide 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.

C. Acoustic Turning Vanes: Provide acoustic turning vanes constructed of airfoil shaped aluminum extrusion with perforated faces and fiberglass fill.

D. Available Manufacturers: Subject to compliance with requirements, manufacturers offering turning vanes which may be incorporated in the work include, but are not limited to, the following:

1. Aero Dyne Co.
2. Airsan Corp.
3. Anemostat Products Div.; Dynamics Corp. of America.
4. Barber-Colman Co.
5. Duro Dyne Corp.
6. Environmental Elements Corp.; Subs, Koppers Co., Inc.
7. Hart & Cooley Mfg. Co.
8. Register & Grille Mfg. Co., Inc.
9. Souther, Inc.

2.4 DUCT HARDWARE:

A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:

1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering duct hardware which may be incorporated in the work include, but are not limited to, the following:

1. Ventfabrics, Inc.
2. Young Regulator Co.

2.5 DUCT ACCESS DOORS:

A. General: Provide where indicated, duct access doors of size indicated.

B. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one size hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering duct access doors which may be incorporated in the work include, limited to the following:

1. Air Balance Inc.
2. Ruskin Mfg. Co.

3. Ventifabrics, Inc.
4. Zurn Industries, Inc.; Air Systems Div.

2.6 FLEXIBLE CONNECTORS:

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 vibration of connected equipment.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering flexible connections which may be incorporated in the work include, limited to the following:

1. American/Elgen Co.; Energy Div.
2. Flexaust (The) Co.
3. Ventfabrics, Inc.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90 degree elbows in supply 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 to small for person to enter.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.3 FIELD QUALITY CONTROL:

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.4 ADJUSTING AND CLEANING:

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

1. Label access doors in accordance with Division-23 section "Mechanical Identification". Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting, and Balancing".

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

3.5 EXTRA STOCK:

A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION 233300

SECTION 233700 – AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Types of outlets and inlets required for project include the following:

1. Ceiling air diffusers.
2. Wall registers and grilles.
3. Louvers.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".
2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".
3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".
4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".
6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria

ratings. Indicate selections on data.

1. Acoustical performance shall be established by ADC 1062GRD and ADC/ARI standard 885 procedures. Sound power data and NC value with correction factors used shall be supplied that meets or exceeds requirements established later in this Specification. (NC data only is not acceptable.)

B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 CEILING AIR DIFFUSERS: (See schedule for additional requirements)

A. Materials: Aluminum Construction, diffusers shall be constructed entirely on extruded aluminum.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule. The following requirements shall apply to nomenclature indicated on schedule.

1. Diffuser Faces:

a. Round: Round housing, core of concentric rings, round duct connection.
b. Half-Round: Semi-circular housing, core of concentric half-rings, rectangular duct connection.
c. Square: Square housing, core of square concentric louvers, square or round duct connection.
d. Rectangular: Rectangular housing, core of rectangular concentric louvers, square or round duct connection.
e. Panel: Square or rectangular housing extended to form a panel to fit in ceiling system module, core of square or rectangular concentric louvers, square or round duct connection.
f. Perforated: Round, square, or rectangular housing covered with removable perforated panel in frame. Conceal air pattern devices above panel.
g. Linear: Extruded aluminum continuous slot, single or multiple.

2. Diffuser Mountings: AS REQUIRED
   a. Stepped-Down: Diffuser housing below ceiling with perimeter flange and gasket to seal against ceiling construction.
   b. Flush: Diffuser housing above ceiling surface with flush perimeter flange and gasket to seal against ceiling.
   c. Lay-In : Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
   d. Snap-In: Diffuser housing sized to fit between ceiling concealed suspension runners, and snap into runners.

3. Diffuser Patterns: AS REQUIRED
   a. Fixed: Fixed position core with concentric rings or louvers for radial air flow around entire perimeter of diffuser.
   b. 2 Position: Manual 2-position core with concentric rings or louvers, upper position for horizontal air flow, lower position for vertical air flow.
   c. Adjustable: Manual adjustable core with concentric rings or louvers, fully adjustable for horizontal to vertical air flow.
   d. Supply and Return: 2-section core, center position for return, perimeter for supply.
   e. 1 Way: Fixed louver face for 1-direction air flow, direction indicated on drawings.
   f. 2 Way: Fixed louver face for 2-direction air flow, directions indicated on drawings.
   g. 3 Way: Fixed louver face for 3-direction air flow, directions indicated on drawings.
   h. 4 Way: Fixed louver face for 4-direction air flow, directions indicated on drawings.
   i. Induction: Internal aspirator designed to mix air drawn into center core with conditioned air.
   j. Rearrangeable Core: Modular directional core which can be rearranged for selected air pattern.

4. Diffuser Dampers:
   a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser.
   b. Butterfly: Two semicircular flaps connected to linkage adjustable from face of diffuser with key, and with straightening grid.
   c. Supply and Return: For supply and return diffusers, butterfly type damper in return neck, annular adjustable dampers in supply duct.
   d. Integral: Combination volume control and pattern adjustment for linear diffusers.
   e. Fire Damper: Combination adjustable opposed blade damper and fusable link fire damper with UL approved link and assembly designed to meet requirements of NFPA 90A.

5. Diffuser Accessories:
   a. Equalizing Deflectors: Adjustable parallel blades in frame for straightening air flow.
   b. Smudge Ring: Extension perimeter frame around diffuser, sized so induced air impinges on frame and not on ceiling.
   c. Plaster Ring: Perimeter ring designed to act as a plaster stop and diffuser anchor.
   d. Extractor: Curved blades mounted on adjustable frame to produce air scooping action in duct at diffuser take-off.
   e. Blank-Off Baffles: Arc segments designed to fit into diffuser housing to divert air flow from impinging on obstruction.
   f. Operating Keys: Tools designed to fit through diffuser face and operate volume control device and/or pattern adjustment.

6. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work limited to the following:

   1. Krueger
   2. Price
   3. Titus Products Div.; Philips Industries, Inc.

2.2 WALL REGISTERS AND GRILLES:

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes.
   1. Register and Grille Materials:
      a. Aluminum Construction: Manufacturer's standard extruded aluminum frame and adjustable blades.

   2. Register and Grille Faces: AS REQUIRED
      a. Horizontal Straight Blades: Horizontal blades, individually adjustable, at manufacturer's standard spacing.
      b. Vertically Straight Blades: Vertical blades, individually adjustable, at manufacturer's standard spacing.
      c. Horizontal 45 Degree Fixed Blades: Horizontal blades, fixed at 45 degrees, at manufacturer's standard spacing.

   3. Register and Grille Patterns:
      a. Single Deflection: 1-set of blades in face.
      b. Double Deflection: 2-sets of blades in face, rear set at 90 degrees to face set.

   4. Register and Grille Dampers:
      a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of register
      b. Opposed Blade Fusible Link: Opposed blade damper with spring closing and UL-listed fusible link for 160 degrees F (71 degrees C).

   5. Register and Grille Accessories:
      a. Extractor: Curved blades mounted on adjustable frame to produce air scooping action in duct at register or grille take-off.
      b. Plaster Frame: Perimeter frame designed to act as plaster stop and register or grille anchor.
      c. Operating Keys: Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustable.

2.3 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, and maximum pressure drop of each type as listed in manufacturer's current data, complying with louver schedule.

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: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.

E. Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

2.4 LINEAR DIFFUSERS

A. Type: Supply Registers shall be adjustable double-deflection type extruded aluminum.

B. Bars: Provide vertical adjustable face bars and horizontal adjustable rear bars spaces ¾ inch on centers.

C. Fins: In lieu of rear bars, fixed horizontal fins, removable as a unit from the register face, and providing three position up-down adjustment may be furnished.

D. Frames: Provide extruded frames fitted with felt, neoprene or plastic gaskets.

E. Dampers: Provide register dampers of formed steel, cadmium plated, gang key operated, opposed blade type and arranged so that the operating mechanism shall not project through any part of the register face.

F. Mounting hardware: Provide round or countersunk head Phillips screws.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

A. General: Install air outlets and inlets in accordance with manufacturer's written

instructions and in accordance with recognized industry practices to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

3.3 SPARE PARTS:

A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

END OF SECTION 233700

SECTION 235200 - HIGH EFFICIENCY CONDENSING BOILERS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. High Efficiency Condensing Boilers.

1.2 REFERENCES

A. ETL

1. ETL

B. American Society of Mechanical Engineers:

1. ASME Section IV - Boiler and Pressure Vessel Code - Heating Boilers

2. ASME CSD-1 – Controls and Safety Devices for Automatically Fired Boilers

C. Hydronics Institute:

1. BTS-2000 - Testing and Rating Standard for Heating Boilers.

D. National Fire Protection Association:

1. NFPA 54 - National Fuel Gas Code.

1.3 SUBMITTALS

A. In accordance with Contract Specifications.

B. Product Data: Submit capacities and accessories included with boiler. Include general layout, dimensions, size and location of water, fuel, electric, air inlet and vent connections, electrical characteristics, weight and mounting loads. Provide wiring diagrams that are specific to this project.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 WORK INCLUDED

A. Furnish and install Firetube gas fired hot water condensing boilers of the size, capacity and quantity as shown on the contract drawings. Include individual hot water circulating pumps as shown on the Plans and as Scheduled.

B. Each boiler shall have a self-contained controls and safety devices and shall be capable of independent operation.

C. Each boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard as defined by the Department of Energy in 10 CFR Part *SS*431.86. The boiler shall be certified for indoor installation. All boilers shall be installed in accordance with local, State, and Federal codes.

D. Contractor shall obtain Certificate of boiler inspection after boiler installation has been completed and shall pay fees associated with such inspection. After receipt of certificate of Inspection, Installing Contractor shall furnish a suitable glass front frame in which to place said certificate. Frame, with Inspection certificate inserted therein, shall then be placed on or posted in a suitable location within the Boiler room in which the new Boilers have been installed.

E. Contractor shall obtain from Boiler Manufacturer Form H-2 Manufacturers Data Report for Firetube Boilers as required by the Provisions of the ASME Code Rules, Section IV and shall transmit to the Owner after Boiler installation for Record Purposes.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum ten (10) years of documented experience.

1.6 REGULATORY REQUIREMENTS

A. Electrical components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Boilers shall have been Certified in accordance with ANSI Z21.13 test standard; ASHRAE 90.1 Standard and ASHRAE 103 Standard; American National Standard /CSA Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers; ANSI Z223.1 (NFPA 54-2012) for Gas-Fired Boilers; minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard; ANSI/ASME CSD-1 and National Electrical Code (NFPA 70).

C. Commercial Boiler efficiency Certification Program AHRI Directory of Certified AHRI Certified Ratings list of Boilers that have earned the AHRI Certified mark. Boiler manufacturer shall be required to provide the Certified Reference Number and Approved Status under the previously specified performance criteria at Submittal Stage.

D. State Building Code, 780 CMR 1305.2.5 Heating System Controls; and Table 1305.3.3.(5) Standard Rating Conditions and Minimum Performance Gas and Oil fired Steam and Hot Water Boilers.

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

F. Emissions shall conform to South Coast Air Quality Management District specifications. Boiler shall have an independent laboratory rating for Oxides of Nitrogen (NOx) to meet the requirements of South Coast Air Quality Management District in Southern California and the requirements of Texas Commission on Environmental Quality. The Manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

G. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

H. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

I. Boiler shall be AHRI Certified t0 96% Thermal Efficiency, with Oxides of Nitrogen (NOx) less than 20 ppm corrected to 3% 02. Boiler shall produce less than 50 Db sound reading at 100% rate of fire. Control system shall comply with UL/CSD-1/GE-GAP criteria.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Install factory assembled packaged boiler carefully to prevent damage, breaking and scoring. Do not install damaged components; replace with new.

B. Comply with manufacturer’s rigging and moving instructions for unloading boilers, and moving them to final location.

1.8 WARRANTY

A. Leakage and Materials: Heat Exchangers on stainless fire-tube boilers have a ten (10) year limited warranty effective 60 days from the date of manufacture as determined by the serial number.

B. All equipment shall be guaranteed against defects in materials and workmanship for a period of 12 months from the date of start-up, or 18 months from the date of shipment, whichever comes first. The warranty shall include parts inly to repair or replace all defective parts and material at no charge to the owner.

C. Installation shall be guaranteed free from defective materials and workmanship for a period of (1) year from date of acceptance by the Owner. Any repairs required during guarantee period shall be done by the Contractor at his own expense.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to installation.

1.10 START-UP OF EQUIPMENT

A. Operating and Maintenance Instructions are to be furnished with each unit.

B. The boiler shall be factory assembled and fire tested requiring only connections to the water circulating system (supply & return), fuel, electrical power, exhaust vent and air inlet (as specified/shown in contract drawings).

C. Factory-authorized representatives shall perform start-up service on each unit.

1.11 MAINTENANCE SERVICE

A. Furnish service and maintenance of boiler for one (1) year from owner's acceptance.

B. Maintenance service shall be performed by qualified personnel under supervision of or trained by the manufacturer's representative.

PART 2 BOILERS

2.1 MANUFACTURERS

A. Lochinvar

B. Thermal Solutions

C. Bryan Boilers

2.2 STAINLESS STEEL BOILER

A. Furnish and install in accordance with plans and specifications including manufacturer's recommendations, state and local codes with capacity as scheduled on the contract drawings and specifications.

B. Direct-Vent sealed combustion, Boiler shall be factory assembled and fire-tested fire-tube condensing boiler with counter-flow heat exchanger sealed pressure-tight, built on a steel base, including insulated metal jacket, flue gas vent, combustion air intake connections, water supply an return connections, condensate drain connections and controls. Multiple pressure vessels in a single enclosure are not acceptable.

C. Boiler shall require only connection to the water circulating system, fuel/electric utilities, condensate drain and flue gas vent. Heat exchanger shall be constructed of 316L stainless steel. Water-tube, Aluminum or Copper tube boilers, or Boilers with secondary heat exchangers are not equivalent and shall not be considered acceptable.

D. Boiler shall be able to operate in a full-flow system or a variable flow system using variable frequency drives on the system pumps, without requiring the use of a three-way valves or primary/secondary piping loops. Boiler heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drops.

E. Boiler shall bear the ASME "H" stamp for 160 PSI working pressure and shall be National Board listed where applicable. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. Each 316L stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. the condensate collection basin shall be constructed of welded 316L stainless steel. A built-in trap shall allow condensation to drain from the collection basin.

F. Boiler shall be equipped with a variable frequency drive blower motor. Burner shall be a premix design, constructed of high temperature stainless steel with a woven metal fiber outer covering to provide full modulating firing rate with a turndown ratio of (17:1) (20:1) and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall have been BTS-2000 tested to an AHRI Certified thermal efficiency of 96%.

G. Burner shall be metal-fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. Burner shall produce not more than 50-dBA sound reading at full firing rate.

H. Boiler shall be supplied with a combination gas control valve that includes dual safety shutoff valves and a pressure regulator in a single body gas valve designed using negative pressure regulation and equipped with a pulse width modulation blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The Boiler shall operate in a safe condition at derated output with gas supply pressures between 4.00" lns. w.c. and 14" lns. w.c. inlet gas pressure. If inlet gas pressure exceeds 13" W.C., a 100% lock-up type gas pressure regulator of adequate size shall be installed in gas supply piping and adjusted to prevent pressure in excess of 13" W.C.

I. Boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assemble, so that integrity of the outer jacket does not affect a proper seal. A flame observation pert shall be provided.

J. Each Boiler shall be equipped with: temperature/pressure gauge; a system supply water temperature sensor; tank sensor; high limit temperature control with manual reset; outlet water temperature sensor with a dual thermistor to verify accuracy; return

water temperature sensor; outdoor air temperature sensor, flue temperature sensor; probe type low water cut off with manual reset and a condensate trap for the heat exchanger condensate drain; ASME certified pressure relief valve set for 80 PSI; Combustion air inlet filter and dirty filter switch.

K. Probe LWCO shall incorporate a Burner circuit test switch that, when depressed, will test out the control circuit by dropping out the Burner if the circuit is properly wired. Boiler shall fitted with either a float type or a probe type LWCO located above the lowest safe permissible water level established by the Boiler manufacturer. LWCO shall be UL listed and FM approved, suitable for commercial hydronic heating service at 80 PSI.

L. A coil type boiler or water-tube boiler with heat input greater than 200,000 BTU's/hr requiring forced circulation to prevent overheating of the coils or tubes shall have a flow sensing device installed in the outlet piping in lieu of the low water fuel cutoff required in 522 CMR 5.07 (15)(a) to automatically cut off the fuel supply when the circulating flow is interrupted.

M. This Contractor shall furnish and install a condensate neutralizing box complete with limestone granules shipped loose for field installation. Furnish and install a condensate trap assembly if a condensate collection tray is not provided by the Boiler manufacturer. The tap allows condensate to drain from sump while retaining flue gases in the boiler. The trap has factory installed overflow switch, which shuts down the boiler in the event the drain line becomes obstructed, preventing proper condensate removal. Extend drain piping from boiler to acid neutralization kit and to suitable floor drain in mechanical rooms.

N. If the point of condensate disposal is above the trap, a condensate pump shall be required to move the condensate to the drain. If overflow from the pump would result in property damage, select a pump with an overflow switch. Wire this switch in series with installer provided external high limit, to shut off boiler, and, if desired, in series with installer supplied alarm, to trigger an alarm in the event of an overflow.

O. Gas Train

1. Gas train shall be ETL and CSD-1 compliant.

2. Pilot gas valve and pilot gas pressure regulator.

3. Main air-gas ratio valve shall have 2 safety valves in one body and also include the main gas regulator.

4. Leak test valve downstream of gas valve.

5. Low gas pressure switch.

6. Manual shut off valve upstream of burner and downstream of last gas valve.

2.3 COMPUTERIZED BOILER CONTROL

A. The factory mounted and wired control system (BMCS) shall incorporate a high resolution LED display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket.

B. Factory installed Boiler Management Control System (BMCS) shall be provided with password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities, USB drive for simple uploading of parameters and a PC port connection for connection to a local computer for programming and trending. A secondary operating control that is field mounted or inside the appliance is not acceptable. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The boiler shall have a built-in "Cascade" with leader redundancy to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, Hybrid plant front-end loading, and rotation of lead boiler every 24 hours. The boiler shall be capable of controlling an isolation valve during heating operation and rotation of open valves in standby operation for full flow applications. The control shall be equipped to communicate via BACnet MSTP communications. All components shall be easily accessed and serviceable from the front of the jacket.

C. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The control system shall be fully integrated into the Boiler Cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. Using parameter menu selections, the control system shall allow the boiler to respond to remote system water temperature and outside air temperatures and warm weather shut down or building automation system remote start/stop commands.

D. A 0-10 VDC output signal shall control a variable speed boiler pump (pump to be offered by manufacturer) to keep a fixed delta T across the boiler regardless of the modulation rates. The boiler shall have the capability to receive 0-10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues such as erratic temperature cycling.

2.4 ELECTRICAL REQUIREMENTS

A. All Boiler room wiring from the main disconnect switch panel to all Boiler controls, Boiler Circulators, system circulators, Limit circuit, Operating controls, gas valves and actuators, switches and additional control devices shall be furnished and installed under this section of the work by the HVAC Subcontractor and shall conform to the job standards as established by Division 26 Sections.

B. Single-Point Field Power Connection: Factory installed and wired switches, motor controller, transformers and other electrical devices necessary shall provide a single-point field power connection to boiler.

C. Boiler Circuit shall be taken from a two-wire branch circuit, one side grounded, not exceeding 150 Volts, line to line. All safety control switching shall be accomplished in the hot ungrounded conductor and through the 24V low voltage wiring provided by the Boiler manufacturer and in accordance with the manufacturer's instructions and recommendations.

D. Control system wiring shall comply with ASME CSD-1 requirements and 522 CMR 5.07 (19). Fuse protection for the control circuit shall be provided. A manually operated remote heating plant shut-down switch shall be furnished and installed just outside the Boiler room door and shall be marked for easy identification. If there is more than one (1) Boiler room door, there shall be a switch located at each door. Shutdown switches must be wired to disconnect all power to the Boiler controls.

E. Each Boiler shall be equipped with two terminal strips for electrical connections as follows:

1. A low voltage connection board with 46 connection points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Domestic Hot Water Building Recirculation Pump Contacts, Domestic Hot Water Recirculation Temperature Sensor Contacts, Remote Enable/Disable, System Supply Temperature Sensor, Outdoor Temperature Sensor, Tank Temperature Sensor, Modbus Building Management System Signal and Cascade Control Circuit.

2. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt/60 hertz/ single phase on all models. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump.

2.5 VENTING KITS

A. Listed special Gas Vents: All products furnished under this Section shall conform to the requirement of the National Fuel Gas Code, ANSI Z223.1/NFPA-54 where applicable and shall comply with and be listed to UL 1738, the U.S. Standard for Venting Systems for Gas-Burning Appliances, Category II, III and IV and ULC-S636-95, the Canadian Standard for Type BH gas vent systems. Components coming in direct contact with products of combustion shall carry the appropriate UL or ULC. PVC, CPVC, PPS Polypropylene shall be ULC-S636 Certified for use as a flue gas vent system.

B. Combustion-Air Intake: the air inlet pipe may be CPVC or ABS.

C. Approved Vent: AL29-4C vent.

PART 3 EXECUTION

3.1 BOILER INSTALLATION

A. Boiler Pumps shall be installed with manufacturer's recommendations, Contract Drawings, and reviewed submittals.

B. Pumps shall be installed so as to ensure easy accessibility for service or removal and replacement of all components such as, but not limited to, impellers, motors, drive couplings, bearings, strainers, other pump appurtenances, isolators, and flex connections.

C. Install circulator, including all valves, strainer and accessories on each boiler as may be required.

D. The Contractor shall properly protect all equipment to prevent damage from water, dirt, etc. Protection shall include temporary plastic wrap to keep equipment in original factory condition.

E. Install in accordance with NFPA 54 and NFPA 58.

F. Provide connections to the natural gas service connection in accordance with NFPA 54, AGA Z223.1 and NFPA 58. Pipe all gas train vents to the outdoors in accordance with all local and State codes. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

G. Provide hydronic piping connections, valves, fittings and accessories as indicated.

H. Pipe water relief valves to nearest floor drain.

I. Provide complete electrical connections to all boilers.

J. Install electrical devices furnished with boiler but not specified to be factory mounted.

K. Install control wiring to filed-mounted electrical devices.

L. Pipe condensing boiler/vent condensate connections to condensate neutralization tank. Neutralization tank shall be piped to the nearest floor drain.

3.2 START-UP

A. Installing Contractor shall supervise al phases of Boiler installation, pressure testing, startup, and training of operating personnel. Installing Contractor shall also provide

all installation verification inspections, system functional and safety operational test, and heating system capacity verification tests. Hydrostatic test. Repair leaks and retest until no leaks exist.

B. Installing Contractor shall include, as part of his Contract, all charges and cost for Boiler testing, start-up, checkout, adjusting, filed and State inspections, including service contracts for systems and equipment as here-in-after specified. Provide signed documentation to the Awarding Authority for completion of specified procedures.

C. The Boiler manufacturer's Representative shall provide the initial start-up, final adjusting and testing of the Boiler and controls in the presence of the Consulting Engineer, ATC/DDC start up representative and the Owners operating personnel. State Gas inspector, and gas company representative shall also be in attendance as may be required by 248 CMR 7.00. Boiler manufacturer's representative shall also provide raining of the Boilers and Controls and in boiler carte and maintenance to Owners Operating Personnel.

D. Initial start-up, testing and adjustment shall comply with all applicable Local and State Regulations and requirements. Start up and final adjustment shall be in accordance with the Boiler manufacturer's start-up instructions Test and adjust Boiler for maximum efficiency. Test and adjust combustion controls, and boiler controls for proper operation and maximum system efficiency. Check and adjust initial operating set points and high and low limit safety set points of fuel supply, water level and water temperature. Set field-adjustable switches and circuit-breaker trip ranges as indicated. Replace damaged or malfunctioning controls and equipment in accordance with the manufacturer's requirements.

E. Purging of the Boilers, and all required tests for proper venting. Start up technician shall determine the presence and proper function of draft interlock switches or spill switches as may be required by Code and in accordance with the Plumbing Engineers design.

F. At time and date of original start up, provide instruction to the Owners operating personnel in the procedures to resolve a "Lockout" condition. At this time, operating personnel shall also be instructed in the operation and routine management of the Burner and safety controls. The Owner shall arrange to have personnel who require training to be present during the oringal lgithoff. in addition, manufacturer's representative shall provide a training session for the Owners operatinbg personnel at a later date prior to Owners Final Acceptance. Installing Contractor to coordinate time and ate of additional training.

G. Boiler combustion shall be tested and adjusted utilizing electronic combustion instruments to verify that the boiler is operating within acceptable tolerances of the factory fire test report, with a print-out copy submitted to the Engineer. A written report of the start-up, including the factors of the factory fire test, and the factory of the start-up, shall also be furnished to the Engineer.

H. Final acceptance of the Heating system installed within this scope of work shall be contingent on passing a satisfactory system pressure test, mechanical performance test and heating function test to determine that the system will perform according to the contract requirements. The above test shall be witnessed by the Engineer and the Owner at his option and acceptance will only be granted in writing by the Owner after receipt of certification from the Engineer that the design criteria have been met.

I. Installing Contractor shall guarantee the entire installation for a period of One (1) years from the date of Owner Acceptance and beneficial usage by the Owner and Date of Final Payment. Installing contractor shall, upon completion of the installation, make available to the Owner an annual service agreement covering all labor and material required to efficiently maintain the boilers for first year of operation.

END OF SECTION 235200

SECTION 23 74 00 PACKAGED ROOFTOP VENTILATORS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes units with integral heating and cooling for outdoor installation. Integral Energy Recovery device shall be a rotary air-to-air total enthalpy wheel. Integral heat source shall be Indirect Gas-Fired furnace. Integral cooling source shall be packaged DX. Airflow arrangement shall be Outdoor Air only. Each unit shall be constructed in a horizontal configuration and shall incorporate additional product requirements as listed in Section 2 of this specification.

B. Related Sections include the following:

1. Section 22 00 00: Scope of Work
2. Section 22 01 00: General Provisions
3. Section 22 07 00: Insulation
4. Section 22 10 00: Plumbing
5. Section 23 09 00: Controls and Instrumentation
6. Section 26 00 00: Electrical

1.2. SUBMITTALS

A. Product Data: For each type or model include the following:

1. Complete fan performance curves for both Supply Air and Exhaust Air, with system operating conditions indicated, as tested in an AMCA certified chamber.
2. Sound performance data for both Supply Air and Exhaust Air, as tested in an AMCA certified chamber.
3. Motor ratings, electrical characteristics and motor and fan accessories.
4. Performance ratings for all chilled water or DX coils.
5. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
6. Estimated gross weight of each installed unit.
7. Installation, Operating and Maintenance manual (IOM) for each model.
8. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
9. Energy wheel performance data for both summer and winter operation.

1.3. QUALITY ASSURANCE

A. Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.

B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.

C. Product Options: Drawings must indicate size, profiles and dimensional requirements of unit and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".

D. End of line test with full report available upon request.

E. Certifications

1. Blowers shall be AMCA Certified for air flow.
2. Entire unit shall be ETL Certified per U.L. 1995 and bear an ETL sticker.
3. Energy Wheel shall be AHRI Certified, per Standard 1060.
4. Coils shall be Recognized Components for ANSI/UL 1995, CAN / CSA C22.2 No 236.05.
5. Indirect gas-fired furnace shall be ETL Certified as a component of the ERU. Indirect gas-fired furnace shall be an ETL Recognized Component of the ERU per ANSI Z83.8.

1.4. COORDINATION

A. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.

B. Coordinate location of water system fittings to ensure correct positioning for connection to the water coil and condensate drain pipe.

C. Coordinate sequencing of construction of associated plumbing, HVAC, electrical supply.

1.5. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: 1 set(s) of MERV 8 disposable Supply Air and Exhaust Air filters and 1 set(s) of MERV 13 disposable final filters for each unit.

2.01 SUMMARY

A. The contractor shall furnish and install package rooftop air conditioning unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. "APPROVED MANUFACTURERS:

Trane:

Carrier:

York:

2.02 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be packaged rooftop as scheduled on contract documents and these specifications. Cooling performance shall be based on AHRI testing procedures. Wiring internal to the unit shall be numbered for simplified identification. Units shall be cULus listed and labeled, classified in accordance with cULus for Central Cooling Air Conditioners. Unit(s) shall be factory assembled, internally wired, fully charged and consist of insulated weathertight casing with compressors, air cooled condenser coil, condenser fans, evaporator coil, filters, supply and/or exhaust motors and drives, unit controls.

B. Unit(s) shall be single piece construction as manufactured at the factory.

C. Unit(s) shall be factory run tested to include the operation of all fans, compressors, heat exchangers, safeties, limits, and control sequences.

D. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

2.03 UNIT CASING

A. Cabinet: Galvanized steel, with baked enamel finish. Cabinet surface shall be tested 672 hours in salt spray in compliance with ASTM B117. Fully gasketed removable access panels. Structural members shall be heavy gauge with access doors and removable panels of heavy gauge. Provide 1/2 inch thick foil faced fiberglass insulation on all exterior panels and roof in contact with the return and conditioned air stream. Cabinet top cover shall be one piece construction or where seams exists, it shall be double hemmed and gasket sealed.

B. Access Doors: Fully-gasketed doors with hold-back apparatus shall provide access to filters, supply air fan section, evaporator coil section, and unit control

2.04 ELECTRICAL POWER CONNECTIONS

A. Factory-made penetrations shall be provided for connection of all electrical wiring. Field penetrations of the unit base pan shall not be acceptable.

B. Unit shall include a phase monitor as standard that protects equipment from phase loss, phase reversal, and low voltage. Any fault condition shall send the unit into an emergency stop condition. The entire unit with this option shall be cULus approved. If not, a field UL inspection is required.

C. Unit shall include a factory-installed non-fused disconnect switch which satisfies NEC requirements for a service disconnect switch. Disconnect handle shall be accessible through the control box door such that high voltage power must be off before door can be opened.

2.05 AIR FILTERS

A. Air Filters: Filters shall mount integrally within unit and be accessible through hinged access panels.

2.06 FANS - SUPPLY

A. Provide forward-curved fan mounted with fixed pitch sheave drive assembly. Complete fans assemblies shall be statically and dynamically balanced.

B. Fan shaft shall be mounted on grease lubricated ball bearings.

C. All motors shall be circuit breaker protected.

D. Provide EISA rated motors for supply and exhaust fans.

E. Provide Internal Shaft Grounding Ring. Motors shall have internal bearing protection for use with VFDs.

2.07 GAS FIRED HEATING SECTION

A. Completely assembled and factory-installed heating system shall be integral to unit, cULus approved specifically for outdoor applications for use downstream from refrigerant cooling coils.

Threaded connection with plug or cap provided. Provide capability for gas piping connection through side of unit.

B. Heating section shall be factory run tested prior to shipment.

C. Gas Burner shall be in-shot tube type with integral carryover and shall include negative pressure gas valve, manual shut-off, direct spark ignition, and flame sensing safety control.

D. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Upon a failure to ignite, three attempts of ignition will occur before lockout of the ignition system.

E. Combustion blower shall be induced-draft type with built-in thermal overload protection on fan motor.

F. Heat Exchanger: Provide tubular heat exchanger manufactured from 18-gauge aluminized steel. Factory pressure and leak tested.

G. Heat Exchanger: Provide tubular heat exchanger manufactured from 18-gauge 409 stainless steel. Factory pressure and leak tested.

H. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

I. Modulating Gas Heaters shall be stainless steel. The heater shall have a turn down ratio of 10 to 1 for natural gas and 6 to 1 for LP.

J. Unit(s) shall be provided with an LP kit for field-installation to allow for use of Liquid Propane instead of Natural Gas

2.08 EVAPORATOR COIL

A. Provide heavy duty aluminum fins mechanically bonded to internally enhanced, copper tubes.

B. Provide a thermostatic expansion valve. All coils shall be leak tested at the factory to ensure pressure integrity. The evaporator coil is pressure tested to 450 psig.

C. Unit shall include a Condensate Overflow Switch to shut the unit down in the event that a clogged condensate drain line prevents proper condensate removal from the unit.

D. Unit shall include Sloped Stainless Steel evaporator coil drain pans that are durable, long-lasting and highly corrosion resistant.

2.09 CONDENSER SECTION

A. Provide all Aluminum Microchannel condenser coils. All condenser coils shall be leak tested at the factory to ensure pressure integrity and pressure tested to 650 psig.

B. Provide integral subcooling circuit(s) to prevent premature refrigerant flashing and to insure maximum operating efficiency.

C. Provide vertical discharge, direct drive fans with steel blades, and three phase motors. Fans shall be statically balanced. Motors shall be permanently lubricated, with built-in current and thermal overload protection in a weathertight casing.

E. Provide wire mesh coil guards on condensing section to protect coils from damage.

F. Provide Corrosion Protected Condenser Coil that includes an all aluminum microchannel condenser coil with a corrosion resistant coating that shall withstand ASTM B117 Salt Spray test for 6,000 hours and ASTM G85 A2 Cyclic Acidified Salt Fog test for 2,400 hours. This coating shall be added after coil construction covering all tubes, headers and fin edges, therefore providing optimum protection in more corrosive environments.

2.1 REFRIGERATION SYSTEM

A. R410A refrigerant

B. Compressor: Hermetic compliant scroll compressor operating at 3600 rpm with isolated mounting, centrifugal oil pump and oil sight glass

C. Provide factory installed service valves which include suction, liquid, and discharge 3-way shutoff valves.

D. Provide with thermostatic temperature motor winding control for protection against excessive temperatures caused by over-/undervoltage operation or loss of charge. Also provide high and low pressure cutouts.

E. Provide integral coil frost protection based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage for all units. Hot Gas Bypass shall not be acceptable.

F. Units shall have cooling capabilities down to 0 degree F as standard or manufacturer shall furnish unit with installed low ambient controls to allow for operation down to 0 degree F. For field installed low ambient accessory, the manufacturer shall provide a factory authorized serviceman that will assure proper installation and operation.

2.11 EXHAUST/RETURN SECTION

A. 100% Fresh Air Tracking Modulating Power Exhaust shall be available on all units and shall be factory installed. It shall assist with maintaining building pressurization by exhausting a proportional amount of the entering fresh air by mechanically linking the Fresh air damper to the exhaust air damper.

2.12 OUTDOOR AIR SECTION

A. Provide a fully integrated factory installed 100% modulating outside air economizer with unit return and barometric relief air dampers. Economizer operation shall be through primary temperature controls that automatically modulate dampers to maintain space temperature conditions.

1 Provide economizer with Differential Enthalpy Controls

2 Provide spring return motor for outside air damper closure during unit shutdown or power interruption.

2.13 ECONOMIZER DAMPERS

A Provide Ultra Low Leak Economizer Dampers. The return air and fresh air dampers shall be provided with airfoil blades and independent direct drive actuators. Dampers shall have a leakage rate of 3 CFM/sq-ft at 1.0 in WC pressure differential (AMCA Class 1A). Dampers shall have a functional life of 60,000 opening & closing cycles.
Note: Based on testing completed in accordance with AMCA Standard 500D.

B Provide Fault Detection and Diagnostic (FDD) control. FDD control shall monitor the commanded position of the economizer compared to the feedback position of the damper. If the damper position is outside +/- 10% of the commanded position, a diagnostic is generated.

2.14 UNIT CONTROLS

A. General: Microprocessor controls shall be provided for all 24 volt control functions. The resident control algorithms shall make all heating, cooling and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures. The control algorithm maintains accurate temperature control, minimizes drift from set point and provides better building comfort. A centralized microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.

B. Multi-Speed Controls: Provide all necessary controls to operate rooftop from a zone based temperature sensor, including microprocessor unit control and economizer control.

1 Provide discharge air temperature sensing. Discharge air temperature sensing shall report cooling and or heating unit leaving air temperature to Building Management System.

2 Single Zone Variable Air Volume - Single Zone VAV option shall be provided with all necessary controls to operate a rooftop unit based on maintaining two temperature setpoints: discharge air and zone. Option shall include factory-installed variable frequency drive (VFD) to provide supply fan motor speed modulation. During One Zone VAV cooling, the unit will maintain zone cooling setpoint by modulating the supply fan speed more or less to meet zone load demand; and the unit will maintain discharge temperature to the discharge cooling setpoint by modulating economizer if available and staging direct expansion cooling.

3 Unit shall be provided with a Variable Frequency Drive (VFD) and bypass

2.16 Ventilation Override: Provide factory installed, tested, and commissioned ventilation override controls. Binary input from independent fire/life safety panel shall cause unit to override standard operation and assume one of two factory preset ventilation sequences: purge or pressurization.

2.17 Clogged filter indication: Provide factory installed differential pressure switch to indicate filter replacement status. Differential pressure switch shall cause a contact closure to display a service indication and unit will continue to operate normally. This option requires a Trane Zone Sensor with Service LED and a Communications option (Lontalk, BACnet/Modbus, AirFi).

2.18 BUILDING MANAGEMENT SYSTEM

A. Interface to Building Management System to be furnished [Factory Mounted] by rooftop unit manufacturer via BACnet/Modbus communication. All Building Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. BACnet/Modbus Comm interface will be furnished with the necessary controls and sensors and shall all be factory mounted (not field mounted). If not furnished by rooftop unit manufacturer, this shall be furnished by Building Management System Contractor for field mounting by said contractor and rated for service up to 140 F. The only field connection to Energy Management System shall be a single communication link.

B. Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown.

C. Diagnostic Functions shall include: Unit operating mode, Unit failure status, cooling failure, heating failure, emergency service stop indication, supply fan proving, timed override activation, high temperature thermostat status, Zone temperature, Supply air temperature, Cooling status (all stages), Stage activated or not, Stage locked out by UCP, HPC status for that stage, Compressor disable inputs, Heating status, Number of stages activated, High temperature limit status, Economizer status, Enthalpy favorability status, Requested minimum position, Damper position, Dry bulb/enthalpy input status, Outside air temperature, Outside relative humidity,] Sensor Failure: Humidity sensor, OAT sensor, SAT sensor, RAT sensor, Zone temperature sensor, Mode input, Cooling/heating setpoints from sensors (CV only), Static pressure transducer, Unit mounted potentiometer, SAT from potentiometer (VAV only), Air reset setpoint from potentiometer (VAV only), Unit Configuration data, Gas or electric heat, Economizer present, High temp input status, Local setpoint, Local mode,

PART 3 EXECUTION

3.01 EXAMINATION

A. Contractor to verify that roof is ready to receive work and opening dimensions are correct.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork. Install roof mounting curb level.

3.03 MANUFACTURER'S FIELD SERVICES

A. If Start up is included, the manufacturer shall furnish a factory trained service engineer without additional charge to start the unit(s).

C. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION 23 74 00

SECTION 237433 – HIGH PERCENTAGE OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes factory-assembled, dedicated outdoor air-handling units, including multiple components, capable of heating and cooling 100 percent outdoor air.

1.3 DEFINITIONS:

A. ECM: Electronically commutated motor.

B. ISCOP: Integrated Seasonal Coefficient of Performance.

C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.

D. MRC: Moisture Removal Capacity.

E. MRE: Moisture Removal Efficiency.

1.4 ACTION SUBMITTALS

A. Product Data: For each dedicated outdoor-air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.

7. Include filters with performance characteristics.
8. Include heat exchangers with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. High Performance Building Submittals:
1. Product Data for Mandatory Requirement: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
2. Product Data for Mandatory Requirement: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Product Data for High Performance Building Standard Option Strategy: Documentation indicating that units are equipped with a direct outdoor airflow-measuring device capable of measuring the minimum outdoor airflow with accuracy within 15 percent of the design minimum airflow rate, as defined by ASHRAE 62.1.
4. Product Data for Mandatory Requirement: Documentation indicating that units include MERV 13 filters rated according to ASHRAE 52.2.

C. Shop Drawings: For each dedicated outdoor-air unit.

D. Shop Drawings:
1. Unit manufacturer shall provide the following information with each shop drawing/product data submission:
    a. Dimensioned arrangement drawings for each air handling unit including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
    b. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.
    c. Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
    d. All performance data, including capacities and airside and waterside pressure drops, for components.
    e. Fans:
        1) Certified fan-performance curves with system operating conditions indicated.
        2) Certified fan-sound power ratings.
        3) Fan construction and accessories.
        4) Motor ratings, electrical characteristics, and motor accessories.
    f. Certified coil-performance ratings with system operating conditions indicated.
    g. Dampers, including housings, linkages, and operators.
    h. Filters with performance characteristics.
    i. Sound data shall be provided using ARI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Startup service reports.

F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One (1) set for each dedicated outdoor air unit.

1.8 WARRANTY

A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.

1. Provide parts warranty extending either 12-months from date of unit start-up or a maximum of 18-months from unit ship date.
2. Provide 25 year heat exchanger limited warranty.
3. Provide 5 year compressor limited warranty.

1.9 REGULATORY REQUIREMENTS

A. Unit shall conform to the appropriate standards listed in Section 103 as well as be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the following applicable standards.
1. Standard for Safety Heating and Cooling Equipment-Fourth Edition, UL 1995/CSA C22.2#236 Issue: 2011/10/14
2. Standard for Gas Unit Heaters And Gas-Fired Duct Furnaces ANSI Z83.8-2013, CSA 2.6-2013, Third Edition – 2006 (indirect gas-fired/e)
3. Standard for Non-Recirculating Direct Gas-Fired Industrial Air Heaters, ANSI Z83.4 / CSA 3.7 - Issued: 2013/03/01 Ed: 3
4. In the event the unit is not approved by an NRTL for compliance with the appropriate standards, the manufacturer shall, at manufacturer's expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

1.10 REFERENCES

A. AHRI Compliance:
1. Comply with AHRI 920 "Performance Rating of DX Dedicated Outdoor Air System Units". Testing for rating is next step in implementation of this rating standard

B. AMCA Compliance:
1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:
1. Comply with ASHRAE 15 for refrigeration system safety.
2. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1,

D. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in

G. NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.11 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

C. Units to be secured via base rail tie-down locations.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install packaged outdoor air units as shown and scheduled on the contract documents. The units shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.2 MANUFACTURERS

A. This specification is based on a dehumidification unit as manufactured by Trane.
   1. Manufacturer shall comply with all specifications, performance requirements listed herein, dimensional requirements, service, start-up, and warranties. Subject to compliance with requirements, equals shall meet or exceed all scheduled values.
   2. Unit manufacturer to provide MRE and MRC efficiency values as established by AHRI 920.

B. Approved manufacturers:
   1. Trane
   2. Carrier
   3. JCI

2.3 GENERAL UNIT DESCRIPTION

A. Units furnished and installed shall be packaged outdoor air units as scheduled on contract documents and described in these specifications. Units shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a

minimum of 6" downstream from the leaving face of the evaporator coil. Heating system shall include modulating controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.

B. Units shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. Unit discharge airflow configuration shall be:
1. Vertical discharge thru unit base or horizontal discharge through side of unit.

2.4 CABINET

A. Cabinet panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed. All interior surfaces exposed to airflow shall be 2" double wall including the floor and ceiling.

B. Insulation: 2" double-wall foamed injected R-13 construction throughout. Unit shall be double wall in all areas in contact with supply and exhaust air streams.

C. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2" thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

D. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.

E. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.

F. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20-gauge for access doors and cabinet panels.

G. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.

H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.
   1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
   2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

K. Drain Pan material shall be Type 430 Stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of drain pan shall be insulated with 1" thick foam insulation.

L. Provide openings either on side of unit or thru the base for power, control and gas connections.

M. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

2.5 FANS AND MOTORS

A. Provide factory mounted variable frequency drive for supply and exhaust fans.

B. Indoor fans shall be high efficiency backward curved impeller.

C. The indoor fan motor shall be an electronic commutated motor with integrated power electronics for variable motor speed.

D. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position.

E. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.6 AIR FILTERS

A. Evaporator Inlet filters shall be:
   1. 2" deep pleated MERV 8
   2. 2" deep pleated MERV 13

B. Energy Recovery Wheel:
   1. 2" deep pleated MERV 8

2.7 DAMPERS

A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.

B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.

C. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

D. Dampers air velocity shall not exceed 2000 fpm.

E. Return Air damper shall be of same material, construction and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.

2.8 DEHUMIDIFICATION/COOLING

A. Compressors
1. All units shall have Digital Scroll Compressors.
2. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
3. Internal overloads shall be provided with the scroll compressors.
4. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
5. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
6. Provide each unit with 1 or 2 hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
7. Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.

B. Coils
1. Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
2. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
3. The condenser coil shall have a fin designed for ease of cleaning.
4. Evaporator coil shall include six or four rows, as scheduled, of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
5. Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
6. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.

C. Condenser Section

1. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
2. Fans shall be statically and dynamically balanced.

D. Compressor Capacity Control
1. Electronic Control.

2.9 FANS AND MOTORS

A. Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access for ease of maintenance.

B. All fan motors shall be premium efficiency ODP and meet the U.S. Energy Policy Act of 2005/10 (EPACT).

C. All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection.

D. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position.

E. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.10 HEATING

A. Heat Pump Heating
1. Unit shall utilize Air Source Heat Pump heating as the first stage of heat above a field-determined setpoint. Auxiliary Gas Heater shall only be engaged on an as-needed basis if heating call exceeds Heat Pump capacity.
2. Heat Pump performance is rated at 5 degF.

B. Fully Modulating Indirect LP Gas Fired Heating System
1. Completely assembled and factory installed heating system shall be located in the primary heating position located downstream of the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at manual shut-off valve. Provide capability for sidewall or thru-base gas piping.
2. Heaters shall include high turn-down burners firing into individual stainless steel tubular heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when ≤150 MBH or a minimum of 10:1 when >150 MBH. Staged burners are not acceptable. Burners shall be operational from 7”-14” w.c. inlet NG pressure.

3. Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet, the inlet shall be hooded and shall be located a minimum of 11" beneath the flue outlet. Inlet hood shall include bird screen.
4. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.
5. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.
6. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.
7. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.
8. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

2.11 ELECTRICAL RATINGS AND CONNECTIONS

A. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

B. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

C. Power wiring to be single point connection.

D. Wiring internal to the unit shall be colored and numbered for identification.

E. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

F. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

G. Unit SCCR rating shall be a minimum of 5kA

H. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.

I. Phase Unbalance Protection: Factory set 2%

J. Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage

K. Phase Loss/Reversal

L. Factory to mount and wire optional120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

M. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

2.12 UNIT CONTROLS

1. Factory- engineered, mounted, configured and tested.
2. Microprocessor control, BacNet communications interface
3. Human interface with touch-pad screen for monitoring, setting, editing and controlling.

A. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include:
   1. Include single program with field selectable:
      a. Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.
      b. Space control with unit conditioning modes enabled and controlled to maintain space setpoints.

   2. Single Zone Variable Air Volume (SZVAV) with unit conditioning modes enabled based on space temperature cooling setpoint and modulate supply fan to maintain setpoint. Cooling will be staged to maintain discharge air cooling setpoint. Heat will modulate to maintain space temperature with indoor fan held at maximum design airflow.

B. MCM shall:
   1. Prevent simultaneous operation of any conditioning modes.
   2. Accept separate setpoints for Occupied and Unoccupied states.
   3. Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible or enthalpy temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.
   4. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   5. Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).
   6. Unit shall include minimum discharge air control.

C. Optional MCM Touch Screen shall include full color display and shall be (factory installed in unit control compartment / field mounted remote from unit and field wired up to a maximum of 300 ft.) and provide a full list of points included in the MCM. The display shall provide a list and history of all unit alarms.

D. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.
   1. Space Control or Single Zone VAV: Factory shall furnish Space Temperature and Space Humidity sensor for field installation and connection to the unit
   2. Economizer Option includes Return Air Temperature and Humidity sensor
   3. ERV Option includes exhaust air leaving temperature sensor
   4. Powered Exhaust with Economizer includes duct pressure sensor to be field installed.

E. System controls shall include:
   1. Anti-cycle timing.
   2. Minimum compressor run/off-times.

F. Factory Mounted and Wired Control Devices:
   1. Outdoor Air Temperature Sensor
   2. Outdoor Air Humidity Sensor
   3. Outdoor Air Flow Measuring Station
   4. Outdoor Air Modulating Damper and Actuator
   5. Return Air/Mixed Air Modulating Damper and Actuator
   6. Return Air Temperature Sensor
   7. Return Air Humidity Sensor
   8. Return Air Duct Pressure Sensor
   9. Filter Differential Pressure Switch – Status
   10. Evaporator Leaving Air Temperature Sensor
   11. 0-10 vDc Input for Hot Gas Reheat Modulation
   12. Supply Fan Status
   13. Supply Fan Piezometer Air Flow Measuring Station
   14. Supply Fan Variable Speed Fan Control
   15. Exhaust Fan Status
   16. Exhaust Fan Piezometer Air Flow Measuring Station
   17. Exhaust Fan Variable Speed Fan Control
   18. ERV Wheel rotation sensor
   19. Modulating Gas Heat
   20. Unit Leaving Air Temperature Sensor for Discharge Air Temperature/Humidity for Dewpoint Control
   21. Liquid Line Pressure sensor
   22. Suction Pressure sensor
   23. Space Temperature
   24. Space Humidity
   25. Monitor Leaving Air Dewpoint

2.13 POWER EXHAUST

A. Provide a factory installed power exhaust assembly that shall be designed to ventilate return air to atmosphere.

B. Plenum mounted direct drive airfoil design exhaust wheel material shall be heavy gauge aluminum, welded construction and rated for up to Class III speed/pressure performance. Belt-drive and/or forward curve plenums fans shall not be used.

C. Exhaust to discharge through powered isolation dampers located on each side of unit cabinet.

2.14 OUTDOOR AIR SECTION ENERGY RECOVERY WHEEL (ERW)

A. The rotor media shall be made of polymer, formed into a honeycomb structure to minimize pressure loss and avoid plugging. The rotor media must be coated to resist corrosion. All

surfaces must be coated with a non-migrating desiccant layer to ensure that adequate latent capacity is provided. The desiccant coating must be firmly bonded to the surface and will not be dislodged when challenged with high velocity air up to 5000 feet per minute. Products that lose desiccant when served with high velocity air are not acceptable. The cassette must be a slide out design for serviceability. The media shall be cleanable with low temperature steam, hot water or light detergent without degrading the latent recovery.

B. Sensible and latent recovery efficiencies must be clearly documented through a testing program conducted in accordance with ASHRAE Standard 84 and AHRI 1060. The testing must have been conducted by a qualified independent organization. The performance test reports must be provided for engineering review as part of the submittals for this project. Sensible and latent efficiencies must MEET OR EXCEED scheduled values.

C. The rotor design shall ensure laminar airflow to minimize parasitic pressure loss and to optimize the operating efficiency of the system fans. The pressure loss across the media shall be no greater than the scheduled pressure loss values. The energy wheel shall operate effectively up to 180 degrees F.

D. The rotor media shall be permanent, with an anticipated life of 20 years. It must be tested in accordance with ASTM Standard E-84 and provide smoke and flame spread ratings of less than 25 and 50 as required by NFPA 90A and UL 1995. A copy of the ASTM E-84 test report confirming the method of test and results shall be provided with the submittal. Heat recovery wheels incorporating “throw-away” media and tested to UL900 for Class 2 filters are not acceptable.

E. The wheel manufacturer must have been producing energy recovery wheels for a minimum of ten years.

F. The rotor shall be supplied with perimeter brush seals and face contact seals to minimize air leakage and wheel bypass.

G. The rotor media shall be supported by a structural aluminum hub and aluminum reinforcing spoke system. The rotor bearings must be greaseable and provide L10 life in excess of 20 years.

H. The cassette framework shall be made of galvanized steel to prevent corrosion.

I. The rotor must be driven by long-life polyurethane/polyester composite link belt system. The rotor/cassette shall be designed so that belt can be removed or serviced without the removal of the bearing. A 3 phase A/C gear motor shall be utilized to accommodate variable speed applications.

24. MANUFACTURER'S FIELD SERVICES

A. Unit start-up and commissioning shall be completed by a Factory-trained and factory-certified technician.

B. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50 mile radius of job site.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine curbs and equipment supports for suitable conditions where units will be installed.

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

3.2 INSTALLATION, GENERAL

A. Contractor shall install in accordance with manufacturer's instructions.

B. Unit Support: Install unit level on structural steel support. Secure units to structural support with anchor bolts. Coordinate sizes and locations of steel supports with actual equipment provided.

1. Comply with requirements for integrated acoustical seismic curb specified in Section 230548.

2. Sustainable design systems require filters with a minimum MERV 13 rating for air delivered to the occupied space. Air-handling units should not be used for temporary heating and ventilating unless expressly approved by Owner. If used during construction, see SMACNA's "IAQ Guidelines for Occupied Buildings under Construction" for procedures to protect HVAC system.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

G. Comply with requirements for gas-fired furnace installation in NFPA 54.

H. Install separate devices furnished by manufacturer and not factory installed.

I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to units, allow space for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Gas Piping: Comply with requirements in **Section 231123 "Facility Natural-Gas Piping."**

1. Connect gas piping to furnace, full size of gas train inlet, and connect with union**, pressure regulator,** and shutoff valve with sufficient clearance for burner removal and service.
2. Install AGA-approved flexible connectors.
3. Provide LP conversion kit.

E. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 MANUFACTURER'S FIELD SERVICES

A. Unit start-up and commissioning shall be completed by a 'Factory-trained and factory-certified technician.

B. Manufacturer’s Representative to assist in 3rd party commissioning as required per specification 019113 “General Commissioning Requirements”.

C. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50 mile radius of job site.

D. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

3.7 STARTUP SERVICE

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

4. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:

a. High-limit heat exchanger.
b. Alarms.

5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:

a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
b. Cooling coil entering-air, dry- and wet-bulb temperatures.
c. Condenser coil entering-air dry-bulb temperature.
d. Condenser coil leaving-air dry-bulb temperature.

7. Simulate maximum cooling demand and inspect the following:

a. Compressor refrigerant suction and hot-gas pressures.
b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.

a. Supply-air volume.
b. Relief-air flow.
c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.8 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Manufacturer’s Representative to assist in 3rd party commissioning as required per specification 019113 “General Commissioning Requirements”.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.11 DEMONSTRATION

A. Provide a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

B. Provide video recordings of how the HVAC system equipment physically operates, etc.

END OF SECTION 237433

PART 1 - GENERAL

1.01 DESCRIPTION

A. General: Materials and methods for performance of all mechanical work.

B. Provide complete and operational mechanical systems including, but not limited to, all required materials, parts, equipment, labor, tools, and accessories.

1.01 CODES AND STANDARDS

B. Except as modified by governing codes, comply with applicable provisions and recommendations of the following:

1. ANSI Standards.

2. Owner's Insurance Company.

3. Current Connecticut Laws and Statutes.

1.02 SUBMITTALS

B. Increase, by the quantity listed below, the number of mechanical related shop drawings, product data, and samples submitted, to allow for required distribution.

1. Shop Drawings: Initial Submittal: 1 additional blue- prints.

2. Product Data: 1 additional copy of each item.

3. Samples: 1 addition as set.

C. Additional copies may be required by individual sections of these Specifications.

D. Shop Drawings:

1. Submit for review, detailed shop drawings and product data of all the equipment and material required to complete the work. No material or equipment may be delivered to the jobsite or installed until accepted shop drawings for the particular material or equipment have been approved by the Owner or his authorized representative.

2. Failure to submit shop drawings in ample time for checking will not entitle Contractor to claim extension of Contract time, or increase in contract cost.

3. The proposed piping layout for the Boiler system is required.

E. Tests & Certificates:

1. As specified in other sections.

1.05 CERTIFIED PRODUCT PERFORMANCE RATINGS

A. All VRF (Variable Refrigerant Flow) and VSMS (Variable Speed Multi-Split and Mini- Split) products shall have published performance ratings certified by AHRI (Air-Conditioning, Heating, and Refrigeration Institute) and listed in the AHRI certified product directories available at www.ahridirectory.org.

1.06 PRODUCTION FACILITY CERTIFICATIONS

A. All system components shall be manufactured in production facilities maintaining the following ISO certifications:

1. ISO 9001 Quality Management System

2. ISO 14001 Environmental Management System

1.07 UL COMPLIANCE

A. All system shall comply with Underwriters Laboratories (UL) 1995 5th edition of the Standard for Safety for Heating and Cooling Equipment Standard for Safety and bear the Electrical Testing Laboratories (ETL) and/or Canadian Standards Association (CSA) mark on the product name plate.

1.08 MANUFACTURERS

A. Acceptable manufacturers:

1. Mitsubishi

2. LG

3. Carrier

PART 2 – SYSTEMS

2.01 MULTI V™ 5 HEAT RECOVERY AND HEAT PUMP SYSTEM(S) – (6 TO 42 TONS NOMINAL)

A. Product design

1. Heating and cooling system shall be an air cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit.

a) Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements.

b) Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery system shall consist of three pipes, liquid, suction and hot gas pipes. Heat recovery systems operating at 0°F that cannot deliver single phase superheated refrigerant vapor at a minimum of 162°F while operating in the heating mode shall not be acceptable.

2. All three-phase VRF heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.

B. Operating conditions

1. Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.

2. Operating Ambient Air Conditions:

a) Cooling: 5°F DB to 122°F DB <With optional low ambient kit from -9.9°F DB to 122°F DB>

b) Heating: -22°F WB to 61°F WB

c) Cooling Based (ODU reversing valve in cooling position) Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)

d) Heating Based (ODU reversing valve in heating position) Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)

C. Electrical

1. All air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with 208-230/60/3 power with the following specifications:

a) <208-230/60/3>

ii. Voltage fluctuation of ± 10%

b) Voltage imbalance of up to two percent;

c) Power surge of up to 5kA RMS Symmetrical.

D. General Features

1. The air-conditioning system shall use R410A refrigerant.
2. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
3. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
4. System shall have following frame configurations vs. capacity.
   a) 6 to 20 ton units shall be a single frame only.
5. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
6. Field Provided Refrigerant Piping:
   a) The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, refrigerant rated copper pipe, piped together with manufacturer supplied Heat recovery unit(s) and Y- branches, as may be required, connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the heat pump operation or simultaneous heating and cooling operation of the heat recovery VRF system. Other pipe materials, if used, shall perform, at a minimum, as well as that specified above, shall not have any adverse reactions, for example galvanic corrosion, to any other components or materials also in use in the system and shall be installed per manufacturer's instructions.
   b) The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, temperature sensor, humidity sensor, contacts, relay(s), fans, power and communications wiring as necessary to perform both Heat Pump and Heat recovery operations.
   c) Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
      i. Refrigerant strainer(s)
      ii. Check valve(s)
      iii. Inverter driven, medium pressure vapor injection, high pressure shell compressors
      iv. Liquid refrigerant cooled inverter PCB
      v. Oil separator(s)

vi. Accumulator /controlled volume receiver(s)

vii. 4-way reversing valve(s)

viii. Vapor injection valve(s)

ix. Variable path heat exchanger control valve(s)

x. Oil balancing control

xi. Oil Level sensor(s)

xii. Electronic expansion valve(s)

xiii. Sub-cooler (s)

xiv. Vapor Injection Valve(s)

xv. High and low side Schrader valve service ports with caps

xvi. Service valves

7. Field Insulation:

a) All refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

xvii. All joints shall be glued and sealed per insulation manufactures instructions to make an air tight assembly.

8. Microprocessor:

a) Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.

9. Inverter PCB Cooling:

a) Cooling of the inverter PCB shall be conducted by way of high pressure, sub-cooled liquid refrigerant via heat exchanger attached to the inverter PCB. The full capacity flow of refrigerant shall pass though the heat exchangers to maximize the cooling effect of the PCBs and to aid in the evaporation process and capacity of the outdoor coil during the heating mode. The recovered heat of the PCBs must be used to enhance the overall heating process, other uses or dissipation of heat to ambient shall not be permitted.

10. Compressor Control:

a) Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance.

11. Initial Test Run (ITR) (Heating or Cooling) / Fault Detection Diagnosis (FDD) Code:

a) This control mode shall monitor and display positive or negative results of system initial startup and commissioning. Heating or Cooling ITR mode will be automatically selected. It shall monitor and provide performance metrics for the following, but not be limited to, refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, and number of indoor units connected. This control mode shall not replace the system error monitoring control system.

12. BMS Integration:

a) The VRF system shall be able to integrate with Building Management Systems via BACnet™ IP gateway. This gateway converts between BACnet™ IP or Modbus TCP protocol, and RS-485 LGAP allowing third party control and monitoring of the A/C system, or LonWorks™ gateways.

13. Wi-Fi Communication:

a) The outdoor unit shall be Wi-Fi enabled and capable. Wi-Fi shall allow service or maintenance personal access to the complete operating system, via mobile, without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc., by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

14. Indoor Unit Connectivity:

    a) The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

15. Power and Communication Interruption:

    a) The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable.

16. Connection Ratios:

    a) The maximum allowable system combination ratio for all VRF systems shall be 130% and the minimum combination ratio shall be 50%.

17. Comfort Cooling Mode:

    a) Comfort cooling shall be initiated via a field setting at the outdoor unit during commissioning or anytime thereafter. Comfort cooling shall allow user to select all or some of the zones on a system to adjust automatically their evaporator temperatures, independent of other zones, based on the impending total loads of that zone determined by using the zone controller temperature sensor.

18. Refrigerant Circuit Safety

    a) The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

19. Refrigerant Flow Control

    a) An active refrigerant control and multi section accumulator-receiver that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system performance and efficiency.

    b) Subcooler: The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a shell and tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required. Brazed plate heat exchangers shall not be allowed for this function.

    c) Smart Load Control: The air source unit shall be provided with Smart Load Control (SLC) enhanced energy saving algorithm that reduces compressor lift during off peak operation.

i. The SLC algorithm shall be monitoring in real time, the rate of change of the outdoor ambient air temperature, either the outdoor ambient air relative humidity or the indoor air relative humidity [field selectable], and the rate of change of the building load.

ii. The SLC algorithm shall foresee pending changes in the building load, outdoor temperature and humidity (or indoor humidity) and proactively reset head and/or suction pressure targets in anticipation of the reduction/increase in building load.

iii. The SLC algorithm shall provide no fewer than 3 field selection options to maximize the control of the VRF system operation during morning warm-up or cool-down following night-setback reset. The selection shall be set by the commissioning agent (or at any other time thereafter). Selectable algorithm choices include:

1. Maximize energy savings

2. Balance the rate of temperature change with energy consumed.

3. Quickly cool/heat the building.

20. Refrigerant Volume Management

a) Active Refrigerant Charge

i. The VRF system shall be able to operate at any and all published conditions year round in cooling or heating mode without the need of adding or removing refrigerant from the system.

ii. The air source unit shall be provided with an isolated vessel to store spare refrigerant and actively pass refrigerant to (or from) the accumulator in real time as necessary to maintain stable refrigeration cycle operation.

iii. The air source unit microprocessor shall be provided with an algorithm that monitors the VRF system head pressure, suction pressure, subcooling, superheat, compressor speed, high and low side temperatures and the load on the system to adjust the volume of refrigerant actively circulating.

b) Manual Seasonal Refrigerant Charge Adjustments

(Applicable for VRF systems without Active Refrigerant Charge)

i. Alternates: Systems that CANNOT passively and automatically modify the active refrigerant charge using the method(s) stated to maintain stable cycle operation shall clearly state so in bold capital letters in the proposal. VRF systems that cannot perform active refrigerant control may submit a

proposal as an Alternate and must include as part of the equipment price the cost of to provide bi-annual refrigerant charging services for 15 years. Service shall be performed by the factory authorized agent only. Service shall include refrigerant, parts, labor, and fees necessary to analyze the current state of the system and perform the refrigerant charge adjustment. Service must occur one month before the winter season and one month before the summer season.

ii. If the VRF system requires a charge adjustment more frequently to maintain stable operation, the VRF manufacturer shall provide additional services at no additional charge.

iii. The 15 year period shall begin on the date the equipment is commissioned or the date the building occupancy permit was issued for the area(s) served by the system – whichever date is later.

iv. This service shall be underwritten, warranted, and administered by the VRF equipment manufacturer – not the local distributor or applied representative.

v. The selected service provider shall be mutually agreeable between the building owner (or owners agent) and must be licensed, insured, and trained to work on the VRF system. No third party service (subcontracted service) providers will be acceptable.

vi. If the service provider is not an employee of the VRF manufacturer, the service provider shall be reimbursed for services rendered directly from the manufacturer. Labor rate for services shall be paid at the prevailing wage rate in place at the time of service.

21. VRF Systems with Onboard Alternate Operating Mode Selection Capability

a) All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered.

b) Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.

c) Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.

d) For systems that provide field selectable Alternate Operating Modes, ALL technical data provided in the submittal data sheets showing product rated

condition performance data, must also provide separate data sheets that show product performance data at each of the field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.

E. Field Supplied Refrigerant Piping Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed subcooler or other forms of performance enhancing booster devices.

2. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.

3. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

4. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer’s published guidelines.

5. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

6. The elevation difference between indoor units on <heat pump systems> shall be 131 feet.

7. The elevation differences for <heat recovery systems> shall be:

   a) Heat recovery unit to connected indoor unit shall be 49 feet

   b) Heat recovery unit to heat recovery unit shall be 98 feet

   c) Indoor unit to indoor unit connected to same heat recovery unit shall be 49 feet

   d) Indoor unit to indoor unit connected to separate parallel piped heat recovery units shall be 131 feet.

8. The acceptable elevation difference between two series connected heat recovery units shall be 16 feet.

F. Defrost Operations

1. The outdoor unit(s) shall be provided with a minimum of 4 independent field adjustable defrost cycle algorithms to maximize the effectiveness of the defrost cycle to the local weather conditions. Intelligent Defrost shall melt accumulated frost, snow and ice from the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables. Intelligent Heating Mode, when outdoor unit humidistat is engaged, shall extend the normal heating sequences by adjusting the outdoor unit coil target temperature to be above the ambient dew point temperature delaying the need for defrost operations, so long as heating demand is being met.

2. Smart Heating: This feature shall be capable of eliminating several defrost actions per day based on outdoor air temperature and humidity conditions. Smart heating shall extend the heating operation cycle by delaying the frost formation on the outdoor coil by adjusting the surface temperature to keep it above the current outdoor ambient dew point. The algorithm shall delay while maintaining indoor space temperature.

3. Defrost Mode Selection: The outdoor unit shall be provided with a minimum of three field selectable defrost operation modes: Normal, Fast, or Forced.

   a) Normal Defrost: Operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is either: a) above 32°F or b) below 32°F with the humidity level below 60% RH, Intelligent Defrost shall continue heating regardless of ice build-up on the coil until the quality of the heated air (i.e. discharge air temperature) decreases. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.

   b) Fast Defrost: Operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods based on current weather conditions to minimize energy consumption and maximize heating cycle time.

c) Forced Defrost: Operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

4. Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods: Split Coil/Frame and Full System. Split Coil/Frame option provides continuous heating of the occupied space during defrost operation.

a) Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat recovery multi-frame outdoor units.

b) Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for a maximum time of six minutes, then the top half for a maximum of six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.

c) When Split Coil/Frame method is selected, a Full System defrost shall occur every 1-9 (field selectable) defrost cycles to assure 100% of the frozen precipitation has been removed to maintain efficient performance.

d) Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall be able to select the Full System only defrost method.

5. Indoor Unit Fan Operation During Defrost

a) During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.

b) During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.

c) During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

G. Oil Management

1. The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate high pressure oil injection pipe directly

into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed.

2. Each compressor shall be provided with a high efficiency independent centrifugal cyclone type oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.

3. The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller. The sensor shall provide data to main outdoor unit PCB to start oil return mode and balance oil levels between multiple compressors.

4. The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor. The system shall display an error if the oil sensor signals low oil level for a period of 130 minutes or longer.

5. A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.

6. Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.

7. Indoor Unit Fan Operation during Oil Return Cycle

   a) During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.

   b) During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.

   c) During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes

H. Fan and Motor Assembly

1. 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.

2. 8 to 20 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.

3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material and incorporate biomimetic technology to enhance fan performance and reduce fan generated noise.

4. The fan(s) motor shall be equipped with permanently lubricated bearings.

5. The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode.

6. The fan shall have a guard to help prevent contact with moving parts.

7. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.

8. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 inch of W.C. to accommodate ducted installations.

9. The fan control shall have a function setting to remove excess snow automatically.

10. The fan control shall have a function setting to remove access dust and light debris from the outdoor unit and coil.

I. Cabinet

1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.

2. Cabinet weights and foot prints shall vary between 430 lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 666 lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. The front panels of the outdoor units shall be removable type for access to internal components.

3. A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws, shall be provided to access the following:

   a) Service tool connection

   b) DIP switches

   c) Auto addressing

   d) Error codes

   e) Main microprocessor

   f) Inverter PCB

4. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.

5. The cabinet shall have a factory installed coil guard.

J. Outdoor Unit Coil

1. Outdoor unit coil shall be designed, built and provided by the VRF outdoor unit manufacturer.

2. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be a 2 or 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger

3. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior

4. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant Black Fin coating. The copper tubes shall have inner riffling to expand the total surface of the tube interior.

a) ISO 21207 Salt Spray Test Method B – 1500 hours

b) ASTM B-117 Acid Salt Test – 900 hours

c) The Black Fin coating shall be certified by Underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply.

5. Variable Path Heat Exchanger: System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency and minimize or maximize the circulating volume of the operating fluids of the system. This feature allows MV 5 to maintain system head pressure that delivers “gas-furnace leaving air temperature” from the indoor unit at moderate and low ambient outdoor air temperatures.

6. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig.

K. Compressor(s)

1. Compressor shall be designed and assembled by the VRF manufacturer specifically for use in the air source VRF product line. Third party manufactured,

branded, or designed to the VRF system's OEM specifications by a third party manufacturer shall not be acceptable.

2. Compressor shall be a hermetic, high-side shell (HSS), commercial grade, compliant scroll direct-drive design.

   a) Compressor Design: The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 150 Hz.

3. The fixed and oscillating compressor scroll components shall be made of high grade (GC25) or denser steel material. All scrolls shall be heat treated and tempered.

4. The oscillating scroll shall be finely machined and polished. PVE refrigerant oil shall be used as the sole liquid used to maintain a seal between the high and low sides of the compression chamber. Compressors that requires the use of any type of mechanical or wearable sealant material between the moving surfaces of the compression chamber is NOT ACCEPTABLE.

5. Vapor Injection: System shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.

6. Bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.

7. An internal, integrated, mechanically driven gear pump shall draw oil from the compressor sump reservoir, pressurize the oil and inject the oil directly to the crankshaft journals maintaining a consistent film of oil between all moving parts. Auxiliary, indirect, or electronically driven pumps are not acceptable.

8. The viscosity property of the PVE oil in the compressor sump shall be maintained irrelevant or compressor operation and the surrounding ambient temperature.

   a) The compressor shall be equipped with an external thermally protected electric crankcase heater that is automatically activated only when the ambient temperature is below freezing and the compressor is not running to maintain the temperature of the oil in the sump above the refrigerant boiling point.

   b) During stable operation, irrelevant of ambient air temperature outside the water source unit, the temperature of refrigerant vapor in contact with the surface of the oil in the compressor sump shall be maintained above 140°F to prevent foaming and to eliminate refrigerant from mixing with the oil degrading the viscosity of the oil in the sump.

   c) <Low side shell (LSS) type compressors that use suction vapor to cool the compressor motor shall not be acceptable.>

9. The compressor motor shall be designed to operate at high temperatures.

   a) The motor winding insulation shall be designed to operate continuously at a minimum temperature of 180°F without deterioration.

   b) The motor cooling system shall be designed to maintain acceptable operational temperature at all times and in all conditions using high pressure, hot refrigerant vapor as motor coolant.

   c) <Low side shell and compressors that use low pressure, low temperature refrigerant gas to cool the motor are not acceptable.>

10. Inverter Compressor Controller(s)

   a) Each compressor shall be equipped with a dedicated inverter compressor drive. The control of multiple compressors using a single drive is not acceptable.

   b) The inverter drive shall vary the speed of the compressor crankshaft between zero (0) Hz and 140 Hz.

   c) The inverter driver controller shall be matched with the physical properties of the compressor. The drive shall be manufactured by the VRF air source unit manufacturer. The inverter drive and matching compressor shall have been thoroughly tested as a matched pair. The inverter drive shall be programmed to avoid operating the compressor at any speed that results in harmonic vibration, nuisance noise, or mechanical damage to either the driver or the compressor with power provided that is within the tolerance specification.

   d) The compressor inverter drive assembly and software must be designed, manufactured, and supplied by the VRF product manufacturer. Third party

branded inverter driver hardware and/or driver software or inverter driver hardware and/or software provided by a third party manufacturer to meet OEM specifications of the VRF water source manufacturer will not acceptable.

e) All inverter drive hardware or software manufactured in, is a product of, or sourced from China, or using a broker or third party provider as an intermediary that obtains the product from CHINA shall not be acceptable.

11. Compressor(s)

a) Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.

b) 12, 14, 16, 18 and 20 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.

c) Each inverter driven, HSS scroll compressor shall be capable of operating from 12 Hz up to 150 Hz in any and all modes (cooling, heating or simultaneous modes).

d) The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.

e) The compressor bearing(s) shall have Teflon™ coating and shall be an aero type design using High lubricity materials.

f) The compressor(s) shall be protected with:

i. High Pressure switch

ii. Over-current /under current protection

iii. Oil sump sensor

iv. Phase failure

v. Phase reversal

vi. Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13°F on both heat pump and heat recovery systems.

g) Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

L. Operational Sound Levels

1. Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed as listed on below chart when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.
2. A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement. This mode is available in both cooling and heating modes.

M. Sensors

1. Each outdoor unit module shall have:
   a) Suction temperature sensor
   b) Discharge temperature sensor
   c) Oil level sensor
   d) High Pressure sensor
   e) Low Pressure sensor
   f) Outdoor temperature sensor
   g) Outdoor humidity sensor
   h) Outdoor unit heat exchanger temperature sensors

N. Wind Load Installations for Outdoor Units

1. FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

O. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

2.02 MULTI V™ S HEAT PUMP AND HEAT RECOVERY SYSTEM(S) – (2 TO 5 TONS NOMINAL)

A. Product Design

1. Variable Refrigerant Flow (VRF) HVAC outdoor unit shall be a variable capacity, direct expansion (DX), Heat Pump or Heat Recovery engineered system. The VRF system shall consist of a single frame outdoor unit, interconnecting piping, multiple indoor units (ducted, non-ducted or mixed combinations), onboard, self-contained, stand-alone communication and controls. Heat recovery systems also include intermediary heat recovery units.

2. Outdoor unit shall be manufactured as either a Heat Pump or a Heat Recovery model capable of heating and/or cooling. Heat pump models shall be able to heat OR cool separate thermal zones. Heat recovery models shall be able to heat AND cool separate thermal zones simultaneously.

3. Heat pump systems shall require two pipes, between the outdoor unit and indoor units. Simultaneous heating and cooling is not supported. One pipe shall support bidirectional flow single state liquid refrigerant. The other pipe shall support bidirectional flow of single state refrigerant gas. In heating mode the gas shall be super-heated high pressure. In cooling mode the gas shall be low pressure, low temperature.

4. Heat pump and Heat recovery outdoor units shall be designed to communicate directly with all VRF indoor units manufactured by the same supplier over a field supplied stranded, twisted and shielded pair wire. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication possible shall not be accepted.

5. Combination Ratio (CR) is defined as sum of nominal cooling capacity of proposed indoor units/nominal cooling capacity of the outdoor unit. The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50%.

B. Operating Conditions

1. The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range. Submittal or technical performance data that indicates the required operating ambient range includes data points that do not guarantee continuous compressor operation, noted or footnoted as reference data, shall not be accepted. The required ambient operating range is defined as follows:

a) Cooling

i. Heat Pump & Heat recovery System: 23°F DB to 122°F DB

ii. <With optional low ambient kit from -9.9°F DB to 122°F DB>

b) Heating

iii. Heat Pump: - 4°F WB to 61°F WB

iv. Heat Pump: -13˚F WB to 61˚F WB

v. Heat Recovery: -13˚F WB to 61°F WB

c) Heat Recovery Synchronous (Simultaneous heating and cooling)

vi. Cooling based: 14°F DB to 81°F

vii. Heating-based: 14°F WB to 61°F WB

C. General Features

1. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor, controls, contacts, relay(s), fan(s), power and communication wiring.

2. The refrigerant shall be R410A. The factory shall supply the following charge of refrigerant R410a:

a) (2 ton) HP 4.0 lbs.

b) (3 ton) HP 6.6 lbs.

c) (4 ton) HP 6.6 lbs.

d) (4.4 ton) HP 6.6 lbs.

e) (5 ton) HP 7.7 lbs

3. All outdoor units, regardless of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of delivery. Manufacturers commissioning agents shall assure the owner in the commissioning report that the latest software version.

4. If the specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock or obsolete models will not be accepted. Products purchased over the

internet and not from the manufacturer's authorized local mechanical representative or authorized distributer will not be accepted.

5. The outdoor unit refrigeration circuit at a minimum shall include the following components:
   a) Refrigerant strainer(s)
   b) Check valve(s)
   c) Inverter driven, high pressure shell compressor
   d) Oil separator
   e) Accumulator/receiver
   f) 4-way reversing valve
   g) Electronic expansion valve(s)
   h) Double spiral tube sub-cooler and EEV
   i) High/low Schrader valve service ports with caps
   j) High/low service valves
   k) Threaded fusible plug
   l) High pressure switch
6. The VRF outdoor unit shall use the sub-cooler while operating in cooling mode to sub-cool liquid refrigerant coming from the condenser coil well below saturation temperature to ensure that refrigerant remains in 100% liquid state when it reaches the farthest indoor unit's EEV valve. The amount of sub-cooling shall be modified by the microprocessor controller and minimized at all times to maximize efficiency by not overcooling the liquid.
7. Third Party Controls platform Integration
   a) The VRF system manufacturer's central controls platform shall be able to communicate with third party building management systems (BMS) via BACnet IP, Modbus TCP, or LonWorks™ protocol allowing third party BMS system control and/or monitoring of the air conditioning and heating system. See controls specification for more detailed description of integration and points to be controlled and monitored.
   b) The VRF system manufacturer shall have available off-the shelf devices that allows on/off binary interfaces between third party ancillary devices such as fans, door locks, photo eyes, key card switches, motion sensors, exhaust fans,

dampers, and a single (or group of) VRF indoor units. Indoor units shall have the ability to start/stop the third party device, receive a contact closure signal from the third party device, or have the third party device change the operating conditions of the VRF indoor unit. Operating conditions shall include one or more of the following indoor unit functions: fan speed, fan on/off, thermal on/off cooling or heating, or indoor unit start/stop.

8. Wi-Fi communication:

   a) The outdoor unit shall be Wi-Fi capable. Wi-Fi shall allow service or maintenance personal access to the operating system diagnostics and monitoring functions, via the manufacturer's provided maintenance and diagnostic software over a mobile device or personal computer. Communication between devices shall include: 1) Real-time system operation monitoring with the ability to capture all system operating data for a field determined period of time into a downloadable csv file format to a wireless connected device; 2) Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures. Systems that require computers with a hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

9. Microprocessor Control

   a) Factory installed microprocessor control in the outdoor unit, heat recovery unit(s), and indoor unit(s) shall communicate using the same protocol. Translators of any kind are not allowed. Communication between VRF system components shall be via field supplied stranded, shielded and twisted wire pair in a RS 485 network configuration. Integrated control system shall perform functions to optimize the operation of the VRF system.

   b) Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

   c) Main microprocessor shall include human interface capability that provides a visual code that reports systems operation status. If any malfunction occurs, or system is operating with an unstable refrigerant cycle sensors shall report the malfunction to the visual display.

   d) Main processor shall provide the commissioning agent the ability to customize the VRF systems operation based on the environment in which it is installed. Customization function to include defrost operation, modifying target superheat,

sub-cooling, low pressure and high pressure values , and invoke other algorithms such as smart load control to optimize system operating efficiency. The main processor board shall include the following features:

i. Service tool connection

ii. DIP switches

iii. Auto addressing

iv. Error codes

v. Main microprocessor

vi. Inverter PCB

10. Outdoor unit microprocessor shall have the capability of reporting malfunction and diagnostic codes to remote control devices such as the VRF manufacturer's central controller, Zone controllers, and Building Management System (BMS).

11. Refrigerant Flow Control

a) The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (Te) to be constant in cooling mode and condensing temperature (Tc) constant in heating mode and maintain system stable operation while operating compressors across the range of environmental conditions guaranteeing continuous compressor operation. VRF system core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.

b) Smart Load Control (SLC): Smart load control operation shall enhance energy savings and increase indoor comfort by monitoring the real time ambient temperature, real time weighted mean average building load, and the outdoor relativity humidity (if enabled).

i. Smart load control shall be field selectable to optimize system operation for project location and building use. Smart Load Control field setting shall select one of three operating algorithms. The commissioning agent shall select at the time of commissioning and can be changed at any other time:

ii. The Smart Load Control available settings shall:

2. The system shall be influenced by any one of the chosen algorithm

3. Off mode: Smart load control algorithm shall be in off mode

4. Smooth mode: Smart Load control shall maximize energy savings. The rate of temperature change shall be insignificant.

5. Normal Mode: Smart Load Control shall balance the rate of temperature change with energy consumed.

6. Peak Mode: Smart Load shall quickly cool/heat the building. The energy consumption shall not be the priority in this mode.

iii. For the first 20 minutes after the initial startup, the Smart Load Control will influence the outdoor unit operation for the chosen algorithm. This operation will be available at every start up.

iv. After 20 minutes of compressor operation

7. Smart Load control will maintain the chosen logic and system will operate with the same core logic.

v. Smart Load Control monitors two or three inputs:

8. Weighted mean average building load

9. Outdoor ambient dry bulb temperature

10. Outdoor ambient relative humidity or indoor relative humidity (when enabled)

c) Enhance energy savings

i. Cooling Mode:

1. Smart Load Control raises the system target low pressure during off-peak operation.

2. Raising the operating low pressure shall reduce the compressor lift, reduce compressor's speed and power consumption.

ii. Heating Mode

1. Smart Load control shall lower the system target high pressure during off-peak heating operation.

2. Lowering the operating high pressure target shall reduce compressor lift, reduce compressor speed and power consumption.

3. Energy saved is in addition to the energy savings basic VRF load control provides.

d) Increased indoor comfort

i. Smart Load control shall use one (or two) sensors to measure changing outdoor weather conditions and shall prepare the VRF system to operate under the revised weather conditions. This operation shall be activated before the changed ambient conditions have an impact on indoor units.

D. Field Supplied Refrigerant Piping Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to of 164 feet above or 131 feet below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.

2. The outdoor unit shall be capable of operating with up to 984 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.

3. The outdoor unit shall be capable of operating with up to 492 actual feet or 574 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

4. The elevation difference between the highest and lowest indoor units shall not exceed 49 feet.

5. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer’s published guidelines.

6. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

E. Defrost Operations

1. Heat Pump

a) The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature and outdoor unit heat exchanger surface temperature.

b) The frequency of operating the defrost cycle shall be determined by the system’s ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.

F. Oil Management

1. The system shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts.
2. The system shall be provided with a factory installed oil separator at the discharge port of the compressor and designed to separate, condense, and collect oil vapor from the discharge refrigerant gas and return oil to the sump of the compressor. The oil separator shall have no moving parts in the separation chamber.
3. The system oil return control algorithm shall operate every 8 hours at a minimum, for a 3-minute period. When activated, the algorithm shall operate the system with the reversing valve in the cooling position, open all electronic expansion valves at the indoor unit(s) and raise the compressor speed to flush oil back to the compressor.

G. Fan and Motor Assembly

1. Heat Pump unit shall be equipped with one direct drive, variable speed, and axial flow fan with a horizontal air discharge. The motors shall be Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors.
2. Heat Pump and Heat Recovery unit shall be equipped with two direct drive variable speed axial flow fan(s) with a horizontal air discharge. Each fan shall be provided with an independent dedicated Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
4. The fan motor(s) shall be equipped with permanently lubricated bearings.
5. The fan assembly(s) shall have a minimum operating speed range from 0 RPM to 850 RPM in cooling mode and heating mode.
6. The fan(s) shall have a polymer fan guard(s) to help prevent contact with moving parts.
7. The fan control shall have a function setting to remove accumulated powder snow from outdoor fan blades and discharge fan guard

H. Cabinet

1. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
2. The cabinet shall have a factory installed coil guard and shall have a baked enamel finish.

3. A removable service panel, shall be provided to access the following internal components:

   a) Service tool connection

   b) DIP switches

   c) Main microprocessor

   d) Inverter PCB

   e) Outdoor unit coil EEV valve

   f) Subcooling heat exchanger and EEV valve.

   g) Reversing valve.

I. Outdoor Unit Coil

1. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior

2. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant GoldFin™ coating. The coils coating shall be tested per ASTM B-117 standard. The test shall be performed for a minimum of 1000 hours. The outdoor unit coil shall have a minimum of 2 rows.

3. The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI).

4. The outdoor unit coil, all indoor units and the interconnecting field provided pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.

J. Compressor

1. Heat Pump models

   a) The compressor shall be a high efficiency high-side shell rotary hermetic design. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) shall not be acceptable. Compressor inverter drive shall allow modulation from 20Hz to 90Hz with control in 1.0 Hz increments depending on the nominal capacity. The compressor shall be a high-side shell hermetic scroll design. Oil sump area and chamber housing the motor shall be operated at the same temperature and pressure of the gas leaving the compressor chamber to ensure that the low

temperature low pressure refrigerant returning to the compressor does not mix with the oil in the sump. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) oil shall not be acceptable. Compressor motor shall be designed to operate at a frequency range of 0Hz to 160Hz. Compressor inverter drive shall allow modulation from 12Hz to 110Hz.

K. Operational Sound Levels

1. The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½" of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.

2. The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.

3. Manufacturers' published data shall include sound pressure and sound power levels.

   a) Sound pressure level shall not exceed 57 dB(A) during cooling operation for Heat Pump and Heat Recovery outdoor units when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.

   b) Sound power level shall not exceed 69 dB(A) when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.

L. Sensors

1. The outdoor unit shall have

   a) Suction temperature sensor

   b) Discharge temperature sensor

   c) High Pressure sensor

   d) Low Pressure sensor

   e) Outdoor temperature sensor

f) Outdoor unit heat exchanger temperature sensors

M. Wind Load Installations for Outdoor Units

1. FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

N. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

2.03 WALL MOUNTED - STANDARD

A. General

1. Unit shall be designed to be installed for indoor application.

2. Unit shall be attached to an installation plate/bracket that secures unit to the wall.

3. The depth of the unit shall not exceed 8.25 inches.

B. Casing/Panel

1. Unit case shall be manufactured using Acrylonitrile Butadiene Styrene (ABS) polymeric resin and has a pearl white finish designed for mounting on a vertical surface and includes an installation mounting template and hanging bracket.

C. Cabinet Assembly

1. Unit shall have one supply air outlet and one return air inlet with a manual or motorized sweeping guide vane that automatically changes the direction of airflow from side-to-side and up-and-down.

2. Unit shall be equipped with factory installed temperature thermistors for:

a) Return air

b) Refrigerant entering coil

c) Refrigerant leaving coil

3. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.

4. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
5. Unit shall have the following functions as standard:
   a) Self-diagnostic function
   b) Auto addressing
   c) Auto restart function
   d) Auto changeover function (Heat Recovery system only)
   e) Auto operation function
   f) Auto clean function
   g) Child lock function
   h) Forced operation
   i) Dual thermistor control
   j) Sleep mode
   k) Dual set point control
   l) Filter life timer
   m) External on/off control input
   n) Wi-Fi compatible
   o) Auto fan operation
   p) Leak detection logic
6. Unit shall be capable of refrigerant piping in four different directions.
7. Unit shall be capable of drain piping in two different directions.

D. Fan Assembly

1. The unit shall have a single, direct driven crossflow tangential Sirocco fan made of high strength ABS BSN-7530 polymeric resin.
2. The fan impeller shall be statically and dynamically balanced.
3. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.
4. The fan motor shall include thermal, overcurrent and low RPM protection.

5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.

6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programed fan speeds in the heating mode and fan only mode and four speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed.

7. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.

8. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.

9. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

10. Unit shall have factory installed motorized guide vane to control the direction of flow of air from side to side.

E. Filter Assembly

1. The return air inlet shall have a factory supplied removable, washable filter

2. The filter access shall be from the front of the unit without the need of tools.

F. Coil Assembly

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.

2. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.

3. Unit shall have a minimum two row coil, 18 fins per inch.

4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).

5. Unit shall be designed for gravity drain.

6. Unit shall have a 5/8” inside diameter factory insulated drain hose to handle condensate.

7. Unit shall have provision of 45° flare refrigerant pipe connections.

8. The coil shall be factory pressure tested at a minimum of 550 psig.

9. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately.

10. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

G. Microprocessor Control

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted zone controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode.

2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core stranded, twisted, and shielded communication cable (RS-485).

3. The unit controls shall operate the indoor unit using one of the five operating modes:

   a) Auto changeover (Heat Recovery System only)

   b) Heating

   c) Cooling

   d) Dry

   e) Fan only

4. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.

5. The unit shall be able to operate with the fan turned off during system cooling thermal off.

6. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.

7. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.

8. Unit shall have a field settable method to choose auto fan speed change operation based on mode of operation, on/off fan operation based on mode of operation, or continuous minimum set fan speed operation.

H. Electrical

1. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

I. Controls

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS485 daisy chain.

END OF SECTION 238129

SECTION 238224 – POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of power ventilators:

1. Ceiling-Roof Mounted Exhausters.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:

1. Product data for selected models, including specialties, accessories, and the following:

a. Certified fan performance curves with system operating conditions indicated.

b. Certified fan sound power ratings.

c. Motor ratings and electrical characteristics plus motor and fan accessories.

d. Materials gages and finishes, including color charts.

e. Dampers, including housings, linkages, and operators.

2. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

3. Coordination drawings, in accordance with Division 23 for roof penetration requirements and for reflected ceiling plans drawn accurately to scale and coordinating penetrations and units mounted above ceiling. Show the following:

a. Seismic Ceiling suspension members.

b. Method of attaching hangers to building structure.

c. Size and location of initial access modules for acoustical tile.

d. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.

4. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field- installed wiring.

5. Product certificates, signed by manufacturers of air-handling units, certifying that their products comply with specified requirements.

6. Maintenance data for air-handling units, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 15 Section "Basic Mechanical Requirements."

1.3 QUALITY ASSURANCE

A. UL Compliance: Fans shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators."

B. UL Compliance: Fans and components shall be UL listed and labeled.

C. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

E. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate the installation of roof curbs, equipment supports, and roof penetrations specified in Division 7.

B. Coordinate the size and location of structural steel support members.

1.6 EXTRA MATERIALS

A. Furnish one additional complete set of belts for each belt-driven fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include but are not limited to, the following:

1. Centrifugal Roof Exhausters:

a. Greenheck Fan Corp.
b. Cook (Loren) Co.
c. CaptiveAire, Inc.

2.2 SOURCE QUALITY CONTROL

A. Testing Requirements: The following factory tests are required:

1. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.

2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2.3 FANS, GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.4.

D. Belts: Oil-resistant, nonsparking, and nonstatic.

E. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" (AFBMA (L(50)) of 200,000, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.

G. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.

2. Exterior Surfaces: Baked-enamel finish coat after assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, roof curbs, equipment supports, and other conditions affecting performance of fans.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated. Vibration control devices are specified in Division 23 Section.

1. Support utility set fans on equipment bases and roof supports using neoprene pads. Secure units to anchor bolts installed in equipment base.
2. Support utility set on equipment bases and roof supports using housed spring isolators. Secure units to anchor bolts installed in equipment base..
3. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

3.3 CONNECTIONS

A. Duct installations and connections are specified in other Division 15 sections. Make final duct connections with flexible connections.

B. Electrical Connections: The following requirements apply:

1. Electrical power wiring is specified in Division 16.

2. Temperature control wiring and interlock wiring are specified in Division 15 Section "Electrical Control Systems."

3. Temperature control wiring and interlock wiring are specified in Division 15 Section "Pneumatic Control Systems."

4. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Inspection: Arrange and pay for a factory- authorized service representative to perform the following:

1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.

2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.6 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.

2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

    a. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

3.7 DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Project Closeout" and Division 15 Section "Basic Mechanical Requirements."

B. Schedule training with at least 7 days' advance notice.

END OF SECTION 23 82 24

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 26.

1.2 SUMMARY

A. This Section includes general administrative, procedural, and other requirements for electrical installations. The following requirements are included in this Section to expand the requirements specified in Divisions 1 through 26:
   1. Submittals.
   2. Quality control.
   3. Definitions and abbreviations.
   4. Scheduling.
   5. Coordination drawings.
   6. Record documents.
   7. Maintenance manuals.
   8. Delivery, storage, and handling.
   9. Products.
   10. Rough-ins.
   11. Electrical installations.
   12. Permits and instructions.
   13. Field quality control.
   14. Protection.
   15. Additional work.
   16. Electrical schedules.
   17. Cutting and patching.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 1.

B. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.
   1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line prints.
   2. Shop Drawings - Final Submittal: 1 additional blue- or black-line prints.
   3. Product Data: 1 additional copy of each item.
   4. Samples: 1 addition as set.

C. Additional copies may be required by individual sections of these Specifications.

1.4 QUALITY CONTROL

A. Functional and Operational Test Procedure:

1. Test procedure to completely test all systems as to their functional and sequential operation.
2. Submit two (2) draft copies for review before conducting test.
3. Certify that the test procedure was used and testing completed, and that all systems are operational and functioning properly.
4. Submit certified Test Procedure for review prior to the date of final inspection.
5. Systems to be covered by test procedure:
   a. Power Distribution
   b. Lighting Systems including General Lighting
   c. Emergency Lighting Systems
   d. Fire Alarm Systems

B. Other Tests and Certifications for:
   1. Grounding System: As specified under Section 26 05 26.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Electrical Definitions: As defined by NEC, Article 100.

B. The term "indicated" shall mean "as shown on contract documents (specifications, drawings, and related attachments)".

C. The term "provide" shall mean "to furnish, install and connect completely".

D. The term "size" shall mean one or more of the following: "length, current and voltage rating, number of poles, NEMA size, and other similar electrical characteristics".

E. The term "space" on panelboard and switchboard schedules shall mean "provide space to install the number of poles and size of the protective device indicated with all the necessary buss and fittings to install the device at some future date".

1.6 SCHEDULING

A. Coordinate electrical work with other divisions of this project.

B. Coordinate electrical work with Owner.

C. Written requests for approval for planned shutdowns or interruption of Owner's operation or equipment shall be made 72 hours prior to the start of the requested periods.

D. Written notification for on site training of Owner's personnel shall be made 1 week prior to the start of the requested training period.

1.7 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
   a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
   b. Fire-rated wall and floor penetrations.
   c. Equipment connections and support details.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, raceway systems components, Exhaust/Kitchen hoods, and other ceiling-mounted devices.

1.8 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, indicate installed conditions for:
   1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.9 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Servicing instructions and lubrication charts and schedules.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As specified under other RELATED SECTIONS.

B. As specified on Drawings.

2.2 MATERIAL

A. General:

1. Unless otherwise indicated, all raceways for service, feeders, branch and control wiring are RSC or IMC. See Section 26 05 33.
2. Unless otherwise indicated, wiring to equipment and motors shall be installed in liquid tight flexible conduit, or in interior dry locations in flexible metal conduit, with a maximum length of six (6) feet.
3. Unless otherwise indicated, all conductors to be copper THHN/THWN-2.
4. Unless otherwise indicated, all outlet and switch boxes to be cast iron with threaded hubs.
5. In interior protected locations, where recessed in ceiling and walls, outlet and switch boxes may be stamped steel.
6. Unless otherwise indicated, provide heavy duty grade, 20 ampere, receptacles and switches. Plates shall be impact resistant thermoplastic nylon. Plates for surface mounted interior boxes within infinished areas shall be stamped steel. Plates exposed to weather or water to be metal, weatherproof type. Receptacles, switches and associated cover plates color by Architect/Owner.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

2.3 EQUIPMENT

A. General:

1. Unless otherwise indicated, externally operated safety switches are unfused, solid neutral, heavy duty, and selected to meet the load requirements.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

2.4 FABRICATION

A. General:

1. Unless otherwise indicated, all enclosures are NEMA Type 1. NEMA Type 3R shall be used for wet/damp locations.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

C. Contractor is to provide connections, both power and control as noted, for HVAC equipment. Division 26 shall coordinate the respective installations with other project disciplines.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components. Electrical plans and details do not show all interferences and conditions, visible and/or hidden, that may exist. Before selecting material and equipment, and proceeding with work, inspect areas where material and equipment are to be installed to insure suitability, and check needed space for placements, clearances and interconnections. Before cutting or drilling into building elements inspect and layout work to avoid damaging structural elements or building utilities.
2. Electrical plans, details, and diagrams show the general location and arrangement of electrical systems. They are diagrammatic and do not show all conduit bodies, connectors, bends, fittings, hangers, and additional pull and junction boxes which the Contractor must provide to complete the electrical system.
3. Verify all dimensions by field measurements.
4. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
5. 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.
6. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Verify dimensional constraints of building door openings and passageways, and the maximum floor loadings, for the movement of selected material and equipment. Order equipment and material, broken down as may be required, to meet these constraints.
7. Measurement from above finished floor (AFF) shall be taken from the finished floor surface to the top of wall receptacles and switch boxes, to the centerline of wall lighting outlet boxes, to the top of wall mounted equipment enclosures, to the centerline of top most switch handle, or to the lowest surface of ceiling lighting fixtures and other ceiling mounted equipment.
   a. Unless otherwise indicated, wall switch boxes shall be 46 inches AFF. Refer to Architectural Drawings. Coordinate with Architect.
   b. Unless otherwise indicated, receptacle boxes shall be 18 inches AFF. Receptacle mounted above counter and at furniture locations shall be coordinated with architectural elements. Refer to Architectural Drawings. Coordinate with Architect.
8. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible. Switch and receptacle heights shall meet handicap accessible code requirements.
9. Coordinate connection of electrical systems with incoming utilities and services. Comply with requirements of governing regulations, power, telephone, and data service companies, and controlling agencies. Provide required connection for each service. Provide power connection to equipment. Coordinate with other Divisions.
10. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements

indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

11. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
12. Conduit Sizing:
    a. Unless otherwise indicated, conduit size for indicated conductor shall be based on Chapter 9 of NEC.
    b. Conduit: 3/4 inch minimum size.
    c. Underground Conduit: 1 inch minimum size

13. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Measure and locate placement of equipment and materials in relation to building structure and surfaces, and between equipment to be installed and wired. Maintain required minimum access spacing for equipment and enclosures.
14. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified elsewhere.
15. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
16. Unless otherwise noted, individual raceway runs are required for each kitchen equipment component. Connection shall be routed down existing walls exposed, concealed in new walls, and/or under slab to the respective area as noted.

3.3 PERMITS AND INSPECTIONS

A. Obtain and pay for all required permits and arrange for all required inspections in accordance with state and local governing authorities.

B. Final Electrical Inspection Certificate from inspection agency or governing authority.

3.4 FIELD QUALITY CONTROL

A. Perform field tests as specified under other electrical sections.

B. Arrange for local Inspection Authorities to inspect work performed prior to burial, closing-in behind wall and above ceiling, or encased in concrete. Also arrange for final inspection of work and obtain Final Inspection Certificate before final inspection of work by Owner or his representative.

3.5 PROTECTION

A. Protect personnel from coming in contact with live parts.

B. During remodeling or alteration work, maintain fire ratings of walls, floors and ceilings when work is left unattended.

C. Protect from damage and theft equipment and materials provided or supplied by others in accordance with manufacturer's recommendation and warranties, and with electrical standards and practices.

3.6 ADDITIONAL WORK

A. Provide temporary electrical service, power outlets and lighting during construction.

B. Provide connections for power and controls to mechanical equipment being supplied under other divisions.

C. Provide power and control wiring to HVAC equipment.

D. Provide fire alarm devices/components, wiring, conduit and interconnections. Refer to respective Fire Alarm Drawings and Specifications for requirement.

E. Provide conduits and power connections for intrusion detection system. Intrusion detection system devices/components, low voltage wiring and interconnections by Division 28. Refer to respective Drawings and Specifications for requirement.

F. Provide conduits and power connections for access control system. Access control system devices/components, low voltage wiring and interconnections by Division 28. Refer to respective Drawings and Specifications for requirement.

G. Provide conduits and power connections for video surveillance system. Video surveillance system devices/components, low voltage wiring and interconnections by Division 28. Refer to respective Drawings and Specifications for requirement.

H. Provide conduit and power connections for PA system. PA system devices/components, low voltage wiring and interconnections by Division 27. Refer to respective Drawings and Specifications for requirement.

I. Provide conduit and power connections for telecommunicatin systems. Telecommunication system devices/components, low voltage wiring and interconnections by Division 27. Refer to respective Drawings and Specifications for requirement.

J. Provide conduit and power connections for audio/visual systems. Audio/visual system devices/components, low voltage wiring and interconnections by Division 27. Refer to respective Drawings and Specifications for requirement.

K. Provide conduit and power connections for clock system. Clock system devices/components, low voltage wiring and interconnections by Division 27. Refer to respective Drawings and Specifications for requirement.

3.7 ELECTRICAL SCHEDULES

A. As specified in related sections or shown on drawings.

3.8 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1. In addition to the requirements specified in Division 1, the following requirements apply:
   1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
      a. Uncover Work to provide for installation of ill-timed Work.
      b. Remove and replace defective Work.

c. Remove and replace Work not conforming to requirements of the Contract Documents.
d. Remove samples of installed Work as specified for testing.
e. Install equipment and materials in existing structures.
f. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.

2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
7. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.9 OWNER TRAINING

A. Contractor shall provide Owner training for the following electrical items/systems. All training shall be done by manufacturer’s authorized representative for respective system. All training shall be done on-site or at an alternate location if so chosen by the Owner.
1. Switchboards.
2. Add Alternate No. 07- Packaged Diesel Generator Assemblies.
3. Add Alternate No. 07- Automatic Transfer Switches.
4. Lighting Controls.
5. Fire Alarm System.

B. All training sessions shall be video recorded. Refer to Division 01 Section 01 79 00 ‘Demostration and Training’ for further requirements.

END OF SECTION 26 05 00

SECTION 26 05 01 – COMMON WORK RESULTS FOR ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with electrical installations as follows:
   1. Miscellaneous metals for support of electrical materials and equipment.
   2. Fire rated wood grounds, nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
   3. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
   4. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for the following products:
   1. Access panels and doors.
   2. Joint sealers.

C. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for electrical materials and equipment.

D. Coordination drawings for access panel and door locations in accordance with Division 26 Section "Common Work Results for Electrical."

E. Samples of joint sealer, consisting of strips of actual products showing full range of colors available for each product.

F. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.

G. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut off of electrical service, and details for dust and noise control.
   1. Coordinate sequencing with construction phasing and Owner occupancy as specified in other Divisions.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer for the installation and application of joint sealers, access panels, and doors.

B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

C. Fire Resistance Ratings: Where a fire resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.
   1. Provide UL Label on each fire rated access door.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi component materials.

B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.6 PROJECT CONDITIONS

A. Conditions Affecting Selective Demolition: The following project conditions apply:
   1. Protect adjacent materials indicated to remain or in the other phases of the proposed construction. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
   2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
   3. Arrange for electric service change-overs during periods when the building is not occupied. This may include week-ends and evening hours. Coordinate with Owner's representatives.

B. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do no apply joint sealers to wet substrates.

1.7 SEQUENCE AND SCHEDULING

A. Coordinate the shut off and disconnection of electrical power with the Owner.

B. Notify the Engineer at least 5 days prior to commencing demolition operations.

C. Perform demolition in sequencing/phases as noted and as required.

PART 2 - PRODUCTS

2.1 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold Formed Steel Tubing: ASTM A 500.

C. Hot Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Nonshrink, Nonmetallic Grout: Premixed, factory packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.

F. Fasteners: Zinc coated, type, grade, and class as required.

2.2 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light framing size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP 2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less that 3/4 inches.

2.3 JOINT SEALER

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Elastomeric Joint Sealers: Provide the following types:

1. One part, nonacid curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
2. One part, mildew resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in service exposure to conditions of high humidity and temperature extremes.
3. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
   a. One Part, Nonacid Curing, Silicone Sealant:
      1) Bostik - "Chem Caulk 2000"
      2) Dow Corning - "Dow Corning 790"
      3) Pecora Corp – “864NST”

b. One Part, Mildew Resistant, Silicone Sealant:
   1) Dow Corning - "Dow Corning 786"
   2) GE - "SCS 1702"
   3) Pecora Corp. - "898"

D. Acrylic Emulsion Sealants: One part, nonsag, mildew resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.
   1. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
      a. Bostik - "Chem Caulk 600"
      b. Pecora Corp. - "AC 20"
      c. Tremco – "Tremflex 834"

E. Fire Resistant Joint Sealers: Two part, foamed in place, silicone sealant formulated for use in through penetration fire stopping around cables, conduit, pipes, and duct penetrations through fire rated walls and floors. Sealants and accessories shall have fire resistance ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.
   1. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
      a. Dow Corning - "Dow Corning Fire Stop Foam"
      b. GE - "Pensil 851"
      c. Hilti – "CP-620 Fire Stop Foam"

2.4 ACCESS DOORS

A. Steel Access Doors and Frames: Factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.

B. Frames: 16 gage steel, with a 1 inch wide exposed perimeter flange for units installed in unit masonry, pre cast, or cast in place concrete, ceramic tile, or wood paneling.
   1. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch wide exposed perimeter flange and adjustable metal masonry anchors.
   2. For gypsum wallboard or plaster: perforated flanges with wallboard bead.
   3. For full bed plaster applications: galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.

C. Flush Panel Doors: 14 gage sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory applied prime paint.
   1. Fire Rated Units: Insulated flush panel doors, with continuous piano hinge and self closing mechanism.

D. Locking Devices: Flush, screwdriver operated cam locks.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:

1. Bar Co., Inc.
2. J.L. Industries.
3. Karp Associates, Inc.
4. Milcor Div. Inryco, Inc.
5. Nystrom, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION FOR JOINT SEALER

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

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

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

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

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

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

D. Do not install wood materials in areas being utilized as air plenum or other spaces where a potential combustible hazard exists.

3.5 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
   1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
   2. Comply with recommendations of ASTM C 790 for use of acrylic emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Installation of Fire Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire stops with fire resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.6 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

END OF SECTION 26 05 01

SECTION 26 05 19 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of other specified Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.

1.3 SUBMITTALS

A. Product Data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following code:

B. NFPA 70 "National Electrical Code."
   1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

C. UL Compliance: Provide components which are listed and labeled by UL under the following standards.
   1. UL Std. 83 Thermoplastic-Insulated Wires and Cables.
   2. UL Std. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   3. UL Std. 1569 Metal Clad Cable.

D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
   1. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

E. IEEE Compliance: Provide components which comply with the following standard.
   1. Std. 82 Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
   1. Wire and Cable:
      a. American Insulated Wire Corp.
      b. Republic Wire Inc.
      c. Southwire Company.

2. Connectors for Wires and Cable Conductors:
   a. AMP
   b. 3M Company
   c. O-Z/Gedney Co.
   d. Square D Company.

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 and lighting circuits no. 10 AWG and smaller. Provide stranded conductors for sizes no. 8 AWG and larger.

C. Conductor Material: Copper for all wires and cables.

D. Conductor sizes indicated are based on copper.

E. Insulation: Provide THHN/THWN-2 insulation for all conductors size 500MCM and larger, and no. 8 AWG and smaller. For all other sizes provide, THHN/THWN-2 or XHHW insulation as appropriate for the locations where installed.

F. Color Coding for phase identification in accordance with Table 1 in Part 3 below.

G. Jackets: Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90 deg. bends, for pulls in conduits underground or under slabs on grade, and where indicated.

H. Cables: Provide the following type(s) of cables in NEC approved locations and applications where indicated. Provide cable UL listed for particular application:
   1. Metal-Clad Cable: Type MC - limited to the following:
      a. Lighting fixtures and outlets concealed within gypsum wallboard partitions and above suspended ceilings.

2.3 CONNECTORS FOR CONDUCTORS

A. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Use the following wiring methods as indicated:
   1. Wire: install all wire in raceway.
   2. Metal Clad Cable, Type MC: where wiring concealed in gypsum wall partitions, ceilings, for connections from raceway outlet boxes to lighting fixtures, unless otherwise noted.

3.2 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Coordinate cable installation with other Work.

C. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

D. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

E. Conceal all cable in finished spaces.

F. Keep conductor splices to minimum.

G. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced.

H. Use splice and tap connectors which are compatible with conductor material.

I. 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 in individual circuits. Make terminations so there is no bare conductor at the terminal.

J. 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 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.

B. Prior to energizing, test wires and cables for electrical continuity and for short-circuits.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. TABLE 1: Color Coding for Phase Identification:

1. Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows:

208Y/120Volts	Phase	480/277Volts

Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

END OF SECTION 26 05 19

SECTION 26 05 26 – 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.

B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Division 26 Section "Low voltage electrical power conductors and cables."

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for ground rods, connectors and connection materials, and grounding fittings.

C. Field-testing organization certificate, signed by the Contractor, certifying that the organization performing field tests complies with the requirements specified in Quality Assurance below.

D. Report of field tests and observations certified by the testing organization.

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.
   1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Field-Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).

D. UL Standard: Comply with UL 467, "Grounding and Bonding Equipment."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Anixter Bros., Inc.
   2. Bashlin Industries, Inc.
   3. Buckingham Mfg. Co.
   4. Erico Products, Inc.
   5. GB Electrical, Inc.
   6. Ideal Industries, Inc.
   7. O-Z/Gedney Co.
   8. Raco, Inc.
   9. Thomas & 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 "low voltage electrical power conductors and cables." Conform to NEC Table 8, 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. Assembly of Stranded Conductors: ASTM B-8.

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.

E. Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lighting Protection Components," or UL 467.

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: 3/4 inch by 10 feet.
   2. Size: 5/8 inch by 8 feet.

B. Plate Electrodes: Copper plates, minimum 0.10 inch thick, size as required per N.E.C. indicated.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Equipment Grounding Conductor Application: Comply with NEC Article 250 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. Lighting circuits.
      b. Feeders and branch circuits.
      c. Receptacle Circuits.
      d. Single-phase motor or appliance circuits.
      e. Three-phase motor or appliance branch circuits.

3.2 INSTALLATION

A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.

B. 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.

C. 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.

D. Bond interior metal piping systems and metal air ducts to equipment ground conductors of pumps, fans, electric heaters, and air cleaners serving individual systems.

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. Aluminum to steel connections shall be with stainless steel separators and mechanical clamps.
   4. Aluminum to galvanized steel connections shall be with tin-plated copper jumpers and mechanical clamps.
   5. 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. 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.

C. 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 and UL 486B.

D. 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.

E. 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 FIELD QUALITY CONTROL

A. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements. Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.

B. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer’s written instructions.

C. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified, at service disconnect enclosure ground terminal, and at ground test wells. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

D. Ground/resistance maximum values shall be as follows:
   1. Equipment rated 500 kVA and less: 10 Ohms
   2. Equipment rated 500 kVA to 1000 kVA: 5 Ohms
   3. Equipment rated over 1000 kVA: 3 Ohms
   4. Unfenced substations and pad mounted equipment: 5 Ohms
   5. Manhole grounds: 10 Ohms

E. Deficiencies: Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values.

F. Report: Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

END OF SECTION 26 05 26

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 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.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. 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.

C. Shop drawings indicating details of fabricated products and materials.

D. Engineered Design consisting of details and engineering analysis for supports for the following items:
   1. Fastener supporting systems.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Slotted Metal Angle and U-Channel Systems:
      a. Allied Tube & Conduit
      b. B-Line Systems, Inc.
      c. GS Metals Corp.

d. Unistrut Diversified Products

2. Conduit Sealing Bushings:
   a. Bridgeport Fittings, Inc.
   b. Cooper Industries, Inc.
   c. O-Z/Gedney
   d. Producto Electric Corp.
   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.

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: 16-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.

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. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:

a. 3-inch and smaller: 20-gage.
b. 4-inch to 6-inch: 16-gage.
c. over 6-inch: 14-gage.

2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

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. 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. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. 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 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
8. In vertical 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.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

E. Miscellaneous Supports: Support miscellaneous electrical components 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.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building

structure 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.

G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL- listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with requirements specified elsewhere.

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. 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. 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.

J. TESTS: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
   1. Expansion anchors.
   2. Toggle bolts.

K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

L. Conduit seals at walk-in cooler& freezer location: Install seals for conduit penetrations into cooler or freezer equipment where conduit enters the repsective conditional areas, and at slab locations.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1)	EMT (1)
1/2,3/4	1 or 2	Flat ceiling or wall.	5	5
1/2,3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7
1/2,3/4	3 or more	Any location.	7	7
1/2-1	3 or more	Any location.		
1 & larger	1 or 2	Flat ceiling or wall.	6	6
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10
1 & larger	3 or more	Any location.	10	10
Any	....	Concealed.	10	10

VERTICAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1,2)	EMT (1)
1/2,3/4	....	Exposed.	7	7
1,1-1/4	....	Exposed.	8	8
1-1/2 and larger	....	Exposed.	10	10
Up to 2	....	Shaftway.	14	10
2-1/2	....	Shaftway.	16	10
3 & larger	....	Shaftway.	20	10
Any	....	Concealed.	10	10

NOTES:

(1) Maximum spacing of supports (feet).
(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations:

EMT Electrical metallic tubing.
IMC Intermediate metallic conduit.
RMC Rigid metallic conduit.

END OF SECTION 26 05 29

SECTION 26 05 33 – RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
   1. Rigid metal conduit.
   2. Intermediate metal conduit.
   3. Liquidtight flexible conduit.
   4. Flexible metal conduit.
   5. Electrical Metallic Tubing (EMT).
   6. Wireways.

B. 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. Cabinets.
   4. Hinged door enclosures.

C. Related Sections: The following Division 26 Sections contain requirements that relate to this Section:
   1. "Low voltage electrical power conductors and cables" for other wiring methods.
   2. "Supporting Devices" for raceway supports.

1.3 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. Outlet Box: A wiring enclosure where current is taken from a wiring system to supply utilization equipment.

E. 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.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
   1. Product data for Raceway systems.
   2. Product data for cabinets and enclosures with classification higher than NEMA 1.
   3. Shop drawings for boxes, enclosures and cabinets that are to be shop fabricated, (nonstock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

1.5 QUALITY ASSURANCE

A. UL Listing and Labeling: Items provided under this section shall be listed and labeled by UL.

B. Nationally Recognized Testing Laboratory Listing and Labeling (NRTL): Items provided under this section shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

C. National Electrical Code Compliance: Components and installation shall comply with NFPA 70 "National Electrical Code."

D. NEMA Compliance: Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

E. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

F. Provide raceway products and components listed and labeled by UL, ETL, or CSA.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

B. Conduit Bodies:
   1. Appleton Electric Co.
   2. Carlon
   3. Killark Electric Mfg. Co.
   4. O Z/Gedney
   5. Spring City Electrical Mfg. Co.

C. Wireways:
   1. Erickson Electric Equipment Co.
   2. GS Metals Corp.
   3. Hoffman Engineering Co.

D. Cabinets:
   1. Erickson Electrical Equipment Co.

2. Hoffman Engineering Co.
3. Spring City Electrical Mfg. Co.
4. Square D Co.

2.2 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. Intermediate Steel Conduit: UL 1242.

C. Electrical Metallic Tubing and Fittings: ANSI C80.3

D. Flexible Metal Conduit: UL 1, zinc coated steel.

E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360. Fittings shall be specifically approved for use with this raceway.

2.3 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 metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.

C. Conduit Bodies 1 Inch and Smaller: Use bodies with compression type threaded connectors.

2.4 WIREWAYS

A. General: Electrical wireways shall be of types, sizes, and number of channels indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for completed system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.

B. Wireway covers to be hinged type.

2.5 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. This applies to kitchen areas.

B. Materials and finish

1. Sheet Steel: Flat rolled, code gage, galvanized steel.
2. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.
3. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.
4. Cast Metal for Boxes, Enclosures, and Covers; Copper free aluminum except as otherwise specified.
5. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.
6. Painted Interior Finish: Where indicated, white baked enamel.

7. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connecters.

2.6 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 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.

2.7 PULL OR 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 Iron Boxes: Molded of cast iron alloy with gasketed cover and integral threaded conduit entrances.

2.8 CABINETS

A. Comply with UL 50, "Electrical Cabinets and Boxes."

B. Construction: Sheet steel, NEMA 4 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 3/4 inch 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.

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.

2.9 STEEL ENCLOSURES WITH HINGED DOORS

A. Comply with UL 50, "Cabinets and Enclosures" and NEMA ICS 6,

B. "Enclosures for Industrial Controls and Systems."

C. Construction: Sheet steel, 16 gage, minimum, with continuous welded seams. NEMA class as indicated; arranged for surface mounting.

D. Doors: Hinged directly to cabinet and removable, with approximately 3/4 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.

E. Mounting Panel: Provide painted removable internal mounting panel for component installation.

F. Enclosure: NEMA 4 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 RACEWAY WIRING METHOD

A. Outdoors: Use the following wiring methods:
   1. Exposed / Concealed: Rigid metal conduit, Intermediate metal conduit.
   2. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor driven equipment: liquidtight flexible metal conduit. Maximum length six (6) feet.

B. Indoors: Use the following wiring methods:
   1. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic or electric solenoid or motor operated equipment: Flexible metal conduit. Maximum length six (6) feet.
   2. Exposed/Concealed branch circuits: EMT.
   3. Exposed/Concealed panelboard feeders: Intermediate metal conduit, Rigid metal conduit.
   4. Connection to vibrating equipment and hydraulic, pneumatic, or electric solenoid or motor driven equipment in moist or humid location or corrosive atmosphere, or where subject to water spray or dripping oil, grease, or water: Liquidtight flexible metal conduit. Maximum length six (6) feet.
   5. All conduits within finished areas shall be concealed.

3.2 RACEWAY INSTALLATION

A. General: Install electrical raceways in accordance with manufacturer's written installation instructions, applicable requirements of NEC, and as follows:

B. Conceal Conduit, unless indicated otherwise, within finished walls, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and hot water pipes. Install raceways level and square and at proper elevations.

C. Elevation of Raceway: Where possible, install horizontal raceway runs above water and sanitary piping.

D. Complete installation of electrical raceways before starting installation of conductors within raceways.

E. Provide supports for raceways as specified elsewhere in Division 26.

F. Prevent foreign matter from entering raceways by using temporary closure protection.

G. Protect stub ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

H. 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.

I. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

J. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.

K. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

L. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways.

M. Join raceways with fittings designed and approved for the purpose and make 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.

N. Tighten set screws of threadless fittings with suitable tool.

O. 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. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.

P. 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.

Q. Install pull wires in empty raceways. Use no. 14 AWG zinc coated steel or monofilament plastic line having not less than 200 lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

R. 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:
1. Where conduits pass from warm locations to cold locations, such as the boundaries of conditioned spaces and mechanical spaces.
2. Where required by the NEC.

S. 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.

T. Flexible Connections: Use short length (maximum of 6 ft.) of flexible conduit for recessed and semirecessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet locations. Install separate ground conductor across flexible connections. Light fixture flexible connections shall not exceed 15 ft.

3.3 CABINETS AND BOXES 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 "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.

3.4 APPLICATIONS

A. Cabinets: Flush mounted, NEMA enclosure Type 1 except as otherwise indicated.

B. Hinged Door Enclosures: NEMA Type 1 enclosure except as indicated.

C. Hinged Door Enclosures Outdoors: Install drip hood, factory tailored to individual units.

D. 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:
   1. Interior Dry Locations: NEMA Type 1, sheet steel or as permitted by local code.
   2. Locations Exposed to Weather, Dampness, or Wet Locations: NEMA Type 3R enclosures.

E. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.

3.5 INSTALLATION OF OUTLET BOXES

A. Outlets at Windows and Doors: Locate close to window trim.

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 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. Where indicated.

E. 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.

F. Mounting: Mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles either vertically or horizontally but consistently either way. 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.

G. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4 inches square by 1 1/2 inches deep, minimum.

H. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.

I. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.

3.6 INSTALLATION OF PULL OR 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

1. 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.
2. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.
3. Size: Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.7 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.

3.8 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.

3.9 RACEWAY ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

3.10 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 26 05 33

SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 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. Identification labeling for switchboards, panelboards, devices, raceways, cables, and conductors.
   2. Operational instruction signs.
   3. Warning and caution signs.
   4. Equipment labels and signs.

B. Related Sections: The following Sections contain requirements that relate to this Section:
   1. Division 26 Section “Low voltage electrical power conductors and cables." for requirements for color coding of conductors for phase identification.

C. Refer to other Division 26 sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. American Labelmark Co.
   2. Ideal Industries, Inc.
   3. LEM Products, Inc.
   4. Markal Corp.
   5. National Band and Tag Co.
   6. Panduit Corp.
   7. Seton Name Plate Co.

2.2 ELECTRICAL IDENTIFICATION PRODUCTS

A. Adhesive Marking Labels for Raceway and Cable: Pre-printed, flexible, self-adhesive labels with legend indicating voltage and service (Emergency, Lighting, Power, Light, Air Conditioning, Communications, Control, Fire, etc.).

B. Label Size: as follows:
   1. Raceways 1-Inch and Smaller: 1-1/8 inches high by 4 inches long.
   2. Raceways Larger than 1-Inch: 1-1/8 inches high by 8 inches long.

C. Color: Black legend on orange background.

D. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

E. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Raceway and Cable Identification: Flexible acrylic bands sized to suit the raceway diameter and arranged to stay in place by pre- tensioned gripping action when coiled around the raceway or cable.

F. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self- adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

G. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field-printed legends to suit the application. Orange background, except as otherwise indicated, with Eyelet for fastener.

H. 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 and punched for mechanical fasteners.

I. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.

J. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide 1/4-inch grommets in corners for mounting.

K. 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.

L. 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 deg F to 350 deg F. Provide ties in specified colors when used for color coding.

PART 3 - EXECUTION

3.1 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:
   1. The following areas shall be identified:
      a. On wall surfaces directly external to conduits run concealed within wall.
      b. On all accessible surfaces of concrete envelope around conduits in vertical shafts, exposed at ceilings or concealed above suspended ceilings.

   2. Apply identification to areas as follows:
      a. Clean surface of dust, loose material, and oily films before painting.
      b. Prime surfaces: For galvanized metal, use single-component acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty acrylic resin block filler. For concrete surfaces, use clear alkali-resistant alkyd binder-type sealer.
      c. Apply one intermediate and one finish coat of orange silicone alkyd enamel.
      d. Apply primer and finish materials in accordance with manufacturer's instructions.

E. Identify Raceways of Certain Systems with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be pretensioned, snap-around colored plastic sleeves, colored adhesive marking tape, or a combination of the two. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 40-foot maximum intervals in straight runs. Apply the following colors:
   1. Fire Alarm System: Red
   2. Fire Suppression Supervisory and Control System: Red
   3. Mechanical and Electrical Supervisory System: Green and Blue
   4. Telephone System: Green and Yellow

F. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained

circuits. Use pressure- sensitive plastic labels at exposed locations and similar labels or plasticized card stock tags at concealed boxes.

G. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

208Y/120 Volts	Phase	120/240Volts
Black	A	Black
Red	B	Red
Blue	C	-
White	Neutral	White
Green	Ground	Green

H. Use conductors with color factory-applied the entire length of the conductors except as follows:
   1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG.
      a. Apply colored, pressure-sensitive plastic tape in half- lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
      b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.

I. 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 or control wiring or signal conductors are present in the same box or enclosure (except for three-circuit, four-wire home runs), label each conductor or cable. Provide legend indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by mean of coded color of conductor insulation. For control and signal wiring, use color coding or wire marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire 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.

J. 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.

K. Install equipment 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 alarm systems, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 1/2-inch-high lettering on 1-1/2-inch-high label (2-inch-high where two lines are required), white lettering in black field. 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. Load centers, electrical cabinets, and enclosures.
      b. Access doors and panels for concealed electrical items.

L. Apply 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. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

M. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

END OF SECTION 26 05 53

SECTION 26 05 73 –
SHORT-CIRCUIT/COORDINATION STUDY & ARC-FLASH HAZARD STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 26.

1.2 SCOPE

A. The contractor shall provide short-circuit and protective device coordination studies. Studies shall be by equipment manufacturer or a third party organization specializing in short-circuit and protective device coordination studies.

B. The contractor shall provide an Arc-Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D. Study shall be by equipment manufacturer or a third party organization specializing in Arc-Flash Hazard studies.

C. All costs associated with the studies noted above shall be included as part of the contractor's base bid.

1.3 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):
1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents

C. The National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code, current adopted edition with State of CT amendments.
   2. NFPA 70E – Standard for Electrical Safety in the Workplace.

1.4 SUBMITTALS

A. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

B. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report.

C. The report shall include the following:
   1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations.
   2. Descriptions, purpose, basis and scope of the study.
   3. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings.
   4. Protective device time versus current coordination curves with associated one-line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings.
   5. Multi-function relay setting file printouts including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.
   6. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout.
   7. Incident energy and flash protection boundary calculations.
   8. Comments and recommendations for system improvements, where needed.
   9. Executive Summary including source of information and assumptions made.

1.5 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 - PRODUCTS

2.1 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer. By using the equipment manufacturer the study allows coordination of proper breakers, fuses, and current transformers. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker and motor starter in the 480 Volt motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all field data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future utility supplies, motors, and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.

D. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, current adopted edition.

B. Transformer design impedances and standard X/R ratios shall be used when test values are not available.

C. Provide the following:
1. Calculation methods and assumptions.
2. Selected base per unit quantities.
3. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted.
4. Source impedance data, including electric utility system and motor fault contribution characteristics.
5. Typical calculations.
6. Tabulations of calculated quantities.
7. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault

at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings.
2. Adequacy of switchgear, motor control centers, and panelboard bus bracing to withstand short-circuit stresses.
3. Adequacy of transformer windings to withstand short-circuit stresses.
4. Cable and busway sizes for ability to withstand short-circuit heating.
5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility's protective device.
2. Medium voltage equipment relays.
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
6. Conductor damage curves.
7. Ground fault protective devices, as applicable.
8. Pertinent motor starting characteristics and motor damage points.
9. Pertinent generator short-circuit decrement curve and generator damage point.

10. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Select each primary protective device required for a delta-wye connected transformer so that the characteristics or operating band is within the transformer parameters which includes a parameter equivalent to 58% of the ANSI withstand point to afford protection for secondary line-to-ground faults.

H. Separate low voltage power circuit breakers from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.

I. Engineer shall provide settings file printouts for all multifunction relays supplied under this contract including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.

2.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2012, Informative Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all 480v locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.6 REPORT SECTIONS

A. Input Data:
1. Utility three-phase and line-to-ground available contribution with associated X/R ratios.
2. Short-circuit reactance of rotating machines with associated X/R ratios.
3. Cable type, construction, size, # per phase, length, impedance and conduit type.
4. Bus duct type, size, length, and impedance.
5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio.
6. Reactor inductance and continuous ampere rating.
7. Aerial line type, construction, conductor spacing, size, # per phase, and length.

B. Short-Circuit Data:
1. Source fault impedance and generator contributions.
2. X to R ratios.
3. Asymmetry factors.
4. Motor contributions.
5. Short circuit kVA.
6. Symmetrical and asymmetrical fault currents.

C. Recommended Protective Device Settings:
1. Phase and Ground Relays:
a. Current transformer ratio.
b. Current setting.
c. Time setting.
d. Instantaneous setting.
e. Specialty non-overcurrent device settings.
f. Recommendations on improved relaying systems, if applicable.

2. Circuit Breakers:
a. Adjustable pickups and time delays (long time, short time, ground).
b. Adjustable time-current characteristic.
c. Adjustable instantaneous pickup.
d. Recommendations on improved trip systems, if applicable.

D. Incident energy and arc flash boundary calculations.
1. Arcing fault magnitude.
2. Device clearing time.
3. Duration of arc.
4. Arc flash boundary.
5. Working distance.
6. Incident energy.
7. Recommendations for arc flash energy reduction.

PART 3 – EXECUTION

3.1 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.2 ARC FLASH WARNING LABELS

A. The vendor shall provide a 4 in. x 4 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, “WARNING, SHOCK & ARC FLASH HAZARD”, and shall include the following information:
   1. Location designation
   2. Nominal voltage
   3. Arc flash boundary
   4. Incident energy
   5. Working distance
   6. Shock Boundaries
   7. Engineering report number, revision number and issue date

C. Labels shall be machine printed, with no field markings

D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
   1. Provide one arc flash label for each 600, 480 and applicable 208 volt panelboards and disconnects.
   2. Provide one arc flash label for each motor control center.
   3. Provide one arc flash label for each low voltage switchboard.
   4. Provide one arc flash label for each switchgear.

E. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.3 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard For Electrical Safety Requirements For Employee Workplaces, shall be provided in the equipment manuals. The training shall be

certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

END OF SECTION 26 05 73

SECTION 26 22 13 – LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for low voltage distribution dry-type transformers as required for the complete performance of the Work, as shown on the Drawings, as specified herein.

B. Section includes transformers with a nominal primary and secondary rating of 600 V and less, with capacities of 15 to 1000 kVA

1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
   1. Low-voltage dry-type distribution transformer:
      a. Input voltage of 600V or less
      b. Output voltage of 600V or less
      c. Covers Step-up and Step- down transformers
      d. Is rated for operation at a frequency of 60 Hz
      e. 15 kVA to 1000 kVA for dry-type units
      f. Is air-cooled; and
      g. Does not use oil as a coolant

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
   1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
   2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.
   3. Product Data and Shop Drawings: Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information:
      a. Copy of ISO 9001 Certification of manufacturing operations
      b. Copy of ISO 14001 Certification of manufacturing operations

c. Confirmation that the selected transformer(s) comply with UL 1561 via third party inspection and Listing
d. Construction Detail including enclosure dimensions; kVA; Primary and Secondary Nominal Voltage, voltage taps, and unit weight
    1) Conduit / Wire Way Access Points, including distance for wiring routing to meeting minimum bending radius
    2) Location for ground lug to be field installed without covering ventilated air flow slots or holes
    3) Center of Gravity
e. Basic Performance characteristics including insulation class, temperature rise, coil material, impedances, no load and full load losses & audible noise level, unit weight, inrush data expressed in either Amperes RMS or Times Rated input current.
    1) Efficiency Data per NEMA ST20 and special 35% 10 CFR Part 431 loading point
    2) No load and full load losses will be calculated per NEMA ST20 test methods
    3) Efficiency at 25%, 50%, 75%, and 100% load points
f. Minimum Distance from all sides of the product
    1) Rear
    2) Side
    3) Front Access
g. Field Installed Accessories – as they are available for a rated kVA
    1) Weather shields
    2) Wall mounting bracket
    3) Ceiling mounting bracket
    4) Floor mounting bracket
    5) Lug Kits
    6) Ground Kits
h. Terminals Sizes
    1) Lug Kits – Acceptable Wire Ranges
    2) Lugs must be AL9CU

B. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified Division 1.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of ten years.
    1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
    2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.

B. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Equipment, assemblies and materials shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

D. Transformer Wrapping
   1. Transformers shall be protected by Cardboard or Wood protective material – all plastic wraps will not be accepted.
   2. Plastic wraps will only be accepted on units 500kVA and greater.

E. Transformer Shipping Base
   1. Transformers shall be shipped on a wood pallets and crates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Eaton Corp.
   2. General Electric Co.
   3. Siemens
   4. Schneider Electric, Square D

B. Acceptable Products: Energy efficient low voltage distribution transformers specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements.

2.2 TRANSFORMERS, GENERAL

A. Transformers: Factory assembled and tested, air cooled units of types specified, having characteristics and ratings as indicated. Units shall be designed for 60 Hz service.

B. Cores: Grain oriented, nonaging silicon steel.

C. Coils: Continuous windings without splices except for taps.

D. Internal Coil Connections: Brazed or pressure type.

E. Arc Flash study must be completed with the following information supplied on the cover
1. Available Fault Current – Primary Terminals – Voltage
2. Available Fault Current – Secondary Terminals Voltage
3. Available instantaneous Energy Level

F. Transformer shall not be installed in areas that are readily accessible.

2.3 GENERAL PURPOSE, DRY TYPE TRANSFORMERS

A. Comply with NEMA Standard ST 20 "Dry Type Transformers for General Applications."

B. Windings: 2 winding type. Three phase transformers shall use one coil per phase in primary and secondary.

C. Provide all copper windings.

D. Sound Level: Minimum of 3 dB less than NEMA ST 20 standard sound levels for transformer type and size indicated when factory tested in accordance with that standard.

E. Transformers shall have the following features and ratings:
1. Enclosure: Indoor, ventilated.
2. Enclosure: Indoor, ventilated, dripproof.
3. Enclosure: Outdoor, ventilated, raintight, NEMA 3R.
4. Enclosure: Totally enclosed, nonventilated.
5. Enclosure: Totally enclosed, nonventilated, suitable for outdoor use.
6. Insulation Class: 185 deg C or 220 deg C class for transformers 15 kVA or smaller; 220 deg C class for transformers larger than 15 kVA.
7. Insulation Temperature Rise: 80 deg C maximum rise above 40 deg C.
8. Insulation Temperature Rise: 115 deg C maximum rise above 40 deg C.
9. Insulation Temperature Rise: 150 deg C maximum rise above 40 deg C, for 220 deg C class insulation; 115 deg C maximum rise for 185 deg C class insulation.
10. Taps: For transformers 3 kVA and larger, full capacity taps in high voltage winding as follows:
    a. 3 kVA through 25 kVA: Two 5 percent taps below rated high voltage.
    b. 3 kVA through 10 kVA: Two 5 percent taps below rated high voltage.
    c. 15 kVA through 500 kVA: Six 2 1/2 percent taps, 2 above and 4 below rated high voltage.
    d. 750 1000 kVA: Four 2 1/2 percent taps, 2 above and 2 below rated high voltage.

F. Accessories: The following accessory items are required where indicated:

G. Accessories: As follows:
1. Surge Arresters: Low voltage type, factory installed and connected to high voltage terminals; complying with NEMA Standard LA 1.
2. Surge Arresters: Low voltage type, factory installed and connected to low voltage terminals; complying with NEMA Standard LA 1.
3. Electrostatic shielding: Insulated metallic shield between primary and secondary windings. Connect to terminal marked "shield" for grounding connection.
4. Wall mounting brackets: Manufacturers standard brackets for transformers sized up to 75 kVA where wall mounting is indicated.
5. Fungus Proofing: Permanent fungicidal treatment for coil and core.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Arrange equipment to provide adequate spacing for cooling air circulation.

B. Identify transformers in accordance with Division 26 Section "Electrical Identification."

C. Tighten electrical connectors and terminals 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.

3.2 EQUIPMENT BASES

A. Construct concrete equipment pads as follows:
1. Coordinate size of equipment bases with actual unit sizes provided. Construct base 4 inches larger in both directions than the overall dimensions of the supported unit.
2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
4. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C 150, 4,000 psi compressive strength, and normal weight aggregate.

3.3 GROUNDING

A. Ground transformers and tighten connections to comply with tightening torques specified in UL Standard 486A.

3.4 FIELD QUALITY CONTROL

A. Tests shall conform to InterNational Electrical Testing Association (INETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems," and the following:
1. Independent Testing Organization: Arrange and pay for the services of an independent electrical testing organization in accordance with the requirements of Division 1 Section "Quality Control Services" to perform tests on transformers.

2. Test Objectives: To assure transformer installation is operational within industry and manufacturer's tolerances, is installed in accordance with Contract Documents, and is suitable for energizing.
3. Procedures: Upon satisfactory completion of tests, attach a label to tested components.
4. Schedule tests and notify Architect at least one week in advance of schedule and of test commencement.
5. Reports: The testing organization shall make a written report of observations and tests. Report defective materials and workmanship and retest corrected defective items.
6. Testing organization shall submit written test reports to the Architect and Contractor.
7. Testing for transformers shall include insulation resistance test, taps verification and excitation test.
8. Testing for voltage regulators shall include functional test throughout operating range of device. Check voltage tolerance correction speed and harmonic content of output for stepped changes in source voltage at 35 percent, 70 percent and 100 percent of rated load.
9. Test Failures: Correct deficiencies identified by tests and make ready for retest. Verify that equipment meets the specified requirements.

3.5 ADJUSTING AND CLEANING

A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove paint splatters and other spots, dirt, and construction debris. Touch up scratches and mars of finish to match original finish.

B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendations within enclosure of each transformer throughout periods during which equipment is not in a space that is continuously under normal control of temperature and humidity.

3.7 DEMONSTRATION

A. Adjustment: Arrange and pay for the services of factory authorized service representatives to adjust and demonstrate voltage regulator for Owner's maintenance personnel.

END OF SECTION 26 22 13

SECTION 26 24 13 – SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SCOPE

A. The Contractor shall furnish and install, where indicated, a free-standing, dead-front type low voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the Contract Documents.

1.3 RELATED SECTIONS

A. Section 26 28 00 – Overcurrent Protective Devices

1.4 SUBMITTALS

A. Submit the following manufacturer's data:
   1. Master drawing index
   2. Front and top view elevations
   3. Floor plan
   4. Single line and schematic diagrams
   5. Component list
   6. Conduit entry/exit locations
   7. Assembly ratings inclusive of the following:
      a. Short-circuit rating
      b. Voltage
      c. Continuous current
   8. Major component ratings inclusive if the following:
      a. Voltage
      b. Continuous current
      c. Interrupting ratings
   9. Cable terminal quantities and sizes
   10. Product data sheets
   11. Wiring diagrams
   12. Certified production test reports
   14. Installation information
   15. Seismic certification and equipment anchorage details

1.5 QUALITY ASSURANCE

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. Installer's Qualifications: Firm with at least five (5) years of successful installation experience with projects utilizing service entrance work similar to that required for this project.

E. Codes and Standards:
1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and current adopted NEC, including Articles 230, 250, and 338, as applicable to installation, and construction of service entrances.
2. NEMA Compliance: Comply with applicable construction and installation requirements of the following NEMA standards for service entrance equipment and accessories:
   a. Stds Pub/No. KS 1: Enclosed Switches.
   b. Stds Pub/No. PB 2: Deadfront Distribution Switchboards.
   c. Stds Pub/No. PB 2.2: Application Guide for Ground fault Protective Devices for Equipment.
3. UL Compliance: Comply with construction and installation requirements of the following UL standards for service entrance equipment and accessories:
   a. UL 50: Electrical Cabinets and Boxes.
   b. UL 489: Molded Case Circuit Breakers and Circuit Breaker Enclosures.
   c. UL 854: Service Entrance Cables.
   d. UL 869: Electrical Service Equipment.
4. Provide switchboard equipment and accessories which are UL listed and labeled, and marked, "SUITABLE FOR USE AS SERVICE EQUIPMENT."
5. IEEE Compliance: Comply with applicable requirements of IEEE Std 241 pertaining to service entrances.

F. Provide Seismic qualified equipment as follows:
1. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the current adopted State Building Code.
2. The IP rating of the equipment shall be 1.5
3. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
   a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
   b. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
   c. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be

considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory fabricated type containers or wrappings for service entrance equipment and components which protect equipment from damage. Install gravity measuring meters in containers which indicate whether container has been bumped or dropped. Return G meters to manufacturer for reuse upon delivery of switchgear. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store equipment in original packaging and in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment. Store indoors to protect from weather and construction traffic.

C. Handle 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.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

1.8 SEQUENCING AND SCHEDULING

A. Schedule delivery of 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. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements as per code.

C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of service entrance / switchboard work with other work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Corp.
   2. General Electric Co.
   3. Siemens

4. Schneider Electric, Square D (Design Base)

B. The listing of the manufacturers specified above does not imply acceptance of their products that do not meet the specified ratings, features and functions called for in the Contract Documents. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 RATINGS

A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of 100,000 amperes symmetrical at rated voltage as indicated on the Contract Documents.

B. Voltage rating to be as indicated on the Contract Documents.

2.3 CONSTRUCTION

A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

B. All sections of the switchboard shall be front and rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling switchboard to be mounted against a wall.

C. The assembly shall be provided with adequate lifting means.

D. The switchboard shall be equal to Square D QED Series utilizing the components herein specified and as shown on the drawings.

E. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

2.4 BUSSING

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient outside the enclosure.

B. Provide a full capacity neutral bus.

C. A copper ground bus (minimum 1/4 x 2 inch) shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

2.5 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.

C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as required and/or as indicated on the drawings.

D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

2.6 MAIN AND TIE PROTECTIVE DEVICES

A. Protective devices shall be fixed mounted insulated case low-voltage circuit breakers. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. Main and tie breakers shall be true two-step stored energy devices and shall be manually operated unless otherwise indicated on contract documents.

C. All main and tie circuit breakers shall have a minimum symmetrical interrupting capacity of 100,000 amperes.

D. All main and tie insulated case circuit breakers shall be UL489 listed.

E. All insulated case circuit breakers shall have a nameplate clearly marking any electrical accessories that are mounted in the breaker at the time of sale. The accessory shall have a label that will indicate its function and voltage. All accessories shall be modular, plug and lock type, and UL listed for easy field installation.

F. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a "Positive On" feature. The breaker flag will read "Closed" if the contacts are welded and the breaker is attempted to be tripped or opened.

G. Each molded case circuit breaker shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.

H. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.

I. Where noted on the contract documents provide zone selective interlocking between trip units.

J. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:
   1. Adjustable long-delay pick-up setting with minimum of 10 settings
   2. Adjustable long-delay time - 0.5 to 24 seconds
   3. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame
   4. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping
   5. Adjustable instantaneous setting 2x to Max allowable by frame
   6. Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x In in 0.10x increments) and time (0.1 – 1.0 sec in 0.10sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

K. Where indicated provide 100% rated UL listed circuit breakers.

L. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.

M. Trip units shall include embedded Modbus RTU communication capability. Breaker status and all monitored parameters shall be available.

N. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.
   1. Number of operations (load and no-load)
   2. Number of trips (overload trips, short circuit trips)
   3. Run time
   4. Breaker ambient temperature.
   5. Breaker remaining life - Then the trip unit shall utilize an algorithm that applies a weighted value to all of these inputs to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.
   6. All breaker health information shall be available via hard wire connection to a PC and via communications.
      1) Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.

a) Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.
b) Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.
c) Waveform events shall capture and store all phase, neutral and ground currents.

2.7 FEEDER PROTECTIVE DEVICES

A. All feeder protective devices shall be Square D or approved equal molded case circuit breakers with inverse time tripping characteristics.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the contract documents.

D. All molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.

E. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.

F. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:
1. Adjustable long-delay pick-up setting with minimum of 10 settings
2. Adjustable long-delay time - 0.5 to 24 seconds
3. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame
4. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping
5. Adjustable instantaneous setting 2x to Max allowable by frame
6. Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x In in 0.10x increments) and time (0.1 – 1.0 sec in 0.10sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

G. Where indicated provide 100% rated UL listed circuit breakers.

H. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.

I. Trip units shall include embedded Modbus RTU communication capability. Breaker status and all monitored parameters shall be available.

J. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.
   1. Number of operations (load and no-load)
   2. Number of trips (overload trips, short circuit trips)
   3. Run time
   4. Breaker ambient temperature.
   5. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.
   6. All breaker health information shall be available via hard wire connection to a PC and via communications.
      1) Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.
         a) Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.
         b) Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.
         c) Waveform events shall capture and store all phase, neutral and ground currents.

2.8 ACCESSORIES

A. Provide shunt trips, bell alarms and auxiliary switches as shown on the contract drawings.

2.9 MISCELLANEOUS DEVICES

A. Key interlocks shall be provided as indicated on the drawings.

B. Control power transformers with primary and secondary protection shall be provided, as indicated on the drawings, or as required for proper operation of the equipment. Control power transformers shall have adequate capacity to supply power to the transformer cooling fans.

C. Each section of the switchboard shall be provided with a space heater thermostatically controlled. Power for the space heaters shall be obtained from a control power transformer within the switchboard. Supply voltage shall be 120 volts AC.

2.10 UTILITY METERING

A. Where indicated on the drawings, furnish a barrier to separate the utility metering compartment complete with hinged sealable door. Bus work shall include provisions for mounting utility company current transformers and potential transformers or potential taps as required by the utility company. Provide service entrance label and provide necessary applicable service entrance features per NEC and local code requirements.

2.11 CUSTOMER METERING

A. Where indicated on the drawings, provide a separate customer metering compartment with a front facing hinged door and a UL listed microprocessor based multifunction power meter with display. Include current transformers wired to shorting-type terminal blocks for each meter. Provide fused potential taps as the potential source for metering as shown on the drawings.

B. The meter surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41.

C. The meter shall accept a direct voltage input range of up to 576 Volts Line to Neutral, and a range of up to 721 Volts Line to Line.

D. The meter shall accept a current input of up to 10 amps continuous. Startup current for a 5A input shall be no greater than 0.005A.

E. Fault Current Withstand shall be 100 Amps for 10 seconds, 300 Amps for 3 seconds, and 500 Amps for 1 second.

F. The meter shall have an accuracy of +/- 0.1% or better for volts and amps, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of ANSI C12.20 (Class 0.2%).

G. The meter shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase and neutral.

H. Meter shall provide per phase % THD. Metered values shall include Volts, Amps, kW, kVAR, PF, kVA, Frequency, kWh, kVAh and kVARh. Provide 1 KYZ pulse output, on board meter limit exceeded alarms. Meter shall have 512MB onboard memory for data logging.

I. The meter shall provide user configured fixed window or sliding window demand.

J. The meter shall allow up to 1500 events to be recorded.

K. The meter shall be able to be configured and viewed from the on-board web server without the need for external software

L. The meter shall include a three-line, bright red, .56” LED display.

M. The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load Bar shall have not less than 10 segments.

N. The meter shall support Modbus RTU, Modbus ASCII, DNP 3.0, Ethernet TCP/IP, Modbus TCP, BACnet/IP, SNMP v1 & v3 (Network), SMTP (email), HTTP and HTTPS communication.

2.12 SURGE PROTECTIVE DEVICES

A. SPD shall comply with ANSI/UL 1449 4th Edition or later listing by Underwriters Laboratories (UL).

B. SPD shall be factory installed integral to the panelboard by the original equipment manufacturer, and shall be a product of the same manufacturer as the panelboard and breakers.

C. The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

D. Electrical Requirements:
1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards. End of life mode to be open circuit. Unit with end of life short-circuit mode are not acceptable.
4. Unit shall operate without the need for an external overcurrent protection device (OCPD), and be listed by UL as such. Unit must not require external OCPD or replaceable internal OCPD for the UL Listing.
5. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection Modes			
Configuration	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

6. Nominal Discharge Current (In) – All SPDs applied to the distribution system shall have a 20kA In rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an In less than 20kA shall be rejected.

7. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

2.13 ENCLOSURES
A. Outdoor NEMA 3R Enclosure

1. Outdoor enclosure shall be non-walk-in and meet applicable NEMA 3R UL requirements.
2. Enclosure shall have flat roof.
3. Outer sections shall be the same widths as indoor structures, except each end of the outdoor assembly shall have an end trim.
4. The enclosure shall be provided with [bolt-on rear covers] [rear hinged doors] for each section
5. Doors shall have provisions for padlocking
6. Ventilating openings shall be provided complete with replaceable fiber glass air filters.
7. Provide space heaters thermostatically controlled for each structure with adequate wattage to prevent the accumulation of moisture
8. Power for space heaters, lights and receptacles shall be obtained from a control power transformer within the switchboard. Supply voltage shall be 120 volts AC.

2.14 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.

B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.15 FINISH

A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which service entrance equipment and components are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected in an acceptable manner.

3.2 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
   1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for

operation under simulated service conditions to ensure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground

B. The manufacturer shall provide three (3) certified copies of factory test reports.

3.3 MANUFACTURER'S CERTIFICATION

A. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.4 TRAINING

A. The Contractor shall provide a training session for up to five (5) owner's representatives for 8 hours at a job site location determined by the owner.

B. A manufacturer's qualified representative shall conduct the training session. The training program shall consist of instruction on operation of the assembly, circuit breakers, fused switches, and major components within the assembly.

C. All training sessions shall be video recorded. Refer to Division 01 Section 01 79 00 'Demostration and Training' for further requirements.

3.5 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's instructions, contract drawings and current adopted National Electrical Code.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to concrete pad per manufacturer's recommendations. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

C. Tighten electrical 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.

D. Set field adjustable GFP devices and circuit breakers for pickup and time current sensitivity ranges as required, subsequent to installation of devices and CB's.

3.6 FIELD ADJUSTMENTS

A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.

B. Necessary field settings of devices, adjustments and minor modifications to equipment to accomplish conformance with an approved short circuit and protective device

coordination study shall be carried out by the Contractor at no additional cost to the owner.

C. All training sessions shall be video recorded. Refer to Division 01 Section 01 79 00 'Demostration and Training' for further requirements.

3.7 FIELD QUALITY CONTROL:

A. Prior to energization of service entrance equipment, check accessible connections for compliance to manufacturer's torque tightening specifications.

B. Prior to energization of service entrance equipment, check with ground resistance tester, phase to phase and phase to ground insulation resistance levels to ensure requirements are fulfilled.

C. Prior to energization, check circuitry for electrical continuity, and for short circuits.

3.8 GROUNDING:

A. Provide equipment grounding connections for service entrance equipment as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

3.9 ADJUSTING AND CLEANING:

A. Adjust operating mechanisms for free mechanical movement.

B. Touch up scratched or marred enclosure surfaces to match original finishes.

3.10 DEMONSTRATION:

A. Upon completion of installation of service entrance equipment and electrical circuitry, energized circuitry and 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 retest to demonstrate compliance.

END OF SECTION 26 24 13

SECTION 26 24 16 – PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

B. Related Sections: The following Division 26 Sections contain requirements that relate to this Section:
   1. "Overcurrent Protective Devices" for circuit breakers, fusible switches, fuses, and other devices used in panelboards.

1.3 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.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type panelboard, accessory item, and component specified.

C. 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.

D. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer installed and field installed wiring.

E. Qualification data for field testing organization certificates, signed by the Contractor, certifying that the organization complies with the requirements specified in Quality Assurance below. Include list of completed projects with project names, addresses, and names of Architect and Owner plus basic organization qualifications data.

F. Report of field tests and observations certified by the testing organization.

G. Panel schedules for installation in panelboards. Submit final versions after load balancing.

H. Maintenance data for panelboard components, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 26 Section "Common Work Results for Electrical." Include instructions for testing circuit breakers.

1.5 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.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Field Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

D. NEMA Standard: Comply with NEMA PB1, "Panelboards."

E. UL Standards: Comply with UL 61, "Panelboards," and UL 50, "Cabinets and Boxes."

1.6 EXTRA MATERIALS

A. Keys: Furnish six spares of each type for panelboard cabinet locks.

B. Touch up Paint for surface mounted panelboards: One half pint container.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:
   1. Eaton Corp.
   2. General Electric Co.
   3. Siemens
   4. Square D (Design Base)

2.2 PANELBOARDS, GENERAL REQUIREMENTS

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as indicated. Comply with Division 26 Section "Overcurrent Protective Devices," with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multipole breakers shall have common trip.

B. Enclosures: Cabinets, flush or surface mounted as indicted. NEMA Type 1 enclosure, except where the following enclosure requirements are indicated.
   1. NEMA 3R: Raintight.

C. Front: Hinged front covers.

D. Directory Frame: Metal, mounted inside each panel door.

E. Bus: Hard drawn copper of 98 percent conductivity.

F. Main and Neutral Lugs: Compression type.

G. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors. Bonded to box.

H. Service Equipment Approval: Listed for use as service equipment for panelboards having main service disconnect.

I. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.

J. 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.
   2. Hinged Front Cover: Entire front trim hinged to box with standard door within hinged trim cover.
   3. Split Bus: Vertical bus of indicated panels divided into two vertical sections with connections as indicated.
   4. Skirt For Surface Mounted Panels: Same gage and finish as panel front with flanges for attachment to panel, wall, and floor.
   5. Extra Gutter Space: Dimensions and arrangement as indicated.
   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. Subfeed: OCPD or lug provision as indicated.

K. Feed Through Lugs: Sized to accommodate feeders indicated, where indicated.

2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch OCPDs: Bolt on circuit breakers, replaceable without disturbing adjacent units.

B. Double Width Panels: Where more than 42 poles are indicated or where otherwise indicated, provide two panelboards under single front.

C. Doors: In panel front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike.

2.4 DISTRIBUTION PANELBOARDS

A. Doors: In panel front, omit single panelboard door in cabinet front for fusible switch panelboards except as indicated. Secure with vault type with tumbler lock, all keyed alike.

B. Branch Circuit Breakers: Where OCPDs are indicated to be circuit breakers, use bolt on breakers except circuit breakers 225 ampere frame size and greater may be plug in type where individual positive locking device requires mechanical release for removal.

C. Motor Starter Branches: Provide units equipped for panelboard mounting. Include the following accessories and pilot devices as indicated:
1. Individual control power transformers.
2. Fuses for control power transformers.
3. Pilot lights.
4. Extra interlock contacts.
5. Pushbuttons.
6. Selector switches.

D. Motor Starter Disconnects: Include overcurrent protection as indicated. Mount integral with or, in same panelboard, adjacent to motor starter. Mechanically interlock starter door with disconnect device. Provide auxiliary contacts on disconnect to deenergize control connections to starter.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: Arranged to permit testing of functions of solid state trip devices without removal from panelboard.

C. Spare Fuse Cabinet: Identified, compartmented, lockable steel box or cabinet with compartments suitable for surface mounting on wall.

2.6 IDENTIFICATION

A. Panelboard Nameplates: Engraved laminated plastic or metal nameplate for each panelboard mounted with epoxy or industrial cement or industrial adhesive.

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. Mounting Heights: Top of trim 6' 2" above finished floor, except as indicated, or required to fit existing wall cavity.

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 four 1 inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub four 1 inch empty conduits into raised floor space or below slab other than slabs on grade.

G. Auxiliary Gutter: Install where a panel is tapped to a riser at an intermediate location.

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 "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. Independent Testing Organization: Arrange and pay for the services of an independent electrical testing organization in to perform tests on low voltage power panelboards and accessories.

B. Pretesting: Upon completing installation of the system, perform the following preparations for independent tests:
   1. Make insulation resistance tests of panelboard buses, components, and connecting supply, feeder, and control circuits.
   2. Make continuity tests of circuits.
   3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.

C. Quality Control Program: Conform to the following:
   1. Procedures: Make field tests and inspections and prepare panelboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.
   2. Schedule tests with at least one week in advance notification.

3. Reports by Testing Organization: Report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
4. 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.
5. Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend final protective device ratings and settings. Use accepted ratings or settings to make the final system adjustments.

D. 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. Perform visual and mechanical inspection and related work for overcurrent protective devices as specified in Division 26 Section "Overcurrent Protective Devices."

E. 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 disconnected from solid state devices. 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."

F. 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 mars of finish to match original finish.

3.7 COMMISSIONING
A. Balancing Loads: After Substantial Completion, but not more than two months after Final Acceptance, conduct load balancing measurements and circuit changes as follows:
1. Perform measurements during period of normal working load as advised by the Owner.
2. Perform load balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24 hour services such as FAX machines and on line data processing, computing, transmitting, and receiving equipment.
3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference between phase loads exceeding 20 percent at any one panelboard is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

B. Infrared Scanning: After Substantial Completion, but not more than two months after Final Acceptance, perform an infrared scan of each panelboard. Remove fronts to make joints and connections accessible to a portable scanner.

C. Follow up Infrared Scanning: Perform one additional follow up infrared scan of each panelboard 11 months after the date of Substantial Completion.

D. Instrument: Use an approved infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide calibration record for device used.

E. Record of Infrared Scanning: Prepare a certified report identifying panelboards checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 24 16

SECTION 26 27 26 – WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 Sections apply to this section:
   1. Common Work Results for Electrical.

1.2 SUMMARY

A. This Section includes the following:
   1. Receptacles
   2. Ground Fault Circuit Interrupter Receptacles
   3. Snap Switches
   4. Wall Plates
   5. Occupancy Sensors
   6. Vacancy Sensors
   7. Lighting Control System
      1. Controller
      2. Occupancy Sensors
      3. Daylight Sensors
      4. Keypads

B. Related Sections: The following sections contain requirements that relate to this section:
   1. Division 26 Section "Enclosed Switches and Circuit Breakers" for devices other than snap switches and plug/receptacle sets used as disconnects for motors.

1.3 SUBMITTALS

A. Product data for each type of product specified.

B. Samples of those products indicated for sample submission in Architect's comments on product data submittal. Include color and finish samples of device plates and other items per Architect's request.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following codes.

B. NFPA 70 "National Electrical Code".
   1. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL and comply with applicable UL and NEMA standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

B. Available Manufacturers: Subject to specifications, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

1. Cooper Wiring Devices
2. Hubbell Inc.
3. Leviton
4. Legrand (Pass and Seymour)

2.2 WIRING DEVICES:

B. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. Provide ivory color devices and wall plates except as otherwise indicated. Verify color selections with Architect.

C. Receptacles: As scheduled in Table 1 in Part 3 below. Comply with UL 498 and NEMA WD1.

D. Ground-Fault Circuit Interrupter (GFCI) Receptacles: As indicated in Table 1 in Part 3 below; provide "feed-thru" type ground-fault circuit interrupter, with integral heavy-duty NEMA 5-20R duplex receptacles arranged to protect connected downstream receptacles on same circuit. Provide unit designed for installation in a 2-3/4 inch deep outlet box without adapter, grounding type, Class A, Group 1, per UL Standard 94.3.

E. Snap Switches: quiet type AC switches as indicated in Table 2 in Part 3 below. Comply with UL 20 and NEMA WD1.

E. Occupancy Sensors (ceiling): Multi-Technology, 360 degree self adjusting ceiling-mounted occupancy sensor. All sensors shall have ready accessible and user adjustable time delay and sensitivity controls. All sensors shall contain manual bypass. 2000 square foot coverage area. Provide appropriate power packs as required for installation.

F. Occupancy Sensors (wall switch): multi-Technology, 180 degree self adjusting wall switch - mounted occupancy sensor. All sensors shall have ready accessible and user adjustable time delay and sensitivity controls. All sensors shall contain manual bypass.

G. Vacancy Sensors (wall switch): multi-Technology, 180 degree self adjusting wall switch - mounted vacancy sensor with manual on – auto off. All sensors shall have ready accessible and user adjustable time delay and sensitivity controls. All sensors shall contain manual bypass.

2.3 WIRING DEVICE ACCESSORIES

A. Wall plates: single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates. Provide wall plate color to match wiring devices except as otherwise indicated. Provide plates possessing the following additional construction features:
   1. Material and Finish: steel plate, galvanized, for building mechanical spaces.
   2. Material and Finish: plastic, smooth, for tenant spaces, and other finished areas.

2.4 LOW VOLTAGE LIGHTING CONTROL SYSTEM DEVICES

A. Modular, stand-alone one room lighting 0-10V dimming and switching control system with keypad control and room occupancy and daylight sensing for daylight harvesting and energy management.

B. Lighting Controller:
   1. Basis of Design: Hubbell Model NXRC2-2RD-UNV.
   2. Concealed mounting, self contained, multichannel 0-10V lighting controller with occupancy and photo sensor inputs, user-adjustable controls.
   3. Mounting: Coordinate in field.

C. Occupancy Sensor:
   1. Basis of Design: Hubbell Model NXOS Series.
   2. Remote Occupancy Sensors: Combination of ultrasonic motion detection and passive infrared detection with internal microprocessor. Sensor independently adjustable for installed conditions. Delayed time off adjustment. Walk-through mode. Adjustable built-in photocell for daylight optimization.
   3. Provide with RJ45 adapter for interconnection to lighting controller.
   4. Coverage: 360 deg., 2000 sq. ft..
   5. Mounting: Ceiling flush mounted and Ceiling bracket mounted.

D. Photo (Daylight) Sensor:
   1. Basis of Design: Hubbell NXDS.
   2. Photocell Sensor, Open Loop Type: Continually monitors daylight entering window or skylight to enable daylight harvesting applications to provide control of room lighting based on presence of daylight.
   3. Provide with RJ45 adapter for interconnection to lighting controller.
   4. Mounting: Coordinate in field.

E. Keypads:
   1. Basis of Design: Hubbell NXSW-ORLO.
   2. Each keypad shall include:
      a. A four button key configuration with on, off, up, down. Lighting level shall be preset to 50% dimming level.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES:

A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements and as required by related sections of Div. 26.

B. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.

C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

D. Install galvanized steel wallplates in unfinished spaces.

E. Install wiring devices after wiring work is completed.

F. Install wall plates after painting work is completed.

H. 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 Standard 486. Use properly scaled torque indicating hand tool.

3.2 INSTALLATION OF LIGHTING CONTROL SYSTEM:

A. Install in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements and as required by related sections of Div. 26 and in accordance with the following:

1. Do not install dimming controls until space is enclosed, HVAC systems are running, and overhead and wet work in dimming control work space are complete.
2. Grounding: Provide electrical grounding in accordance with NFPA 70.
3. Perform setup for each lighting system.

B. System Startup:

1. Provide system startup and adjustment to occupied conditions in accordance with manufacturer's recommendations.
2. Perform operational testing to verify compliance with Specifications. Adjust as required.
3. Measure and record load on each controlled circuit in each scene. Submit report of load measurements.

3.3 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.4 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

B. Test ground fault interruptor operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. TABLE 1

RECEPTACLES

DESIG-NATION (1)	CURRENT RATING AMPS	VOLTAGE RATING	SINGLE/ DUPLEX	NEMA CONFIG-URATION	UL GRADE	NOTES

-	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	
GFCI	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	INTEGRAL GFCI
GFCI WP	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	INTEGRAL GFCI WEATHER-PROOF

NOTES

(1) Letter designations are used where symbols alone do not clearly designate on plans locations where specific receptacle types are used.

D. TABLE 2

SNAP SWITCHES

DESIG-NATION (1)	TYPICAL APPLICATION	VOLTAGE LOAD RATING	RATING (AC)	POLES	UL GRADE	NOTES
S	CONTROL LIGHTS	20A	120/277	1	HEAVY DUTY	-
S3	CONTROL LIGHTS	20A	120/277	3-way	HEAVY DUTY	-
S	DISCONN. MOTOR	1HP	120/277	1	HEAVY DUTY	(2)
STOL	DISCONN. MOTOR	2HP	208/480	3	HEAVY DUTY	(2)

NOTES

(1) For snap switches, designation is the same as the symbol used on plans for the device. Type of switch is determined from plan context including type of device or circuit being controlled.
(2) With overload element in switch.

3.6 DEMONSTRATION / TRAINING

A. Demonstration: Schedule dimming controls demonstration with Owner to allow verification that dimming controls function as required.

B. Training: Furnish the services of a factory authorized service representative to instruct Owner's personnel in the operation and maintenance of the lighting control system. Provide a minimum of two (2) two hours sessions of instruction scheduled seven days in advance.

C. All training sessions shall be video recorded. Refer to Division 01 Section 01 79 00 ‘Demostration and Training’ for further requirements.

END OF SECTION 26 27 26

SECTION 26 28 00 – OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes overcurrent protective devices (OCPDs) rated 600 V and below and switching devices commonly used with them.

B. Panelboards: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 26 sections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Cartridge Fuses:
   a. Bussmann
   b. Ferraz Shawmut
   c. Littelfuse Inc.

2. Fusible Switches:
   a. Allen Bradley Co.
   b. Crouse Hinds Distribution Equipment.
   c. Eaton Corp.
   d. General Electric Co.
   e. Siemens Energy & Automation, Inc.
   f. Schneider Electric (Square D)

3. Molded Case Circuit Breakers:
   a. Eaton Corp.
   b. General Electric Co.
   c. Siemens Energy & Automation, Inc.
   d. Schneider Electric (Square D)

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDs), GENERAL

A. General: Provide OCPDs in indicated types, as integral components of panelboards and also as individually enclosed and mounted single units.

B. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards, and motor control centers; and also as individually enclosed and mounted single units.

C. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."

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. Class J Fuses: UL 198C, "High Interrupting Capacity Fuses, Current Limiting Type."

C. Class L Fuses: UL 198C, "High Interrupting Capacity Fuses, Current Limiting Type."

D. Class RK1 and RK5 Dual Element Time Delay Fuses: UL 198E, "Class R Fuses."

E. Class RK1 Fast Acting Fuses: UL 198E, "Class R Fuses."

2.4 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. Padlocking Provisions: For 2 padlocks, whether open or closed.

H. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

2.5 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: Bolt in type, except breakers 225 ampere frame size and larger may be plug in type if held in place by positive locking device requiring mechanical release for removal.

C. Construction: Bolt in type, except breakers in load center type panelboards and breakers 225 ampere frame size and larger may be plug in type if held in place by positive locking device requiring mechanical release for removal.

D. Characteristics: Indicated frame size, trip rating, number of poles, and a short circuit interrupting capacity rating of 10,000 amperes symmetrical, unless a greater rating is indicated.

E. Tripping Device: Quick make, quick break toggle mechanism with inverse time delay and instantaneous overcurrent trip protection for each pole.

F. Enclosure for Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.

G. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer's written installation instructions.

B. OCPDs in distribution equipment shall be factory installed.

3.2 IDENTIFICATION

A. Identify components in accordance with Division 26 Section "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between OCPDs and control/indication devices as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables" for hard wired connections.

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. Independent Testing Organization: Arrange and pay for the services of an independent electrical testing organization to perform tests and observations on OCPDs.

B. Reports: Prepare written reports certified by testing organization on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made.

C. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

D. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.

E. Pretesting: Upon completing installation of the system, perform the following preparations for independent tests:
1. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.
2. Make continuity tests of circuits.
3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
4. Provide manufacturer's instructions for installation and testing of OCPDs to test personnel.

F. Visual and mechanical inspection: Include the following inspections and related work.
1. Overcurrent Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.
2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
3. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
4. Check tightness of electrical connections of OCPDs with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Clean OCPDs using manufacturer's approved methods and materials.
6. Verify installation of proper fuse types and ratings in fusible OCPDs.

G. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:
1. Insulation resistance test of OCPD conducting parts. Insulation resistance less than 100 megohms is not acceptable.
2. Contact resistance test or measurement of millivolt drop across contacts of drawout circuit breakers and fused power circuit devices at rated current. Compare contact resistance or millivolt drop values of adjacent poles and of similar breakers. Deviations of more than 50 percent are not acceptable.
3. Insulation resistance test of fused power circuit devices and insulated case and molded case circuit breakers over 600 ampere frame size at 1000 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.
4. Use primary current injection to check performance characteristics of trip units of molded case breakers over 600 ampere frame size. Trip characteristics not falling within manufacturer's published time current characteristic tolerance bands when adjusted to approved parameters are not acceptable. Perform the following tests:
    a. Determine minimum pickup current acceptable per manufacturer's instructions.

b. Determine long time delay at 300 percent pickup current.
c. Determine short time pickup current and corresponding delay time.
d. Determine ground fault current pickup and corresponding delay time.
e. Determine instantaneous pickup current value.

5. Make adjustments for final settings of adjustable trip devices.
6. Activate auxiliary protective devices such as ground fault or undervoltage relays, to verify operation of shunt trip devices.
7. Check operation of electrically operated OCPDs in accordance with manufacturer's instructions.

H. 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 CLEANING

A. Upon completion of installation, inspect OCPDs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 DEMONSTRATION

A. Training: Arrange and pay for the services of factory authorized service representatives to demonstrate OCPDs and train Owner's maintenance personnel.

B. Conduct a minimum of one half day of training in operation and maintenance as specified under "Instructions to Owner Employees" 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.

3.9 COMMISSIONING

A. Infrared Scanning: After Substantial Completion, but not more than 2 months after Final Acceptance, perform an infrared scan of OCPDs including their line and load connections, fuses, and fuse clips. Also scan OCPD contact structures where accessible to a portable scanner. Include individual OCPDs and those installed in switchboards, panelboards, and motor control centers.

B. Follow up Infrared Scanning: Perform two additional follow up infrared scans of the same devices: one four months after Substantial Completion, and one 11 months after Substantial Completion.

C. Instrument: Use an infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

D. Record of Infrared Scanning: Prepare a certified report identifying all OCPDs checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and rescanning observations after remedial action.

END OF SECTION 26 28 00

SECTION 26 28 16 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes circuit and motor disconnects.

1.3 SUBMITTALS

A. Product data for each type of product specified.

B. Maintenance data for circuit and motor disconnects, for inclusion in Operation and Maintenance Manual specified in Division 1 and Division 26 Section "Common Work Results for Electrical."

C. High Performance Building Submittal Requirements: The contractor or subcontractor shall submit the following High Performance Building certification items:

1. A Connecticut High Performance Building Compliance letter shall be provided verifying agreement with relevant High Performance requirements. Information to be supplied includes, but is not limited to:

    a. The percentage by weight of recycled content in the product(s). Identify post-consumer and/or pre-consumer recycled content.
    b. The manufacturing location for the product(s); and the location (source) of the raw materials used to manufacture the product(s).
    c. Provide material costs for the materials included in the contractor’s or subcontractor’s work. Material cost does not include costs associated with labor and equipment.

2. Letters of Certification, provided from the product manufacturer on the manufacturer’s letterhead, to verify the amount of recycled content.
3. Product Cut Sheets for all materials of this Section that meet High Performance Building Requirements.
4. Material Safety Data Sheets (MSDS), for all applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings applied on the interior of the building. MSDS shall indicate the Volatile Organic Compound (VOC) limits of products submitted (If an MSDS does not include a product’s VOC content, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC content)

1.4 QUALITY ASSURANCE

A. Electrical Component Standards: Provide components complying with NFPA 70 "National Electrical Code" and which are listed and labeled by UL. Comply with UL Standard 98 and NEMA Standard KS 1.

B. High Performance Building Requirements:

1. Adhesives, sealants, paints or coatings used for work in this section for interior applications shall meet the requirements of Division 1, Section 018113: “Volatile Organic Compound (VOC) Limits for Adhesives, Sealants, Paints and Coatings”, where applicable.
2. Materials manufactured within a radius of 500 miles from the project site where all or a portion of the raw resources also originate within a radius of 500 miles shall be documented in accordance with the High Performance Building Requirements of this Section.
3. Materials that contain recycled content shall be documented in accordance with the High Performance Building Requirements of this Section.

1.5 HIGH PERFORMANCE BUILDING GENERAL REQUIREMENTS

A. Implement practices and procedures to meet the project’s environmental goals, which include complying with Connecticut Standard Guidelines Compliance Manual for High Performance Buildings, September 2011 with additional mandatory building project requirements for schools. Specific project goals which may impact this and the other sections of this specification include: use of recycled-content materials; use of locally-manufactured materials; use of low-emitting materials; use of certified wood products; construction waste recycling; and the implementation of a construction indoor air quality management plan. Ensure that the requirements related to these goals, as defined in this Section and other Sections of the contract documents, are implemented to the fullest extent. Substitutions or other changes to the work shall not be allowed if such changes substantially com-promise the stated High Performance Building criteria.

B. Comply with Connecticut Standard Guidelines Compliance Manual for High Performance Buildings, September 2011 with additional mandatory building project requirements for schools and the Department of Administrative Services / Office of School Construction Grants & Review High Performance School Construction Bulletin, June 2017.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
1. Appleton
2. Crouse-Hinds Co.
3. Eaton Corp.

4. Square D Company.

2.2 CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features ratings, and enclosures as indicated. Provide NEMA 1 enclosure except for outdoor switches, and other indicated locations 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: Heavy duty switches, with fuses of classes and current ratings indicated. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.

C. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated.

D. Double-Throw Switches: Heavy duty switches of classes and current ratings as indicated.

E. Provide weatherproof, NEMA Type 3R rated enclosures at exterior locations.

2.3 ACCESSORIES

A. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated.

B. Captive Fuse Pullers: Provide built-in fuse pullers arranged to facilitate fuse removal.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUITS AND MOTOR DISCONNECTS

A. General: Provide circuit and motor disconnect switches as indicated and where required by the above Code. Comply with switch manufacturers' printed installation instructions.

3.2 FIELD QUALITY CONTROL

A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION 26 28 16