Division of Finance and Business Operations

Procurement & Strategic Sourcing
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August 24, 2018

Addendum #3 To
Request for Proposal
For Prentis Computer Lab Relocation 2018: Project 122-313456

Dated August 14, 2018

Please find the following clarifications for the above RFP opportunity.

1. **Additional information provided from FTCH:** Bid Addendum No.03 with revised drawings LS101, A101, A201, F101, MD101, M101, M102, M103, M105, M106, M107, M201, M501, M502, M601, M602, M901, E001, ED101, E102, TC101 and reissued specifications 01 23 00, 23 05 46, 23 09 00, 23 22 13, 23 31 13, 23 82 00

2. The questions due date has been extended to September 04, 2018 and the bid due date is September 10, 2018 at 2:00 pm.

3. There is a new form of proposal with this addendum. Please use the new form to submit your bid

IMPORTANT- This is an addendum which MUST be acknowledged on your bid form

We will require your lump sum proposals, vendor qualification questionnaire and your bid bond documents as a single PDF in your electronic submission.

All questions concerning this project must be emailed to: **Robert Kuhn**. Email: **ac6243@wayne.edu**, and copy **Leiann Day**, at leiannday@wayne.edu. Questions are due by September 04, 2018 at 12:00 pm

A copy of this Addendum will be posted to the Purchasing web site at **http://go.wayne.edu/bids**.

Bids are due **by electronic submission on** no later than 2:00 p.m., **September 10, 2018.** The link for bid submission will be posted with the bid details at **http://go.wayne.edu/bids** beginning **August 14, 2018**.

Thank you,

Robert Kuhn,
Sr. Buyer

ADDENDUM

CONTRACT FOR:	Prentis Computer Lab Relocation
OWNER:	The Board of Governors of Wayne State University
WSU:	Bob Kuhn, Procurement & Strategic Sourcing Wayne State University Detroit, MI 48202
ARCHITECT/ENGINEER:	Fishbeck, Thompson, Carr & Huber, Inc. 39500 MacKenzie Drive, Suite 100 Novi, MI 48377
DRAWING REVISION NO.:	A3
ISSUED HEREWITH:	
SPECIFICATION SECTIONS:	01 23 00, 23 05 46, 23 09 00, 23 22 13, 23 31 13, 23 82 00
SKETCHES:	None
SHEETS:	LS101, A101, A201, F101, MD101, M101, M102, M103, M105, M106, M107, M201, M501, M502, M601, M602, M901, E001, ED101, E102, TC101
DISTRIBUTION:	Allen Gigliotti – Wayne State University

This Addendum, issued to all Bid Set Holders through WSU - Procurement, is a part of the Contract Documents, and modifies the previously issued Bidding Documents. Acknowledge receipt of this Addendum in the space provided on the Bid form; failure to do so may result in rejection of the Bid.

ITEM NO. 1:
Specification 01 23 00 – Alternates (reissued)
1. Revised alternate numbers.

ITEM NO. 2:
Specification 23 05 46 – Sound and Vibration Control for HVAC (reissued)
1. Revised acoustic duct liner materials and requirements.

ITEM NO. 3:
Specification 23 09 00 – Instrumentation and Control for HVAC (reissued)
1. Added requirement for integration of new HVAC control system into existing BMS.
2. Revised controls manufacturer list.
3. Revised HVAC unit controls and system features.

ITEM NO. 4:
Specification 23 22 13 – Steam and Condensate Piping (reissued)
1. Revised manufacturer list.

ITEM NO. 5:
Specification 23 31 13 – Metal Ducts (reissued)
1. Revised duct testing section to clarify relief ducts are part of testing.
2. Removed unedited bracket information.

ITEM NO. 6:
Specification 23 74 43 – Packaged Indoor Heating and cooling Units (deleted)
1. Removed specification from set of specifications. Unit will be purchased directly by WSU and the purchasing of the unit is not the responsibility of the contractor.

ITEM NO. 7:
Specification 23 82 00 – Hydronic Unit Heaters (added)
1. Added specification section for Hydronic Unit Heaters.

ITEM NO. 8:
Sheet LS101 Second Floor Life Safety Plan (reissued)
1. Add Wayne State University Standards references.

ITEM NO. 9:
Sheet A101 Second Floor Plan (reissued)
1. Revise note in Bathroom Sill Detail 3 to reflect existing ductwork abandoned in place.
2. Add keynote #20 to cap existing floor registers in Men's Restroom 202.

ITEM NO. 10:
Sheet A201 Wall Types & Door Schedule (reissued)
1. Revise door panel height to 7'-6" at doors adjacent to corridor to match existing door height.

ITEM NO. 11:
Sheet F101 Fire Protection Plans and Details (reissued)
1. Revise spelling in New Wet Sprinkler and Domestic Water Service Detail.
2. Revise note #6 to clarify firestop penetration locations.
3. Delete note #13 because it was a duplicate note.

ITEM NO. 12:
Sheet MD101 Basement and Mezzanine Level Mechanical Demolition Plans (reissued)
1. Revise ductwork to be shown abandoned instead of demolished.
2. Revise keynotes to describe abandoning of ductwork.

ITEM NO. 13:
Sheet M101 Basement Hydronic Heating Piping Replacement Plan (reissued)
1. Revise drawing to show all hydronic piping to be replaced.
2. Add keynotes to clarify extent of hydronic piping replacement on each floor.
3. Add general notes for additional information on wall and chase removal.

ITEM NO. 14:
Sheet M102 First Floor and Mezzanine Hydronic Heating Piping Replacement Plan (reissued)
1. Revise drawing to show all hydronic piping to be replaced.
2. Add keynotes to clarify extent of hydronic piping replacement on each floor.
3. Add general notes for additional information on wall and chase removal.

ITEM NO. 15:
Sheet M103 Second and Third Floor Hydronic Heating Piping Replacement Plan (reissued)
1. Revise plan titles to show the correct base Bid and alternate number.
2. Revise drawing to show all hydronic piping to be replaced.
3. Add keynotes to clarify extent of hydronic piping replacement on each floor.
4. Add general notes for additional information on wall and chase removal.

ITEM NO. 16:
Sheet M105 Mezzanine and Second Floor Mechanical Plans (reissued)
1. Revise keynotes with additional information.
2. Revise size of diffuser run-out ductwork to 8 inches in some locations.
3. Revise mezzanine level ductwork to show existing ductwork as abandoned, not demolished.
4. Remove check valves from CWS and CWR piping.

ITEM NO. 17:
Sheet M106 Third Floor Mechanical Plans (reissued)
1. Revise keynotes with additional information.
2. Add hydronic unit heater and piping to Mechanical Room.

ITEM NO. 18:
Sheet M107 Roof Level Mechanical Plans (reissued)
1. Remove note about third party responsibility for rooftop supports, detail added to M501.

ITEM NO. 19:
Sheet M201 Mechanical Sections (reissued)
1. Revised model for outside air intake hood.
2. Added dimension for intake hood height above roof.

ITEM NO. 20:
Sheet M501 Mechanical Details (reissued)
1. Remove rooftop equipment support details and replaced with new support detail.
2. Reorganize details.

ITEM NO. 21:
Sheet M502 Mechanical Details (added)
1. Add additional detail sheet.

ITEM NO. 22:
Sheet M601 Mechanical Control Diagram (reissued)
1. Replace HVAC-1 control diagram and replaced with new.

ITEM NO. 23:
Sheet M602 Mechanical Control Diagram (reissued)
1. Revise condensing water system sequence of operation.
2. Revise condensing water flow diagram.

ITEM NO. 24:
Sheet M901 Mechanical Schedules (reissued)
1. Revise various schedule information.
2. Add Unit Heater schedule.

ITEM NO. 25:
Sheet E001 Legends and General Notes (reissued)
1. Revise Luminaire Schedule adding remarks for 4000K CCT for all LED fixtures.

ITEM NO. 26:
Sheet ED101 Electrical Demolition Plans (reissued)
1. Three existing data outlets to be demolished on the Second Floor.

ITEM NO. 27:
Sheet E102 Second Floor Electrical Plans (reissued)
1. Revise keynote #2 to provide part number for new power poles.
2. Revise keynote #5 adding conduit size for the data sleeve.
3. Show location of wireless access points and keynote 10 for requirement.
4. Data cabling for security cameras is base bid. Furnishing and installation of security cameras is an alternate to the base bid.
5. All data outlets and cables to be new.
6. Add keynote 11 for Card Reader requirement.

ITEM NO. 28:
Sheet TC101 Communication Legend and Details (reissued)
1. Add detail for IDF Room 305.
2. Add part number for data jack to be used.

END OF ADDENDUM

SECTION 01 23 00 – ALTERNATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including Owner's Division 00, General and Supplementary Conditions, and Division 01 Specification Sections, apply to this Section.

B. Division 01 provisions of the Construction Specification, and the Construction Drawings, apply to this Section.

1.2 SUMMARY

A. This Section identifies each alternate and describes the basic changes to be incorporated into the Work, only when that alternate is made a part of the Work by specific provisions of the Contract Documents.

1.3 SCHEDULE OF ALTERNATES

A. Alternate 1:
   1. Basement HHW piping replacement.
   2. First floor HHW piping replacement.

B. Alternate 2:
   1. Third floor HHW piping replacement.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION 01 23 00

SECTION 23 05 46 – SOUND AND VIBRATION CONTROL FOR HVAC

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. This Section includes the furnishing and installation of all equipment for and related items incidental to isolation and attenuation of mechanical vibration and sound:
   1. Major Items:
      a. Isolate mechanical rotating or vibrating equipment with vibration isolators.
      b. Connect ductwork and piping to equipment by means of flexible connections.
      c. Install mechanical equipment, piping and ductwork on, or suspended from, approved and specified foundations or supports.
   2. All vibration isolation devices shall be furnished by a single Manufacturer.

B. Division of Work: In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
   1. General Contractor: Provide concrete equipment pads.
   2. Mechanical Subcontractor:
      a. Provide miscellaneous structural steel necessary for support of mechanical work.
      b. Coordinate necessary alterations in structural steel.

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ASC - Adhesive and Sealant Council: A-7001C - Adhesives for Duct Liner.
   2. ASHRAE - 2015 Handbook - Table 47 of Chapter 48 - "Selection Guide for Vibration Isolation".
   3. ASTM:
      a. C423 - Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
      b. C665 - Specification for Mineral Fiber Blanket Thermal Insulation.
      c. C916 - Specification for Adhesives for Duct Thermal Insulation.
      d. C1071 - Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
      e. E84 - Test Method for Surface Burning Characteristics of Building Materials.
      f. E90 - Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.
      g. E477 - Test Method for Measuring Acoustical and Air Flow Performance of Duct Liner Materials and Prefabricated Silencers.
      h. G21 - Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
      i. G22 - Practice for Determining Resistance of Plastics to Bacteria.
   4. NAIMA - North American Insulation Manufacturers Association: Fibrous Glass Duct Liner Standard.
   5. NFPA Standard:
      a. 90A - Installation of Air Conditioning and Ventilating Systems.
      b. 255 - Surface Burning Characteristics of Building Materials.
   6. SMACNA: HVAC Duct Construction Standards - Metal and Flexible.
   7. UL: 181 - Factory-Made Air Ducts and Air Connectors.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. The isolation materials Manufacturer shall be responsible for the proper selection of isolators to achieve the specified minimum static deflections, for all isolators, based on the actual weight distribution of equipment to be isolated.

B. The isolation materials Manufacturer shall be responsible for the structural design of steel beam bases and concrete inertia bases, to support mechanical equipment scheduled to receive such supplementary bases.

C. Be responsible for verifying the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this Specification. All additional equipment needed to meet the intent of this Specification, even if not specifically mentioned herein or in the Contract Documents, shall be supplied by the Contractor without claim for additional payment.

D. Sealing of Penetrations: Designated building structures designed to isolate air-borne noise surrounding all critical and noisy spaces. Proper routing of and sealing or lagging (enclosure), or both, around mechanical services penetrating these structures are necessary to maintain the integrity of the isolating structure.

1.5 NOISE CRITICAL SPACES

A. Areas of this building require special attention (special acoustical provisions and restrictions) to the allowed background noise levels. The following areas are designated as “noise-critical” spaces:
   1. Mechanical Rooms.

B. Noise-critical walls are [indicated on the architectural Drawings] [all walls enclosing the above spaces], and include spaces that contain noise producing equipment in addition to the “noise-critical” spaces listed above. Noise-critical slabs are those slabs (and all associated isolated ceilings or floating floor slabs) that are above and below rooms enclosed by noise critical walls.

C. Penetrations of noise critical walls and slabs by ducts, pipes, and conduit shall be sleeved, packed, and sealed airtight with non-hardening sealant as described in Division 23 Section “Penetrations for HVAC.”

1.6 SUBMITTALS

A. Manufacturer's Literature: For all products described under Part 2 of these Specifications.
   1. General:
      a. Dimensions.
      b. Construction details.
      c. Manufacturer's name.
      d. Model number.
   2. Spring Isolators:
      a. Rated deflection.
      b. Spring constant.
      c. Model number.
      d. Type of isolator.
      e. Size.
      f. Height when uncompressed and maximum allowed static deflection.
      g. Isolator location shown on an outline of the isolated equipment.
      h. Detail drawings of inertia bases isolators.
      i. Location of isolators on plan drawings of the isolated area, where applicable.
      j. The weight of all isolated equipment, and the loads on each isolator and the static deflection of each isolator under the specific design load shall be listed along with the proposed isolators.
      k. Pipe isolators shall be shown and identified on piping layout Drawings.

B. Furnish a complete set of approved Shop Drawings of all mechanical and electrical equipment to receive vibration isolation devices to the vibration isolation materials Manufacturer, based upon the selection of vibration isolators and design of supplementary bases will be completed. The Shop Drawings to be furnished shall include operating weights of the equipment to be isolated and the distribution of weight at support points.

1.7 QUALITY ASSURANCE

A. Fabrication and Installation Personnel Qualifications:
   1. Trained and experienced in the fabrication and installation of the materials and equipment.
   2. Knowledgeable of the design and the reviewed Shop Drawings.

B. Manufacturer or Qualified Representative Services:
   1. Provide necessary field supervision.
   2. Ensure correct installation and adjustment.

C. Regulatory Agencies Requirements:
   1. Comply with all state and local codes and ordinances.
   2. Insulation, facing, and adhesive shall have a composite rating:
      a. 25 flame spread maximum.
      b. 50 smoke developed maximum.
      c. In accordance with NFPA 255.
   3. Installation of acoustic duct liner shall be in accordance with:
      a. SMACNA - HVAC Duct Construction Standards - Metal and Flexible:
         1) Acoustical Liner Installation Standards.
         2) Mechanical Fastener Standard.
      b. NAIMA - Fibrous Glass Duct Liner Standards.

1.8 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered in original, unbroken, brand marked containers or wrapping as applicable.

B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.

C. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Flexible Duct Connectors:
   1. Ventfabrics; "Ventglas and Ventsil".
   2. Duro Dyne; "Neoprene".

B. Vibration Control: All vibration control apparatus shall be provided by a single Manufacturer except as specifically noted herein:
   1. Amber-Booth.
   2. Mason Industries, Inc.
   3. Vibron.
   4. Kinetics.

C. Vibration Isolation Curbs:
   1. Pate.
   2. Kinetics.
   3. Mason.

D. Acoustic Duct Liner:
   1. Armacell AP Coilflex closed-cell elastomeric acoustical duct liner.
   2. Equivalent by Johns Manville.
   3. Equivalent by Knauf.

E. Acoustic Duct Liner Adhesives:
   1. Foster Products.
   2. Baldwin-Ehret-Hill.
   3. Armstrong.
   4. Goodloe E. Moore.
   5. Precision Adhesive, Inc.
   6. Mon-Eco Industries, Inc.
   7. Johns Manville.

2.2 MATERIALS

A. Acoustic Duct Liner:
   1. Shall only be used where noted on Drawings.
   2. Elastomeric closed-cell duct liner, fiber free.
   3. Density: 1.9 pounds/cubic foot.
   4. Thickness: 1-inch.
   5. Thermal Conductance (c): 0.25 at 75 degrees F mean temperature.
   6. Acoustical Performance:

Minimum Sound Absorption Coefficients at Octave Band Center Frequencies (Hz)						
125	250	500	1,000	2,000	4,000	NRC
0.08	0.22	1.03	0.37	0.68	0.50	0.52

   7. Facing:
      a. Factory-applied black acrylic coating.
      b. Fire-Resistant:
         1) Comply with NFPA 90A.
         2) UL listed.
         3) 25 flame spread and 50 smoke developed rating.
      c. Rated for velocities at 10,000 fpm tested in accordance with UL 181 without wearing of the surface or entrainment of glass fibers into air stream.
      d. Designed to minimize friction loss.
      e. The insulation must be resistant to microbial growth as determined by:
         1) UL 181: Mold Growth and Humidity Test.
         2) ASTM C1071: Fungi Resistance Test.
         3) ASTM G21: Synthetic Material Fungi Resistance Test.
         4) ASTM G22: Synthetic Material Bacteria Resistance Test.
   8. Use Johns Manville “Permacote Superseal” for edge coating and in areas requiring repair.

B. Duct Liner Fasteners:
   1. Mechanically Secured:
      a. 12-gage galvanized steel.
      b. Impact-driven into duct.
      c. Form positive mechanical attachment to sheet metal.
      d. Fastener shall not compress the insulation more than 1/8-inch.
   2. Weld-Secured:
      a. Attached to Duct by:
         1) Resistance welding.
         2) Capacitance discharge welding.
      b. Fastener Head:
         1) 0.075 square inch minimum area.
         2) 0.01-inch minimum thickness.
         3) Cupped or beveled.
         4) Shall not compress the insulation more than 1/8-inch.

C. Acoustic Duct Liner Adhesives:
   1. As recommended by Manufacturer of insulation.
   2. Solvent or water-based.
   3. Fire-resistant: 25 flame spread and 50 smoke developed rating.
   4. Comply with ASTM C916.

2.3 VIBRATION ISOLATION EQUIPMENT

A. Flexible Duct Connectors:
   1. Flexible sleeves for duct connections shall be fabricated from flexible, airtight, coated fabric. Each sleeve shall be installed with at least 3 inches (75 mm) slack across a clear metal to metal gap of at least 4 inches (100 mm). That is, 7 inches (175 mm) of this fabric is required for each sleeve.
   2. Standard Temperature Type:
      a. Glass fabric, double coated with polychloroprene.
      b. Coated Fabric Weight: 30 ounces per square yard.
      c. Thickness: 0.024 inches.
      d. Temperature Range: -20 to 200 degrees F.
      e. Tensile Strength:
         1) 480 pounds per inch warp.
         2) 360 pounds per inch fill.
      f. Abrasion Resistance: 600 cycles.

B. Vibration Isolation Curb:
   1. Isolation assembly shall consist of extruded aluminum upper and lower members incorporating cadmium plated steel springs with 1-inch static deflection and insuring uniform deflection for the entire system.
   2. Spring diameter shall be equal to or greater than the loaded spring height and shall be equal to 50% of the rated deflection.
   3. A continuous flexible waterproof seal shall be riveted to both upper and lower members. Assembly shall include both upper and lower gasket material.

C. Spring Isolators:
   1. Isolator Type CSNM:
      a. Type CSNM (constrained spring and neoprene mounts) shall be a spring and neoprene mount that incorporates a housing which includes vertical limit stops to prevent spring expansion when weight (water or other fluid) is removed from the equipment and limits the movement of equipment when it is subjected to wind loading. A minimum clearance of 1-inch (25 mm) shall be maintained around restraining bolts and between the housing and the spring, so as not to interfere with the spring operation. Limit stops shall be out of contact during normal operation, backed away from contact by at least 1/2-inch (12 mm); a neoprene washer shall be installed beneath the bolt head/washer used to restrain the isolator. In outdoor rooftop installations isolators must be bolted to the roof or supporting structure with a neoprene mounting sleeve.
      b. Unless otherwise specified, the minimum static deflection for Type CSNM mounts shall be 2 inches (50 mm).
      c. Type CSNM: Mason Industries Type SLR; or as pre-approved by Engineer.

D. Neoprene Mounting Sleeves: Neoprene mounting sleeves for hold-down applications of equipment with vibration isolators shall be Uniroyal Type 620/660; or as pre-approved by Engineer.

E. Pipe Flexible Connectors:
   1. Isolator type PFC (pipe flexible connectors) shall be Kevlar-reinforced neoprene, single or double-sphere design. Flexible connectors with control rods will not be permitted.
   2. Type PFC: Mason Industries “Safelex” Type SFEJ or SFDEJ; or as approved by Engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. Unless otherwise indicated, all equipment mounted on vibration isolators shall have a minimum operating clearance of 2 inches (50 mm) between the bottom of the equipment or inertia base (and height-saving bracket) and the concrete housekeeping pad (or bolt heads, whichever is closest) beneath the equipment. The clearance shall be checked to ensure that no scraps have been left to short-circuit the vibration isolators. There shall be a minimum 4-inch (100 mm) clearance between isolated equipment and the walls, ceiling, floors, columns, and any other equipment not installed on vibration isolators.

B. Piping, ductwork, conduit or mechanical equipment shall not be hung from or supported on other equipment, pipes, or ductwork installed on vibration isolators. It shall be supported on or suspended from building structure.

C. Equipment connected to fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping. Equipment should be blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims, and confirm that the isolators for the fluid-filled pipes, pumps, and other elements deflect the specified amounts and no more.

D. All mechanical equipment not specifically identified in this Specification that contains rotating or vibrating elements, and all associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or RBA neoprene isolators as appropriate. In all such instances, submit the proposed isolators with the isolator Shop Drawings.

E. All isolators that are to be installed outdoors or exposed to the weather shall be hot-dipped galvanized and shall be furnished with neoprene mounting sleeves for hold-down bolts to prevent any metal-to-metal contact.

F. Elastomeric isolators that will be exposed to temperatures below 32 degrees F (0 degrees C), shall be fabricated from natural rubber instead of neoprene.

G. Wiring:
   1. All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with a minimum 36-inch (1 m) long flexible conduit in a 360-degree loop.
   2. All ties used to form the loop shall be removed prior to adjusting the isolators.

3.2 FAN ISOLATION

A. General:
   1. Fans in air handlers shall be mounted on vibration isolators as described herein.
   2. Fans in air handling units shall be leveled with the fans operating before the flexible connectors are attached.
   3. All fan bases and isolators shall be sized so that thrust restraints (which would act against turning moment caused by static pressure) are not required.
   4. Fan plenums, air mixing plenums, and package air handler plenums shall be installed on a 4-inch (100 mm) high reinforced concrete housekeeping pad, and with a continuous Type WP neoprene isolator at the entire perimeter of the base.

B. Roof-Mounted Equipment:
   1. Roof-mounted condensing units, packaged air-conditioning units, and fans shall be installed on rooftop isolation curbs using Type CSNM isolators.
   2. All hardware must be plated or galvanized to provide a rust-resistant finish. Weather-proofing shall be provided by a continuous flexible seal.
   3. All springs shall have removable waterproof covers to allow for adjustment or replacement of the springs.

3.3 SHEET METAL DUCTWORK

A. Duct Isolation: Ducts shall be connected to fans, fan casings, and fan plenums by means of flexible connectors. Flexible duct connectors shall not be used outside the mechanical room in systems serving noise-critical spaces unless expressly indicated on the Drawings.

B. Ductwork Fabrication: Fabricate ductwork so as to be free from vibration, rattle, or drumming under all operating conditions; provide all materials necessary for specified construction, whether or not they are specifically called for or detailed on the Drawings.

C. Bracing of Ductwork: Do not install tie rods inside ducts.

D. Ductwork Wall Penetrations: Seal around ductwork wall penetrations as specified in Division 23 Section "Penetrations for HVAC."

3.4 MISCELLANEOUS EQUIPMENT

A. Chiller: Each chiller shall rest on Type MWP neoprene sandwich pads on a 4-inch concrete housekeeping pad. All piping and conduit connections shall be isolated with flexible connectors and supported with Type DDNH isolators.

B. Flexible Duct Connectors:
   1. Install at duct connections to air moving equipment.
   2. Install at locations indicated on Drawings.

C. Transfer Silencers:
   1. Install at all locations as indicated on Drawings.
   2. Seal around transfer silencer wall penetrations as specified in Division 23 Section "Penetrations for HVAC."

3.5 ACOUSTIC LINING OF DUCTS

A. Application:
   1. Ducts, where noted on the Drawings, shall be acoustically lined internally:
      a. All ductwork used exclusively to transfer air connected to one room to another.
      b. Where indicated on the Drawings.

B. Thickness:
   1. Lining shall be 2 inches (50 mm) or as indicated on the Drawings.

C. Installation:
   1. The acoustic liner shall be fixed to the duct with a minimum of 50% coverage of a fire-resistant adhesive. All perimeter acoustic liner edges shall be coated with adhesive.
   2. Where the duct width exceeds 12 inches (300 mm) or a height of 24 inches (600 mm), the liner shall be additionally secured with mechanical fastening on maximum 16-inch (400 mm) centers, and no more than 3 inches from ductwork edges or insulation joints.
   3. Mechanical fasteners that pierce the duct are unacceptable.
   4. All portions of duct specified to receive acoustic liner shall be completely covered.
      a. Transverse joints shall be neatly butted and there shall be no interruption or gaps.
      b. All transverse edges are to be 100% covered with Manufacturer-supplied edge coating.
      c. Cut liner to ensure tight corner joints.
      d. All corner joints are to be either lapped and butted, or folded.
      e. Black coated surface is to face air stream.
   5. Acoustic liner shall be 100% covered with Manufacturer supplied coating at all exposed surfaces, edges, and transverse joints.
   6. Where acoustic duct lining is installed, the dimensions of the sheet metal shall be increased to include the thickness of the lining material. Dimensions indicated on the Drawings are the net clear internal dimensions after the acoustic liner has been installed.
   7. Exposed and leading edges will be covered with metal nosing around the entire perimeter.

3.6 FIELD QUALITY

A. Work in accord with best trade practices, fabricate and install all items in accordance with Manufacturer's recommendations and Engineer's directions, and consult with trades doing adjoining work in order to provide an installation of first class quality.

3.7 ADJUSTMENT AND TESTING

A. Vibration Isolation Report:
   1. The vibration isolation Manufacturer shall inspect and approve the installation of the vibration isolators and shall submit a report to Engineer which verifies that all of the isolation equipment has been properly installed and that the installation is in full conformance with the Specification.
   2. The report shall record the model or type of each isolator.
   3. For isolators containing steel springs, the report shall also record the size and uncompressed height, design static deflection, and measured static deflection of the isolators provided.

B. Site Access: During installation of equipment, arrange for access as necessary for inspection of isolation and noise control equipment by Engineer.

END OF SECTION 23 05 46

SECTION 23 09 00 – INSTRUMENTATION AND CONTROL FOR HVAC

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. This Section includes the design, furnishing and installation of HVAC instrumentation and controls (HI&C) systems:
   1. The Work of this Section also includes the integration of the Work of other trades as necessary to provide a complete operational control system as defined in the Contract Documents.

B. Major items unique to the work of this Section:
   1. Direct digital control (DDC) hardware.
   2. DDC software.
   3. All remote sensing devices and interconnecting wiring or tubing.
   4. All secondary control devices including, but not necessarily limited to, the following:
      a. Thermostats and humidistats.
      b. Temperature and humidity sensors.
      c. Primary and secondary controllers.
      d. Automatic valves and dampers.
      e. Damper and valve operators.
      f. Relays.
      g. Control panels.
      h. Operator interface.
      i. Network devices.
      j. Miscellaneous sensors.
   5. Electric power supply source.
   6. Conductor and conduit.
   7. Necessary appurtenances to make a complete and functional system to satisfy the functional intent.
   8. Final and complete operational demonstration.
   9. BMS/SCADA interface, integration devices and programming.

C. Mechanical systems included in the Work of this Section:
   1. Except as specifically described below, it is the work of this Section to provide, install and integrate complete control of the HVAC systems, including, but not limited to the following:
      a. Primary heating
      b. Condensing water system controls.
      c. Air handling unit controls.
      d. Terminal unit controls.
      e. Ventilation system controls.

D. Integration:
   1. Provide communication interface and network integration for the following packaged control systems furnished under the Work of other Sections:
      a. Package HVAC units as specified in Division 23 Section “Packaged, Indoor Heating and Cooling Units.”
      b. Variable air volume boxes as specified in Division 23 Section “Air Terminal Units.”
      c. Smoke detectors in ductwork and air handling units.
   2. Existing Control Equipment:
      a. Provide for interface between new controls installation and Owner's existing Siemens control and building management systems:
         1) As required to satisfy the functional intent description of this Section.
      b. All existing equipment is assumed to be fully functional and in proper working order as it relates to the work of this Section for Base Bid.

1.3 DIVISION OF WORK

A. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades.

B. The integration of new controls into the Owner's existing Siemens building management system shall be performed by the Siemens corporate office. Third party installation is not acceptable.

C. The following are suggestions as to how the Work may be divided. This is not intended to be a complete list of all the Work:
   1. Mechanical Subcontractor:
      a. Install automatic valves and separable wells that are specified to be supplied by HI&C Subcontractor.
      b. Provide all necessary valved pressure taps, steam, water drain and overflow connections and piping.
      c. Provide all necessary piping connections required for flow devices, valve position indicators, flow switches, etc.
      d. Install all automatic dampers unless furnished as a factory mounted item with HVAC equipment.
      e. Provide all necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
      f. Assemble multiple section dampers with the required interconnecting linkages and extend required number of shafts through ductwork for external mounting of damper motors.
      g. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation and seal permanently in place only after all stratification problems have been eliminated.
      h. Provide access doors or other approved means of access through ducts for service to control equipment.
      i. Mount duct smoke detectors.
   2. Electrical Subcontractor:
      a. Provide conduit, conductors, and wire for all 120 volt or higher devices which interlock equipment provided under Division 23 with equipment and devices provided under other Divisions of the Specifications as indicated on Electrical Drawings and Division 26 Specifications.
      b. Provide power to DDC panels as indicated on the Drawings.
      c. Furnish smoke detectors.
      d. Furnish power and control wiring of duct smoke detectors. Termination by HI&C Subcontractor.
      e. Provide devices, conduit and wiring as indicated on Electrical Drawings.
   3. HI&C Subcontractor:
      a. Be responsible for controls systems operation in accordance with sequence of operations description defined in Division 23 Section "Sequences of Operation for HVAC."
      b. Furnish all automatic dampers, valves, operators and linkages.
      c. Provide a detailed schedule for the Mechanical Subcontractor of all automatic dampers and valves requiring their assembly or installation as suggested above.
      d. Provide 120 volt and low voltage power to all valve/damper motors requiring same.
      e. Wire all 120 volt flow, pressure and temperature sensing devices.
      f. Coordinate with Electrical Subcontractor for smoke detector interface compatibility and functional intent.
      g. Make final terminations to controlled components, including terminations from smoke detectors.
      h. Provide conductors and conduit, including low voltage and 120 volt, as required to provide functional intent, except as specifically indicated otherwise on Drawings or in the specifications.
      i. Provide all interface devices necessary for required communication to other systems.
      j. Provide for power supply for all DDC panels that are required that are in addition to those indicated on the Drawings.
      k. Support Commissioning Authority in functional performance testing in accordance with the requirements of Division 23 Section "Commissioning of HVAC."
      l. Provide certification to Commissioning Authority of complete control system function and calibration.
   4. Commissioning Authority (CxA): Provide verification of system function in conformance with design intent, including selected sensor calibration.

1.4 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the Work of this Section shall comply with the following:
   1. ANSI - American National Standards Institute:
      a. ANSI/ISA S5.1 - 1984 - Instrumentation Symbols and Identification (Joint Standard with ISA - Instrument Society of America).
      b. ANSI X3.4 (ASCII).
      c. ANSI/ASHRAE Standard 135 - BACNet.
      d. ANSI/EIA Standard 709 - Control Network Protocol Specification (LONWorks).
   2. EIA - Electronic Industry Association: EIA Standard RS-232-C.
   3. NFPA – National Fire Protection Association:
      a. 70 – National Electrical Code.
      b. 90A – Standard for the Installation of Air-Conditioning and Ventilation Systems.

1.5 DEFINITIONS

A. Where applicable, the terminology used herein uses the definitions listed in ASHRAE Standard 13.

B. Other definitions used include:
   1. Low Voltage:
      a. Voltage less than 120V single phase, typically 24V AC.
      b. Low voltage is used primarily for communication and control of devices.
   2. Large Valves: Valves for piping greater than 2 inches in diameter.
   3. Large Dampers: Greater than 133-inch/pound torque required or 30 square feet.
   4. DDC: Direct digital controls.
   5. IP: Internet protocol.
   6. LAN: Local area network.
   7. HVAC: Heating, ventilating and air conditioning systems. Generally, the work of Division 23.
   8. Primary Controller: A device that includes IP to field bus router, automatic time scheduling, trend logging, alarm handling, and supervisory logic control functionality. Sometimes referred to as a Building Controller.
   9. Secondary Controller:
      a. Advanced Application Controller: A controller with provisions and the control logic for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air-handling unit, chiller or boiler. An Advanced Application Controller may or may not have data management features such as time schedules, trend data storage and alarm message generation capabilities. These features may be provided by the Building Controller.
      b. Application Specific Device or Controller: A sensor, controller, or end device that is pre-programmed by the vendor. It may have physical inputs and physical outputs. The control logic, while not programmable, may be configurable through the use of configuration parameters. The application may require input network variables and may send output network variables onto the network.
   10. Control Logic Diagram: A graphical representation of control logic for the multiple processes that make up a system. Logic symbols are used to represent:
      a. Input/Output (I/O) data.
      b. Control functions such as PID, two-position control, switches, etc.
      c. Math functions such as addition, subtraction, multiplication, division, etc.
      d. Boolean functions such as greater than, less than, equal to, etc.
      e. Limit functions such as maximum, minimum, ramps, etc.

11. Enterprise Level Data Manager (ELDM): A logic only device (controller without I/O) that is installed on the building LAN as the first node beneath the IP router. This device shall be programmable and be from the same Manufacturer that provides the enterprise level server and operator workstation software. The enterprise level data manager may be multiple identical devices installed on the building LAN in series in order to have sufficient capacity to support the building level controls. The enterprise level data manager may be combined in a single device with the IP router. The enterprise data manager serves 3 functions:
    a. Time Schedules: Time schedule algorithms shall reside in the enterprise level data manager. Occupancy/energize commands shall be broadcast to the building level controllers in the number required by the sequence of control.
    b. Trend Data Storage: The enterprise level data manager shall collect data from the building level controls at specified intervals and store the data for periodic uploading to the server. Polling communication techniques are acceptable for data collection by the data manager.
    c. Alarm Generation: The enterprise level data manager shall receive binary alarm variables from the building level controllers and transmit this data to the alarm handling software module within the server and operator work stations. Receipt of alarm data from the building level controls shall be based on broadcasting from the building level controls and not based on polling by the enterprise level data manager.
12. JACE: Java Control Engine. A term used within the Niagara Framework to describe a enterprise level data manager:
13. Managed Communication: The transmission of data from a controller to a data manager, which in turn rebroadcasts the data to a second controller. The data manager may be referred to a network controller
14. Peer to Peer Communication: Data is broadcast from its origin and is received by the final device requiring the data without being received and retransmitted by a third device.
15. Standalone Controller: A standalone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A standalone controller will also have data management features such as time schedules, trend data storage and alarm message generation capabilities.
16. TCP/IP: Transmission Control Protocol/Internet Protocol. A basic communications protocol in a private network, either an intranet or an extranet.
17. Web Server: A software package installed on a primary/secondary controller or ELDM that provides for operation access to the Enterprise Level system from a computer on the LAN, using only a browser.

1.6 DESIGN AND PERFORMANCE REQUIREMENTS

A. System layout and design responsibility are included as Work of this Section:
    1. Details of construction, quantities, components and accessories indicated on the Drawings and in the Specifications are minimum requirements.
    2. Increases in system component requirements beyond these minimums that are determined by the system designer to be necessary to provide the functional intent and for a complete system shall not be a basis for an increase in cost to Owner.

B. Comply with the following performance requirements:
    1. Graphic Display: Display graphic with minimum 20 dynamic points or as required to display required data.
    2. Graphic Refresh: Update graphic with display with current data within 8 seconds.
    3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
    4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
    5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within 5 seconds of each other.
    6. Program Execution Frequency: Run capability of applications as often as 5 seconds, but selected consistent with mechanical process under control.
    7. Performance: Programmable controllers shall execute DDC/PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
   a. Water Temperature: ±1 degree F (0.5 degree C).
   b. Water Flow: ±5% of full scale.
   c. Water Pressure: ±2% of full scale.
   d. Space Temperature: ±1 degree F (0.5 degree C).
   e. Ducted Air Temperature: ±1 degree F (0.5 degree C).
   f. Outside Air Temperature: ±2 degree F (1.0 degree C).
   g. Dew Point Temperature: ± 3 degree F.
   h. Temperature Differential: Plus or minus 0.25 degree F (0.15 degree C).
   i. Relative Humidity: ± 5%.
   j. Airflow (Pressurized Spaces): ±3% of full scale.
   k. Airflow (Measuring Stations): ±5% of full scale.
   l. Airflow (Terminal): ±10% of full scale.
   m. Air Pressure (Ducts): ±0.1-inch wg (25 Pa).
   n. Carbon Dioxide: ± 50 ppm.
   o. Electrical: ±5% of reading.

1.7 SUBMITTALS

A. Submit the following in accordance with Division 01 Section “Submittal Procedures.”

B. Bid Submittals:
   1. A description of the proposed system, including a schematic diagram showing system architecture and all major components. Indicate all controllers and devices at the LAN layer.
   2. Original Manufacturer's literature for each type of controller, processor and input/output device that is shown on the schematic diagram.
   3. Written verification that specified sequences of operation can be followed and performance requirements met, or a written list of variances required.
   4. Written verification that all accessibility and interoperability requirements will be met, or a written list of variances required.
   5. A specific description of proposed hardware and software expansion capabilities beyond the requirements described herein.
   6. A sample logic schematic for at least 1 system similar to one used in this project.
   7. Installer’s Qualifications: Include certifications, experience of similar projects and other evidence of qualifications for this Work.

C. Submittals Prior to Construction:
   1. A description of the complete system, including a schematic diagram showing system architecture and all major components, cabinets, panels, sensors, controllers, hubs and operated devices, and required cabling between each.
      a. Include any environmental and space requirements for equipment.
      b. Anticipated deviations from performance and response time specified.
      c. A layout drawing indicating locations of controllers and major devices.
   2. Front-End Hardware and Software:
      a. Dimensions and installation requirements.
      b. Equipment and material specification data.
      c. Function/identification labeling.
      d. Clearly mark (in ink) all preprinted information.
   3. Sensors, Controllers, Actuators and Related Devices:
      a. Complete system wiring diagrams and/or piping schematic including motor starters.
      b. Specification sheets on all individual control system components, including rated accuracy of sensors.
      c. Schedule of valves and dampers including size and performance characteristics.
   4. Complete Descriptions of Operation:
      a. Written sequences for software and hard-wired controls.
      b. A sequence of control for each system being controlled. Include the following as a minimum.
         1) Process control sequence for each end device.
         2) Supervisory logic sequence of control for each system.

3) The impact of each global application program on the sequence of control (Example: Demand Control).
4) A list of all physical inputs and outputs associated with each sequence.
5) Within the sequence of control, all application parameters that are to be user adjustable from an operator work station (OWS) shall be annotated with (adj) after the name of the parameter. This shall include setpoints, reset schedule parameters, calibration offsets, timer settings, control loop parameters such as gain, integral time constant, sample rates, differentials, etc.
6) Within the sequence of control, all calculated values that are to be viewable at the OWS shall be annotated with (rpt) after the name.
7) All points that shall be subject to manual control from an operator workstation.
8) A list of all alarm points, a description of the alarm and a description of the alarm criteria.
9) A list of all variables for which historical trending will be applied, the sample rates and any criteria used to start and stop the historical trending.

5. Graphic Pages: Submit a sample graphic page for each type of page described in the specification section of graphic pages.
6. Wiring diagrams.
7. System Schematics: Include systems furnished by others that are integrated into the DDC system.
8. Logic Schematics:
   a. Provide for each system and subsystem a complete logic schematic indicating all inputs, outputs, decisions, etc.
   b. Provide schematic format which includes all of the elements defined above.
   c. Provide a legend for all symbols used.
9. Information of a general, non-project specific nature is not acceptable.
10. Start-up Testing Plan: Submit a start-up testing plan for each unique system.
    a. The purpose of a start-up test is to demonstrate the “completeness” of the physical tasks associated with installation and the physical performance of the components.

D. Submittals After Construction:
1. Start-up Testing Report.
   a. Start-up testing reports shall be submitted on a per system basis.
   b. Start-up testing reports shall be the documented results of the executed start-up testing plans.
2. Operating and Maintenance Instructions: For all system components requiring maintenance include all maintenance information as required in Division 1 Section “Submittal Procedures” in addition to the following:
   a. Descriptive System Information: Include system logic schematics, input/output functions and Sequences of Operation.
   b. Operating Instructions: Include schedules and procedures for starting, stopping, cleaning, protection, testing, adjustments, calibration and replacement of components.
3. As-Built Documentation:
   a. Upon completion of the installation, and prior to acceptance by the Owner's representative, HI&C Contractor shall furnish as-built documentation and should include, but is not limited to the following:
      1) Points list in accordance with processor.
      2) Process flow diagram.
      3) Location plans.
      4) Operating sequences.
   b. All changes to the above submitted drawings, equipment descriptions and operation manuals shall be clearly identified on the as-built documentation.
4. Software:
   a. Submit a copy of all software installed on the servers and workstations.
   b. Submit all licensing information for all software installed on the servers and workstations.
   c. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
   d. Submit all licensing information for all of the software used to execute the project.
   e. All software revisions shall be as installed at the time of the system acceptance.

5. Firmware Files:
   a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
      1) This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
   b. Submit a copy of all application files that were created during the execution of the project.
   c. Submit a copy of all graphic page files created during the execution of the project.
   d. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.8 QUALITY ASSURANCE

A. Fabrication, Programming and Installation Personnel Qualifications:
   1. Trained and experienced in the fabrication and installation of the materials and equipment.
   2. Knowledgeable of the design and the reviewed Shop Drawings.
   3. 3 years minimum experience in the design and installation of HI&C work similar to that specified herein.
   4. Have a field office within 150 miles of Owner's installation staffed with factory-trained personnel capable of routine maintenance and emergency service.

B. Pre-Approved Installers: The following organizations are acceptable and are considered to meet the qualification requirements of this project:
   1. Siemens Building Technologies, Inc., Grand Rapids, Michigan.

C. Regulatory Agencies Requirements:
   1. All temperature control wiring shall comply with NEC.
   2. All pneumatic piping installation shall comply with all state and local codes and ordinances.
   3. All smoke detectors shall bear the UL label and be FM approved.
   4. All components used for smoke control shall comply with UL864.
   5. All DDC I/O Devices (Specified and Future):
      a. ASCII (American Standard Code for Information Interchange) coded.
      b. Furnished with EIA (Electronic Industries Association) interface hardware.
   6. All instrumentation hardware shall be ISA (Instrument Society of America) compatible.
   7. All primary components of DDC hardware shall be UL listed (UL916).
   8. Installation shall comply with FCC (Federal Communications Commission) rules for Class A and Class B computing devices pursuant to Subpart J of Part 15.
   9. ASHRAE Standard 135, BACnet/IP.
   10. Network wiring shall comply with EIA/TIA Standards.

1.9 WARRANTY

A. In addition to the warranty provisions defined in the General Conditions, provide an extended warranty of a minimum 1 additional year (2 years total).

1.10 SERVICE AGREEMENT

A. Provide 12-month service and maintenance contract paid in full:
   1. Within 30 days after Substantial Completion.
   2. Signed by Manufacturer's authorized representative.

B. Programming and Setpoint Adjustments:
   1. In addition to service and maintenance, include 20 hours for adjustments in setpoints, reset schedules, and sequence revisions as directed by the Owner to "fine tune" control systems to building and occupant characteristics through 1 year of seasonal changes under full operation.
   2. Documentation:
      a. Submit documentation of actual time spent for programming and setpoint adjustments within 30 days after completion of the work for approval by Owner or Engineer.
      b. Time spent for service and maintenance as included above is not part of this allotment and is to be documented separately.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. The Owner shall retain all rights to software for this project.

B. The Owner shall sign a copy of the Manufacturer's standard software and firmware licensing agreement as a condition of this Contract. Such license shall grant use of all programs and application software to the Owner as defined by the Manufacturer's license agreement, but shall protect the Manufacturer's rights to disclosure of trade secrets contained within such software.

C. The licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use only for the purpose of commissioning, servicing or altering the installed system.

D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
   1. Server and workstation software.
   2. Application programming tools.
   3. Configuration tools.
   4. Addressing tools.
   5. Application files.
   6. Configuration files.
   7. Graphic files.
   8. Report files.
   9. Graphic symbol libraries.
   10. All documentation.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. General:
   1. Provide a micro-processor based logic system using low voltage electricity as a communication medium with an open architecture and distributed intelligence.
   2. All controlled components, sensors and controllers shall be addressable except:
      a. Terminal heating units such as unit heaters, cabinet heaters, convectors, finned tube.
      b. Ventilation fan and damper systems serving a single room and moving 1,000 cfm or less.
   3. Provide completely computerized system using low voltage electricity as the operating medium.
   4. System Functions:
      a. Digital operation in accordance with preprogrammed strategies to control temperatures, energy use and selected electrical/mechanical equipment.
      b. Capable of mathematical computation and logical/relational functions as required to achieve specified control strategies.
      c. Capable of off-loading programs and accumulated data to magnetic media and a web browser.
      d. Provide battery-powered RAM devices for program storage.
      e. Continuous self-checking capability.
      f. English language message display for all alarm and fault conditions.

B. Interoperablility:
   1. The system specified herein is a peer-to-peer addressable, standalone distributed control system integrating ANSI/ASHRAE Standard 135 (BACnet) technology and communication protocols in a common interoperable system. The system shall allow future expansion and modifications to the system with complete addressability without the use of proprietary components or software.
   2. All software and intelligent devices shall comply with BACnet standards to provide complete interoperability between all system components.
      a. Each BACnet device shall be furnished with a protocol information conformance statement (PICS) certifying compliance to a minimum of Level 3.
   3. System shall provide complete password-protected accessibility to all devices, controllers and data using Java enabled web browsers without the requirement for proprietary software.

C. System Architecture:
   1. The system architecture shall consist of 2 layers, the LAN layer and the field bus layer.
   2. The TCP/IP layer connects all of the buildings on a single-wide area network (WAN) isolated behind the Owner's firewall. Fixed IP addresses for connections to the Owner's WAN shall be used for each device that connects to the WAN.
   3. Each field bus shall consist of multiple segments with no more than 125 total connected devices. Each segment shall be isolated from the other segments by a repeater. Each segment shall have no more than 30 connected devices.

D. Networking:
   1. All devices that connect to the LAN/WAN shall be capable of operating at 10 megabits per second or 100 megabits per second.
   2. LAN/WAN To Field Bus Routing Devices:
      a. A BACnet Building Controller shall be used to provide this functionality.
      b. These devices shall be configurable locally with RS232 or IP crossover cable and configurable via the LAN/WAN.
      c. The routing configuration shall be such that only data packets from the field bus devices that need to travel over the LAN/WAN level of the architecture are to be forwarded.

2.2 MANUFACTURERS

A. Subject to compliance with interoperability requirements and these Specifications, hardware, software, and components shall be supplied by and bear the name of 1 or more of Manufacturers listed below. Alternate Manufacturers are also listed in this Specification for individual components.

B. Acceptable Manufacturers:
   1. Siemens Building Technologies, Inc.
   2. Honeywell, International, Home & Building Controls.
   3. Johnson Controls, Inc., Controls Group.

C. Stocking Requirements: All valves, operators, standard electrical components, and other replaceable parts shall be normally stocked within a 100 mile radius of the job Site.

D. Electrical Components: Provide electrical components as specified in Division 26 and as manufactured by the acceptable Manufacturers listed therein.

2.3 HARDWARE SYSTEM REQUIREMENTS

A. System Architecture:
   1. Provide hardware comprised of a local building level primary controller and local control modules.
   2. User programmable.
   3. Provide Communication Networks:
      a. Local links for distributed programming, data interchange and control at all system levels.
      b. Web server for remote access through Internet lines to all system functions and levels with firewall.
   4. Standalone capability for local control modules.
   5. Analog Input:
      a. Analog sensing elements for remote indication to be independent of local sensors used for local control loops.
      b. The A/D conversion resolution shall not exceed 0.01 volts per count.
   6. Binary Input:
      a. Air flow status for each fan shall be indicated by means of a differential pressure sensing device which opens an electrical contact as the differential pressure falls below an adjustable pressure range setting.
   7. Output Control:
      a. Provide the necessary relays and wiring required to start and stop points, specified on the point list, through their respective existing control circuit.
      b. Wiring required to complement the following control functions:
         1) Auto: In the auto control, the existing control sequence is not changed.
         2) Close: In the close control, the controlled device is maintained in the fully closed position.

B. System Features:
   1. Modular construction and interoperable protocol to ensure future expansion capability with interconnection of system modules.
   2. Software configurable input and output points.
   3. Expandable Point Capacity:
      a. At any point along the network without hardwiring points back to a central control panel.
      b. Provide a minimum of 10% spare outputs user configurable for digital or analog.
      c. System shall be modularly expandable to at least twice the installed capacity using additional hardware.

C. System Communication:
   1. High Speed LAN and/or WAN Based, Arcnet or Ethernet Compatible: Capacity for a minimum of 2 operator stations, allowing concurrent multiuser, multitasking access to DDC network and control units.
   2. Provide transparent peer-to-peer communication between all control panels.
   3. Support an Internet communication link utilizing standard Internet protocol.

D. Operator Interface:
   1. Provide fully programmable remote web based access capabilities allowing alarm management and setpoint and schedule adjustments.
      a. User interface shall be graphical in accordance with requirements below.
   2. Building Level Processor:
      a. Run and print reports on specific equipment including AHUs and terminal units.
      b. Monitor and edit equipment scheduling parameters.
      c. Receive and monitor alarms.
      d. Exchange data (read and edit) between all the various control panels.
      e. Receive and send data such that, from an off Site work station, all the functions listed under Items a, b, c, and d above, can be performed without the addition of new hardware or software.
   3. At Local Control Modules:
      a. Peer-to-Peer Communications:
         1) Through an operator interface device, such as a laptop, hand held computer or touch pad screen, transparent interfacing to all other control panels shall be achieved such that it shall be as if being connected to the other control panel itself, without having to set up any separate communication services.
         2) Data, status information, reports, system software, custom programs, sensor data, etc., for all controllers shall be available for viewing and editing purposes.
      b. Any Manufacturer's HVAC equipment using BACNet control and communication protocol provided with it, could be installed and connected at any time to the control panel system and transparently provide all sequence of operation controlling points and alarms, as if it came with the central control system's brand name controls on it, without having to add additional equipment.
      c. Additional input and output points can be conveniently added via adding expansion modules.
   4. Application Software (latest versions reside on microcomputer):
      a. Input/output capability from operator station.
      b. System access level via software password.
      c. Database creation and support.
      d. Dynamic color graphic displays.
      e. Alarm processing.
      f. Event processing.
      g. Data collection.
      h. Full building graphics development.
      i. Maintenance management.
      j. Control software.
      k. Report writing.
      l. Trending applications.
      m. Control Manufacturer's internet website server link.
   5. Portable Access Device: Furnish a hand-held control system interface device that will be used during commissioning and will be turned over to Owner upon completion of Project.

E. Primary Controller:
   1. Features:
      a. Building-level control system, with on-board storage of programs and data, and with monitoring capabilities over all points in the building system.
      b. Capable of standalone operation, supervising local control modules without a host computer.
      c. Built-in, password-protected, multi-function keypad/display providing complete access to building-level monitoring and control.
      d. RS-232-C port for connecting an optional ASCII terminal and/or printer to supplement the built-in keypad/display terminal.
      e. Equipped with multiple processors, battery backup of RAM, and a battery backed-up real time clock.
   2. Functions:
      a. Supervise all necessary building and energy management functions programs, including global data distribution (phase/power loss, outdoor temperature, external alarm status), time-of-day scheduling, holiday scheduling, optimized start/stop, duty cycle control, demand control, run time logging, equipment and system alarm monitoring, and self-diagnostics.
      b. Network of local control modules (up to 256 input/output control points).

F. Secondary Controller:
   1. General:
      a. Provide input/output, electronic thermostat, and terminal box controller modules as indicated on the Drawings and as required to satisfy the functional intent description of this Section.
      b. Microprocessor-based with on-board program storage.
      c. Capable of functioning as the input/output interface between the system and the building/equipment environment, providing control and management functions as programmed.
      d. Capable of built-in bi-directional communication capability, over 2-wire cable or Ethernet, with the Primary Processor for programming and reporting functions and for supervision of all control and energy management operations.
      e. Standalone capability to maintain programmed local control functions and operations including direct digital control in the event communications with the Primary Processor are lost.
      f. Equipped with timed override switches to allow programmed off-hours operation.
      g. Provide with LED indicators or LCD display to show schedule status, output status and communication status.
   2. Input/Output Modules:
      a. Capable of the following local control capabilities:
         1) Supervisory and closed loop control.
         2) Setpoint and setback control.
         3) Positioning control.
         4) Proportional reset.
         5) Status monitoring.
         6) Equipment alarms.
         7) Sequencing (staging).
      b. Local parameters and settings shall be monitorable and modifiable through the Primary Processor keypad/display terminal.
      c. Perform energy and building management functions under supervisory control from the Primary Processor.
      d. After initial communication with the Primary Processor, standalone programmed capabilities shall be stored on-board, in memory with 2,000 hour battery backup.
      e. Equipped with 8 inputs and 8 outputs which shall be software configurable as either analog, digital or pulsed digital.
      f. Configuration:
         1) Inputs and outputs shall be surge and spike protected.
         2) Inputs shall employ noise immunity circuits.
         3) Outputs shall employ noise suppression circuits.
         4) Outputs shall be equipped with internal manual/auto selection capability for local maintenance and troubleshooting use.
         5) Provide suitable intermediate devices where the load being controlled exceeds the rating of the output, or uses a different operating medium.

3. Electronic Thermostat Modules:
   a. Provide modules capable of the following:
      1) All necessary programmed functions.
      2) Energy and building management.
      3) Local control and monitoring.
   b. Features Required:
      1) Automatic downloading by Primary Processor.
      2) Standalone operation after initial Primary Processor communication.
      3) RAM memory storage for failsafe, fixed setpoint program items.
      4) Permanent ROM memory storage for failsafe, fixed setpoint program items.
   c. Local control functions include, but are not necessarily limited to:
      1) Cooling sequencing.
      2) Heating sequencing.
      3) Scheduling.
      4) Fan on/off.
      5) Mixed air damper modulation.
      6) Temperature setback.
      7) Optimized start and stop.
      8) Timed override.
   d. Provide for input device signal interface:
      1) Temperature Sensor: 4-20 mA.
      2) Air flow switch.
      3) Override pushbutton.
4. Terminal Box Controller Modules:
   a. Provide modules capable of the following:
      1) All necessary programmed functions.
      2) Energy and building management.
      3) Local control and monitoring.
      4) Integrating Primary Processor functions into local programs.
   b. Features Required:
      1) Automatic downloading by Primary Processor.
      2) Standalone operation after initial Primary Processor communication.
      3) RAM memory storage for failsafe, fixed setpoint program items.
      4) Permanent ROM memory storage for failsafe, fixed setpoint program items.
   c. Local control functions include, but are not necessarily limited to:
      1) Damper positioning.
      2) Fan start/stop.
      3) Reheat coil valve modulation.
      4) Temperature setback.
      5) Timed override.
   d. Provide for input device signal interface:
      1) Temperature Sensor: 4-20 mA.
      2) Air flow switch.
      3) Override pushbutton.

G. HVAC Unit Controls:
1. Provide unit controller modules as indicated on the Drawings and as required to satisfy the functional intent description of this Section.
   a. Microprocessor based with on-board program storage.
   b. Provide communication interface with existing Siemens building management system.
   c. Capable of functioning as the input/output interface between the system and the building/equipment environment, providing control and management functions as programmed.
   d. Capable of built-in bi-directional communication capability, over 2-wire cable, with the Primary Processor for programming and reporting functions and for supervision of all control and energy management operations.
   e. Standalone capability to maintain programmed local control functions and operations including direct digital control, in the event communications with the Primary Processor are lost.
   f. Equipped with timed override switches to allow programmed off hours operation.
2. The HVAC controller shall be capable of monitoring and communicating the following information back to the system control panel:

a. Analog Input Points:
   1) Outdoor air temperature.
   2) Supply air temperature.
   3) Space air temperature.
   4) Return air temperature.
   5) Active setpoint.
   6) Outdoor air relative humidity (%).
   7) Outdoor air damper position.
   8) Return air damper position.
   9) Space carbon dioxide level.
b. Binary Input Points:
   1) Smoke/fire alarm status.
   2) Economizer enable/disable status.
   3) Supply fan on/off status.
   4) Supply fan failure.
   5) Exhaust fan on/off status.
   6) Exhaust fan failure.
   7) Cooling contactor status.

3. The system control panel shall provide the following control functions for each AHU:
   a. Schedule night setup during cooling.
   b. Schedule all AHUs for optimum start and provide a program that automatically adjusts on a daily basis the morning start-up time based on the zone temperature versus the occupied setpoint and the historical recovery rate for each unit.
4. Remote Sensors:
   a. Air Temperature Sensor Quantity:
      1) See location detail on the Drawings.
   b. Each space shall be provided with a temperature sensor.
   c. Sensors shall provide input to the AHU controllers.
   d. Sensors shall be located as indicated on the Drawings.

2.4 SOFTWARE SYSTEM FEATURES

A. The programmable energy and building management functions include, but are not necessarily limited to:
   1. User Setpoint Control:
      a. Time Of Day Scheduling:
         1) Capable of optimally starting based on individual unit recovery ramps.
         2) Time of day scheduling shall be continuous, such that if power is lost, on power up, the panel will look back for each device to see whether it should be on/off or in occupied/unoccupied temperature setpoints.
      b. Space temperature setpoint control.
      c. Space humidity setpoint control.
      d. Space ventilation setpoint control.
      e. Timed Override:
         1) Each scheduled device shall be able to be overridden at the operator work station and space sensor to the occupied mode for up to 4 hours.
         2) The override shall also be cancelable from the operator work station at any time during the override.
   2. System Controller Features:
      a. Temperature reset.
      b. Economizer control (free cooling).
      c. Temperature control.
      d. Terminal box grouping.
      e. Power fail restart sequencing.
      f. PID loop control.
      g. Data logging.
      h. Optimized start/stop.
      i. Event Log: The last 100 events shall be maintained for review at the OWS and remotely.

j. Daylight Savings Time:
   1) The system panel software shall automatically update time according to daylight savings at the legislated time and date, and reset time at the end of the daylight savings period.
   2) This function shall be able to be disabled.

3. Control programs include, but are not necessarily limited to:
   a. Setpoint (closed loop).
   b. Proportional reset.
   c. Sequencing by time and/or temperature.
   d. Limit and status monitoring.
   e. Local emergency overrides.
   f. Local timed schedule overrides.
   g. Outdoor temperature operating limits.
4. Capable of combining functions as required for specific user requirements.

B. User and Programmer Access:
   1. User password protected.
   2. Programmer password protected.

C. Custom Programming:
   1. Provide a user-friendly, interactive, "on-line" programming language for the purpose of creating custom programs for specific, unique applications.
   2. All custom programming must be performed in English language commands, and all inputs, outputs, variables and flags shall be addressable by user specific English names without requiring alphanumeric addresses or point numbers.
   3. The system shall be programmable to allow or secure each of the above setpoint controls at each level.

D. Logs/Alarms:
   1. Provide automatic logging of control alarms, critical alarms, kW demand history and kWh consumption.
   2. Additional logging shall be programmable including, but not limited to:
      a. Equipment run time.
      b. Historic trends and logs.
      c. User defined meters.
      d. User access logs and point scans.
   3. Provide alarm monitoring and reporting capabilities for all input points, including phase loss alarms, external alarms, load control alarms, critical alarms with auto-dial-up feature, alarm summary on printer, including time and date of alarm, and programmable power-failure restart sequence.
   4. Audible Alarms:
      a. Provide audible alarm at building level processor for each alarm condition.
      b. Provide operator silencing. Reset daily.
   5. At Control Panel Systems:
      a. Peer-To-Peer Communications:
         1) Through an operator interface device, such as a laptop, hand held computer or touch pad screen, transparent interfacing to all other control panels shall be achieved such that it shall be as if being connected to the other control panel itself, without having to set up any separate communication services.
         2) Data, status information, reports, system software, custom programs, sensor data, etc., for all controllers shall be available for viewing and editing purposes.
      b. Any Manufacturer's HVAC equipment using BACNet control and communication protocol provided with it, could be installed and connected at any time to the control panel system and transparently provide all sequence of operation controlling points and alarms, as if it came with the central control system's brand name controls on it, without having to add additional equipment.
      c. Additional input and output points can be conveniently added via adding expansion modules.
      d. Run and print trends of selected equipment performance characteristics in table and graph forms.
      e. Run and print reports on specific equipment including AHUs and terminal units.
      f. Monitor and edit equipment scheduling parameters.
      g. Receive and monitor alarms.
      h. Manage the network including monitoring of the loss of communication and clock setting functions.
      i. Exchange data (read and edit) between all the various control panels.

j. Receive and send data such that from another control Manufacturer's PC work station off Site from the primary head end, all the functions listed under Items a, b, c, d, e and f, above, can be performed without the addition of new hardware or software.

E. Program Descriptions:
1. Time-Of-Day Scheduling:
   a. Decrease energy consumption by turning off loads during unoccupied hours or unoccupied days.
   b. Programmable in 1 minute increments.
   c. Up to 64 discrete schedules in accordance with Primary Processor system.
   d. Up to 16 groups of loads (consisting of up to 16 loads each) for concurrent scheduling.
   e. Ability to assign loads to existing alternate schedules by linking.
   f. Timed overrides and temporary "today" and "tomorrow" schedules, for each schedule.
2. Setpoint/Setback Control:
   a. Decrease energy consumption by modifying space temperature setpoints during scheduled unoccupied hours, thereby reducing use of mechanical heating or cooling.
   b. Timed override off hours setpoint operation.
3. Optimized Start/Stop:
   a. Decrease energy consumption by learning building response to changing weather and automatically turning on HVAC as late as possible in the morning and off as early as possible in the evening, while meeting ambient temperature requirements during occupied hours.
   b. Optimized start and stop times updated daily.
4. Holiday Scheduling:
   a. Allow up to 16 holiday periods to be programmed.
   b. Each holiday period programmable for a maximum of 99 consecutive days.
5. Temperature Reset:
   a. Capable of user-defined linear proportional reset functions.
   b. Programmable reset parameters, variables and limits.
   c. Variables programmable as the highest, lowest or average of multiple inputs.
6. Economizer Control (Free Cooling):
   a. Reduce energy consumption by utilizing outside air for cooling:
      1) Enthalpy based.
      2) In lieu of mechanical cooling equipment.
   b. Programmable to operate fan systems during unoccupied hours of the cooling season in the maximum outside air mode.
7. Direct Digital Temperature Control:
   a. Maintain automatic temperature control directly by the local control module microprocessor.
   b. Local module capable of performing all necessary local control functions.
8. Terminal Box Grouping: The DDC shall be able to group VAV boxes via keyboard commands. These terminal unit groups shall make it possible to:
   a. Send a common command to all boxes in a group to operate in the same mode.
   b. Offset heating or cooling setpoints of 1 or more terminal unit groups by an adjustable amount.
   c. Receive and display information on a group basis, including, but not necessarily limited to:
      1) Minimum group temperature.
      2) Maximum group temperature.
      3) Average group temperature.
      4) Current airflow through boxes in group.

2.5 ELECTRICAL DEVICES AND WIRING

A. Comply with all local codes and applicable Sections in Division 26 of these Specifications.

B. Low Voltage Wiring (24V or Less):
1. Installed in a ceiling plenum used for return air shall be plenum rated wire securely fastened in accordance with the requirements of Division 26.
2. Exposed wiring shall be installed in accordance with the requirements of Division 26.

C. Approved Manufacturers:
   1. Siemens.
   2. Allen-Bradley.
   3. GE.
   4. Square D.

D. Limit Switches: Limit switches shall be oil tight type with appropriate operator to provide required function. Limit switches used on dampers should be set at approximately 75% of full stroke.

E. Control Relays and Contactors:
   1. Relays shall be a minimum DPDT, of proper coil voltage, with indicator light, and of sufficient rating for specified purpose. Relay base shall be of the screwed terminal type.
   2. Contactors shall be definite purpose type, have adequate number of poles, of proper coil voltage, and of sufficient rating for specified purpose.

F. Selector Switches:
   1. Switches shall be multiple position type, oil-tight, watertight, dust-tight, have the adequate number of contact blocks, capable of additional contact blocks, and of sufficient rating for specified purpose.
   2. Nomenclature plate shall be provided with appropriate wording, units, etc.

G. Push Buttons and Pilot Lights
   1. Push button switches and pilot lights shall be, oil-tight, watertight, dust-tight, have the adequate number of contact blocks, capable of additional contact blocks, and of sufficient rating for specified purpose.
   2. Nomenclature plate shall be provided with appropriate wording, units, etc.
   3. Pilot lights shall be LED, push-to-test type with replaceable lamps and lens. Lens shall be of the appropriate color for application served.

H. Environment:
   1. All devices shall be of the correct NEMA rating for the environment in which it is installed.
   2. Refer to Electrical Drawings for area classifications.

2.6 ELECTRIC INSTRUMENTS

A. Thermistor Temperature Sensors and Transmitters:
   1. Accuracy: ± 0.5 degrees F (0.3 degrees C) at calibration point.
   2. Wire: Twisted, shielded pair cable.
   3. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sf (0.84 sq. m).
   4. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
   5. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Setpoint Adjustment: Exposed.
      b. Setpoint Indication: Exposed.
      c. Thermometer: Concealed.
   6. Outside Air Sensors: Watertight inlet fitting, shielded from direct sunlight. Provide vandal resistant enclosures where accessible to the public.

B. RTDs and Transmitters:
   1. Accuracy: ±0.2 percent at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
   4. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
   5. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Setpoint Adjustment: Exposed.
      b. Setpoint Indication: Exposed.
      c. Thermometer: Concealed.
   6. Outside Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. Low Temperature Detection:
   1. Provide Electric Thermostat:
      a. With 20-foot sensing element installed in a serpentine manner across the coil face area.
      b. 2-position manual reset type with adjustable differential and of range to match the application.
   2. Provide multiple thermostats wired in series as required to provide complete coil area coverage.
   3. Shut down the unit supply fan upon detection of a low temperature along any 1-foot length of its sensing element.

D. Static Pressure Transducer:
   1. Factory installed and wired in the control box.
   2. The transducer shall have a range of 0 to 5-inch W.G. and shall have an accuracy of ±2% of the range, including nonlinearity and hysteresis.
   3. The static pressure probe shall be field installed 2/3 down the duct or as indicated on the Drawings.

E. Differential Air Pressure Switch:
   1. The differential air pressure switch shall be factory installed across the supply fan inlet and discharge and field wired to the fan relay.
   2. The switch shall be SPDT and shall include a manual reset button.
   3. The switch shall be factory set at 3.0-inch W.G. and shall have the ability of being field adjusted over a range of 1.4-inch to 6.0-inch W.G.

F. Relative Humidity Transmitter:
   1. Polymer film capacitance change type.
   2. Temperature compensated.
   3. Accuracy: ± 2%.
   4. Range: 0 - 100% relative humidity.
   5. Ambient Temperature: 0 - 120 degrees F.
   6. Output Signal: 4 to 20 mA or 0 to 10 VDC, as required.
   7. Manufacturers:
      a. General Eastern Instruments Corporation.
      b. Vaisala, Inc.

G. Dew Point Transmitter:
   1. Saturated salt lithium chloride type.
   2. Accuracy: ±1 degree F.
   3. Range: 12 to 99% relative humidity.
   4. Ambient Temperature: -40 to 140 degrees F.
   5. Input Power: 24 VDC or 115 VAC, as required.
   6. Manufacturers:
      a. General Eastern Instruments Corporation.
      b. Vaisala, Inc.

H. Carbon Dioxide Sensor:
   1. Manufacturer and Model: Johnson Controls, CDS-2000-2; or approved equal.
   2. Description: Carbon dioxide sensor using non-dispersive infrared (NDIR) sensing technology to measure carbon dioxide and provide a 1-10 VDC output signal corresponding to 2-2000 parts per million (ppm) concentration of carbon dioxide.
   3. Components:
      a. Carbon dioxide sensor capable of measuring carbon dioxide concentration in air from 0-2000 ppm.
      b. 24V AC transformer to power carbon dioxide sensor.
      c. Supply air flow filter which inhibits sensing chamber contamination.
      d. 2 front-mount wiring terminals blocks.
   4. Performance Requirements:
      a. Accuracy: ±100 ppm carbon dioxide.
      b. Repeatability: ±20 ppm carbon dioxide.
      c. Drift: ±100 ppm carbon dioxide per year.
      d. Response Time: Less than, or equal to 30 seconds maximum.
      e. Airflow Rate: 500 milliliters per minute at 1.4 psi ±10% through 1/4-inch O.D. tubing.

2.7 GAGES

A. Comply with the requirements of Division 23 Section "Meters and Gages for HVAC Piping."

B. Air Pressure Gages:
   1. Provide 1-1/2-inch diameter gages at all input sensor lines, switch lines, branch side of each controller and at each controlled device.
   2. Stem or surface mounted as required.
   3. Compatible with tubing size.

C. Temperature, Humidity and Pressure Indicators:
   1. Dial type having a minimum diameter of 3-1/2 inches, adjustable calibration, and accuracy of ±1/4% of dial range.
   2. Thermometer ranges to match the range of the transmitter with which used.
   3. Furnish for all transmitters as described in the Functional Intent article of this Section.

D. Alternate Manufacturers: As listed in Division 23 Section "Meters and Gages for HVAC Piping."

2.8 AIRFLOW MEASURING STATIONS

A. Pitot Tube Type:
   1. Manufacturers:
      a. Air Monitor Corporation.
      b. Cambridge Filter Corporation.
   2. Multi-pitot type with output signal based on equal area static pressure sensors.
   3. Accuracy of +2% of air flow quantity.
   4. Designed for direct insertion in the duct system and of a configuration compatible with ductwork at installation point.
   5. Frame constructed of 16 gage minimum galvanized steel.
   6. Device shall include necessary velocity treatment and flow straightening devices to achieve stated accuracy.
   7. Provide permanent nameplate with the following information:
      a. Manufacturer's name and address.
      b. Unit size and serial number.
      c. Design air flow, velocity and direction.

B. Electronic Thermister Type:
   1. Manufacturer: Ebtron.
   2. Hermetically sealed bead in glass thermisters.
   3. 304 stainless steel mounting brackets.
   4. Plenum rated cabling.
   5. Accuracy: ±2% of reading at 0-5000 fpm.
   6. Repeatability: ±0.25% of reading.
   7. 16 character LED display.
   8. Fully temperature compensated.
   9. Equal to Ebtron Gold series.
   10. Interface with central building automation system.
   11. Device shall include necessary velocity treatment and flow straightening devices to achieve stated accuracy.

C. Provide as indicated on the Drawings or stated herein or in Division 23 Section "Sequences of Operation for HVAC."

2.9 AUTOMATIC CONTROL VALVES AND ACTUATORS

A. Furnish valves in accordance with the requirements of Division 23 Section "General Duty Valves for HVAC."

B. Control Valve Actuators:
1. Size to operate with sufficient reserve power to provide smooth modulating action or 2-position action.
2. Close-off (differential) pressure rating.
3. Hydronic Systems: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system (pump) head for 2-way valves and 100% of pressure differential across valve or 100% of total system (pump) head.
4. Steam Systems: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of operating (inlet) pressure.
5. Provide with neck extension on insulated service
6. Electric Actuators and Motors:
   a. Manufacturers: Subject to compliance with the requirements, provide products by one of the following:
      1) Johnson.
      2) Honeywell.
      3) Belimo Aircontrols (USA), Inc.
      4) Siemens.
   b. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   c. Serviceable and rebuildable.
   d. Coupling: V-bolt and V-shaped, toothed cradle.
   e. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
   f. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.

2.10 AUTOMATIC CONTROL DAMPERS AND OPERATORS

A. Furnish dampers in accordance with the requirements of Division 23 Section "Dampers."

B. Damper Operators:
1. General:
   a. Sized for ample power to overcome friction of damper linkage and air pressure acting on the blades.
   b. Capable of operating at varying rates of speed to correspond to the dictates of the controllers and variable load requirements.
   c. The operator linkage arrangement shall be such as to permit normally open or normally closed positions of the dampers as required.
2. Electronic Damper Actuators:
   a. Direct coupled type designed for minimum 60,000 full stroke cycles at rated torque.
   b. Coupling: V-belt and V-shaped, toothed cradle.
   c. Overload Protection: Electronic overload or digital rotation sensing circuitry.
   d. Fail Safe Operation: Mechanical, spring return mechanism. Provide external, manual gear release on non-spring return actuators.
   e. Temperature Rating: -22 to +122 degrees F.

2.11 INSTRUMENT TEST HOLES

A. Provide surface mounted, flanged test holes with removable caps and of sufficient length to extend beyond external duct insulation.

B. Install at all control points in ductwork, including, but not necessarily limited to:
1. Discharge air controllers.
2. Return air controllers.
3. Mixed air controllers.
4. Pressure sensors.
5. Limit thermostats.
6. Temperature sensors.

C. As manufactured by Ventfabrics, Inc.; Ventlock, Model 699; or equal.

2.12 CONTROL PANELS

A. Located within mechanical equipment rooms.

B. UL listed for line voltage system with removable face panel.

C. Furnish in Manufacturer's standard color.

D. Constructed and installed in accordance with Article 409 of the NEC (NFPA 70).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Air Piping:
1. Install in neat and workmanlike manner, parallel to walls.
2. Concealed runs of nonmetallic tubing must be in conduit.
3. Exposed runs must be hard copper or suitably protected nonmetallic tubing.
4. Seal all tubing and conduit penetrations at fire rated walls:
   a. With approved fire stop system.
   b. As specified in Division 7 Section “Penetration Firestopping.”
5. Run all tubing concealed in finished areas.

B. Electrical Wiring:
1. Motor Starters:
   a. Provide independent control circuit to each motor starter contactor coil.
   b. Provide a normally open interlock contact in each motor starter to indicate contactor status at DDC.
   c. Provide one electrically separate, normally open contact to start or stop each motor controlled by the system.
2. Limit Interlocks:
   a. Wiring of limit interlocks and dampers shall include on-off-auto switch on speed controllers.
   b. Wiring of all limit interlocks shall be such that the equipment will be de-energized in all operating positions of the starter.
3. Provide separate branch circuits for all 120 VAC power serving DDC equipment and related components.

C. Duct Pressure Sensors:
1. Locate and set duct static pressure sensors as indicated on the Drawings or as instructed by the Engineer.
2. Allow for one relocation and one reset of each static pressure sensor as instructed by the Engineer at no additional cost to the Owner.

3.2 FIELD QUALITY CONTROL

A. Demonstration and Acceptance Test:
1. Operate each and every phase of the control system separately, or in conjunction one with the other:
   a. For a sufficient period of time to demonstrate the ability of the system to meet performance requirements in accordance with the true intent and purpose of these Specifications.
   b. Provide for notification and approval of Engineer as required by Division 01 Section “Starting and Adjusting.”
2. The HI&C Subcontractor is responsible for verifying and demonstrating that each Sequence of Operation is being performed and design conditions stably maintained under operating conditions.
3. Acceptance of performance will be provided by the CxA.

4. Provide 8 hours of field service time for demonstration and acceptance test. Additional costs required due to retesting due to failure of system to perform satisfactorily shall be the responsibility of HI&C Subcontractor.
5. Trend Logging:
   a. Submit a 2 week log in graph form of inputs and outputs on a 1/2-hour basis. As indicated on the Table (included at end of this Section), a minimum of the following systems will be included:
   b. Data is to be provided in an electronic spreadsheet or ASCII format on electronic media.
   c. Submit trend data at start-up and also during cold and warm weather for the systems indicated on Table at the end of this Section:

B. Operator Instruction:
1. During system commissioning, and at such time acceptable performance of the system hardware and software has been established, provide onsite operator instruction to Owner's operating personnel.
2. Operator instruction during normal working hours shall be performed by competent Manufacturer's representative familiar with the software, hardware and accessories.
3. At a time mutually agreed upon during system commissioning as stated above, provide 8 hours of instruction to Owner's designated personnel on the operation of all equipment within the system and describe its intended use with respect to the programmed functions specified.
4. Includes, but is not necessarily limited to:
   a. The overall operational program, equipment functions (both individually and a part of the total integrated system).
   b. Commands.
   c. Advisories.
   d. The appropriate operator's intervention required in responding to the system's operation.
   e. A description of the chronological information flow from field sensors, contacts and devices to the centrally located control console.
   f. The overview of the system's communication network to acquaint the operator of the interplay between initiating devices, remote processing units, loop communications and their importance within the operating system.
5. Provide additional information time, as deemed necessary by Owner's authorized representative, on a negotiated basis with Owner.

C. Troubleshooting: Comply with the requirements of Division 23 Section “General HVAC Provisions,” Article 1.7, for troubleshooting.

3.3 ADJUSTMENTS AND CALIBRATION

A. Upon completion of this Project, adjust and validate all thermostats, controllers, valves, damper operators, relays, and other components provided as part of the temperature control system.

B. Calibration:
1. After completion of installation, the pneumatic piping shall be tested for leaks.
2. Provide calibration documentation to Engineer, which shall include:
   a. Airflow transmitter calibration curves to relate the transmitter output signal to the actual airflow as well as to the pressure drop across the primary flow measuring element.
   b. For pressure, differential pressure, flow, and other transmitter's provide calibration curves using the zero, span and 3 other points between 10% and 90% of span. These curves shall relate the output signal of the transmitter to the primary measured value.
   c. Indicating instruments shall read true conditions and be checked with test instruments.
   d. Calibration of temperature and humidity sensors.

C. Adjustments, Tuning and Start-up:
   1. After the completion of calibration, adjust and tune the controls.
   2. Provide documentation, which is to include:
      a. Input/output relationship of all controllers, positioners, and final drive units.
      b. Gains and time constants established in all controllers.
      c. Loop setpoints.
      d. Limits on control actions.
      e. Alarm limits.
      f. Control dead bands.
   3. Provide seasonal adjustments as required under Article 1.10 - Service Agreement.

PROVIDE THE FOLLOWING TRENDS IN GRAPH FORM:															
Control Systems	Trend with Cold Weather	Trend with Warm Weather	Supply Air Temp	Outdoor Air Temp	Control-led Setpoint	Distri-bution Supply Wtr Temp	Distri-bution Return Wtr Temp	Source Equip On-Off Cycles	Distri-bution Pumps On-Off Cycles	Control-led RH Level	Mixed Air Temp	Space Temp	Sensed Static Pressure Level	Damper or Valve Position	Speed Drive Output Level
AHU Econ-omizer Cycle	X	X	X	X							X			X	
AHU Heating Coil	X		X	X							X			X	
AHU Cooling Coil		X	X	X		X	X		X		X			X	
VAV Terminals	X	X	X									X	X	X	
Duct Pressure Control	X	X			X								X		X

END OF SECTION 23 09 00

SECTION 23 22 13 – STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the furnishing and installation of the steam and condensate piping systems.

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. American Society of Mechanical Engineering (ASME):
      a. B31.1 - Power Piping.
      b. B31.9 - Building Services Piping.
      c. Power Boiler Code.
      d. Heating Boiler Code.

1.4 SUBMITTALS

A. Shop Drawings: For all pressure reducing stations.
   1. Dimensions.
   2. Construction and installation details.
   3. Performance criteria, including valve Cv.
   4. Manufacturer/model number.

B. Manufacturer's Literature: For all traps, vents, vacuum breakers and steam control valves.
   1. Manufacturer/model number.
   2. Size and capacity (Cv).
   3. Construction details.

C. Drip and Trap Circuit Layout Drawings: Submit for Engineer's and Owner's review, a dimensional layout drawing for all trap circuits. Drawings shall be to scale and may be 3-dimensional or include sufficient section cuts to indicate spatial relationships of steam and condensate piping, drip legs, bleeders, and valve orientation.

1.5 QUALITY ASSURANCE

A. Qualifications: All welders shall be certified per the requirements of ASME B31.1 and B31.5, as applicable.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. As indicated on the Drawings.

B. Provide in accordance with the requirements of Division 23 Section “Steel Pipe and Fittings for HVAC” and as follows:
   1. Steam – To 60 psig – Above Ground:
      a. For Piping Through 2-Inch:
         1) Pipe: Black Steel, Schedule 40, ASTM A53, ERW or seamless, Grade B.
         2) Fittings: Forged Steel, ASTM A181, ANSI B 16.11 unions, 250 pound ASTM A197.
         3) Joints: Screwed.

b. For Piping 2-1/2-Inch and Larger:
   1) Pipe: Black Steel, Schedule 40, ASTM A53, ERW or seamless, Grade B, standard weight for 12-inch and above.
   2) Fittings: Schedule 40, wrought Steel, butt welded, black steel, ASTM A234, ASTM B16.9.
   3) Joints: Welded. Flanged ASTM A181, forged steel at valves, and equipment.

2. Steam Condensate (prior to trap) - to 60 psig - Above Ground:
   a. For Piping Through 2-Inch:
      1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless.
      2) Fittings: Schedule 80, Forged Steel, ASTM A181, ANSI B 16.11 or; unions, 250 pound ASTM A197; unions, 250 pound ASTM A197.
      3) Joints: Screwed.

3. Steam Condensate (Gravity or Pumped After Trap) - to 60 psig - Above Ground:
   a. For Piping Through 2-Inch:
      1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless.
      2) Fittings: Cast Iron, ASTM EB16.4, 150 pound.
      3) Joints: Screwed.
   b. For Piping 2-1/2-Inch and Larger:
      1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless, Grade B.
      2) Fittings: Schedule 80, Wrought Steel, ASTM B16.9, ASTM A234.
      3) Joints: Welded. Flanged ASTM A181, 150 pound, forged steel at valves, and equipment.

2.2 VALVES

A. Provide in accordance with Division 23 Section “General Duty Valves for HVAC.”

2.3 STEAM TRAPS

A. Manufacturers:
   1. Armstrong Machine Works:
   2. Spirax-Sarco.
   3. ITT Hoffman.

B. Float and Thermostatic: Cast semi-steel, 125 psi class body, seamless copper or stainless steel float, stainless steel valve heads and seats.

C. Trap Universal Connector:
   1. Traps shall be mounted to 360 degree universal connector able to accept multiple manufacturer thermostatic and bimetallic steam trap models.
   2. Manufacturers: Armstrong, Spirax Sarco; or equal.

2.4 VACUUM BREAKERS

A. Provide manufactured unit supplied by Manufacturer listed above similar to Hoffman No. 62.

B. Alternately, use check valve with opening force of 3-inch W.G. or less complying with the requirements of Division 23 Section “General Duty Valves for HVAC.”

2.5 STEAM CONTROL VALVES

A. Refer to Division 23 Section “General Duty Valves for HVAC.”

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping:
1. All piping shall be installed in such a way that it will be free to expand and contract, without noise, or damage to itself or to the building. It shall be the duty of this Contractor to prevent others from altering this purpose.
2. All piping shall be installed in such a manner that it will NOT interfere with the necessary passage, head room or opening of doors or windows.
3. Risers and vertical pipe shall be plumb, straight and have no unnecessary fittings or offsets.
4. Filings, dust, or dirt shall be wiped from interior of the pipe or tubing before connections are made.
5. Changes in direction shall be made with fittings.
6. Vent pipes shall be installed through the roof as directed and shall be flashed as specified.
7. Pitch:
   a. Horizontal supply mains shall pitch up in the direction of flow.
   b. The grade shall be not less than 1-inch in 40 feet.
8. Reducing fittings shall be used for changes in pipe sizes, eccentric, flat on bottom.
9. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the systems.
10. Pipe not otherwise specified shall be uncoated.
11. Connections between ferrous piping and copper piping shall be electrically isolated from each other with dielectric unions.
12. Branch connections for steam and condensate shall be taken off mains on top, up at a 45 degree angle, or horizontal.

B. Steam Traps:
1. Install with union or flanged connection at both ends.
2. Provide gate valve and strainer at inlet, gate valve (and check valve) at discharge.
3. Provide minimum 10-inch (250 mm) long dirt pocket of same pipe size as apparatus return connection.
4. Do not install thermostatic elements in traps until system has been operated and dirt pockets cleared of sediment and scale. Provide temporary covers for use prior to this time.
5. Install for proper drainage of all low points of piping and equipment.
6. If orifice types are used, all traps shall be orifice type, with the exception of apparatus with constant steam pressure but variable loads (i.e., steam coil with face and bypass damper). Provide Y-type strainer with 40 MESH stainless steel insert upstream of all orifice traps.
7. All trap circuits in tunnels must be installed to provide full access to all components and connections for service and system maintenance. Layout must also minimize risk from contact with hot piping, valves and blow-offs. Refer to submittal requirements.

C. Vacuum Breakers:
1. Vacuum breakers shall be installed on all tank heaters, jacketed kettles, converters, coils and similar apparatus where a possibility of damage may occur because of high vacuum.
2. Vacuum breakers shall be installed above the highest fixtures it is protecting as required by codes in such a manner that it will preclude back pressure.
3. Vacuum breaker shall be installed where it will be accessible for periodic testing and where spillage will not be objectionable.

3.2 INSPECTIONS

A. Inspections are the responsibility of the Owner and may be performed by employees of the Owner or party authorized by the Owner.

B. Prior to initial operation, the "Non-Boiler External Piping" installation shall be inspected to ensure compliance with the engineering design and with the material, fabrication, assembly, examination and test requirements of the Code.

3.3 EXAMINATIONS

A. Visual Examinations:
   1. Visual examinations are to be performed by the fabricator, erector, or a party authorized by the Owner which include visual examinations and observations.
   2. Visual examinations as defined are to be performed as necessary during the fabrication and erection of the piping components to provide verification that the design and WPS requirements are being met.
   3. Visual examinations shall also be performed to verify that completed welds in pipe and piping components comply with the acceptance standards specified in the Code.
   4. Personnel who perform nondestructive examinations of welds shall be qualified and certified for each examination method in accordance with a program established by the employer of the personnel being certified based on the Code requirements.
   5. Owner may examine welds at structural supports and pipe attachment assemblies at their discretion.

3.4 PRESSURE TESTING

A. Hydrostatic Testing:
   1. Provide complete hydrostatic testing for leaks of all piping systems in accordance with ASME B31.1 "Code for Pressure Piping," latest revision.
   2. Test pressure shall be at least 1.5 the design pressure, but in no cases less than 150 psig.
   3. Following the application of hydrostatic test pressure for at least 4 hours, examination shall be made for leakage of the piping and at all joints and connections.
   4. If leaks are found, they shall be eliminated as appropriate, and the test repeated until no leakage is found.
   5. Testing must be witnessed and approved by the Owner's representative on each section of pipe before insulating.

B. Pneumatic Testing:
   1. May be used in lieu of hydrostatic testing only when necessary for conditions and pre-approved by Engineer.
   2. Provide complete pneumatic testing for leaks of all piping systems in accordance with ASME B31.1 "Code for Pressure Piping," latest revision.
   3. Apply not more than 25 psig for at least 10 minutes to identify major leaks.
   4. Final test pressure shall be at least 1.5 the design pressure, but in no cases less than 150 psig.
   5. Hold at full test pressure for a minimum of 10 minutes and gradually reduce to design pressure.
   6. Following the application of pneumatic test pressure for at least 4 hours, examination shall be made for leakage of the piping and at all joints and connections using soap bubbles or other acceptable method to visually identify leaks.
   7. If leaks are found, they shall be eliminated as appropriate, and the test repeated until no leakage is found.

C. Test Procedures:
   1. Blank off or replace with spool pieces items of devices and equipment such as vessels, valves, instruments, etc. rated for pressure less than the test pressure. Reconnect equipment after testing.
   2. Perform tests before piping is covered or concealed.
   3. A pressure recorder shall monitor the testing of piping systems to verify test results.

D. Cycle Testing:
   1. Following the completion of the leak testing procedures, the Contractor shall coordinate with the Owner's staff to conduct a cycle test on both the steam and condensate piping installed under this Contract.
      a. All testing shall be scheduled through the Owner's with a minimum of 72 hours notice.
      b. The cycle test may also be performed in conjunction with the in service test as authorized by the Owner.
      c. The Contractor shall be present while the cycle test is being conducted.
   2. The cycle test shall consist of a single warm-up cycle and cool-down cycle where the systems are gradually brought up to normal operating pressure and temperature for a period of 8 hours.
   3. Prior to beginning the test, the Contractor shall mark the position of the steam and condensate expansion joints and guides at ambient conditions.

4. The position of the expansion joints and guides shall also be marked after the system has been brought up to operating temperature and pressures.
5. Following the cool down period, and when the system has been cooled to ambient conditions, the Contractor shall visually inspect these components including pipe slide supports to ensure their return to the initially marked position. The Contractor shall note misalignment and failure of the system to return to the original position.

3.5 PROTECTION AGAINST FREEZING

A. At any time that any of the piping is full of water for testing purposes or otherwise prior to actual heated operation, the system shall be protected against freezing by the introduction of an acceptable anti-freeze which will be flushed out before acceptance. Provision for introducing anti-freeze shall be made by means of valved connections to the system in an acceptable manner.

3.6 CLEANING AND FLUSHING

A. Piping shall be cleaned before the installation, and flushed after the installation and before system start up.

B. Equipment, detergents, solvents and other cleaning agents shall be furnished by a qualified water treatment service.

C. Disconnect piping to be flushed. Remove instruments which may be damaged by the cleaning procedures. Such items shall be replaced with spool pieces, plugs, or blind flanges.

D. Before the piping is put in service, clean it using a pressure tank with a hose equipped with a nozzle to direct a high velocity stream of water against the inside wall of the pipe. Make a minimum of 2 passes through the pipe with the hose. A minimum pressure of 250 psi shall be developed at the nozzle.

END OF SECTION 23 22 13

SECTION 23 31 13 – METAL DUCTS

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.

B. Refer to Division 23 Section “Hangers and Supports for HVAC Piping and Equipment” for ductwork and equipment.

1.2 SUMMARY

A. This Section includes the furnishing and installation of sheet metal ductwork and appurtenances:
   1. As indicated on the Drawings.
   2. As specified herein.
   3. As required to provide a complete and operational air distribution system.
   4. As necessary for the proper and complete performance of the Work.
   5. Including all hangers, supports and anchors.

1.3 DESIGN AND PERFORMANCE REQUIREMENTS

A. Provide all hangers, supports, braces and connections as required to meet the seismic restraint requirements of International Building Code of 2015 and in accordance with the guidelines of the SMACNA Seismic Restraint Manual.

B. Comply with the requirements of Division 23 Section “Sound and Vibration Control for HVAC” for vibration isolation of ductwork.

1.4 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ASHRAE Guidelines:
      a. 2000 Handbook - Chapter 16 - "Duct Construction."
      b. 2001 Handbook - Chapter 34 - "Duct Design."
      c. ASHRAE 62.1, current version.
   2. ASTM Specifications:
      a. A480 - General Requirements for Flat-Rolled Stainless Steel and Heat-Resisting Steel Plate, Sheet, and Strip.
      b. A653 - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
      c. A924 - General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
      d. B209 - Aluminum and Aluminum - Alloy Sheet and Plate.
   3. ASTM Standard Test Methods:
      a. A90 - Weight of coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
      b. C731 - Extrudability, after Packaging, Aging, of Latex Sealants.
      c. D2202 - Slump of Sealants.
   4. NFPA Standards:
      a. 90A - Installation of Air Conditioning and Ventilating Systems.
      b. 90B - Installation of Warm Air Heating and Air Conditioning Systems.
      c. 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operation.
   5. SMACNA Guidelines:
      a. "HVAC Duct Construction Standards, Metal and Flexible," 1985 Edition.
      b. "Rectangular Industrial Duct Construction Standards."
      c. “Round Industrial Duct Construction Standards.”
      d. “Guide for Steel Stack Construction.”

6. UL Standards: 181 - Factory Made Air Ducts and Connectors.

1.5 SYSTEM DESCRIPTION

A. Duct sizes indicated on Drawings are net clear inside dimensions.

B. Duct Construction Pressure Classifications:

	Duct System	SMACNA Pressure Classification
1.	Supply duct downstream of VAV terminals	1" W.G.
2.	Supply duct upstream of VAV terminals	3" W.G.
3.	Return duct	-1" W.G.

1.6 SUBMITTALS

A. Manufacturer's Data: Sequential parts list for each part.
1. Name of Manufacturer.
2. Part name and model number.
3. Dimensions.

B. Shop Drawings: Construction details for special fabricated parts.

C. Duct Pressure Test:
1. Written procedure for leak testing installed supply, and return ductwork system 30 days prior to testing.
2. Duct pressure test report.

1.7 QUALITY ASSURANCE

A. Fabrication and Installation Personnel Qualifications:
1. Trained and experienced in the fabrication and installation of the materials and equipment.
2. Knowledgeable of the design and the reviewed Shop Drawings.

B. Regulatory Agencies Requirements:
1. All state and local codes and ordinances.
2. Owner's insurer.
3. Flexible ductwork shall comply with:
a. UL listed - Class 1 Air Duct Material, Standard 181.
b. NFPA Standard 90A - Flame spread: 25, Smoke developed: 50.

1.8 DELIVERY, STORAGE AND HANDLING

A. All materials shall be delivered in original, unbroken, brand marked containers or wrapping as applicable.

B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter and damage by weather or elements in accordance with Manufacturer's directions.

C. Reject damaged, deteriorated or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Duct Connection Systems:
1. Ductmate Industries, Inc.
2. Lindab, Inc.

B. Flexible Duct:
   1. Flexmaster USA, Inc., Type 3 uninsulated or 3M insulated as specified.
   2. General Environment Corporation.
   3. Wiremold Company.

C. Prefabricated Fittings:
   1. United McGill Corporation.
   2. Buckley Air Products, Inc.
   3. Eastern Sheet Metal, Inc.
   4. LaPine Metal Products.
   5. Lindab, Inc.
   6. Semco.
   7. Universal Spiral Air.

D. Manufactured ductwork and fittings shall be of one Manufacturer to ensure tight fit of ductwork and components.

E. Manufacturer's Stamp:
   1. Manufacturer's stamp shall be on the outside of the ductwork.
   2. Stamp shall be clean and clear, indicating the metal gage.

2.2 MATERIALS

A. Galvanized Steel:
   1. Galvanized steel of lock-forming quality with minimum ASTM A653, G90 zinc coating, both sides in accordance with ASTM A90.
   2. Use for all ductwork systems unless noted otherwise.

B. Acceptable Fasteners:
   1. Rivets, bolts, or sheet metal screws.
   2. Stainless steel.

C. Tapes:
   1. High pressure rated, non-hardening, water resistant and fire-resistant.
   2. Compatible with duct material.

D. Sealants:
   1. Fire and Smoke Hazard Rating:
      a. As tested by ASTM E84, NFPA 255, or UL 723.
      b. Not to exceed: Flame spread 25, smoke developed 50.
   2. Exterior Mastic Sealant: Certified to pass 600 hours QUV; or equivalent weather testing.
   3. Comply with ASTM C731 and D2202.
   4. Specifically formulated for sealing the field joints.
   5. UL listed.
   6. Hardcast, Inc. Sure Grip 404, Iron Grip 601, Flex Grip 550, Duct Seal 321.
   7. Foster 32-19 Duct Fas, 32-17 Safetee, 32-14 High Velocity Duct Sealant.
   8. Childer CP-146, Chil Flex C—147.

E. Hangers:
   1. Galvanized steel band iron.
   2. Rolled angle and 3/8-inch minimum galvanized steel rod.

F. Wall Supports:
   1. Galvanized steel band iron.
   2. Fabricated angle bracket.

G. Vertical Supports at Floors:
   1. Rolled steel angle 1-1/2 x 1-1/2 x 1/8 minimum.
   2. Mechanically attached to duct.

2.3 FABRICATION

A. General: Construct rectangular, round and flat oval ductwork and fittings in accordance with the SMACNA HVAC Duct Construction Standards, Metal and Flexible, current edition.

B. Transitions: Make every change in size or shape of duct with taper not exceeding 20 degrees.

C. Connections:
   1. Make connections to equipment as indicated on Drawings or called for by these Specifications.
   2. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 2-inch on center.
   3. Flexible Ductwork Connections:
      a. Securely fasten flexible duct to round sheet metal ducts or duct collars with stainless steel or zinc-coated iron draw bands with worm gear fastener.
      b. Flexible duct 10-inch diameter or less, installed on 1-inch W.G. pressure classification duct may be attached with nylon cable ties.
      c. Fabric shall not be stressed other than by air pressure.

D. Elbows and Tees:
   1. Maintain centerline radius of 1-1/2 times duct width in plane of turn wherever possible.
   2. Provide short radius fittings with a minimum of 2 turning vanes full length of turn or square elbows with multiple blade airfoil turning vanes set at 45 degree angle.

E. Turning Vanes and Distribution Devices: Where registers, grilles or diffusers are located less than 5 equivalent duct diameters from the main duct, provide necessary distribution grids or turning vanes to ensure even distribution of air over the entire face of the outlet.

F. Provide necessary plastering frames and drawbands required.

G. Branch Ducts:
   1. Construct with full radius elbow turning into a transition section in the main duct.
   2. Provide with damper and quadrant as specified in Division 23 Section “Dampers.”

H. Mixing Boxes:
   1. Modify, by experimentation if necessary, the return and outdoor air mixing section of duct if nuisance tripping of freeze-stat occurs due to inadequate mixing of airstreams.
   2. Install sheet metal baffle plates to promote mixing and eliminate stratification.

2.4 MANUFACTURED UNITS

A. Turning Vanes:
   1. Hem the leading edge of vanes in ducts over 20-inch width with 1/2-inch fold-back.
   2. Reinforce turning vanes in ducts over 24-inch diameter with rods or sectional construction to limit unsupported length to 24 inches.
   3. 24 gage, minimum.
   4. Use in rectangular elbows with R/D ratio of less than 1.5.
   5. Double wall.

B. Bellmouth Fittings:
   1. Use spun bellmouth connections at each round take-off from the high pressure plenum.
   2. Manufactured spun Bellmouth fittings may be used in lieu of take-offs indicated on Drawings: Buckley Air Products Type BM; or equal.

C. Takeoffs from Round 1-inch Pressure Classification Duct:
   1. Made with factory fabricated lateral type fittings.
   2. At an angle of no more than 45 degrees.
   3. As manufactured by United McGill Corp., Model SRL; or approved equal.
   4. In accordance with detail on Drawing.

D. Flexible Duct:
   1. Construction:
      a. Liner of laminated aluminum foil/fiberglass/aluminated polyester.
      b. Zinc-coated steel helix bonded to liner.
      c. 1-inch thick, 1 pound/cubic foot insulation.
      d. Seamless copolymer vapor barrier jacket.
      e. Rated for pressure class of system in which duct is used.
   2. Maximum flexible duct length shall not exceed 5 feet, maximum flex duct turn not to exceed 45 degrees.

E. Manufactured Ductwork Connection Systems:
   1. General:
      a. In lieu of SMACNA Duct Construction Standards, Contractor may use an alternative engineered connection system such as Ductmate, “Spirosafe” by Lindab; or approved equal.
      b. Designed to provide equivalent reinforcing and pressure characteristics.
   2. Description:
      a. Duct, gasket, and fitting providing an airtight outer pressure shell.
      b. The construction shall have mechanical means to maintain positive or negative pressure requirement, or both, and rigidity equivalent to SMACNA joints and metal gages.
   3. Duct Material:
      a. Outer Shell: Galvanized steel.
      b. Metal Gage: As required to meet pressure classification indicated.
   4. Fittings:
      a. As indicated on Drawing and of same Manufacturer as duct section.
      b. Sized to slip fit into the duct sections, without sharp projections for noise and airflow disturbances.

2.5 DUCT ACCESS DOORS

A. Manufacturers:
   1. Prefco.
   2. Pottorff.
   3. Ventfabrics, “Ventlock.”
   4. Greenheck.

B. Provide In Ductwork:
   1. As indicated on the Drawings.
   2. Wherever necessary for proper access to instruments, controls, fire dampers, motorized dampers, coils and equipment.
   3. For convenient inspection, maintenance and replacement.
   4. Reinforce openings on sides with material or ductwork in which doors are installed.

C. Construction:
   1. Two-piece 22 gage minimum pan construction, consisting of outer side crimped over inner dished side.
   2. Continuous piano hinge and not less than 2 heavy cam latches. A removable type door is acceptable only where there is inadequate clearance for a hinged door.
   3. Contact surfaces of doors covered with heavy dense felt securely fastened in place to make doors air tight.
   4. Insulated or soundproofed with same materials as ducts or casings where located.
   5. Ruskin ADH22 or ADC22; or equal.

2.6 SOURCE QUALITY CONTROL

A. Certified Testing:
   1. Suppliers of manufactured round and oval ductwork shall have on file with Engineer certified copies of test data made by an independent United States laboratory covering pipe and fittings as manufactured by that Supplier.
   2. Spiral Pipe Test Data:
      a. Cover leakage rate, bursting strength, collapsing strength, seam strength and friction loss.
      b. Friction loss test data shall cover both the duct and the assembled coupling joints.
      c. This friction loss data shall be equal to or less than the friction loss data used in the design of this system.
   3. The fitting test data shall cover the friction loss tests of all fittings used on the project.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install ductwork and accessories to provide a system free from buckling, warping, breathing, vibration, rattling, or whistling.
   2. Lap ducts in direction of air flow with longitudinal seams locked and hammered tight.
   3. Provide flat "S" cleats on all exposed traverse duct connections in finished areas.
   4. Install ducts straight with building walls where possible and exposed duct tight against roof or walls where possible.
   5. Ducts shall be air-tight, rigid, securely hung or bracketed in position.
   6. At the end of an uninsulated section or run, where internally insulated duct connects to uninsulated spiral duct or fitting, fire damper or flex, install an insulation end fitting to bring the outer shell down to nominal size.
   7. Install screws and rivets of such length that they do not interfere with the operation of manual or automatic dampers.

B. Protection of System:
   1. Cap the ends of sheet metal ductwork, including the roof openings, registers and diffuser openings with temporary durable air-tight and water-tight covers during all stages of construction in order to keep system clean.
   2. If permanent heating and cooling equipment is used prior to Substantial Completion, protection of ductwork systems shall comply Division 23 Section “General HVAC Provisions.”

C. Hanging Duct:
   1. Allow swing in long direction of duct for movement.
   2. Double nut hanger rods.

D. Duct Anchoring:
   1. Galvanized sheet metal hanger straps attached to construction.
   2. Angle metal screwed to the ductwork.

E. Turning Vanes:
   1. Use in rectangular mitered elbows with R/D ratio of less than 1.5 and elsewhere as indicated.
   2. Install evenly spaced along elbow diagonal with leading and trailing edges aligned to sides of duct.
   3. Install vanes on 3-3/4-inch centers.
   4. Elbows Where Duct Changes Size:
      a. Mount vanes individually (not on premanufactured vane runners).
      b. Ensure that leading and trailing edges align parallel to sides of duct.

F. Exterior Ductwork: Refer to SMACNA Guidelines specified in Paragraph 1.3.A.5.a, Pages 5-6, 5-7, and 5-8 for requirements of construction and installation.

G. Joint Sealing of Duct Systems:
   1. Except where using gasketed duct connection systems, seal ductwork in accordance with SMACNA Class A:
      a. Seal ductwork including supply, return, mixed, outdoor, and exhaust air systems.
      b. For Round and Flat Oval Ductwork:
         1) Apply approved sealant to the male end of the couplings and fittings.
         2) After the joint is slipped together, place sheet metal screws 1/2-inch from the joint bead for mechanical strength.
         3) Apply sealer to the outside of joints including longitudinal joints, extending 1-inch on each side of the joint.
         4) Cover screw heads.
      c. For Rectangular Ductwork:
         1) Apply approved sealant to transverse and longitudinal joints.
         2) Extend sealant a minimum of 1-inch on each side of joint.
      d. Follow sealant Manufacturer's directions for application, storage and cure time.
      e. Ductwork located outside shall be air and watertight.
   2. Manufactured Connection Systems:
      a. Acceptable in accordance with Paragraph 2.1.
      b. Seal flanged joints with neoprene rubber gaskets.

H. Appearance: Where exposed ducts pass through walls or floors: Refer to Division 23 Section "Penetrations for HVAC."

3.2 HANGING AND SUPPORT

A. All Ducts:
   1. Support in a secure manner.
   2. Subject to Engineer's approval.
   3. In compliance with International Building Code of 2015.

B. In accordance with Chapters 5 and 6 of the SMACNA HVAC Duct Construction Standards.

C. Do not support ductwork from metal roof deck.

D. Unacceptable work shall be removed and replaced at no additional cost to Owner.

3.3 FIELD QUALITY CONTROL

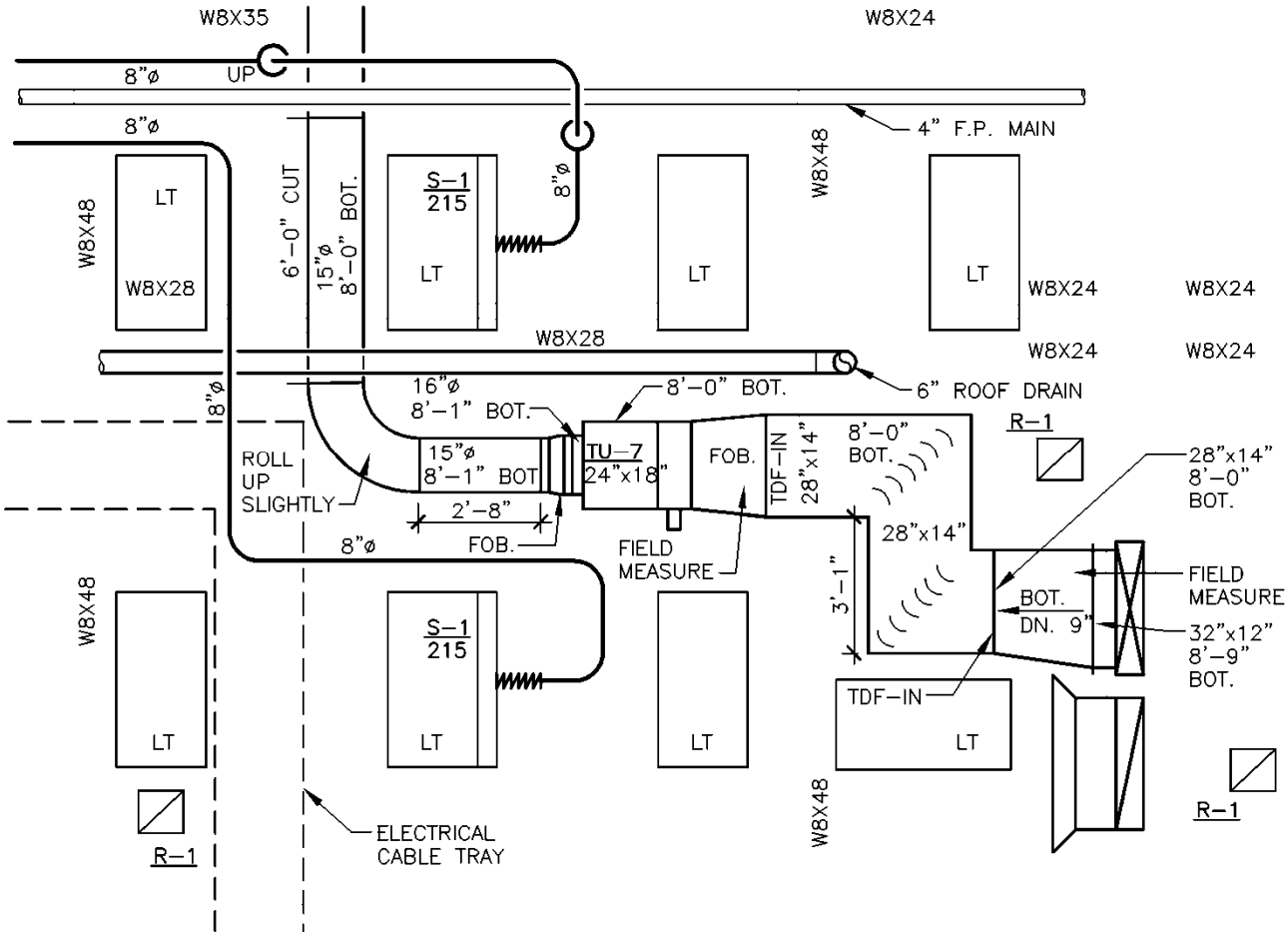
A. Duct Systems to be Tested:
   1. Supply ducts.
   2. Return ducts.
   3. Exhaust/Relief ducts.
   4. Outdoor air intake ducts.

B. Pressure Testing:
   1. Pressurize the installed duct system to a test pressure 50% over the designated SMACNA pressure classification.
   2. Measure air leakage at the test pressure by an orifice type of flow meter which has been individually calibrated against a primary standard and this calibrated curve permanently attached to the orifice tube assembly.
   3. If the system is tested in sections, add the leakage rates to give the performance of the whole system.
   4. Total allowable leakage of the system shall not exceed 2.5% of the air handling capacity of the system.
   5. Correct Objectionable Noise:
      a. Even if the system passes the leakage rate criteria.
      b. To the satisfaction of Engineer.
   6. Apply duct tape over sealed joints prior to testing, if the system is to be tested before the recommended sealer curing time has elapsed.

C. Perform testing in accordance with a printed procedure reviewed by Engineer.

D. Notify Engineer 1 week prior to duct pressure test to allow Engineer the option to be available to observe testing.

E. Pressurization Control:
   1. Protection against duct overpressurization or underpressurization during testing is the responsibility of Contractor.
   2. Verify that control, variable air volume, balancing, and fire dampers are open.
   3. Verify that pressure relief panels or controls are operational.



END OF SECTION 23 31 13

SECTION 23 82 00 – HYDRONIC UNIT HEATERS

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. This Section includes, but is not necessarily limited to, the furnishing and installation of the major items listed below:
   1. Unit heaters.

1.3 SYSTEM DESCRIPTION

A. All terminal heat transfer equipment shall be as indicated on the Drawings.

B. Manufacturer name and model number information given in equipment schedules represent quality and performance standards for that equipment.

C. Design performance for terminal heat transfer is based on the following:
   1. Heating:
      a. 60 degrees F entering air temperature.
      b. 170 degrees F entering water temperature.

1.4 SUBMITTALS

A. Manufacturer's Literature: For all equipment specified herein.
   1. General:
      a. Dimensions.
      b. Details of construction and installation.
      c. Name of Manufacturer.
      d. Model.
   2. For Each Device:
      a. Identify by equipment schedule tag number.
      b. Design capacity.
      c. Color.
      d. Electrical characteristics and project specific wiring diagrams including controls wiring..
      e. List of accessories furnished.

B. Operation and Maintenance Manuals: For powered equipment.
   1. Equipment function, normal operating characteristics and limiting conditions.
   2. Assembly, installation, alignment, adjustment and checking instructions.
   3. Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions.
   4. Lubrication and maintenance instructions.
   5. Guide to "troubleshooting".
   6. Parts lists and predicted life of parts subject to wear.

1.5 QUALITY ASSURANCE

A. Fabrication and Installation Personnel Qualifications:
   1. Trained and experienced in the fabrication and installation of the materials and equipment.
   2. Knowledgeable of the design and the reviewed Shop Drawings.

B. Manufacturer Qualifications: Regularly engaged in production of such equipment.

PART 2 - PRODUCTS

2.1 UNIT HEATERS

A. Manufacturers:
1. Modine.
2. Trane.
3. McQuay.
4. York.
5. Sterling.

B. Casing: 18 gage steel threaded connections for hanger rods and bonderized baked enamel finish.

C. Heating Element:
1. Seamless copper tubing, 0.025-inch minimum wall thickness.
2. Silver brazed to steel headers.
3. Evenly spaced aluminum fins mechanically bonded to tubing.
4. Tested with air under water at 200 psi.

D. Fan:
1. Direct drive propeller type.
2. Statically and dynamically balanced.
3. Complete with fan guard.

E. Air Outlet:
1. Adjustable pattern diffuser on projection models.
2. 4-way louvers on horizontal throw models.

F. Motor:
1. Totally enclosed, permanently lubricated and resiliently mounted.
2. Motor rated at 1/8 hp and below shall have internal overload protection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with Manufacturer's installation instructions and installation details indicated on Drawings.

B. Thoroughly clean all exposed equipment pieces.

C. Vacuum clean all heating/cooling elements prior to job acceptance.

3.2 COORDINATION

A. Coordinate with Temperature Control Subcontractor to verify proper operating sequence for all units with factory installed controls which interface with the building temperature control system.

B. Coordinate with Electrical Subcontractor for power supply to units equipped with fans.

END OF SECTION 23 82 00