SECTION 230020

BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. All drawings and general provisions of Contract, including all General and Supplementary Conditions, Division 1 Specification Sections, and Instructions to Bidders apply to this section and all other sections of Division 23.

1.02 SCOPE OF WORK

A. Responsibility for performance of subcontractors and trades as lower tier contracts, such as electrical, shall be included as part of Contractor's scope of work.

B. Include in bid all labor, materials, tools, plant, transportation, excavation, equipment, insurance, temporary protection, permits, taxes, services and all necessary and related items required to provide complete and operational systems shown and described.

C. References to codes and standards called for in the Contract Documents mean the latest edition, amendment and revisions to the codes and standards in effect on the date of these Contract Documents.

D. Minimum composition requirements and/or installation methods for the following materials and work are included in this section:

1. Miscellaneous Supports
2. Access Doors and Panels
3. Fire Stopping
4. Flashing and Sealing
5. Cutting and Patching

1.03 REGULATIONS AND CODE COMPLIANCE

A. All work and materials shall conform to and be installed, inspected and tested in accordance with the governing rules and regulations of federal, state and local governmental agencies having jurisdictional authority. In the event of conflict between these contract documents and the governing rules, regulations, and codes, the most stringent standards shall apply as directed by the Engineer and/or Authorities having jurisdiction.

B. Codes and standards that apply to this project include, but are not limited to:

1. Building Code of New York State.
2. Energy Conservation Construction Code of New York State.
3. New York State Department of Labor Rules and Regulations.
4. New York State Department of Health.

5. ASHRAE Standard 62.
6. Federal Occupational Safety and Health Administration - OSHA.
7. National Electrical Code, NFPA 70.
8. Local Codes and Ordinances for Buffalo, NY, Erie County
9. NEMA Standards
10. Underwriters Laboratory (UL)
11. Factory Mutual and/or Owner's Insurance Carrier
12. International Standards Organization (ISO)
13. New York Board of Fire Underwriters.
14. National Fire Protection Association (NFPA) - All chapters

1.04 LICENSING & PERMITS

A. The Contractor shall hold a license to perform the work as issued by the State University Construction Fund.

B. Apply for and obtain all required permits and inspections, include costs for all fees and charges within bid.

C. Refer to General Conditions of the Contract for additional requirements.

1.05 GLOSSARY

ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AGA	American Gas Association
AGCA	Associated General Contractors of America, Inc.
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWSC	American Welding Society Code
BCNYS	Building Code of New York State
EIA	Electronic Industries Association
FCC	Federal Communications Commission
FM	Factory Mutual Insurance Company
IEEE	Institute of Electrical and Electronics Engineers
IRI	Industrial Risk Insurers
ISO	International Standards Organization
MCNYS	Mechanical Code of New York State
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association

NYS/DEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety and Health Administration
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriter's Laboratories, Inc.

1.06 DEFINITIONS

Approved / Approval	Written permission to use a material or system.
As Called For	Materials, equipment including the execution specified/shown in the contract documents.
Code Requirements	Minimum requirements.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
Design Equipment	Refer to the article, BASIS OF DESIGN
Design Make	Refer to the article, BASIS OF DESIGN.
Equal or Equivalent	Equally acceptable as determined by Owner's Representative
Exposed	Work not identified as concealed.
Final Acceptance	Owner acceptance of the project from Contractor upon certification by Owner's Representative.
Furnish	Supply and deliver to installation location.
Furnished by Others	Receive delivery at job site or where called for and install.
Inspection	Visual observations by Owner's Site Representative.
Install	Mount and connect equipment and associated materials ready for use.
Labeled	Refers to classification by a standards agency.
Make	Refer to the article, BASIS OF DESIGN.
Or Approved Equal	Approved equal or equivalent as determined by Owner's Representative.
Owner's Representative	The Prime Professional
Prime Professional	Architect or Engineer having a contract directly with the Owner for professional services.
Provide	Furnish, install and connect ready for use.
Relocate	Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use
Replace	Remove and provide new item.
Review	A general contractual conformance check of specified products.
Roughing	Pipe, duct, conduit, equipment layout and installation.

Satisfactory	As specified in contract documents.
Site Representative	Construction Manager or Owner's Inspector at the work site.

Refer to General Conditions of the Contract for additional definitions.

1.07 BASIS OF DESIGN

A. The contract documents are prepared on the basis of one manufacturer as "design equipment," even though other manufacturers' names are listed as acceptable makes. If Contractor elects to use one of the listed makes other than "design equipment," submit detailed drawings, indicating proposed installation of equipment. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements. Show maintenance clearances, service removal space required, and other pertinent revisions to the design arrangement. Make required changes in work of all other trades, at no increase in any contract. Provide larger motors, electrical feeders, circuit breakers, equipment, additional control devices, valves, fittings and other miscellaneous equipment required for proper operation, and assumes responsibility for proper location of roughing and connections by other trades. Remove and replace door frames, access doors, walls, ceilings or floors required to install other than design make equipment. Contractor shall retain the ultimate responsibility for function of equipment and materials which are not the basis of design for the contract documents. If revised arrangement submittal is rejected, revise and resubmit specified "design equipment" item which conforms to contract documents.

1.08 INTENT OF DRAWINGS

A. The drawings are diagrammatic, unless detailed dimensioned drawings are included. Drawings show approximate locations of equipment, and fixtures. Exact locations are subject to the approval of the Owner's Representative.

B. In the event of conflict between the drawings and specifications, or discrepancies within either, this shall be brought to the attention of the Engineer for resolution prior to submission of bids. In the event that the contractor fails to note these discrepancies prior to submission of bids or in writing within their bid submission, the Engineer shall resolve the discrepancy such that the design intent is provided. The contractor shall provide all labor, materials and equipment to correct the installation deficiencies as defined by the Engineer.

1.09 ELECTRONIC CAD DRAWING FILES

A. The Engineer may provide the Contractor with Cad files for this project with the understanding that these Cad files shall be used for reference purposes only, and not as shop drawings or as-built documents. It is the Contractors' responsibility to provide detailed, coordinated shop drawings and documentation prior to installation. The purpose of the Contractors' coordination shop drawings is to account for all trades and field conditions and identify any conflicts that shall be resolved prior to installation.

B Any additional cost for changes due to conflicts as a result of the Contractors' failure to provide properly coordinated documents will be the responsibility of the Contractors and not of the Engineer.

C. If the Contractor requests electronic Cad files from the Engineer and this request is granted, the Contractor shall pay the Engineer's $100 per drawing to processing the request. The cost for this may be deducted from any moneys owed to the Contractor.

1.10 QUALITY ASSURANCE

A. Manufacturers of equipment shall be firms regularly and currently engaged in the production of equipment and accessories provided. The design and size/capacity of each item of equipment provided for this project needs to have been in satisfactory and efficient operation on at least three (3) installations for not less than three (3) years.

B. Suppliers of equipment must have factory trained and authorized personnel for the service of all equipment provided.

C. Apply and install materials, equipment, and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents shall be referred to the Owner's Representative for resolution.

D. The contractor shall engage the services of a qualified installer for the installation and application of joint sealers, flashing, access panels, cutting and patching.

E. All work shall be done in a neat and workmanlike manner. All methods of construction or details of workmanship, not specifically described or indicated in the contract documents, shall be subject to the control and approval of the Owner's Representative. Equipment and materials shall be of the quality and construction indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIAL MINIMUM REQUIREMENTS

A. Provide Materials that meet the following minimum requirements:

1. Materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, in accordance with NFPA 255.

2. All equipment and material for which there is a listing service shall bear a UL label.

3. Electrical equipment and systems shall meet UL Standards and requirements of the N.E.C. This listing requirement applies to the entire assembly. Any modifications to equipment to suit the intent of the specifications shall be performed in accordance with UL Standards and the requirements of the N.E.C.

4. Communications equipment shall meet all FCC Regulations

5. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Used equipment or damaged material will be rejected.

6. The listing of a manufacturer as “acceptable” does not indicate acceptance of a standard or catalogued item of equipment. All equipment and systems must conform to the Specifications.

2.02 SUBSTITUTIONS

A. The materials, products and equipment described in the Bidding Documents establish a standard of required quality, functions, dimensions and appearance that must be met by any proposed substitution.

B. Proposed substitutions must be submitted in writing to the Architect and Engineer a minimum of ten (10) days prior to the date for receipt of Bids. Each request shall include the name of the proposed material, product or equipment being substituted, cut sheets, installation drawings, performance and test data, warranties and location of three(3) similar installations with reference names of owner or facility personnel responsible for maintaining equipment. At that time the equipment or will be evaluated and if determined to be acceptable an Addendum will be issued to all bidders. Failure to follow the guidelines described above may result in equipment being rejected at submittal based solely on failure to follow the above guidelines.

C. Approval by the Architect and/or Engineer to proceed with a substitution does not relieve the contractor from meeting all of the dimensional requirements and maintaining the full functionality and performance of the material, product or equipment used as the basis of design.

D. Requests for substitution shall be made only by a Bidder. Requests for substitution from sales representatives, vendors or suppliers are unacceptable and will not be considered.

2.03 FACTORY-ASSEMBLED PRODUCTS

A. Provide maximum standardization of components to reduce spare part requirements.

B. Manufacturers of equipment assemblies which include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of the same manufacturer.

2. Constituent parts which are alike shall be products of a single manufacturer.

3. Components shall be compatible with each other and with the total assembly for intended service.

4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear the manufacturer's name or trademark, model number and serial number on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment which serve the same function must be the same make and model. Exception will be permitted if performance requirements cannot be met.

2.04 COMPATIBILITY OF RELATED EQUIPMENT

A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that a complete and fully operational system will result.

2.05 SPECIAL TOOLS

A. If any part of equipment requires a special tool for assembly, adjustment or maintenance thereof and such tool is not readily available in the commercial tool market, it shall be furnished by the Contractor as required for the duration of the project and turned over to the Owner in serviceable condition upon completion of the scope of work. Contractor shall obtain written sign off by the Owner certifying that the Owner is in receipt of such tools.

2.06 SAFETY GUARDS

A. Provide guards on all shafts and couplings and all V-belt and sheave assemblies to prevent damage to equipment and injury to personnel.

2.07 LIFTING ATTACHMENTS

A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered without bending or distortion of shape, such as rapid lowering and braking of load.

2.08 MISCELLANEOUS SUPPORTS

A. Metal bars, plates, tubing, etc. shall conform ASTM standards:

1. Steel plates, shapes, bars, and grating - ASTM A 36
2. Cold-Formed Steel Tubing - ASTM A 500
3. Hot - Rolled Steel Tubing - ASTM A 501
4. Steel Pipe - ASTM A 53, Schedule 40, welded

B. Metal fasteners shall be zinc-coated (type, grade and class as required).

2.09 ACCESS DOORS AND PANELS

A. Steel access doors and frames shall be factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush.

B. Provide access doors at all locations where equipment access for service, repair, and/or adjustment may be required. This shall include access to all air balance dampers. (In lieu of access to air balance dampers above hard ceilings or in chase walls, Contractor may submit for approval for use of remote regulators).

C. Construction:

1. Frames:

   a. 16 gage steel with 1 inch wide, exposed, perimeter flange and adjustable masonry anchors for units installed in masonry, pre-cast, cast-in-place concrete, or ceramic tile.
   b. 16 gage steel, perforated flanges with bead for gypsum or plaster wall board.
   c. 16 gage steel with galvanized, expanded metal lath and exposed casing bead, welded to perimeter of frame for full bed plaster applications.

2. Access Doors:

   a. Provide 14 gage sheet steel, flush panel doors with concealed, continuous, factory-installed piano hinge, primed and painted, set to open 175 degrees in unrated partitions.
   b. Provide fire-rated, insulated, flush panel doors, with continuous piano hinge and self-closing mechanism rated for 1-½ hour “B” labeled, in fire-rated partitions.

3. Provide flush, screwdriver operated cam locks on all access doors.

2.10 CONCRETE BASES

A. Provide concrete bases for all floor mounted equipment. Provide 3,000 lb. concrete, chamfer edges, trowel finish, and securely bond to floor by roughening slab and coating with cement grout. Provide a minimum of one ½” rebar dowel for every 2 sq ft of base area, anchored 2” into floor and base, to eliminate movement. Bases shall be 4" high (unless otherwise indicated); shape and size to accommodate equipment, to extend 4” beyond equipment footprint in all directions. Set anchor bolts in sleeves before pouring. After anchoring and leveling, fill equipment bases with grout.

2.11 FIRE STOPPING

A. Fire-stopping for Openings Through Fire and Smoke Rated Walls and Floor Assemblies shall be listed or classified by an approved independent testing laboratory for "Through-Penetration Fire-Stop Systems." The system shall meet the requirements of "Fire Tests of Through-Penetration Fire-Stops" designated by ASTM E814.

B. Acceptable Manufacturers:

1. Dow Corning Fire-Stop System Foams and Sealants.
2. Nelson Electric Fire-Stop System Putty, CLK and WRP.
3. Thomas & Betts - S-100 FS500/600,
4. Carborundum Fyre Putty.

PART 3 - EXECUTION

3.01 SUBMITTALS: SHOP DRAWINGS/PRODUCT DATA/SAMPLES

A. Submit Shop Drawings on all items of equipment and materials to be furnished and installed. Submission of Shop Drawings and samples shall be accompanied by a transmittal letter, stating name of project and contractor, number of drawings, titles, and other pertinent data called for in individual sections. Shop Drawings shall be dated and contain: name of project; name of prime professional; name of prime contractor; description or names of equipment, materials and items; and complete identification of locations at which materials or equipment are to be installed. Incomplete submittals will not be accepted. Number each submittal. Indicate deviations from contract requirements on Letter of Transmittal. Corrections or comments made on the Shop Drawings during the review do not relieve the Contractor from compliance with requirements of the drawings and specifications. The Contractor is responsible for confirming and correcting all quantities; checking electrical characteristics and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of all other trades; and performing his work in a safe and satisfactory manner.

B. Approval of shop drawings will not relieve this contractor from responsibility for errors and omissions therein. All such errors or omissions must be corrected by this contractor irrespective of any approvals by the Architect or Engineer.

C. Pre-test submittals must be written in report format, submitted and signed off on by Owner and Engineer prior to the start of any construction work, including demolition.

D. Shop drawings include, but are not limited to, the submissions listed below. Refer to individual specification sections for specific requirements and additional submission requirements:

SECTION	DESCRIPTION	REQUIRED SUBMISSIONS
230020	Basic Mechanical Requirements	
230513	Motors	Generally None Required.
230514	Electric Wiring	Complete wiring diagram for equipment and systems.
230519	Gauges and Thermometers	Manufacturer's data for each gauge and thermometer type. Submittal shall clearly designate where each device shall be utilized, including the scale range.
230523	Valves	Valves and accessories
230533	Electric Heat Tracing	Shop drawings on electric heat tracing including wiring diagrams for electric heat tracings, connections to electric power feeders and associated wiring.
230548	Vibration Isolation	Shop drawings on the products provided for each piece of equipment.

230553	Mechanical Identification	Manufactures technical product data and installation instructions for each identification material and device. Valve schedule for each piping system typewritten on a 8-1/2. X 11 in. (minimum) indicating code number, location and valve function. Schedule of pipe, equipment and name identification for review before stenciling or labeling. Confirm naming/numbering is consistent with Owner's convention.
230593	Testing, Adjusting and Balancing	Quality-Assurance Submittals: Submit 2 copies of evidence that the Testing, Adjusting, and Balancing qualifications have been meet the qualifications list in the "Quality Assurance" article below. Sample Report Forms: Submit required number of sets of sample testing, adjusting, and balancing report forms. Certified Testing, Adjusting, and Balancing Reports: Submit required number of copies of reports prepared, as specified in the Submission of Certified Balance Reports Section, on approved forms certified by the registered contractor; include registration number. Warranty: Submit required number of copies of the warranty specified in the "Warranty" Article below.
230700	Insulation	Manufacturer data. Schedule of insulation applications. Certification.
230714	Fired Rated Duct Insulation	Listing agency's detailed drawing showing opening, penetrating items, and fire-stopping materials, identified with the listing agency's name and number or designation, fire rating achieved, and date of listing. Indentify which rated assembly each system is to be used in. Any installation instructions that are not included on the detailed drawing. For proposed systems that do not conform strictly to the listing, submit listing agency's drawing marked up to show medications and stamped approved by fire-stop system manufacturer's fire protection engineer. Product Certificates: Submit certificates signed by fire-stop system manufacturer certifying that materials furnished comply with requirements. Product Data: Manufacturer's data sheets on each material to be used in fire-stop systems, including: Product characteristics and Materials Safety Data Sheets (MSDS). Listing numbers of systems in which each product is to be used. Preparation instructions and recommendations. Storage and handling requirements and recommendations. Installation methods. Installers Qualification Documentation. Verification Samples: For each finish product specified, two samples representing actual product, color, and patterns.
230800	Mechanical Systems Commissioning	
230810	Mechanical Testing Requirements	

230923	Temperature Controls	Detailed piping and wiring control diagrams and systems description for each system under control. Detailed layout and nameplate list for component control panels and DDC panels. Submit a valve and damper schedule showing size, pressure drop configuration, capacity, and locations. Provide apparatus Bulletins and data sheets for all control system components. A complete listing of input and output points, control loops and/or routines, including time of day functions, and facilities management system functions for each controlled system. This listing shall include point logical names, identifiers, and alarmable ranges. Provide as part of a separate submittal a hard copy of all graphics showing system components, sensor locations, setpoints and fixed/variable data. Engineer shall review and approve graphic format prior to final acceptance of system.
230963	Gas Monitoring Systems and Accessories	Product Data: Submit for approval the manufacturer's technical product data for each component furnished as part of the gas detection system. Data shall include dimensions, capacities, performance characteristics, electrical requirements, and material finishes. Data shall also include installation and start-up requirements. Shop Drawings: Before commencing any work or ordering any materials, submit for approval drawings.
232000	Piping Systems and Accessories	Schedule of pipe materials, fittings and connections by system. Grooved mechanical connections systems. Refrigerant piping diagram. Anchors, sleeves, hanger shields, guides.
232023	Pumps	Shop drawings and performance curves on pumps and pump accessories. Clearly indicate which equipment is being submitted.
232133	Water Systems Specialties	Shop drawings on water system specialties
232223	Condensate Pump and Receiver Unit	Condensate pump and receiver unit. Control panel schematic wiring diagram.
232233	Steam Specialties and Accessories	Shop Drawings on steam specialties and accessories. Schedule of equipment, capacities, and pressure drops.
232236	Steam Pressure Reducing / Relief Valves	Reducing valve station and accessories. Pressure relief valves.
233000	Sheet Metal and Ductwork Accessories	Shop drawings of all sheet metal equipment being provided. Submit a complete shop standard manual including construction details for all shop fabricated materials. Ductwork Detail Drawings.
233316	Fire and Smoke Dampers	Types, schedule of sizes, locations, and installation arrangements of all dampers. Manufacturers UL listed installation details for each mounting arrangement.

233400	Fans	Shop drawings on fans, motors, drives, and accessories. Include all fan curves and fan operating point.
233600	Variable Volume Terminal Units	Terminal units by room number, maximum and minimum CFM, accessories, pressure drops, discharge and sound power data by octave band. Clearly indicate box sizes being proposed. Submit separately the controller and control interface devices being utilized.
233623	Chilled Beam	Performance Data, Mechanical Data
233713	Registers and Diffusers	Registers/Grilles/Diffusers. Room schedule listing size, throw, direction of throw, accessories, finish, material type and color chart.
233726	Louvers and Penthouses	Louvers including all blade types, finishes and arrangements. Provide original color charts for selection of finish
236416	Water Chillers	Water chilling unit and accessories. Motor starter. Auxiliaries and accessories.
236513	Cooling Tower	Cooling tower and accessories
237313	Air Handling Units	Shop drawings on air handling units.
238116	Split System Air Conditioner	Split system air conditioner. Manufacturers wiring diagrams Refrigerant piping schematics showing accessories.
238210	Hydronic Gravity Heating Equipment	Shop drawings on gravity heating equipment with color selection chart. Clearly indicate which equipment is being submitted.
238231	Radiant Ceiling Panel	Shop drawings on radiant panel heating equipment with color selection chart. Clearly indicate which equipment is being submitted. Provide 12" long sample showing face pattern, tubing in place, cross channels and clips in place.
238239	Unit Heaters and Cabinet Unit Heaters	Unit heaters and cabinet unit heaters

3.02 COORDINATION DRAWINGS

A. Before construction work commences, Contractors for all trades shall submit Coordination Drawings in the form of reproducible transparencies drawn at not less than 3/8" = 1'-0" scale, and electronic format. Coordination Drawings are required throughout all areas for all trades. These drawings shall identify and show resolutions of trade conflicts. Mechanical Equipment Rooms shall be drawn early in the Coordination Drawing process, simultaneous with all other congested areas. Prepare Coordination Drawings as follows:

1. Division 23 Contractor shall prepare the base plan Coordination Drawings showing all ductwork and all pertinent piping and equipment. These drawings may be sepias of the required ductwork Shop Drawings. The drawings shall be coordinated with cable tray, light fixtures, sprinklers, air diffusers, other ceiling mounted items, ceiling heights, structural work, maintenance clearances, electric code clearance, reflected ceiling plans, and other contract requirements. Re-position proposed locations of work after coordination drawing review by the Construction Manager and the Architect. Provide adjustments to exact size,

location and offsets of ducts, pipes, conduit, etc., to achieve reasonable appearance objectives. Provide these adjustments as part of Base Bid Contracts. Minor revisions need not be re-drawn.

2. Division 26 Contractor will provide sepia transparencies and/or prints and submit the base plan to all major trades' sub-contractors.

3. Division 26, Division 28, Division 22, and Division 21 sub-contracts will each draft location of piping, conduits, equipment, etc. on the base plan as provided by the HVAC Contractor such that a complete coordination of all trades is represented and areas of conflict and recommended resolutions are noted.

4. Do not install equipment, equipment foundations or piping until Coordination Drawings have been approved.

3.03 PROTECTION OF PERSONS AND PROPERTY

A. Contractor shall assume responsibility for Construction Safety at all times and provide, as part of contract, all trench or building shoring, scaffolding, shielding, dust/fume protection, mechanical/electrical protection, special grounding, safety railings, barriers, and other safety feature(s) required to provide safe conditions for all workmen and site visitors.

3.04 EXISTING SYSTEMS AND CONDITIONS

A. Prior to beginning work, inspect the entire work area for defects in the existing construction such as scratches, holes etc. Submit a complete list and photographs of existing damage, to the Owner prior to beginning work. If existing damage is not documented and submitted, the Contractor shall repair all damage found at the completion of the project that is determined to have been caused by the work of this contract. Repairs shall restore the area to like new condition.

B. The Owner’s Representative shall determine if the Contractor has damaged existing systems or construction and shall approve the repairs.

3.05 ASBESTOS RECOGNITION AND PRECAUTIONS

A. The Contractor shall be responsible for coordination of all required removal work, coring, cutting and patching with the Owner’s asbestos management plan. Prior to performing such work, identify areas containing asbestos. Notify the Owner so that arrangements may be made for abatement and/or containment prior to work proceeding. The Contractor shall be responsible for cleaning all areas where asbestos is released due to the failure to coordinate with the asbestos management plan. Refer to Division 1 Sections for further requirements.

B. The disturbance or dislocation of asbestos-containing materials causes asbestos fibers to be released into the building's atmosphere, thereby creating a health hazard to workmen and building occupants. Consistent with Industrial Code Rule 56 and the content of recognized asbestos-control work, the Contractor shall apprise all of his workers, supervisory personnel, subcontractors, Owner and Consultants who will be at the job site of the seriousness of the hazard and of proper safeguards and work procedures which must be followed, as described in New York State Department of Labor Industrial Code Rule 56.

3.06 REMOVALS

A. Where existing equipment removals are called for, submit complete list to Owner's Representative. All items that the Owner wishes to retain that do not contain asbestos or PCB Material shall be delivered to location directed by the Owner. Items that the Owner does not wish to retain shall be removed from site and legally disposed of. Removal and disposal of material containing asbestos and/or PCB's shall be in accordance with Federal, State and Local law requirements. Where equipment is called for to be relocated. Contractor shall carefully remove, clean and recondition, then reinstall. Remove all abandoned piping, wiring, equipment, lighting, ductwork, tubing, supports, fixtures, etc. Visit each room, each crawl space and each roof to determine total Scope of Work. Consistent with Industrial Code Rule 56 and the content of recognized asbestos-control work, the Contractor shall apprise all of his workers, supervisory personnel, subcontractors, Owner and Consultants who will be at the job site of proper safeguards and work procedures which must be followed, as described in New York State Department of Labor Industrial Code Rule 56.

B. Completely remove all piping, conduit, controls, and other devices associated with the equipment not to be reused in the new work. This includes all pipe, valves, fittings, insulation, conduit, panels, and all hangers, including the top connection and any fastenings to building structural systems. Seal all openings, after removal of equipment, pipes, ducts, conduits and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the architectural, structural, mechanical, site, and electrical drawings and specifications for additional facilities to be demolished or handled.

3.07 STORAGE AND PROTECTION OF MATERIALS

A. Store Materials on dry base, at least 6" above-ground or floor. Store so as not to interfere with other work or obstruct access to buildings or facilities. Provide waterproof/windproof covering. Remove and provide special storage for items subject to moisture damage. Protect against theft or damage from any cause. Replace items stolen or damaged, at no cost to Owner.

3.08 FREEZING AND WATER DAMAGE

A. Take all necessary precautions with equipment, systems and building to prevent damage due to freezing and/or water damage. Repair or replace, at no change in contract, any such damage to equipment, systems and building. Perform first seasons winterizing in presence of Owner's operating staff.

3.09 ROUGH-IN

A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. **DO NOT SCALE PLANS**. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the Owner’s Representative for approval before proceeding.

B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.

1. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Coordinate all work with the architectural reflected ceiling plans and/or existing Architecture. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans.
2. Before roughing for equipment furnished by Owner or in other contracts, obtain from Architect and other contractors, approved roughing drawings giving exact location for each piece of equipment. Do not "rough in" services without final layout drawings approved for construction. Cooperate with other trades to insure proper location and size of connections to insure proper functioning of all systems and equipment. Obtain written authorization from the Owner's Representative or other contractor for any "rough ins" that, due to project schedule, are required before approved coordination drawings are available. Any work installed without written authorization or approved coordination drawings, causing a conflict will be relocated by the Contractor at no expense to the Owner.
3. For equipment and connections provided in this contract, prepare roughing drawings as follows:
    a. Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings.
4. Where more than one trade is involved in an area, space or chase, all shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements. In general, ductwork shall be given preference except where grading of piping becomes a problem, followed by piping then electrical wiring. If, after installation of any equipment, piping, ducts, conduit, and boxes, it is determined that ample maintenance and passage space has not been provided, rearrange work and/or furnish other equipment as required for ample maintenance space. Any changes in the size or location of the material or equipment supplied, which may be necessary in order to meet field conditions or in order to avoid conflicts between trades, shall be brought to the immediate attention of the Owner's Representative and approval received before such alterations are made.

C. Provide easy, safe, and code mandated clearances at controllers, motor starters, valve access, and other equipment requiring maintenance and operation. Contractor shall relocate existing work in the way of new construction. VISIT SITE BEFORE BIDDING TO DETERMINE SCOPE OF WORK. Provide new materials, including new piping and insulation for relocated work.

D. All equipment requiring service and / or access shall be provided adequate clearances for this purpose. Any clearances described in manufacturer's information, code requirements, etc., shall be taken into account in determining final rough-in positions. Reasonable access for maintenance and service shall be maintained. The most stringent standard, as determined by the Engineer, shall apply.

3.10 CUTTING AND PATCHING

A. Each trade shall include their required cutting and patching work unless shown as part of the General Construction work on the architectural drawings. Refer to "General Conditions of the Contract for Construction," for additional requirements. Cut and drill from both sides of walls and/or floors to eliminate splaying. Patch, cut or abandoned holes left by removals of equipment or fixtures. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering, other finished surfaces. Patch openings and damaged areas equal to existing surface finish. Cut openings in prefabricated construction units in accordance with manufacturer's instructions.

3.11 CONCEALMENT

A. **Conceal all contract work** above ceilings and in walls, below slabs, and elsewhere throughout building. If concealment is impossible or impractical, notify Owner's Representative before starting that part of the work and install only after his review. In areas with no ceilings, install only after Owner's Representative reviews and comments on arrangement and appearance.

3.12 ACCESS DOORS AND PANELS

A. Provide access doors, sized to permit complete access for any concealed and/or inaccessible junction boxes, control and monitoring devices, duct mounted fire alarm detectors and other electrical equipment requiring access for maintenance or operation.

B. Provide access doors, sized to permit compete access for all items requiring adjustment, such as balance dampers above solid ceilings.

C. Set frames accurately in position and securely attach to supports with face panels plumb and level in relation to adjacent finish surfaces.

D. Adjust hardware and panels after installation for proper operation.

E. Access doors and panels shall operate freely and be fully usable for their intended function.

3.13 CHASES

A. Drill holes for floor and/or roof slab openings.

B. Multiple pipes smaller than 1" properly spaced and supported may pass through one 6" or smaller diameter opening.

C. Seal voids in fire rated assemblies with a fire-stopping seal system to maintain the fire resistance of the assembly. Provide 18 gauge galvanized sleeves at fire rated assemblies. Extend sleeves 2" above floors.

D. In wall openings, drill or cut holes to suit. Provide 18 gauge galvanized sleeves at shafts and fire rated assemblies. Provide fire-stopping seal between sleeves and wall in drywall construction. Provide fire-stopping similar to that for floor openings.

3.14 FIRE-STOPPING

A. Fire-stopping for openings through fire and smoke rated wall and floor assemblies:

1. Provide materials and products listed or classified by an approved independent testing laboratory for "Through-Penetration Fire-Stop Systems." The system shall meet the requirements of "Fire Tests of Through-Penetration Fire-Stops" designated ASTM E814.
2. Provide fire-stop system seals at all locations where piping, tubing, conduit, electrical busways/cables/wires, ductwork and similar utilities pass through or penetrate fire-rated wall or floor assembly. Provide fire-stop seal between sleeve and wall for drywall construction.
3. The minimum required fire resistance ratings of the wall or floor assembly shall be maintained by the fire-stop system. The installation shall provide an air and watertight seal.
4. The methods used shall incorporate qualities, which permit the easy removal or addition of electrical conduits or cables without drilling or use of special tools. The product shall adhere to itself to allow repairs to be made with the same material and permit the vibration, expansion and/or contraction of any items passing through the penetration without cracking, crumbling and resulting reduction in fire rating.
5. Apply fire stopping within the temperature and humidity limits permitted by the manufacturer.
6. Provide rigid steel sleeves where non-armored cables pass through fire rated walls and barriers.

3.15 FLASHING AND SEALING

A. Openings through roofs shall be flashed in a manner to not affect roof guarantee or bond. Engage qualified Roofing Contractor licensed by the Roofing Manufacturer, as part of the contract. Provide non-ferrous flashing pieces, skirts, hoods and collars as required to make ducts, pipes, conduits, and other penetrations watertight. Where curbs are called for with respect to rectangular openings in new roofs, flashing will be done by others unless specifically indicated otherwise. Caulk and waterproof with additional material so as to seal airtight and watertight.

B. Where openings for pipe/duct penetrate through roofs into equipment pipe chases, mechanical spaces or penthouses, the penetration of the roof deck/slab shall be sleeved, sealed and firestopped as required. Insulate at base of pipe chase, mechanical space or penthouse to match insulation value of the roofing system.

C. Apply all flashing and sealers within the temperature and humidity limits permitted by the manufacturer.

3.16 SUPPORTS

A. Provide required supports, beams, angles, hangers, rods, bases, braces, and other items to properly support contract work. Supports shall meet the approval of the Owner's Representative. Modify studs, add studs, add framing, or otherwise reinforce studs in metal stud walls and partitions as required to suit contract work. If necessary, in stud

walls, provide special supports from floor to structure above. For Precast Panels/Planks and Metal Decks, support mechanical/electrical work as determined by manufacturer and Owner's Representative. Provide heavy gauge steel mounting plates for mounting contract work. Mounting plates shall span two or more studs. Size, gauge, and strength of mounting plates shall be sufficient for equipment size, weight, and desired rigidity.

3.17 GENERAL INSTALLATIONS REQUIREMENTS

A. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed

B. Coordinate ordering and installation of all equipment with long lead times or having a major impact on work by other trades so as not to delay the job or impact the construction schedule. Pay close attention to equipment that must be installed prior to building enclosure.

C. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible.

D. Set all equipment to accurate line and grade, level all equipment and align all equipment components.

E. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from premises when no longer required.

F. No equipment shall be hidden or covered up prior to inspection by the Owner’s Representative. All work requiring inspection which is concealed prior to approval shall be re-opened for inspection at the Contractor’s expense. All work that is determined to be unsatisfactory shall be corrected immediately.

G. All work shall be installed level and plumb, parallel and perpendicular to other building systems and components.

H. Install access panels or doors where units are concealed behind finished surfaces.

3.18 PAINTING

A. This Contract Includes the following:

1. Painting for all cut and patch work performed as part of Division 23 contract.
2. Painting required for touch-up of surfaces damaged due to the installation of Division 23 work.
3. Painting as required to repair finish of equipment furnished.

3.19 ADDITIONAL ENGINEERING SERVICES

A. In the event the Consultant is required to provide additional engineering services as a result of substitution of equivalent materials or equipment by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Consultant is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Consultant's hourly rate and expenses in connection with such additional services shall be paid by the Contractor and shall be deducted from any moneys owed to the Contractor.

B. In the event the Consultant is required to provide additional engineering services as a result of Contractor's errors, omissions or failure to conform to the requirements of the Contract Documents, or if the Consultant is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Consultant's hourly rate and expenses in connection with such additional services shall be paid by the Contractor and shall be deducted from any moneys owed to the Contractor.

C. In the event the Consultant is required to initiate design changes due to failure of the contractor to properly coordinate with the construction schedule, and / or other trades, then the Consultant's hourly rate and expenses in connection with such additional services shall be paid by the Contractor and shall be deducted from any moneys owned to the Contractor.

3.20 CLEANING

A. It is the Contractor's responsibility to keep clean all equipment and fixtures provided under this contract for the duration of the project. Each trade shall keep the premises free from an accumulation of waste material or rubbish caused by his operations. The facilities require an environment of extreme cleanliness, and it is the Contractor's responsibility to adhere to the strict regulations regarding procedures on the existing premises. After all tests are made and installations completed satisfactorily:

1. Thoroughly clean entire installation, both exposed surfaces and interiors.
2. Remove all debris caused by work.
3. Remove tools, surplus, materials, when work is finally accepted.

B. Cleanliness of construction shall extend to include the interior and exterior surfaces of all equipment and systems provided under this contract. This includes, but is not limited to:

1. Unitary equipment exposed to occupant use (fin tube radiation, chilled beam systems, etc.) Shall be thoroughly cleaned for final use both inside and out prior to project completion.
2. Equipment located in mechanical spaces shall be cleaned on the exterior such that no significant accumulation of debris or dirt is evident.
3. Interiors of all air handling equipment shall be thoroughly cleaned on the interior such that no evidence of dust, dirt or debris remains prior to project turnover.
4. Ductwork systems – Ductwork shall be delivered to the job site with ends capped or covered to eliminate contamination during transportation and site storage. All open ends shall remain covered during the entire course of the construction process. Ductwork with evidence of dust, dirt or debris shall be thoroughly cleaned by an approved method prior project turnover.

3.21 HVAC EQUIPMENT CONNECTIONS

A. Provide final steam, condensate, hot water, glycol, chilled and condenser water, drain, vent, oil line and gas connections to all equipment as required by the equipment. Provide final connections, including domestic water piping, wiring, controls, and devices from equipment to outlets left by other trades. Provide equipment waste, drip, overflow and rail connections extended to floor drains.

B. Provide for Owner furnished and Contractor furnished equipment all valves, piping, piping accessories, traps, pressure reducing valves, gauges, relief valves, vents, drains, insulation, sheet metal work, controls, dampers, as required.

C. Refer to manufacturer's drawings and specifications for requirements of medical equipment, laboratory equipment and special equipment. Verify connection requirements before bidding and confirm prior to roughing.

3.22 START UP AND OWNER INSTRUCTIONS

A. Before acceptance of the work, furnish necessary skilled labor to operate all systems by seasons. Instruct the Owner's designated personnel on the proper operation and maintenance of all systems and equipment. Obtain written acknowledgment from person(s) instructed. Prior to acceptance repeat the instructions, if asked to do so. Contractor is fully responsible for systems until acceptance, even though operated by Owner's personnel, unless otherwise agreed in writing. Provide operating, maintenance and starting precautions and procedures to be followed by the Owner for operating systems and equipment. Mount the instruction in clear plastic holder on or adjacent to the equipment.

B. Where supervision by a manufacturer is called for, provide manufacturer's certified technician or engineer to supervise the startup, testing and adjustment of the equipment or system. Where two or more manufacturers are involved (i.e. variable frequency drive and air handling unit) both manufacturers shall be present at start up. The manufacturer shall provide a written report detailing the testing and start-up, including problems that occurred and their method of resolution.

3.23 OPERATION AND MAINTENANCE MANUALS

A. Provide Operation and Maintenance Manuals. Include one copy each of: approved Shop Drawings, wiring diagrams, piping diagrams, spare parts lists, as-built drawings and manufacturer's instructions. Include typewritten instructions, describing equipment, starting/operating procedures, emergency operating instructions, seasonal changeover, freeze protection, precautions and recommended maintenance procedures. Include name, address, and telephone number of supplier, manufacturer's representative and service agency for all major equipment items. Bind above items in a three ring binder with name of project on the cover. Deliver to Owner's Representative before request for acceptance.

3.24 RECORD DOCUMENTS

A. In addition to all requirements elsewhere in the Contract Documents, prepare and provide record documents of the as-constructed work which meets the following minimum standards:

1. Utilities below floors, slabs and grade: During construction, maintain accurate records of all final locations and inverts for all services inside and outside of the buildings, beneath grade and below floors.

2. Take dimensions from a given fixed bench mark, such as the corner of a building, and neatly and clearly indicate same on reproducible prints.

3. Provide Record Drawings for all Contract Work. Document the location of control devices isolation valves, safety devices and equipment.

4. Submit reproducible tracings, with all required corrections and submit complete set of final approved record drawings in PDF file format on CD.

5. Incorporate all field changes, change orders and other modifications into the final Record Drawings.

3.25 SALVAGEABLE MATERIALS

A. Salvageable materials will be reviewed and identified by the Owner. Instruction shall be given to the Contractor whether the Owner will remove salvageable materials, or whether contractor is to remove and deliver salvageable materials to a pre-designated site.

B. HVAC items normally accepted as salvage by the Owner:

1. Window air-conditioning units

END OF SECTION

SECTION 230513

MOTORS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents. Contractor shall provide to the Owner a completed application form as prescribed by the NYSERDA "Existing Facilities Pre-Qualified Motors Incentives" program including application, required documentation, and post-installation inspection, if required.

1.02 SUBMITTALS

A. None required.

PART 2 – PRODUCTS

2.01 MOTORS

A. General Requirements:

1. Motors built for 60 Hz operation, three phase for 1/2 hp and larger; single phase for 1/3 hp and smaller. In compliance with NEMA Standards, wound specifically for nameplate voltage, and selected for appropriate duty and environment. Minimum service factor of 1.15 at rated voltage and frequency. Bearings rated for 20,000 life hours. V-belt connected motors with adjustable slide rail bases and pulleys. Motors shall have Class F insulation system, with Class B temperature rise. Maximum allowable motor temperature rise for open drip-proof or totally enclosed fan cooled (TEFC) type at 1.15 service factor shall be 80 ^{o}C above 40^{o}C ambient up to 300 hp. NEMA locked rotor KVA code as required to match unit equipment torque characteristics. Single-phase motors shall be capacitor start, induction run, or split phase type. Polyphase motors shall be constant speed, squirrel cage, unless otherwise called for. Motors for solid state driven, variable speed fans or AHU units shall be designed for definite purpose energy efficient drive control.

2. Three Phase Motors rated 1 hp and greater shall be special design, NEMA Premium, energy-saver type with a guaranteed NEMA nominal full-load efficiency, by IEEE Standard 112 Test Method "B". Efficiency rating shall appear on nameplate, and shall be not less than the National Electrical Manufacturer's Association (NEMA) efficiency criteria for NEMA Premium ™ motors. These efficiency requirements are as follows:

MINIMUM NOMINAL FULL-LOAD MOTOR EFFICIENCY						
HP	OPEN MOTOR RPM			ENCLOSED MOTOR RPM		
	1200 6 Pole	1800 4 Pole	3600 2 Pole	1200 6 Pole	1800 4 Pole	3600 2 Pole

MINIMUM NOMINAL FULL-LOAD MOTOR EFFICIENCY						
HP	OPEN MOTOR RPM			ENCLOSED MOTOR RPM		
	1200 6 Pole	1800 4 Pole	3600 2 Pole	1200 6 Pole	1800 4 Pole	3600 2 Pole
1.0	82.5	85.5	77	82.5	85.5	77
1.5	86.5	86.5	84	87.5	86.5	84
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91	88.5	91	91.7	89.5
10	91.7	91.7	89.5	91	91.7	90.2
15	91.7	93	90.2	91.7	92.4	91
20	92.4	93	91	91.7	93	91
25	93	93.6	91.7	93	93.6	91.7
30	93.6	94.1	91.7	93	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93	94.1	94.5	93

3. Nominal Motor Voltage Table:

Nominal System Voltage	Motor Nameplate
480V - 3 phase	460 volt
240V - 1 phase and 3 phase	230 volt
208V - 1 phase and 3 phase	200 volt
120V - 1 phase	115 volt

4. Motor Application:

Environment/Location	Motor Enclosure Type
General Purpose	Open drip-proof, TEFC, or encapsulated
Outdoors, below grade or high humidity	TEFC
Packaged Refrigeration Compressors	Hermetic or semi-hermetic

5. Make: Need not be all of same make, but one of the following: General Electric, Gould, Reliance, Westinghouse, or equal.

PART 3 – EXECUTION

3.01 MOTORS

A. Furnished by equipment manufacturer and especially manufactured and/or selected, mounted, and installed for intended use. Install motors accessible for maintenance and belt adjustment.

END OF SECTION

SECTION 230514

ELECTRIC WIRING

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services for the complete installation of motor control wiring and temperature control wiring as required in Contract Documents. Provide wiring and conduit required to connect devices furnished as part of or adjunctive to the automatic temperature control system and for motor control regardless of the source of supply. Control wiring includes 120 volt and lower voltage wiring for control signals directing equipment operation. Control circuits shall be 120 volt maximum. Provide wiring in accordance with requirements specified in Division 26, "Electrical" and the National Electrical Code. Provide devices required for proper system operation, including special electrical switches, transformers, disconnect switches, relays, and circuit breaker protection.

B. Coordinate all work with Division 26, "Electrical".

1.02 WORK NOT INCLUDED

A. Power wiring for motors, motor starters and associated starting and control equipment, as well as the motor starters (except in the case of equipment specified to have packaged controls/starters), are included in Division 26, "Electrical," unless otherwise called for.

1.03 QUALIFICATIONS

A. Wiring installed in compliance with all requirements of Division 26, "Electrical."

1.04 SUBMITTALS

A. Provide submittals including complete wiring diagrams for equipment and systems. Deliver wiring diagrams to proper trades in time for roughing of conduit, equipment connections, and to avoid delay in construction schedule. Wiring diagrams and roughing information shall clearly indicate scope of work that is part of the Work of Division 26, "Electrical".

PART 2 – PRODUCTS

2.01 PRODUCTS

A. Refer to Division 26 specifications for required wiring materials.

PART 3 – EXECUTION

3.01 GENERAL

A. Check electrical wiring pertaining to equipment for completeness and correctness of connections. Correct any misapplied motor and/or motor starter, improper thermal overload device, or device which fails to function and resultant damage, whether due to incorrect connections or improper information on wiring diagrams.

3.02 WIRING FOR CONTROL SYSTEMS

A. Provide motor control, temperature control and instrumentation wiring for equipment. All wiring shall be in conduit, unless otherwise noted. Refer to Section 260000 sections for type of conduit to be used in specific applications. Provide 18 in. long flexible conduit at motors and devices subject to vibration. Conduit shall be supported on 5 ft. centers. Do not attach directly to hot surfaces, piping, or ductwork. Control wiring shall be in separate conduit from all other wiring. Provide green grounding wire circuited from starter, and run ground wire through conduit to each remote auxiliary relay, pushbutton station, remote panel heating device, thermostat, or device with potentials in excess of 50 volts. Size ground wire as required by NEC.

B. Provide pushbutton stations, pilot lights, selector switches, auxiliary starter contacts, and other devices required to provide specified functions.

C. Where allowable by Code and contract documents, temperature control wiring may be installed without conduit. Installation and wire insulation types shall be as described by NEC, Article 725. All low voltage wiring circuits 50V and under shall:

1. When installed horizontally above accessible ceilings low voltage wiring may be run without conduit. Cables shall be supported using bridle rings attached to building structure.

2. All exposed wiring in occupied spaces shall be run in surface metal raceway, wiremold v700 series where no access is available to wall cavity.

3. In locations where control wiring is being run to wall mounted sensors, the conduit within the stud wall, as well as the junction box, shall be of non-metallic construction. Carlon Flex-Plus Blue Electrical Non-metallic Tubing and Accessories, or equal.

4. All cases not specifically covered by the above cases shall be run in conduit.

3.03 EQUIPMENT WIRING

A. Provide power and control wiring between sections of electric radiation units, between shipping splits, and between remote panels, thermostats, disconnect switches, and their respective units. Provide control wiring from the package control system, to each respective electric heat coil, reheat coil or motor. Properly mount control package. Power wiring to and including disconnect switch shall be by Division 26 "Electrical".

3.04 FIELD WIRING IN STARTERS, CONTROLLERS, AND PANELS

A. Wiring within starters, controllers, and temperature control panels, shall be routed neatly in gutter space, away from moving and/or heat producing parts. Provide 30 ampere, 600 volt rated terminal blocks. Do not place more than two wire connections on pilot device or relay terminal. Where more than two circuit connections are required, use terminal blocks. Provide nylon self-insulated, locking type spade lugs for all control wires. Cables and wires shall be neatly bundled and lashed with nylon cable straps.

END OF SECTION

SECTION 230519

GAUGES AND THERMOMETERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTALS

A. Submit manufacturer's data for each gauge and thermometer type. Submittal shall clearly designate where each device shall be utilized, including the scale range.

PART 2 - PRODUCTS

2.01 WATER PRESSURE GAUGES

A. Construction shall be Bourdon tube type; 4-1/2 in. diameter minimum dial face, in stainless steel case and plastic lense. Phosphor bronze tube, phosphor bronze bushed rotary movement, silver brazed or soldered to brass socket and brass tip, 1/4 in. bottom connection. Accuracy, one (1.0) percent of included scale range. White dial face with black numerals, graduated in pounds per square inch (psi); equipped with bronze pulsation dampener and needle valve.

B. Make: American, Ashcroft, Crosby, Duro, Marsh, Moeller, Trerice, Weiss, Weksler.

2.02 PIPING SYSTEM THERMOMETERS

A. Industrial type, black molded ABS (aluminum) case with glass (plastic) front, blue reading column (mercury free), V-shaped aluminum scale, black numerals. Union flange mounted, separable socket, extension necks where required; range as called for based on service. Universal adjustable type, 9 in. scale size. For installation in water systems where the maximum temperature is less than 120^{o}F: graduations of 1^{o}F, accurate to within 1^{o}F. For installation in hot water systems: graduations of 2^{o}F, accurate to within 2^{o}F.

B. Make: American, Moeller, Trerice, Weiss, Weksler.

2.03 STEAM PRESSURE GAUGES

A. Bourdon tube type, 4-1/2 in. diameter face, range of double normal operating steam pressure. Phosphor-bronze tube, bronze bushed rotary movement, suitable for pressure and temperature involved. Supply with iron steam siphon.

B. Make: American, Duro, Marsh, Trerice, Weiss.

PART 3 - EXECUTION

3.01 WATER PRESSURE GAUGES

A. Provide bar stock needle valve on each gauge line.

B. Provide water pressure guage in piping systems where called for and where scheduled below:

1. Provide ball valve in each pump inlet and outlet tapping, or in piping adjacent to same. Range: 30 in. vacuum to 100 psi.

2. Compression tanks: 0 to 100 psi range.

3. Each water make-up valve assembly: 0 to 60 psi range.

3.02 STEAM PRESSURE GAUGES

A. Provide each steam pressure gauge with ball valve and siphon tailpiece.

B. Provide steam pressure gauges where called for and where scheduled below:

1. High and low sides of each pressure reducing station.

2. Main steam building entrance

3.03 PIPING THERMOMETERS

A. Mounted in oversize tee or elbow if necessary, to provide as little restriction as possible to fluid flow, with stems of proper length to allow accurate reading. Locate adjacent to control sensing equipment. Arrange so as to be easily read from floor.

B. Provide in piping systems where called for and where scheduled below:

C. Cooling Coil: Inlet and outlet; range 20^{o} to 120^{o}F.

D. Heat Exchanger: Inlet and outlet; range 30^{o} to 220^{o}F.

E. Hot Water Zone: Supply and return pipe; range 30^{o} to 220^{o}F.

F. Heating Coil: Inlet and outlet; range 40^{o} to 220^{o}F.

G. Condenser: Inlet and outlet; range 0^{o} to 100^{o}F.

END OF SECTION

SECTION 230523

VALVES

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide labor, martials, equipment, and services as required for the complete installation and related work designated in contract documents.

1.02 SUBMITTALS

A. Valves and accessories.

PART 2 – PRODUCTS

2.01 VALVES

A. General: Valves shall meet the following requirements:

1. Working pressure shall be stamped or cast on bodies.

2. Stem packing shall be serviceable without removing valve from line.

3. To establish a standard of quality and identify features, certain manufacturer's numbers are given in the following paragraphs.

B. Gate Valves:

1. 2-1/2" & larger: IBBM, solid wedge disc, OS&Y flanged, rising stem, 125 lb SWP, Milwaukee F-2891.

2. 2" & smaller: Bronze, solid wedge disc, rising stem, 125 lb SWP, union bonnet, screwed or solder ends.

3. Make: Jenkins, Hammond, Milwaukee, Mueller, Powell, Victaulic.

C. Check Valves:

1. 2-1/2 & larger: IBBT, renewable seat and disc, bolted flange cap, flanged ends, 125 lb SWP.

2. 2" & smaller: Bronze, swing check, 125 lb SWP, screwed or solder ends.

3. Silent check valves: Resilient seat globe type, bronze body with bronze trim and stainless steel spring, 125 lb SWP. Conbraco 61-500 Series.

4. Make: Jenkins, Hammond, Milwaukee, Mueller, Powell, Victaulic.

D. Ball Valves:

1. For chilled water and hot water 2” and under: Bronze body with type 316 shaft, 316 stainless steel ball glass reinforced, carbon impregnated seats, standard porting, 225 psi WP, W.O.G, adjustable packing gland, screwed or soldered ends. Watts [B6000SS].

2. Make: Apollo, Jamesbury, Jenkins, Milwaukee, Powell, Watts, Victaulic.

E. Valves for Gauges and Instruments:

1. 1/4" size: Brass bar stock for 1000 psi and 300°F. Trerice #735 needle valve.

F. Butterfly Valves:

1. For water systems:

a. 100% bubble tight shutoff, 150 psi WP, lug type carbon steel ASTM A216, ductile iron ASTM A536, or cast iron ASTM A126B body. 316 stainless steel disc, replaceable EPDM resilient seat for water temperatures up to 250°F at 150 psi. 316 or 416 stainless steel shaft with corrosion resistant bearings. Equal to Keystone AR2.

b. Operators:

(1) Valves up to 6”: lever operator.

(2) Valves 8” and above: heavy duty manual gear actuator.

2. For low pressure steam (below 15 psig)

a. 100% bubble tight shutoff, 150 psi WP. Lub type cast or carbon steel body. 315 stainless steel disc with corrosion resistant bearings. Replaceable, reinforced, fiber filled TFE, resilient seat. 17-4 PH stainless steel shaft. Equal to Jamesbury #815L, Class 150.

b. Operators:

(1) Valves up to 6”: lever operator.

3. Make: DeZurick, Jamesbury, Keystone, Milwaukee, Powell, Watts, Victaulic

G. Hose Thread Drain Valves:

1. 1/2" ball valve, bronze body, hardened chrome ball with hose thread end, cap and chain, Watts B6001CC.

H. Relief Valves

1. To relieve full heating capacity, as required by ASME Code:

a. Design Equipment: McDonnell Miller Series 240.

b. Make: Bell and Gossett, McDonnell Miller, Kunkle

2. Chilled water coils: equal to Consolidated, Cash-Acme K-10 size 1/2". Set to relieve at 125 psi.

I. Flow Control Valves

1. To prevent overheating by gravity flow. Screwed or soldered ends. Angle or straight pattern, same size as main. Constructed so that entire valve mechanism may be removed for cleaning. Equipped with rising stem opening mechanism to open valve for gravity circulation or draining system.

2. Design Equipment: Bell & Gossett.

3. Make: Armstrong, Bell & Gossett, Taco.

J. Balance Valve

1. Balancing and flow meter stations suitable for use on heating and cooling systems. Constructed for 125 psi and 250^{o}F.

2. Maximum Pressure Drop 5.0 Ft. or less.

3. Use temporary meter furnished by manufacturer/contractor.

4. 3” and Smaller: Calibrated balance valve with provisions for connecting a portable differential pressure meter suitable as a service valve. Meter connections to have built-in check valves. An integral pointer shall register degree of valve openings. Valve shall have internal seals. Install device in pipe line per manufacturer’s instructions for upstream and downstream distances.

   a. Balance valve sizes shall be based upon gpm range rather than pipe size. Select flow balancers such that the range of pipe flow resides in the middle 50% of the manufacturer’s recommended operating range for the device.

   b. Design equipment: Armstrong “ArmFlo”

   c. Make: Bell & Gossett Circuit Setter, Taco, Tour & Anderson.

5. 4” and Larger: Nickel-plated flow meter with provisions for connecting a portable differential pressure meter. Shall be individually calibrated. Provide with a butterfly valve with memory stop at each location.

   a. Flow meter sizes shall be based upon gpm range rather than pipe size.

Flow Meter Size	GPM Range
4”	180 - 300
5”	300 - 500

b. Design equipment: Bell & Gossett.

c. Makes: Bell & Gossett, Illinois, Taco.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Provide valves of type called for and where required to service equipment.

2. Provide at major building and system sections.

3. Provide chain wheels, guides, and chain loops for valves, where called for or in Mechanical Rooms where valves are mounted higher than 8’-0” AFF.

4. Isolating valves for individual terminal units, or other similar apparatus may be inside cabinet or at connection to branch main where accessible.

5. Locate valves with stems at or above horizontal positions and swing check valves in horizontal position only.

6. Butterfly valves may be used for water service and low pressure steam (under 15 psig) over 2” as noted.

7. Ball valves may be used for water service through 3”, unless otherwise noted

8. Provide hose threaded drain valves at low points, strainers, equipment, and as called for.

B. Relief Valves

1. Hot Water System: Pipe discharge to floor drain and place hanger at elbow. Install piping so as not to introduce stress on PRV body.

2. Chilled Water System: Provide as protection for each cooling coil, piped so as to relieve back into system should shutoff valves be closed. Provide check valve in relief valve discharge.

C. Balance Valves:

1. Provide on zone or riser returns, on each hydronic unit and where called for. Meter connection points shall <u>not</u> point downward.

2. On details where a shut-off valve is shown in conjunction with the flow balancer (3" and smaller), if the Armstrong "CBV", Flow Design “AP” or Tour & Anderson "ST" type is used, the additional shut-off valve may be deleted.

3. Install device in pipe line per manufacturer's instructions for upstream and downstream distances.

END OF SECTION

SECTION 230533

ELECTRIC HEAT TRACING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related work as required in contract documents.

1.02 SUBMITTALS

A. Electric heat tracing, wiring diagrams for electric heat tracings, connections to electric power feeders, and associated wiring.

1.03 QUALIFICATIONS

A. Heat tracing and installation shall comply with applicable requirements of NEC pertaining to installation of electric heat tracing.

B. Manufacturer shall have similar products in service for not less than 5 years.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Except as otherwise indicated, provide Manufacturer's standard electric heat tracing materials and components as indicated by published product information, and as required for complete installation.

2.02 ELECTRIC HEAT TRACING

A. Provide electric heat tracing for indicated duty and rated for indicated capacity. The heater shall consist of a flat flexible, low heat density electric heater strip of parallel circuit construction, consisting of a continuous inner core of conductive polymer material. This core shall be insulated with a polyolefin jacket and designed with a flexible metallic overshield. The heater strip shall be capable of being cut to desired length in the field. Only components manufactured by electric heat tracing manufacturer shall be used for all power connection points, tees and end-seal terminations.

B. Heat trace all outdoor condenser water loop and make-up water piping.

C. Capacity:

Watts/Ft.	Pipe Size Range
3	1/4" - 2"
5	2-1/2" - 4"
8	6”

D. Temperature Controls: The heater shall respond to varying localized temperature conditions along the pipe by self-regulating its heat output at each point along its length without reliance on thermostat controls. A constant wattage heater is not acceptable. The heater and components shall be U.L. listed as an approved system for maintaining

water temperature in piping system.

E. Heat tracing shall be rated for 120 volt single phase operation.

F. Design Make: RayChem Corporation.

G. Acceptable Makes: RayChem Corporation, Dekoron Corporation, Chromalox.

PART 3 - EXECUTION

3.01 GENERAL

A. Installer must examine areas and conditions under which electric heat tracing is to be installed and notify the Contractor in writing of any conditions detrimental to the proper and timely completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner complying with the Contract Documents and acceptable to the Installer.

B. Install electric heat tracing as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable installation requirements of NEC and NECA's "Standard of Installation".

C. Coordinate with other mechanical work, including insulation work, as necessary to properly interface installation of electric heat tracing with other work. The heater strip shall be secured to the outside surface of the pipe by glass fiber tape. PVC piping shall have aluminum tap securing heater strip to pipe. Insulation shall be installed over the pipe and heat tracing. Install all components per manufacturer's written instructions.

D. HVAC Contractor shall provide heat tracing and electrical contractor shall connect to power wiring.

E. Provide grounding connections as indicated in manufacturer's written instructions. Tighten connections to comply with tightening torque values specified in UL Standard 486A to assure permanent and effective grounds.

F. Upon completion of installation of electric heat tracing and after building circuitry has been energized, test electric heat tracing to demonstrate capability and compliance with requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance.

END OF SECTION

SECTION 230553

MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 QUALIFICATIONS

A. All identification devices shall comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles.

1.03 SUBMITTALS

A. Submit manufacturer's technical product data and installation instructions for each identification material and device. Submit valve schedule for each piping system typewritten on a 8-1/2 in. X 11 in. (minimum), indicating code number, location and valve function. Submit schedule of pipe, equipment and name identification for review before stenciling or labeling. Confirm naming/numbering is consistent with Owner’s naming/numbering convention prior to stenciling or labeling.

1.04 MAKES

A. Allen Systems, Inc., Brady (W.H.) Co.; Signmark Div., Industrial Safety Supply Co., Inc., Seton Name Plate Corp.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide manufacturer's standard products of categories and types required for each application. In cases where there is more than one type specified for an application, selection is installer's option, but provide single selection for each product category.

2.02 PIPING IDENTIFICATION

A. Identification Types:

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

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

3. Stencil paint: Apply black or yellow stencil paint directly to covering or bare pipe; color to contrast with background. Stencil as follows:

Pipe or Covering	Size Stencil Letter
½", ¾", 1", 1-1/4"	1/2"
1-1/2", 2"	3/4"
2 ½" and over	1"

B. Lettering:

1. Piping labeling shall conform to the following list:

Pipe Function	Identification
Medium Pressure Steam	MPS
Medium Pressure Condensate	MPC
Low Pressure Steam	LPS
Low Pressure Condensate	LPC
Pumped Condensate	PC
Heating Water Supply	HWS
Heating Water Return	HWR
Chilled Water Supply	CWS
Chilled Water Return	CWR
Condenser Water Supply	C
Condenser Water Return	CR
Refrigerant	R
Vent	V
Overflow	OF
Drain	D
Boiler Feed	BF

2.03 VALVE IDENTIFICATION

A. Valve Tags:

1. Standard brass valve tags, 2" diameter with 1/2" high numerals. Identify between heating and plumbing services with 1/4" letters above the valve number.

2. Equal to Seton Style 300 Cat.

B. Valve Chart:

1. Provide valve chart for all valves provided as a part of this project. Frame and place under clear glass. Hang in Mechanical Room.

2.04 EQUIPMENT IDENTIFICATION

A. General:

1. Provide engraved vinyl plates for each major piece of mechanical equipment provided.

2. Nameplates: 3/4" x 2-1/2" equal to Seton Cat. #2060-20.

3. Provide for the following equipment:

   a. Air handling units
   b. Make-Up Air Units
   c. Fans
   d. Pumps
   e. Chillers
   f. Cooling towers
   g. Heat exchangers
   h. Condensate pumps
   i. Unit heaters/cabinet heaters
   j. Terminal units (VAV)
   k. Fire dampers
   l. Smoke dampers

2.05 MISCELANEOUS IDENTIFICATION

A. Provide identification and warning at any ductwork or piping run that is installed below 6'-6" above finished floor.

B. Warning shall read:

CAUTION - UTILITIES INSTALLED WITH RESTRICTED HEAD CLEARANCE

PART 3 - EXECUTION

3.01 GENERAL

A. Provide valve tags for all valves provided on project.

B. Provide equipment tags for all equipment listed in Equipment Identification Section above.

C. Provide piping identification with directional flow arrows for all piping on project. Maximum every 15'-0". Provide tags on piping at all coil terminations. For piping installed through rooms, provide at least one pipe label in each room, for each pipe function.

END OF SECTION

SECTION 230593

TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. All work under this section is subject to the Contract Documents and this Contractor shall be responsible for and governed by all the requirements therein.

B. This Contractor shall reference the entirety of Divisions 23 as they apply to this work.

1.02 SUMMARY

A. Provide labor, materials, equipment and services to perform operations required for testing, adjusting, and balancing HVAC systems to produce design objectives, including, but not limited to the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
3. Measuring electrical performance of HVAC equipment.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly.
6. Reporting results of the activities and procedures specified in this Section

1.03 SUBMITTALS

A. Quality-Assurance Submittals: Submit 2 copies of evidence that the Testing, Adjusting, and Balancing qualifications have been meet the qualifications list in the "Quality Assurance" article below.

B. Sample Report Forms: Submit required number of sets of sample testing, adjusting, and balancing report forms.

C. Certified Testing, Adjusting, and Balancing Reports: Submit required number of copies of reports prepared, as specified in the Submission of Certified Balance Reports Section, on approved forms certified by the registered contractor; include registration number.

D. Warranty: Submit required number of copies of the warranty specified in the "Warranty" Article below.

1.04 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing professional certified/registered by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Professional shall have performed as a member in good standing with recognized procedures for no less than five (5) years including projects of the magnitude and design of this project. Balancing Professional must be approved by the Engineer.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.

2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC or NEBB's Standards for Testing, Adjusting, and Balancing, or approved equal.

D. Instrumentation Type, Quantity, and Accuracy: As described in AABC or NEBB national standards

E. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.05 PROJECT CONDITIONS

A. The Owner may occupy all or part of the site and existing building during the entire testing, adjusting, and balancing period as required. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations. It is the intent to have all possible balancing procedures complete prior to any Owner occupancy. Contractor shall perform the necessary work in an expedient and accurate manner which best serves the need of verifying proper installation and operation of the installed systems and allowing prompt Owner occupancy.

1.06 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 30 days advance notice for each test. Include scheduled test dates and times.

1.07 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by this Contractor under requirements of the Contract Documents.

B. National Project Performance Guarantee: Provide a guarantee stating that AABC or NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing professional fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified contractor has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

3. Copy of the performance guarantee shall be included in each final certified air balance report.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide tools, ladders, recording meters, gauges, thermometers, voltmeters, anemometers, Picot tubes, inclined gauge manometers, magnehelic gauges, amprobes, voltmeters, psychrometers and tachometers required. Instruments used shall be accurately calibrated as per AABC or NEBB requirements

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.Approval of shop drawings will not relieve this contractor from responsibility for errors and omissions therein. All such errors or omissions must be corrected by this contractor irrespective of any approvals by the Architect or Engineer.

B. Contract Documents are defined in the General and Supplementary Conditions of the Contract.

C. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are located as required in the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operations. All deficiencies shall be reported to the Engineer in writing within 60 days from award of contract. Failure to provide notice within this time period may require that any devices required for proper balance of these systems be installed at the cost of this contractor.

D. Examine approved submittal data of all HVAC systems and equipment.

E. Examine equipment performance data, including fan and pump curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions and/or cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems"; or in SMACNA's "HVAC Systems-Duct Design". Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and ready for testing.

G. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing. Any noted deficiencies should be reported immediately to the Engineer for further action.

I. Examine air-handling equipment to ensure fan rotation is correct, clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine strainers for clean screens, removal of startup screens and proper perforations.

L. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine automatic temperature control system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multi-zone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

P. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures immediately to the Engineer for further action.

3.02 PREPARATION

A. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete. Equipment rotation has been checked.
2. Hydronic systems are filled, clean, strainers cleaned, startup screens removed and system free of air.
3. Automatic temperature control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices has been provided.
8. Filters are clean and in place, including pre-filters and final filters where applicable.

3.03 GENERAL TESTING AND BALANCING PROCEDURES

A. All systems shall be tested and verified to be in compliance with the performance characteristics contained in the contract documents. All testing shall be performed in compliance with the requirements of NEBB or AABC Standards for Testing and Balancing, or within the standards described in this section. The more stringent standard shall apply.

B. Adjusting and balancing shall be accomplished as soon as the systems are completed to the extent required to allow the work to proceed, and before the Owner takes possession. Verify that the system is properly vented, cleaned, and strainers are cleared with startup mesh removed prior to balance.

C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the Insulation Specifications for this Project.

D. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan speed control levers, and similar controls and devices, indicating final settings.

E. Adjusting and balancing shall be accomplished under appropriate outdoor temperature conditions. All outdoor conditions (Db, Wb, and a description of the weather conditions) at the time of testing shall be documented in the report.

F. Identify flow balancers, balance cocks, and dampers in systems which cannot be manipulated to satisfy balancing requirements. Return to site after remedial actions are performed to adjust corrected systems.

G. Traverse duct mains to determine total air system delivery quantities after all outlets have been set and, if necessary prior to final adjustment if the system does not meet design requirements. A sum of room CFM's is not acceptable.

H. Provide partial system start-up, operation and air balance (i.e. system start up before entire duct/pipe system is complete) to suit Project phasing/construction requirements. Provide damper positioning, etc., as required such that acceptable system operation is possible. Provide final system balance on completed system, including unit and/or damper readjustments.

I. Balance all existing outlets marked with air quantities on the remodel plans and rebalance any relocated existing equipment or any equipment so noted on the remodel plans or under the remodel work.

3.04 FUNDAMENTAL AIR SYSTEM BALANCING PROCEDURES

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan total volume.

1. Prepare schematic diagrams of system "as-built" duct layouts.
2. Variable air volume systems: develop a plan to simulate diversity.
3. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
4. Check the airflow patterns from the outside air louvers and dampers and the return and exhaust air dampers, through the supply fan discharge and mixing dampers.
5. Locate start-stop and disconnect switches, electric interlocks, and motor starters.
6. Verify that motor starters are equipped with properly sized thermal protection.
7. Check dampers for proper position to achieve desired airflow path.
8. Check for airflow blockages.
9. Check condensate drains for proper connections and function.
10. Check for proper sealing of air-handling unit components.

B. Air System Balancing Procedures:

1. The procedures in this article apply to all supply, return, and exhaust air systems. Additional procedures are required for variable air volume systems; these additional procedures are specified in the following articles in this specification.
2. Adjust fans to deliver total design air flows within the maximum allowable speed (rpm) listed by the fan manufacturer.
3. Measure fan static pressures to determine actual static pressure as follows:
    a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
4. Measure static pressure across each air-handling unit component.
5. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions in the event that adverse resulting conditions occur which make the system unable to achieve design performance levels.
6. Adjust fan speed higher or lower as required to meet as installed conditions. Provide new sheaves as required. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan speed changes.
7. Do not make fan speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.
8. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design air flows within specified tolerances.
    a. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved. Where sufficient space in submains and branch ducts is unavailable for pitot tube traverse measurements, measure air flow at terminal outlets and inlets and calculate the total air flow for that zone.
    b. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design air flows within specified tolerances.

9. Measure terminal outlets and inlets without making adjustments. Measure terminal outlets using a direct reading hood or the outlet manufacturer's written instructions and calculating factors.

10. Adjust terminal outlets and inlets for each space to within +/- 10% of design airflow. Make adjustments using volume dampers rather than the dampers at the air terminals, where available:

    a. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.

    b. Adjust patterns of adjustable outlets for proper distribution without drafts.

    c. Where pressure gradients are required between spaces, provide adjustment of supply and return / exhaust air such that the supply vs return / exhaust rate shown on the plan is maintained.

    d. Record final air volume and air flow pattern for each inlet and outlet.

C. Variable Air Volume System Additional Procedures

1. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

2. Pressure-Independent, Variable Air Volume Systems: After the fan systems have been adjusted, adjust the variable air volume systems as follows:

    a. Set outside air dampers at minimum; return and relief air dampers at a position that simulates full cooling load.

    b. Select the terminal unit that is most critical to the supply fan airflow and static pressure. Measure terminal unit static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal unit discharge duct losses.

    c. Measure total system airflow. Adjust to within 5 percent of design airflow.

    d. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as previously described for Air Systems.

    e. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow.

    f. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return air ducts and inlets as described for Air Systems.

    g. Measure static pressure at the most critical terminal unit and adjust the

static-pressure controller at the main supply air sensing station to ensure adequate static pressure is maintained at the most critical unit.

h. Record the final fan performance data.

3.05 FUNDAMETAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts to identify terminals.

C. Verify pump rotations.

D. Verify that systems are prepared for hydronic systems testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check make up-water station pressure gage for adequate pressure for highest vent.
4. Check flow control valves for specified sequence of operation and set at design flow.
5. Set differential pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive displacement type, unless several terminal valves are kept open.

E. Hydronic System Balancing Procedures:

1. Determine water flow at pumps. Use the following procedures:

a. Verify with the pump manufacturer that the following procedure will NOT damage the pump. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer’s pump curve at zero flow and confirm that the pump has the intended impeller size; report discrepancies immediately.

b. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer’s head-capacity curve. Adjust pump discharge valve until design water flow is achieved.

c. Verify pump motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer’s performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

2. Set calibrated balancing valves, if installed, at calculated pre-settings.
3. Measure flow at all stations and adjust, where necessary, to obtain first balance.
    a. System components that have C_V rating or an accurately cataloged flow pressure drop relationship may be used as a flow indicating device.
4. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.
5. Adjust balancing stations to within specified tolerances of design flow rate as follows:
    a. Determine the balancing station with the highest percentage over design flow.
    b. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
    c. Record settings and mark balancing devices.
6. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and system pressures and temperatures, including outdoor air temperature.
7. Measure the differential pressure control valve settings existing at the conclusion of balancing.

3.06 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data as it applies.
    1. Manufacturer, model, frame and serial numbers.
    2. Complete nameplate data.
    3. Efficiency rating if high efficiency motor.
    4. Measured voltage and amperage, each phase
    5. Starter thermal protection element rating.

3.07 HEAT TRANSFER COILS

A. Hydronic (Water) Coils (except reheat/zone coils): Measure the following data for each coil:
    1. System identification.
    2. Location.
    3. Coil Type and complete nameplate data.
    4. Water flow rate (coil and bypass, as applicable) and coil water pressure drop.
    5. Dry bulb temperatures of entering and leaving air.

6. Wet bulb temperature, entering and leaving air, on cooling coils.
7. Total airflow rate in CFM.
8. Air pressure drop and face velocity.

B. Reheat (Zone) Coils (Hydronic): Measure the following data for each coil:

1. System identification.
2. Location.
3. Coil Type and nameplate data
4. Dry-bulb temperatures of entering and leaving air.
5. Total airflow rate, face velocity, and air pressure drop.
6. Adjust water flow rate to achieve discharge air temperature rise per schedule with entering water temperature at scheduled design.
7. Adjust bypass water flow on three-way circuits for 50% of total coil water flow scheduled.
8. Record water flow rate as required to achieve specified discharge air temperature.

3.08 TEMPERATURE CONTROL VERIFICATION

A. Verify that all control devices are calibrated and fully operational.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify free travel and proper operation of control devices such as damper and valve operators.

3.09 TOLERANCES

A. Set HVAC system airflow and waterflow rates within the following tolerances:

1. Supply, Return, and Exhaust, Air Inlets and Outlets: +/- 10%, maintaining required pressure balance between adjacent spaces / zones.
2. Fans at +/- 5% of delivery requirements.
3. Cooling and Heating-Water-Flow Rates (Other than zone coils): +/- 5%.

3.10 FINAL REPORT

A. General: Typewritten, or computer printout in letter quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. A certification sheet in front of binder signed and sealed by the certified testing and balancing agent. All reports shall bear the seal of the certifying agent for the balancing professional. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include approved Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page including:
    a. Name and address of testing, adjusting, and balancing professional.
    b. Project name.
    c. Project location.
    d. Architect's name and address.
    e. Engineer's name and address.
    f. Contractor's name and address.
    g. Report date
2. Signature of testing, adjusting, and balancing agent who certifies the report.
3. Summary of contents, including the following:
    a. Design versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
4. Nomenclature sheets for each item of equipment.
5. Data for terminal units, including manufacturer, type, size, and fittings.
6. Report shall document all information items requested within this specification section

E. System Diagrams: On complete set of reproducible contract drawings provide single line sketch of system (designer – one or the other) marked up with terminal unit numbers, room numbers, test locations, register, grill, and diffuser numbers to correlate with test sheet. Include the following:

1. Quantities of outside, supply, return, and relief/exhaust airflow.
2. Water flow rates.
3. Pipe and valve sizes and locations.
4. Terminal units.
5. Balancing stations.

F. Air Handling Unit Test Reports: In addition to other requirements for air handling units with coils, include the following (each as applicable):

1. Unit Data: Include the following:

   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches, and bore.
   i. Sheave dimensions, center-to-center and amount of adjustments in inches.
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.

2. Test Data: Include design and actual values for the following:

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Static pressure differential in inches wg for each component (coils, filters, etc.).
   f. Outside airflow rate in cfm.
   g. Return airflow rate in cfm.
   h. Outside air damper position.
   i. Return air damper position.
   j. VFD percentage.
   k. Motor data.

G. Fan Test Reports: : In addition to other requirements for supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:

   a. System identification.

   b. Location.

   c. Make and type.

   d. Model number and size.

   e. Manufacturer's serial number.

   f. Arrangements and class.

   g. Fan and motor sheave make, size in inches, bore, and key size.

   h. Fan and motor sheave dimensions, center-to-center and amount of adjustment in inches.

   i. Number of belts, manufacturer, and size

2. Test Data: Include design and actual values for the following:

   a. Total airflow rate in cfm.

   b. Total system static pressure in inches wg.

   c. Fan rpm.

   d. Discharge static pressure in inches wg.

   e. Suction static pressure in inches wg.

   f. Motor data.

H. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record and report the following data as a minimum:

1. System and air handling unit number.
2. Location and zone.
3. Traverse air temperature in deg F.
4. Duct static pressure in inches wg.
5. Duct size in inches.
6. Duct area in sq. ft.
7. Design airflow rate in cfm.
8. Design velocity in fpm.
9. Actual airflow rate in cfm.
10. Actual average velocity in fpm.

I. Air Terminal Unit Reports: : In addition to other requirements for terminal units, include the following:

1. Unit Data: Include the following:

a. System and air handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air terminal make.
f. Air terminal number from system diagram.
g. Air terminal type and model number.
h. Air terminal size.

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm (minimum and maximum).
b. Preliminary airflow rate as needed in cfm.
c. Final airflow rate in cfm.
d. Space temperature in deg F.
e. Duct Supply Air Temperature in Deg F.

J. Pump Test Reports: In addition to other requirements for pumps, include the following data:

1. Unit Data: Include the following:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Fluid and concentration (if other than water).
g. Fluid flow rate in gpm.
h. Fluid pressure differential in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches (nameplate).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.

n. Amperage for each phase.

o. Full-load amperage and service factor.

2. Test Data: Include design and actual values for the following (as applicable):

a. Static head in feet of head or psig.

b. Pump shutoff pressure in feet of head or psig.

c. Impeller diameter in inches (as calculated by plotting the shutoff head on pump curves).

d. Full open flow rate in gpm.

e. Full open pressure in feet of head or psig.

f. Final discharge pressure in feet of head or psig.

g. Final suction pressure in feet of head or psig.

h. Final total pressure in feet of head or psig.

i. Final fluid flow rate in gpm.

j. Voltage at each connection.

k. Amperage for each phase.

K. Instrument Calibration Reports: For instrument calibration, include the following data in report, as a minimum:

1. Instrument type and make.

2. Serial number.

3. Application.

4. Dates of use.

5. Date of calibration.

3.11 ADDITIONAL TESTS

A. Balance Contractor shall be prepared to re-balance or re-verify the balance of devices selected by the Engineer at his discretion. One man day of labor shall be provided for this purpose. If, in the opinion of the Engineer these checks contain adequate discrepancies to provide doubt as to the accuracy of the balance procedures performed, the Engineer may order additional re-balancing or re-verification until such time as these discrepancies are eliminated throughout the systems; this verification shall be at the Contractor's expense.

B. Seasonal Periods: Initial testing, adjusting, and balancing procedures at start-up will not provide a good representative sample of system performance due to seasonal conditions. Therefore the Contractor shall return at a later time to perform the required balancing work, up to 8 hours of balancing work, to address seasonal conditions. This shall not delay the submittal of the certified balance reports for all work otherwise performed.

3.12 SUBBMISSION OF CERTIFIED BALANCE REPORTS

A. Time is of the essence in the completion of this portion of the contract. It is expected that the certified balance reports will be submitted in a timely manner, within thirty (30) days of the work performed. At the completion of the project, it shall be the responsibility of this Contractor to assemble a single certified report and submit 10 completed copies to the Engineer as closeout documentation

END OF SECTION

SECTION 230700

INSULATION

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in the Contract Documents. The extent of insulation work is indicated on the drawings and by the requirements of this section.

B. Insulate all new piping systems, ductwork systems and equipment installed under this contract as indicated in the Exhibits at the end of this section and on the drawings.

C. Insulate all existing piping systems, ductwork systems and equipment after removal of existing insulation whether by this contractor or another, including but not limited to removal of asbestos products.

D. Remove existing insulation where indicated on the drawings or specified here-in.

1.02 SUBMITTALS

A. Manufacturers' data. Submit manufacturer's data and installation instructions.

B. Schedule of insulation applications.

C. Certification: Provide certifications as necessary to show compliance with these specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

PART 2 – PRODUCTS

2.01 GENERAL

A. Insulation, Jackets, Adhesives, and Coatings, shall comply with the following:

1. Treatment of jackets or facings for flame and smoke safety must be permanent. Water soluble treatments are not permitted.

2. Insulation, including finishes and adhesives on the exterior surfaces of ducts, pipes, and equipment, shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, as tested by ASTM E84 (NFPA 255) and UL 723 methods.

3. Asbestos or asbestos bearing materials are prohibited.

4. Latest edition of the Energy Conservation Construction Code of New York State.

2.02 PIPE INSULATION (RIGID TYPE)

A. Preformed rigid sectional pipe covering, 4 lb./cu. ft. nominal density fiberglass. Maximum thermal conductivity (k), on a flat surface, shall be 0.23 Btu/ft²•hr.• F/in. at 75°F mean temperature. White Kraft outer surface bonded to aluminum foil and reinforced with fiberglass yarn.

2.03 METAL JACKETING

A. Aluminum, ASTM B 209, 0.016 inch thick, factory pre-formed sectional pipe jacketing. Jacketing shall have smooth outer finish with integral bonded laminated polyethylene film - kraft paper moisture barrier underside; Pittsburg or modified Pittsburg longitudinal lock seams, and; 2 inch overlapping circumferential joints with integral locking clips, or butt joints sealed with 2 inch wide mastic backed aluminum snap bands.

B. Strapping shall be Type 18-8 stainless steel, 0.020 inch thick, 1/2 and 3/4 inch wide as specified.

C. Wing Seals shall be Type 18-8 stainless steel, 0.032 inch thick.

2.04 DUCT INSULATION

A. Conductivity: Maximum thermal conductivity (k) shall be 0.285 Btu/ft²•hr.• F/in. excluding air film at l00°F mean temperature.

B. Rigid Board Type - Concealed: 3 lb./ft^3 minimum density, glass fiberboard, 1 in. minimum thickness. Factory applied vapor barrier finish consisting of aluminum foil reinforced with fiberglass yarn; seams and joints taped.

C. Rigid Board Type - Exposed: 6 lb./ft^3 minimum density, glass fiberboard, 1 in. minimum thickness. Factory applied white Kraft outer surface bonded to aluminum foil and reinforced with fiberglass yarn joints finished with corner beading and fiberglass tape.

D. Flexible Blanket Type: Long glass fiber blanket, factory applied, fiberglass yarn, reinforced aluminum foil faced vapor seal.

E. Kitchen Hood Exhaust Duct Board: Refer to section 230714 – Fire Rated Duct Insulation.

2.05 EQUIPMENT INSULATION

A. Segmented board, sheets, blocks, size, shape, and material as called for.

2.06 MAKES

A. Fiberglass: Certainteed, Knauf Insulation, Johns Manville, Owens-Corning.
B. Adhesives: Benjamin Foster; (BF) numbers designate quality of adhesive.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Provide Thermal Insulation:

1. Insulation is required on piping, ductwork, and equipment unless otherwise called for.

2. Insulate existing piping, ductwork equipment after removal of existing insulation whether by this contractor or another, including but not limited to insulation after removal of asbestos products.

3. Only on clean, dry surfaces and after piping, ductwork, and equipment have been tested.

4. Continuous through hangers, openings and sleeves on refrigerant piping.

5. On cold surfaces provide continuous unbroken vapor seal. Do not cover inspection stampings, nameplate data, openings, petcocks, handholes, manholes, access doors, plugged outlets, air vents, plugged openings or petcocks.

3.02 PIPE INSULATION

A. Insulate piping systems including fittings, valves, flanges, unions, strainers, and other attachments installed in piping system, whether exposed or concealed, except for the piping within radiation enclosures where 2-way control valves are utilized. Note: where 3-way control valves are utilized within radiation enclosures, piping within enclosure shall be insulated.

B. Piping in exterior walls, spaces, overhangs, attics, or where subject to freezing. Insulate pipe with double the thickness called for. Piping In Wall Chases: In addition to the above, pack chase with loose glass fiber insulation.

C. Hanger Shields: Refer to Section "Piping Systems and Accessories."

1. Pre-insulated type: Butt insulation to hanger shields and apply a wet coat of vapor barrier cement to the joints and seal with 3 in. wide vapor barrier tape.

2. Field insulated type: Provide 1-1/2" calcium silicate insulation between pipe and shield.

D. Joints in sections of pipe insulation shall be made as follows:

1. Standard: Longitudinal laps and butt joint sealing strips cemented with BF 85-20, or factory applied pressure sensitive adhesive lap seal.

2. Vapor barrier: For cold services, Longitudinal laps and 4 in. vapor barrier strip at butt joints shall be sealed with white BF 85-20. Seal ends of pipe insulation at valves, flanges, and fittings with white BF 85-20.

E. Fittings, Valves and Flanges:

1. Hot services and domestic cold water: Premolded fitting insulation of the same material and thickness as the adjacent pipe insulation.

2. 0.030" thick white PVC jacketing.

3. Equal to Zeston or Proto System.

3.03 METAL JACKETING ON PIPING

A. Secure jacketing to insulated piping with preformed aluminum snap straps and stainless steel strapping installed with special banding wrench.

B. Jacket exposed insulated fittings, valves and flanges with mitred sections of aluminum jacketing or factory fabricated, preformed, sectional aluminum fitting covers. Seal joints with sealant and secure with preformed aluminum bands.

C. Jacket exposed insulated piping installed in finished rooms including Mechanical Equipment Rooms, Penthouses, and Machine Rooms within eight feet of the finished floor. Jacket with preformed sectional aluminum metal jacketing,

D. Piping Exterior to Building: Jacket insulated piping with preformed sectional aluminum metal jacketing.

1. Lap longitudinal and circumferential joints a minimum of 2 inches.

2. Secure jacketing in place with a continuous longitudinal friction type joint to provide a positive weatherproof seal. Circumferential joints shall be weatherproof sealed with 2 inch x 0.016 inch thick aluminum straps lined with permanent plastic sealing compound.

3. Cover insulated fittings, valves, and offsets with mitered sections of jacketing. Seal joints with mastic, and secure with aluminum strapping and wing seals.

4. Factory fabricated, preformed fitting covers of same material as jacketing may be used instead of mitered jacketing.

5. Install jacketing to avoid trapping condensation and precipitation.

3.04 DUCTWORK INSULATION

A. Provide external thermal insulation for duct. Not required where ducts have internal acoustical insulation and are located inside the conditioned space (All exterior ductwork must be insulated compliant with external insulation requirements of this specification). Make special provisions at dampers, damper motors, thermometers, instruments, and access doors. Apply as Follows:

1. Rigid board type: Impale board over mechanical fasteners, welded pins or adhered clips, 12 in. to 18 in. centers; minimum of two rows per side. Secure insulation with washers on clips. Seal breaks and joints in vapor barrier with 4 in. wide matching tape or 4 in. glass-fab applied with BF 35-00. Apply tape over corner beading where exposed.

2. Flexible blanket type: Joints and seams made with 2 in. lap of vapor barrier. Round ducts: Apply BF 85-20 adhesive to ducts in 6 in. brush widths at 1 ft. intervals and at each facing edge. Square ducts: Over 18” duct face width, fasten by impaling insulation on adhered or welded clips. Secure insulation with washers on clips. Seal joints and breaks with 4 in. wide matching tape or 4 in.

glass-fab applied with BF 35-00.

3. Insulate the tube bends and all exposed surfaces of duct coils operating in excess of 10 degrees differential from ambient conditions.

3.05 EQUIPMENT INSULATION

A. Equipment insulation surfaces shall be a hard, smooth, uniform finish. Install Work ready for painting.

EXHIBIT "I" - PIPE INSULATION MATERIALS
(Notes are at end of Exhibit I)

SERVICE	INSULATION MATERIAL	PIPE DIAMETER	THICKNESS	REMARKS
Hot water (below 250^{o})	Glass fiber	2 in. and larger 1-1/2 in. & smaller	2 in. 1-1/2 in.	SEE NOTE 4
Chilled water (40^{o} and above)	Glass fiber	All sizes	1-1/2”	SEE NOTE 2
Condenser water	Not insulated	Not insulated		SEE NOTE 1
Condenser water (exposed to the ambient)	Glass fiber	All sizes	2”	SEE NOTE 2 (Not required to be double listed thickness)
Steam (up to 15 psi)	Glass fiber	2 in. and larger 1-1/2 in. & smaller	3 in. 1-1/2 in.	SEE NOTE 2 SEE NOTE 3
Condensate, pumped return.	Glass fiber	1-1/2 in to 6 in. 1-1/4 “ & smaller	2 in. 1-1/2 in.	SEE NOTE 2 SEE NOTE 3
Domestic cold water	Flexible Glass fiber	2-1/2 in. and larger 2 in. and smaller	1 in. 1/2 in.	
AC unit drains and overflows	Flexible Glass fiber	All sizes	1/2 in.	
Steam (over 15 psi)	Glass fiber	1-1/2 in. and larger 1 in to 1-1/4 in. 3/4 in and smaller	3 in. 2-1/2 in. 1-1/2 in.	SEE NOTE 2
Steam and Condensate Vents	Glass fiber	All sizes	1-1/2 in.	

NOTES FOR EXHIBIT “I”:

NOTE 1: For outdoor locations, provide "flexible" insulation, 1-1/2 in. thick for condenser water, and 1/2" thick for refrigeration piping ,with two coats of recommended finish. Apply insulation over heat tracing. Cover insulation with aluminum jacket. Install in accordance with manufacturer's recommendations.

NOTE 2: Pipe insulation exposed to weather shall be double the above listed thickness. Cover insulation with aluminum jacket and seal watertight. Install in accordance with manufacturer's recommendations. Apply insulation over heat tracing.

NOTE 3: Exposed insulation at kitchen, laundry, and sterilizer equipment shall be insulated with glass fiber and covered with aluminum jacket. Install in accordance with manufacturer's recommendations.

NOTE 4: Hot water piping one inch and smaller may have one inch thick insulation if it is a runout direct to a terminal unit where the pipe length is less than 12 feet.

EXHIBIT "II" - DUCT INSULATION MATERIALS

SERVICE & LOCATION	INSULATION MATERIAL	MINIMUM INSULATION THICKNESS	MINIMUM REQUIRED R VALUE	REMARKS
Air conditioning & heating supply (within building envelope)	Exposed: Rigid fiberglass	1-1/2 in.	R-5	
	Concealed: Flexible fiberglass	2 in.	R-5	
Air conditioning & heating supply (exterior to building envelope)	Rigid board duct insulation with VentureClad 1577CW jacketing system.	2-1/2 in.	R-8	
Air conditioning & heating return		Not insulated		
Air conditioning & heating return (exterior to building envelope)	Rigid board duct insulation with VentureClad 1577CW jacketing system.	2-1/2 in.	R-8	
Outside air ducts and plenums, connections, and mixing boxes	Rigid fiberglass	2 in.		Provide neat fit at intake plenum
Exhaust, relief, or vent ducts and plenums	Exposed: Rigid fiberglass	1 in.		Insulate 15 ft. from exterior opening and plenums or 5 ft. beyond damper, whichever is greater.
	Concealed: Flexible fiberglass	1-1/2 in.		
Kitchen hood exhaust				Refer to specification section 230714 – Fire Rated Duct Insulation. SEE NOTE 1
Dishwasher exhaust	Exposed: Rigid fiberglass	1 in.		
	Concealed: Flexible fiberglass	1-1/2 in.		

NOTES FOR EXHIBIT III

NOTE 1: Ductwork located within building envelope shall be wrapped per the requirements of specification section 230714 – Fire Rated Duct Insulation. Ductwork located outside the building envelope is not required to be wrapped with fire rated insulation. Ductwork located outside the building envelope shall be insulated with 2" thick mineral wool and providing with aluminum jacket.

EXHIBIT "III" - EQUIPMENT INSULATION MATERIALS
(Notes are at end of Exhibit III)

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Flash tanks, heat exchangers.	6 lb. fiberglass suitable for 450^{o}F service.	1-1/2 in. segmented blocks or molded sections	SEE NOTE 1 SEE NOTE 3
Air removal assembly	Same as water piping.	Same as water piping.	SEE NOTE 2
Heating system compression/expansion tanks		Not insulated.	
Cooling system compression/expansion tanks	Same as chilled water piping.	Same as chilled water piping.	SEE NOTE 2
Chilled water pumps, and strainers	Flexible sheets	1/2 in.	SEE NOTE 4

NOTES FOR EXHIBIT III

NOTE 1: Where required, provide welded studs, clips or angles as anchors for bands, wires and mesh.

NOTE 2: Insulate per machine manufacturer's installation instructions, match colors, materials and methods as much as practical. Allow for parts removal.

NOTE 3: Secure blocks with galvanized steel bands, 12 in. on center. Secure fiberglass with pins, studs or clips, then apply 2 in. galvanized hexagon mesh wire. Cover with 1/4 in. layer insulating cement.

NOTE 4: Install on "box" framing per manufacturer's construction specifications. Arrange for easy removal and replacement. Coat with white finish.

END OF SECTION

SECTION 230714

FIRED RATED DUCT INSULATION

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in the Contract Documents

1.02 RELATED SECTIONS

A. Section 042000 – Unit Masonry.

B. Section 078000 – Fire Stopping.

C. Section 061643 – Gypsum Sheathing.

D. Section 233000 – Sheetmetal and Ductwork Accessories

1.03 REFERENCED STANDARDS

A. ASTM C 518 – Standard Test for Durability.

B. ASTM C 1338 – Fungi Tests of Through-Penetration Fire Stops Stands.

C. ASTM E 84 – Standard Test Method for Surface Burning Characteristics of Building Materials.

D. ASTM E 119 – Standard Test Method for Fire Tests of Building Construction and Materials.

E. ASTM E 136 – Standard Test Method for Non-Combustibility.

F. ASTM E 814 – Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

1. Flame spread index < 25 and smoke developed index < 50.

G. International Code Council Evaluation Services (ICCES).

H. Building Code and Mechanical Code of New York State.

I. Mechanical Code of New York State, Latest Edition.

1.04 PERFORMANCE REQUIREMENTS

A. Provide products that are listed by at least one of the following:

1. Underwriters Laboratories Inc. (UL), in “Fire Resistance Directory” category XHEN or XHBN as appropriate.

2. Omega Point Laboratories (OPL), in “Directory of Listed Products, Through Penetration Fire Resistance Directory.”

3. Any other qualified independent testing and inspection agency that conducts periodic follow-up inspections and is acceptable to authorizes having jurisdiction (AHJ).

B. Furnish products identical to those tested for classification by listing agency.

C. Mark product packing with classification marking of listing agency.

D. Fire-stopping exposed to view, traffic, moisture, or physical damage: Provide products that after curing do not deteriorate when exposed to those conditions during and after construction.

E. Use only products specifically listed for use in listed systems.

F. Provide products that are compatible with each other, with the substrates forming openings, and with the items, if any, penetrating the fire-stopping, under the conditions represented by this project, based on testing and field performance demonstrated by the manufacturer.

G. Fire-stopping material must be asbestos-free and capable of maintaining and effective barrier against flame, smoke, and gases in compliance with the requirements of ASTM and UL standards cited in this section.

H. Fire-stopping materials must meet and be acceptable for use by all building codes and NFPA codes cited in this section.

I. Materials must be suitable for the fire-stopping of penetrations made by steel, glass, plastic, and insulated pipe. All duct wraps must be 2 hour rated, but in no case less than the rating of any time-rated assemblies which are penetrated.

1.05 SUBMITTALS

A. For each different fire-stopping configuration, provide the following:

1. Listing agency’s detailed drawing showing opening, penetrating items, and fire-stopping materials, identified with the listing agency’s name and number or designation, fire rating achieved, and date of listing.

2. Indentify which rated assembly each system is to be used in.

3. Any installation instructions that are not included on the detailed drawing.

4. For proposed systems that do not conform strictly to the listing, submit listing agency’s drawing marked up to show medications and stamped approved by fire-stop system manufacturer’s fire protection engineer.

B. Product Certificates: Submit certificates signed by fire-stop system manufacturer certifying that materials furnished comply with requirements.

C. Product Data: Manufacturer's data sheets on each material to be used in fire-stop systems, including:

1. Product characteristics and Materials Safety Data Sheets (MSDS).
2. Listing numbers of systems in which each product is to be used.
3. Preparation instructions and recommendations.
4. Storage and handling requirements and recommendations.
5. Installation methods.

D. Installers Qualification Documentation.

E. Verification Samples: For each finish product specified, two samples representing actual product, color, and patterns.

1.06 QUALITY ASSURANCE

A. General: All through-penetration fire-stop systems shall be installed with approved methods using materials that have been tested and classified to produce an approved assembly.

B. Manufacturer Qualifications: All primary products specified in this section shall be supplied by a single manufacturer with a minimum of ten years experience.

C. Installer Qualifications: Firm must be qualified by having experience, staff, and training to install the specified products, and meets the following criteria:

1. Contractor is acceptable to or licensed by the manufacturer.

2. Contractor is acceptable to or licensed by the AHJ.

3. Contractor has completed the manufacturer's certified product installation training.

4. Contractor must provide a list of completed projects as evidence of experience; include project name and address, Owner's name and address, and Architect's name and phone number.

D. Codes: Where manufacturer's application procedures are in conflict with the codes followed by the AHJ, the more strict guidelines will prevail.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products until ready for installation in manufacturer's original unopened packaging, legibly marked with manufacturer's name and product identification, date of manufacture, lot number, shelf life, and listing agency's classification marking.

B. Store and handle in such a manner as to prevent deterioration or damage due to moisture, temperature changes, contaminants, and other causes; follow manufacturer's instructions.

C. Store and dispose of hazardous materials, and materials contaminated by hazardous materials, in accordance with requirements of local authorities having jurisdiction.

1.08 PROJECT CONDITIONS

A. Coordinate construction and cutting of openings so that each fire-stop system may be installed in accordance with its listing, including sixing, sleeves, and penetrating items.

B. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by the manufacturer for optimum results. Do not install fire-stopping under environmental conditions outside manufacturer's absolute limits.

C. Provide ventilation as required by the fire-stopping manufacturer.

1.09 WARRANTY

A. At project closeout, provide to the Owner or Owner's Representative and executed copy of the manufacturer's standard limited warranty against manufacturing defect, outlining its terms, conditions, and exclusions from coverage.

PART 2 – PRODUCTS

2.01 GENERAL

A. Provide single layer flexible enclosure for fire protection of grease ducts as a shaft alternative. Enclosure shall allow for zero clearance to combustibles at all locations and a 2 hour fire rating.

B. Provide installed fire-stopping that limits the spread of fire, heat, smoke, and gasses though otherwise unprotected openings in rated assemblies, including walls, partitions, floors, roof/ceilings, etc.

2.02 FIRED RATED DUCT WRAP INSULATION

A. Single layer duct wrap system: High temperature, biosoluble, non-asbestos thermal insulation made from Calcium, Magnesium, and Silicate woven wool blanket. Thickness shall be 1-1/2" for all systems listed in section 2.1.

1. Color: White blanket, aluminum foil encapsulated.

2. Weight: 0.75 psf.

3. Thermal Conductivity: Minimum R-6.

4. Fire Resistance: 2 hour fire resistance.

5. Product complies with ISO 6944 test standard.

2.03 RELATED DUCT WRAP PRODUCTS

A. Tapes: High performance filament tape, 1” wide. Aluminum oil tape 3” or 4” wide (for sealing cut blankets edges and seams).

B. Banding material:

1. Carbon Steel Banding: 1/2" wide x 0.015” thick.

C. Insulation pins and clips:

1. Copper-coated steel pins, 1/8”, 10 gauge x 4” or 5” long.

2. Square galvanized steel speed clips: 1-1/2” diameter.

D. Through-penetration fire-stop materials:

1. Packing Materials: Pieces of fire barrier duct wrap or 4 pcf mineral wool.

2. Sealant: SSS100 intumescent fire-stop sealant, 5/8” nominal depth, both sides of wall and overlapped 1/2" onto duct and wall surfaces. Design Make: Specified Technologies.

2.04 MANUFACTURERS

A. Design Equipment: Unifrax FyreWrap EZ 1.5

B. Acceptable Make: Unifrax, 3M, Thermal Ceramics

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Do not begin installation until substrates have been properly prepared.

B. Conduct tests according to manufacturer’s written recommendations to verify that substrates are free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt and other foreign substances capable of impairing bond of fire-stopping.

C. Verify that items penetrating fire rated assemblies are securely attached, including sleeves, supports, hangers, and clips.

D. Verify that openings and adjacent areas are not obstructed by construction that would interfere with installation of fire-stopping, including ducts, piping, equipment, and other suspended construction.

E. Verify that environmental conditions are safe and suitable for installation of fire-stopping.

F. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 PREPARATION

A. Prepare substrates in accordance with manufacturer's instructions and recommendations.

B. Install masking and temporary coverings as required to prevent contamination or defacement of adjacent surfaces due to fire-stopping installation.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install in strict accordance with manufacturer's detailed installation instructions and procedures.

B. Install so that openings are completely filled and material is securely adhered.

C. Where fire-stopping surface will be exposed to view, finish to a smooth, uniform surface flush with adjacent surfaces.

D. After installation is complete, remove combustible forming materials and accessories that are not part of the listed system.

E. Repair or replace defective installations to comply with requirements.

F. At each through penetration, attach identification labels on both sides in location where label will be visible to anyone seeking to remove penetrating items or fire-stopping.

G. Clean fire-stop materials off surfaces adjacent to openings as work progresses, using methods and cleaning materials approved in writing by fire-stop system manufacturer and which will not damage the surfaces being cleaned.

H. Notify AHJ when fire-stopping installation is ready for inspection; obtain advance approval of anticipated inspection dates and phasing, of any, required to allow subsequent construction to proceed.

I. Do not cover fire-stopping with other construction until approval of AHJ has been received.

3.04 FIRE RATED DUCT WRAP INSULATION

A. Kitchen Grease Exhaust Ducts: Install fire resistive duct wrap insulation in direct contact with ductwork to manufacturer's instructions and referenced standards, to applicable Intertek design numbers, including listed penetration fire-stop system.

B. Kitchen Grease Exhaust Ducts: Overlap perimeter and longitudinal joints 3". If required, tape seams using minimum 3" wide aluminum foil adhesive tape. Use of either telescoping, checkerboard, or butt splice overlap is acceptable. If using butt splice, provide 6" wide collar of blanket that is centered over the splice.

C. Filament tape may be used as a temporary securing measure during application of duct wrap. Finish installation using 1/2" wide x 0.015" steel banding on exterior layer of wrap. Spacing 10-1/2" on center and within 1-1/2" of all overlapped seams. Consult individual listings for approved banding type.

D. Duct widths greater than 24" but less than 48": Weld insulation pins to bottom of horizontal ducts on a 12" x 10-1/2" maximum grid spacing. Welded insulation pins to one of the wider sides of all vertical ducts on a 12" x 10-1/2" maximum grid spacing. Impale duct wrap insulation over pins and secure with speed clips.

E. Duct widths 48" and greater: Weld insulation pins to all sides of ducts on a 12" x 10-1/2" maximum grid spacing. Impale duct wrap insulation over pins and secure with speed clips.

F. Duct Access Doors: Install duct wrap to protect access doors per the manufacturer's instructions and procedures.

G. Fire-stopping at Fire Separations:

1. Fire-stop all wrapped ductwork penetrating fire rated concrete floors, gypsum board, block and concrete wall assemblies and gypsum board shaft wall assemblies using UL and/or Intertek fire-stop system listings appropriate for the applicable duct wrap system.

2. Kitchen grease exhaust ducts: Fire resistive duct wrap insulation to be continuous through wall or floor penetrations. Maximum 3" clearance permitted between outer layer of duct wrap insulation and edge of opening. Fill annular space between edge of opening and wrapped duct with pieces of duct wrap insulation or mineral wool insulation firmly packed into opening. Compress to percentage stated in manufacturer's instructions to minimum depth of 4". Recess packing material below surface on both sides of walls of top side only for floors to depth stated in manufacturer's instructions. Seal over packing material using fire-stop sealant to depth stated manufacturer's instructions, flush with top side of floor and both sides of wall surfaces.

3. Ventilation ducts: Fire resistive insulation may pass continuously through fire rated wall or floor penetrations of may tightly butt to both sides of fire rated separations. Maximum 3" clearance permitted around unwrapped duct in opening or from edge of opening to outer layer of duct wrap. Consult individual listed fire-stop systems for specific requirements.

a. Option A: Terminate wrap at fire separation. Fill space around unwrapped duct where it passes through a fire rated wall or floor with pieces of duct wrap insulation or mineral wool insulation firmly packed into opening. Compress to the percentage stated in the manufacturer's instructions to full depth of floor or wall. Recess packing on both sides of wall or top side of floor to depth stated in manufacturer's instructions. Seal over packing material using fire-stop sealant to depth stated in manufacturer's instructions, flush with top side of floor and both sides of wall surfaces. Tightly butt fire resistive duct wrap insulation to each side of wall of floor assembly and seal interface with a continuous bead of fire stop sealant.

b. Option B: Wrap continuous through fire separation. Fill space around continuously wrapped duct where it passes through fire rated wall of floor with pieces of duct wrap insulation or mineral wool insulation firmly packed into opening. Compress to the percentage stated in the manufacturer's instructions to a minimum depth of 4". Recess packing on both sides of wall or top side of floor to depth stated in manufacturer's instructions. Seal over packing material using fire-stop sealant to depth stated in manufacturer's instructions, flush with top side of floor and both sides of wall surfaces.

H. Where kitchen exhaust hoods are located within a fire rated area or zone, begin application of duct wrap insulation inside fire rated area 6" from face of fire rated wall or ceiling assembly for non-combustible fire separations, and 18" from face of wall of ceiling surface for combustible fire separations, or as indicated on Drawings. Apply duct wrap continuously to ductwork through fire separation for distance indicated on the Drawings.

3.05 CLEANING AND PROTECTION

A. Remove left over material and debris from work area. Use necessary means to protect material before, during, and after installation.

B. Touch-up, repair, or replace damaged products before Substantial Completion.

C. Install identification labels for through penetration systems: Pressure Sensitive self-adhesive vinyl labels, preprinted with the following information:

1. The words "Warning – Through Penetration Fire-Stop System – Do Not Disturb. Notify Building Management of Any Damage".

2. Listing agency's system number or designation.

3. System manufacturer's name, address, and phone number.

4. Installer's name, address, and phone number.

5. General contractor's name, address, and phone number (if applicable).

6. Date of Installation.

END OF SECTION

SECTION 230923

TEMPERATURE CONTROLS

PART 1 - GENERAL

1.01 WORK INCLUDED

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

B. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents. Extend existing Siemens Industry Direct Digital Control System to perform the functions described in this Section. All new equipment shall be compatible with the existing system. The new control components shall seamlessly integrate with the existing Direct Digital Control system without the use of integrator panels, routers, or any other hardware or software. The control system manufacturer shall guarantee that all new controls operate with the existing system so that a single homogeneous system shall be provided. The new controls shall maintain complete functionality of all existing systems and all existing systems shall remain fully functional during the duration of the project. Provide wiring and conduit required to connect devices furnished as a part of, or accessory to, this automatic control system. Control wiring is defined as wiring up to 120 volts. Install wiring in accordance with requirements of "Electric Wiring" in Section 230019, and the National Code. Provide all required devices for proper system operation, including special electrical switches, transformers, relays, pushbutton stations, etc.

C. Coordinate all work with individual equipment controller.

1.02 WORK NOT INCLUDED

A. Power wiring for motors, motor starters and associated with it power starting and control equipment, as well as the motor starters (except in the case of equipment specified to have packaged controls/starters) are included in Division 26, "Electrical," unless otherwise called for.

1.03 SYSTEM INTEGRATION

A. Integration with control systems furnished by others:

1. Coordination Meeting: The Installer furnishing the DDC network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network. The Owner or their designated representative shall be present at this meeting. Each Installer shall provide the Engineer and all other Installers with details of the proposed interface including PICS for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.

2. Packaged AHU: Unit shall be furnished configured to accept control inputs from an external building automation system controller as specified in Section 230993. Factory mounted safeties and other controls shall not interfere with this controller.

3. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a Modbus interface for integration into the Direct Digital Control System described in this section.

1.04 QUALITY ASSURANCE

A. The complete automatic temperature control system shall be comprised of control devices with a microprocessor based Direct Digital Control System. All work shall be installed only by skilled mechanics.

B. The Temperature Control Subcontractor/Supplier shall have a minimum of five years experience in systems of similar size, type and complexity installed within a 100 mile radius.

C. The Temperature Control Subcontractor/Supplier shall have a local service department (within a 75 mile radius) and have available a minimum of three factory trained technicians within a 24 hour period.

D. All components shall be fully tested and documented to operate as a complete system.

E. Supplier must guarantee that all replacement parts will be carried in stock for a period of 10 years minimum from the data that the system is commissioned.

1.05 ACCEPTABLE MANUFACTURERS

A. The complete control system is designed and based on that manufactured by Siemens Building Technologies, Inc.

B. Acceptable Make: Siemens Building Technologies, Inc, Andover Building Controls.

1.06 INCIDENTAL WORK

A. Furnish the following materials for installation by Division 23.

B. For piping work:

1. Control valves in piping.
2. Immersion sensing wells in piping systems.
3. Valved pressure taps.

C. For sheet metal work:

1. All automatic dampers, assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.

2. Division 23 shall provide access doors or other means of access through ducts or ceilings and walls for service and adjustment of controllers, valves, and dampers.

3. Control manufacturer shall furnish written details, instructions and supervision for the above trades to ensure proper installation, size, and location of any equipment furnished for installation by others.

1.07 QUALITY ASSURANCE

A. Acceptable Products: All products shall be proven to be functional and suitable in accordance with this specification for a period of warranty commencing on the day of transfer of completed project to the Owner. Demonstration of such warranty may be required prior to the submittal approval.

B. Contractor Qualifications: The controls system installer shall be factory-authorized by the respective manufacturer to provide pertinent installation and service.

C. Field Representation: The controls system installer shall staff the project with a field representative that has been factory-trained in the installation, programming and commissioning of the equipment specified. This representative must be in the direct employ of the Controls installer.

D. Coordination of work during construction:

1. The controls system installer shall protect work installed by other trades.
2. The controls system installer shall coordinate its work with other trades.
3. The controls system installer shall repair any damage caused by his work.
4. The controls system installer shall promptly correct all work that Engineer finds as defective or failing to conform to Contract Documents.
5. The controls system installer shall bear all cost of correcting of work found defective as described above.

1.08 SHOP DRAWINGS AND SUBMITTALS

A. Detailed piping and wiring control diagrams and systems description for each system under control.

B. Detailed layout and nameplate list for component control panels and DDC panels.

C. Submit a valve and damper schedule showing size, pressure drop configuration, capacity, and locations. Provide apparatus Bulletins and data sheets for all control system components.

D. A complete listing of input and output points, control loops and/or routines, including time of day functions, and facilities management system functions for each controlled system. This listing shall include point logical names, identifiers, and alarmable ranges.

E. Provide as part of a separate submittal a hard copy of all graphics showing system components, sensor locations, setpoints and fixed/variable data. Engineer shall review and approve graphic format prior to final acceptance of system.

1.09 OPERATION AND MAINTENANCE MANUALS FOR COMPLETE PROJECT

A. Upon completion of installation and prior to the training, provide manuals containing the following information:

1. Installation and Service Manuals for all products and components.
2. Calibration and Troubleshooting Procedures for all installed equipment and components.
3. List of location of all enclosures, controllers, sensors, transformers and other components as specified above.
4. As-built Control Drawings with all modifications, changes and wiring details that depict actual installation. These shall include all final controller and device names, wire tags, etc.
5. Sequence of operation – Describing in detail the operation of every piece of equipment subject to control by the DDC system. Each section of the sequence should contain the following:

    a. Overview – describes what the intent is, what components are involved and provides a concise description of the piece of equipment to be described.

    b. Occupied Mode – Describes the operation of this system during occupied periods.

    c. Unoccupied Mode – Describes the operation of this system during unoccupied periods.

    d. Alarm Mode - Describes operation of the system in the event of alarm condition and steps to restore system to normal operation. List all anticipated alarm conditions.

    e. Each Component's individual Sequence - Describes the detailed operation of each component and how it interacts with the entire system.
6. Listing of the entire DDC controllers with database, software and programs and program locations.
7. Provide spreadsheets of schedules for enclosures, control modules, dampers, valves, wiring, fans, well, tap and other miscellaneous components if they are part of this control contract showing sizes, characteristics, model numbers and specific locations.

B. Provide laminated control diagrams in each control panel for each piece of major controlled equipment or system.

C. CD backup disk(s) to be left on-site that will allow the Owner to fully download the entire DDC System software, including programming point database, configuration, graphic screens and a library of typically composed objects, and details supporting navigation,

screens and graphics.

D. Within ten (10) working days from the time of the final system commissioning, four (4) sets of Operation and Maintenance Manuals shall be turned directly to the Engineer.

E. A Programmers Manual shall be provided with graphic and text descriptions of all functions required for software modifications and developments. The use and installation of high-level programming language shall be included in this manual. The manual shall include ASCII text (or block diagram printouts for graphical programming language based systems) of all DDC programs with the spreadsheet inventorying the name and location of each program. Each file shall be accompanied by a "plain English" description of the program operation by subroutine to assure that future programmers can easily modify the existing database. The manual shall contain computerized printouts of all data file construction including all point information, physical terminal relationships, scales and offsets, alarm limits, messages, schedules, etc.

F. The manual should also contain:

1. System overview
2. Networking concepts
3. Launching browsers from log in
4. Schedule manipulation
5. Software upload and download instructions, including field devices
6. Trend and alarm creation and maintenance
7. Report generation
8. Backup procedure for entire system and modular controllers
9. Sequence of Operation

G. Section for each Major Piece of equipment – Contains the cutsheets for the controllers, custom programs, and relevant information pertaining to that piece of equipment. (IE: schedules for AHUs showing Equipment Tag, Controller address, serial #, airflow, and pertinent engineering units like MBH, GPM, etc…).

H. Wiring Details – Contains 8-1/2" x 11" drawings of all the wiring details shown throughout the set of drawings.

I. Instrumentation Cut sheets – Contains the Manufacturer's original cut sheets for all the instrumentation used on the job. (IE: Well sensor, transformers, enclosures, pressure sensors, etc.).

J. AutoCAD Drawings – All drawings shall be provided in Auto CAD format (i.e. each file format should have the ".dwg" extension), made as set of both, a set 11"x17" black and white and a set of 24"x36" (1 color set and 3 black and white sets). Drawing Sets consists of the following:

1. System Description Drawing – Shows the overview of the job and what is being controlled.

2. Network Riser Drawings – Shows how the network is connected between all the devices on the job.
3. Detail drawing(s) – Shows all the wiring and piping details for the entire job – all other drawings refer to these drawings.
4. Individual Control panel drawings & Schematics (1 or 2 drawings per piece of equipment) Shows the EXACT wiring and layout of each control panel. Also shows the schematic representation of the system that is being controlled. (IE: AHU, HW Plant, RH Coil, Pump, Etc.)
5. Controls Floor plans (at least 1 for each floor) – Shows the approximate location of the control panels, thermostats, equipment, network wiring, thermostat wiring and any specific controls required for the job. All this information is overlaid on top of the mechanical floor plan showing the architectural layout (Wall and room #'s).

K. All above shall be copied to a CD and released to the Owner.

1.10 SYSTEM COMMISSIONING

A. All points connected to the EMS shall operate fully in accordance with this specification before final completion is determined.

B. Equipment Start-up: Upon completion of installation, all equipment being controlled shall be initially started and tested on site, using a contractor-provided temporary workstation able to communicate with all individual controllers of entire installed system. Upon completion of this process whole content of the temporary PC should be reloaded to the Owner's operator workstation(s), which thereafter should continue to operate in a manner required by this specification. Additionally perform the following:

1. Measure, calibrate and adjust all analog inputs.
2. Stroke all analog outputs from 0% to 100% and verify that all linkage adjustments are set properly.
3. Valves and Dampers shall fully close and provide tight shut-off.
4. Verify that all digital outputs are properly energizing the controlled device.
5. Adjust setpoints so that equipment operates properly. Tune all PID control loops to avoid unnecessary cycling of control equipment, it's overheating, sub-cooling, tripping the freezestats and other limit switches and safeties. Create trends and print the results to verify tuning operation.
6. Provide reasonable control and operational assistance to the balancing personnel as needed to achieve reliable and energy-efficient system operation.

C. Communication Network Start-up: Verify from a host computer that all configured controllers are engaged in proper communication passing all configured points to viewing stations. Verify communication speed and level of transactions until it is acceptable and meets the requirements of this specification.

D. Software Verification: All programs and software functions shall be verified for proper sequence of operation.

E. Contractor shall, during the ensuing four seasons (one year), conduct periodic inspections to fine-tune all dynamic elements of the system with all costs of testing to be included in this scope of work. In addition, the Contractor shall dedicate one full day during each of the four subsequent seasons, during which all necessary tuning of dynamic parameters shall be conducted in the field.

F. Coordination: Work with the air-balancing professional, Division 23, and Division 26 to provide a proper and obstruction free component location, and a complete system commissioning.

G. As built Drawings: All drawings shall be reviewed after the final installation and corrected to provide accurate, as-built representation of the complete system.

H. Systems Startup Report: A report shall be provided to the Engineer detailing the dates, times and person(s) performing the start-up. This report shall detail when and who performed the individual processes mentioned above.

I. The controls system installer, the commissioning agent, and the Owner shall perform a physical walk-through of the project and the complete set of required documentation and software shall be transferred to the Owner. The Owner has no right to refuse or delay a reasonably scheduled walk through meeting, during which time every major components should be inspected if the Owner wishes so. Commissioning is considered completed only after the installation has been accepted by the commissioning agent and the Owner.

1.11 TRAINING

A. Provide EMS training. Training session shall be up to four (8) hours for Owner selected personnel, number of attendees to be determined by the Owner.

B. After commissioning is complete as specified, the controls system installer shall provide an on-site session detailing the layout of the EMS. This shall include network wiring routes, control panel locations, transformer locations, etc.

C. The controls system installer shall then provide an on-site session to review the entire Operations and Maintenance manual(s) with the Owner. This session shall also include but not be limited to:

1. Fundamental operation of the system.
2. Training on setpoint adjustment and scheduling modifications.
3. Operation and sequencing of control loops for all mechanical equipment being controlled.

D. Provide telephone support and answer system relevant questions throughout the warranty period.

1.12 WARRANTY

A. Guarantee the new control system to be free from defects in material and workmanship, for a period of one (1) year after final acceptance. Guarantee System to:

1. Maintain temperatures within 1°F above and below setting.

2. Humidity devices shall maintain relative humidity conditions within 3% of span 0-100% RH.

B. Warranty for the entire control system shall commence upon completion and acceptance by the Engineer of the system commissioning as specified. The warranty includes fine-tuning of all dynamic elements of control system to achieve reasonable, efficient end equipment protective mode of operation.

C. Provide a one-year warranty on all DDC controllers and all other components.

D. Disclose to Owner and accommodate longer warranty periods if provided by components manufactured at the time of purchasing.

PART 2 – PRODUCTS

2.01 SYSTEM DESCRIPTION

A. General Requirements:

1. A distributed logic control system, complete with Direct Digital Control (DDC) software shall be provided. This system is to control all mechanical equipment, as described in section 230993 – Sequence of Operation.
2. All logic controllers for terminal units, air handlers, central mechanical equipment and the Microsoft Windows-based operator's terminal(s) shall communicate and share data.
3. All logic controllers shall be fully programmable.
4. The controls system installer shall assume complete responsibility for the entire controls system as a single source, providing installation, program debugging and service of all portions of logic control system. This shall include designated server, operator’s terminal, global controllers, routers, terminal unit controllers, sensors and all other sections of the system.
5. The system must interface with the existing campus fiber network. All devices to accomplish this shall be the responsibility of this contractor.
6. Contractor shall provide fiber to Ethernet switch to accomplish conversion from campus fiber loop to Ethernet within the building. Contractor shall provide the following equipment to accomplish conversion:
    a. Cisco Industrial Ethernet 3000 Series switch, appropriately selected for this application.
    b. Cisco Industrial Ethernet 3000 Series LAN Base w/o crypto device manager, appropriately selected for this application.
    c. Cisco Industrial Ethernet 3000 Power Transformer, appropriately selected for this application.
    d. Cisco Fast Ethernet Interface Converter, appropriately selected for this application, 2 required.
    e. NECSecure Cisco Smartnet 8x5xNBD extended service agreement on Cisco Industrial Ethernet 3000 Series switch.

B. Basic System Features:

1. Direct digital logic control of temperature, scheduling, optimum start, equipment alarm reporting and override devices for unoccupied mode of operation.

2. System Operator's terminal software shall run under Microsoft Windows XP based operating system. Software shall be multi-tasking, capable of executing and displaying multiple instances in individual windows while running concurrently with other Windows programs such as word processors or database programs. Operation of the terminal software shall be simple and intuitive.

3. Security:

   a. The system shall be capable of restricting any operator to any level of the system using a password system. Passwords shall be changeable through on-line keyboard entry. A minimum of seventeen (17) security levels shall be available.

   b. Operator inputs executed under a valid password shall be recorded on the line printer.

   c. A password summary shall be available showing password initials, 24-character name, time out value, degree of capability.

   d. At no time shall the actual password numbers be printed on the CRT screen. The operator with the strictest level of password shall be able to generate a password summary listing.

   e. The software shall, through various security levels, allow the user to command points to a different state, gather information points, build parameters and modify parameters. Changes shall be accomplished on-line at the operator workstation as allowed by password. The operator shall have the ability to modify the system software on-line as allowed by his password restriction.

   f. Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for network communications and interface to the internet.

4. The system shall meet peer-to-peer communication services such that the connection of any operator interface to any one controller shall allow the operator to interface with all other controllers. The software shall provide transparent viewing and editing of all data, control programs, schedules, trends, alarms from any one controller through connection to any other controller on the internet work, regardless of subnetwork routers.

5. Alarm Reporting:

   a. Change-of-state or out-of-limits alarms (adjustable range for each point) shall be reported to the operator workstation and shall contain point description data. An alarm character string shall be printed in hard copy form whenever an alarm is received and shall take precedence over other functions.

   b. When multiple alarms are received, they will be output to the line printer as they are received. Non acknowledgeable changes-of-state shall be

output on a prioritized level format.

c. Alarm messages shall include time, date, actual value, setpoint and alarm setpoint.

6. The complete system, including, but not limited to terminal unit controllers, and higher level shall auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in any controller's memory shall reside error free for a minimum of 30 days. Logic controllers for all air handlers and all unitary equipment shall utilize EEPROM or battery backup for all variable data storage.

7. The data base shall be expandable to adapt to system hardware or software changes.

8. The system shall be capable of providing logs and summaries of system hardware on a per point basis using special characters and flags.

9. The operator shall have the ability to review the condition of field hardware and communication trunks through the operator workstation.

10. Control points common to systems (e.g. outside air) may be shared by field panels providing a minimum of two values are sensed and averaged. This information shall be available at all times on the local area network.

11. All hardware shall be Listed Underwriters Laboratory for Open Energy Management Equipment (PAZX) under the UL Standard for Safety 916 in both the US and Canada, with integral labels showing rating.

12. All hardware shall be in compliance with FCC Part 15, Subpart J, Class A.

2.02 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation.

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.

2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.

3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.

4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.

5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.

6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.

7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.

8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.

9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.

10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1 - Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±1ºF
Ducted Air	±1ºF
Outside Air	±2ºF
Dew Point	±3ºF
Water Temperature	±1ºF
Delta-T	±0.25ºF
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Water Pressure	±2% of full scale (see Note 1)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 2)

Note 1: For both absolute and differential pressure
Note 2: Not including utility-supplied meters

Table 2 - Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±0.1 in. w.g.	1-6 in. w.g.
Air Pressure	±0.05 in. w.g.	±0.25-1 in. w.g.
Air Pressure	±0.005 in. w.g.	±0-0.25 in. w.g.
Airflow	±10% of full scale	
Space Temperature	±1.0ºF	
Duct Temperature	±3ºF	
Fluid Pressure	±0.75 psi	

2.03 TEMPERATURE SENSORS

A. Provided by unit manufacturers

1. Duct Sensors:

a. Single point duct mounted sensors shall have a minimum 9" rigid probe and be used when the duct size is less than 24".

b. Averaging duct-mounted sensors shall have a minimum 12.5' long averaging element and be used when the duct size is greater than 24". All averaging sensors shall use true averaging elements, such as platinum. Averaging bridges [multi-point sensors] are specifically not permitted. Provide averaging sensors in all locations where specified or where temperature stratification can occur. Minimum element to be provided 1 ft per 4 sq ft of area. Securely support all elements to avoid movement in air stream or long term damage at stress / mounting locations.

2. Well Sensors:

a. Liquid immersion sensors shall have a stainless steel probe and a stainless steel or brass well. Length of the sensor well shall be selected based on the diameter of the pipe to provide accurate, reliable sensing of the liquid temperature. Sensors shall be installed as required in the pipe or an oversized elbow to provide accurate measurement of the media and complete immersion of the sensing element. All wells shall be filled with thermo-conductive media prior to installing the sensor in the well.

3. Outside Sensors:

a. The sensing element shall be sheathed in a stainless steel tube and mounted inside a ventilated, treated, PVC sun shield to minimize the radiant energy and wind effects. Sensor location shall be selected to minimize effects from sunlight, building heat, exhaust systems, etc.

2.04 FLOW SWITCHES

A. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

B. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.

C. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

2.05 RELAYS

A. Control Relays. Control relays shall be UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

B. Time Delay Relays. Time delay relays shall be solid-state, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

2.06 OVERRIDE TIMERS

A. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

2.07 CURRENT TRANSMITTERS

A. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

B. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

C. Unit shall be split-core type for clamp-on installation on existing wiring.

2.08 CURRENT TRANFORMERS

A. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

B. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

C. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

2.09 VOLTAGE TRANSMITTERS

A. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

B. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

C. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

2.10 VOLTAGE TRANSFORMER

A. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

B. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

C. Windings (except for terminals) shall be completely enclosed with metal or plastic.

2.11 POWER MONITORS

A. Power monitors shall be provided with the electrical switch gear.

2.12 CURRENT TRANSDUCER / EQUIPMENT INTERFACE RELAY

A. Low voltage, single phase:

1. Combined status sensor, command relay, and hand-off-auto switch.
2. Sized for monitor and control of small motors.
3. Field selectable relay output.
4. High and low voltage isolation.
5. Industrial grade load switching relay.
6. Mountable on single or double gang boxes, flush on starter enclosures, or stand-alone.
7. Approved for installation in the following environmental conditions:
   a. 0-95% relative humidity, non-condensing.
   b. 5° to 140°F
8. Design equipment: Veris Hawkeye H500.
9. Alternative components combining the total functionality of the specified device may be submitted for approval.

2.13 PRESSURE TRANSMITTERS

A. Pressure transmitters shall be of 2-wire, 4-20 mA output type with a capacitance element having an accuracy of +/- 1% over the entire range. Transmitter shall include protection against reverse polarity and supply voltage transients. Accuracy and zero span adjustment shall be provided with each transmitter to allow for recalibration as necessary.

1. Liquid Differential Pressure
   a. The operating range shall be -40 to 176°F.
   b. Maximum safe overpressure shall be 150% of the rated pressure.
   c. Sensor range to be selected so anticipated control setpoint resides in the middle third of the sensor span.
   d. Use of two discrete pressure sensors and mathematical determination of system differential pressure is acceptable.
   e. Differential pressure sensor shall use a five valve manifold to allow proper service without damage.
   f. Shall be contained in an aluminum NEMA-1 enclosure.

2.14 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

2.15 ELECTRONIC DAMPER MOTORS

A. Provide 24 VAC control operators which are 0-10 VDC input proportional or two positions with spring return as needed by control sequence and designed to operate control dampers. Operator shall be synchronous motor driven with up to 150 in. lb. force sensor safety stop and return as required.

B. Design Make: Siemens "Open Air" Series.

2.16 CONTROL DAMPERS

A. Automatic dampers shall have minimum 16 gauge galvanized frames and blades, and 13 gauge corner braces. Extruded vinyl or PVC coated fabric blade edge seals with flexible metal jambs. Axles to be 1/2" diameter with bearings or machined bushings. Dampers subject to corrosive fumes shall be stainless steel. Two-position dampers to have parallel blades and modulating dampers shall have opposed blades. Dampers over 48 in. in length and height shall be made into multiple sections.

B. Automatic dampers are required at all exterior wall and roof openings. Dampers to open when respective fan starts.

C. Where damper sizes are not specifically indicated, they shall be sized by the temperature control manufacturer. Maximum velocity shall be 1500 fpm and maximum pressure drop shall be 0.1 in w.g.

D. Leakage based on 1500 fpm approach velocity with 4 in. w.g. static pressure shall be no more than 6 cfm/ft.^{2}.

E. Design Make: Ruskin RCD 46, or equal.

2.17 CONTROL VALVES

A. Sized by temperature control manufacturer and guaranteed to meet the heating and cooling requirements. Water valves shall be sized on the basis of 15% of the total system pressure drop, but not more than 8 ft. of head drop. Size three-way hot water zone valves for not more than 3 psi drop. Steam valves shall be sized on a 45% (max.) of design steam pressure. Pressure drop for valves shall be submitted for review, including all Cv values.

B. Valves shall be equal percentage type, equipped with characteristic type throttling plug, #316, stainless steel or Monel stem, removable composition discs, and rubber diaphragms. Provide with necessary features to operate in sequence with other valves or damper operators and adjustable throttling range as required by the sequence of operations.

C. Valves 2 in. and smaller shall be screwed bodies with unions; 2-1/2 in. and larger: flanged bodies; designed for 125 psi operating pressure. Arranged to fail-safe as called for, tight closing and quiet operating.

D. Electric Operators (Valve):

1. Provide 24 VAC control operators which are 0-10 VDC input proportional with spring return as needed by control sequence and designed for water service valve bodies. Operator shall be synchronous motor driven with up to 150 in. lb. force and force sensor safety stop.

2. Siemens 599 Series, MT Series, MZ Series.

2.18 SAFTEY/STATUS DEVICES

A. Two (2) Pole Low Limit Detector: Electric type, with 20' long serpentine element, with manual reset and auxiliary contacts to the DDC, set for 37°F for "freeze" protection and 55oF for fan discharge application. Provide a 20' long element for every 25 $ft.^2$ of coil face area.

B. High Limit Detector: Electric type, with manual reset and auxiliary contacts to the DDC, UL listed for fire, set for 180°F.

C. Pump status shall be provided through adjustable range current sensing element on pump motor.

D. Fan status shall be provided through adjustable range current sensing element on the fan motor.

2.19 NETWORKING/COMMUNICATIONS

A. Inherent in the system's design shall be the ability to expand or modify the network either via the local area network.

B. Local Area Network:

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: The system shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network.

3. General Network Design: Network design shall include the following provisions:

a. The minimum baud rate shall be 19,200 BPS.

b. Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

c. Message and alarm buffering and default device definition to prevent information from being lost.

d. Synchronization of the realtime clocks in all DDC panels shall be provided.

2.20 OPERATOR INTERFACE

A. Operator Interface is existing to remain.

B. The following programs shall reside on the existing operators workstation:

1. Trend Log:

a. Points shall be assignable at the host computer. Trended values shall be historically retained on the system hard disk for future inquiry. Provide customized trend log reports with up to eight variables per report.

b. Refer to specification section 019113 for additional trend logging required by the commissioning authority.

2. Alarms and Summaries:

a. System log shall log the status of points within system.

b. Alarm summary shall log specified alarm points which are actually in alarm.

c. Off-normal summary shall log points specified by the operator to be in the off-normal mode.

d. Lockout summary shall log points specified to be in the lockout condition.

3. Messages:

a. The system shall support a minimum of 500 alarm messages in English as defined by the operator. Minimum message length shall be 256 alpha-numeric characters. Messages shall also indicate whether acknowledgement is necessary.

b. Alarm messages may be assignable to system messages.

4. Totalization:

a. The system shall allow for analog or digital point totalization with respect to time.

b. Run time totalization shall be provided to track the run time of point assigned. A summary shall list run time points and their present values.

c. Analog totalization shall be provided to measure analog data over real time span. A summary shall list analog totalization points and their current period values, current day values, previous period and previous day totalized values.

d. Provide 3 customized totalization reports.

5. Scheduling:

   a. The system shall be capable of initiating equipment based on a preselected time-of-day schedule. This program shall provide scheduling for seven days of the week with 500 unique schedules. The user shall not be required to enter control programs to alter time-of-day schedules.

   b. Provisions shall be made to program in holidays up to one year in advance; up to 366 consecutive holidays shall be enterable.

6. One-line Graphic Generation:

   a. This program shall allow the operator to generate chromatic graphics on-line using symbols selected from a standard library of symbols.

   b. Provide one (1) customized graphic with dynamic point values and set points for each system.

C. Energy Management Features: The following energy management programs shall reside in the existing host computer for global control purposes:

1. Duty cycling program shall periodically turn selected loads off to reduce energy consumption.

2. Optimal run time program shall control the start-up and shutdown of HVAC equipment based on the most energy efficient schedule.

3. Programs shall be supervised by an energy management program which shall oversee the execution of global energy management functions. These programs may also reside in individual field panels on systems of this architecture. If the host computer is to act only in a supervisory mode, specific panels shall be assigned to global function duty.

2.21 ENCLOSURES

A. Central DDC control panels shall be fully enclosed cabinet, baked enamel, steel, aluminum or composite material construction and shall meet the requirements of NEMA 1 enclosures. Panels shall have hinged door with a locking latch. Cover exposed electrical connections. Each component on front panel shall have an appropriate engraved label describing its function. Components inside the panel shall be appropriately labeled for ease of identification. Stick-on labels are not acceptable. Panels shall be either free-standing or wall-mounted. Provide support steel framing.

2.22 CENTRAL DDC PANELS

A. General: Central DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each DDC panel shall consist of required processors, communication controllers, power supplies, and input/output devices.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Software for engineer defined sequence of operation
7. Operator I/O
8. Dial-Up Communications

C. Serial Communication Ports: Central DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals.

D. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

E. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical codes.

F. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all Central DDC panels to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 48 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

2.23 SYSTEM SOFTWARE

A. General:

1. The system shall be Windows NT based, and shall include all necessary software to form a complete operating system as described in this specification. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.
2. All programmed control functions in each DDC controller associated with each piece of mechanical equipment shall be operational as indexed by the status feedback from that piece of equipment. The output command shall not be used

to index the unit program logic. No gateways to terminal and HVAC units will be allowed. Workstation shall have full functionality of mechanical equipment.

B. Control Software Description:

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:
   a. Two Position Control
   b. Proportional, Integral, plus Derivative Control
   c. Automatic Control Loop Tuning
2. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
3. Equipment Start-Up: The system shall provide protection against excessive demand situations during start-up periods (morning or power failure restart) by automatically introducing time delays between successive start commands to electrical loads.
4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.
5. Database Download: Upon system failure/loss of database, workstation will have the ability to download database to field panels and restore system automatically.

C. Energy Management Applications: DDC Panels shall have the ability to perform the following energy management routines:

1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start
6. Optimal Stop
7. Night Setback Control
8. Enthalpy Switchover (Economizer)
9. Temperature Compensated Load Rolling
10. Fan Speed/CFM Control
11. Heating/Cooling Interlock
12. Hot Water Reset
13. Chilled Water Reset

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed and independent alarm analysis.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

2. Prioritization: The user shall be able to prioritize (2 levels minimum) and define the specific system reaction for each point. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point and define which alarms need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

a. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response. Each Central DDC panel shall be capable of storing a library of at least 250 Alarm Messages.

b. The computer shall have the capability to dial up to two (2) phone numbers or pagers and leave a message in the event an alarm is received and not acknowledged at the host computer, if so required, within 15 minutes. The first phone number shall be from a library of numbers assigned to the watch engineers and shall be changed when the watch engineer logs on each shift. The second phone number shall be supplied by the Owner.

F. Historical Data and Trend Analysis: Data collection utilities shall be provided to automatically sample, store, and display system data as follows:

1. Continuous Point Histories: System shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

2. Control Loop Performance Trends: System shall provide sampling capability with an operator-adjustable resolution of 10-300 seconds for verification of control loop performance.

3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours, in one-minute intervals, shall be provided. The system shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

4. Data Storage and Archiving: Trend data shall be stored and downloaded to hard disk storage when archival is desired. Downloads shall occur based upon either user-defined interval or manual command. All trend data shall be available in disk file form for use in 3rd party software.

G. Runtime Totalization: The system shall automatically accumulate and store runtime hours and number of on/off cycles per time period for binary input and output points.

2.24 CONTROLLERS

A. Each Central DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases including:

1. Control Processes
2. Energy Management Applications
3. Operator I/O (Portable Terminal)

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable operator's terminal connected to any Central DDC panel in the network. The same tool sets shall be used for all field and terminal controllers.

E. Application Specific Controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable terminal in the ASC port shall include:

1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters
5. Override binary output control
6. Override analog setpoints
7. Modification of gain and offset constants

H. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller. A second backup shall reside on workstation.

2.25 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to all controller hardware.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.26 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

1. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
2. Line voltage units shall be UL recognized and CSA listed.

C. Power Line Filtering:

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

a. Dielectric strength of 1000 V minimum

b. Response time of 10 nanoseconds or less

c. Transverse mode noise attenuation of 65 dB or greater

d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

PART 3 - EXECUTION

3.01 GENERAL SYSTEM REQUIREMENTS

A. The control of each system shall be guaranteed to perform as described in the Sequence of Operation Section of this specification. Equipment, remote switches, in finished rooms shall be flush-mounted, if possible. Stay clear of equipment access. Wiring shall be supported independent of mechanical equipment. Interlock supply and return fans, condensers with air conditioning equipment and similar situations demanding coordinated operation.

3.02 SYSTEM COMPONENTS

A. Valves: Union or flanged connected. Locate close to apparatus controlled with pipe reducers and increasers located close to valve. Locate, arrange, and pipe per installation diagram.

B. Mounting height for all room thermostats or sensors shall be 54" to the top of the cover.

C. Locate thermostats on walls symmetrical with adjacent items. Verify exact room location to avoid doors, fixed and portable equipment. Install to minimize damage. Do not install adjacent to lighting dimmers or other heat generating equipment.

D. Dampers and Damper Operators: Tag dampers for proper location. Install per manufacturer's printed instruction as to motor size and quantity, linkage arrangement, drive connection point. Adjust to close tightly. Allow for conduit sleeve or blank space for roof fan dampers. Where ducts are insulated, set damper operators at least 2 in. away from side of duct to allow for insulation.

E. Thermometers: Provide with diagrams indicating exact locations prior to start of Work. Arrange for easy reading.

3.03 GENERAL SYSTEM DESCRIPTION

A. Provide normally open hot water coil valves.

B. Provide normally open return air damper, normally closed relief air and normally closed outside air dampers and operators.

C. Mode of operation (occupied/unoccupied) including building warm-up and pull-down cycles, as well as all system functions shall be programmable and controlled by the DDC system.

D. Shutdown of air handling units and fans due to a fire alarm shall be by Division 26. The fire alarm system will send a signal to the DDC system for monitoring purposes only. The DDC system will provide a staggered restart of the units once the alarm is cleared.

E. All setpoints shall be adjustable.

3.04 WIRING

A. Unless noted otherwise, all electrical wiring required to interconnect the components of the control system shall be furnished and installed by the controls system installer. Perform all wiring in accordance with the requirements listed below, code requirements and Division 26.

B. Communication wiring shall be installed using the particular system recommended, plenum rated, jacket shielded cable. The communication network wiring shall be clearly marked with a specific color code. Communication wiring shall not be installed near noise producing equipment, such as ballasts, magnetic starters, etc. Communication wiring shall comply with the optimum requirements necessary to assure communication integrity and speed.

C. All analog inputs and analog outputs shall be wired using 18 gauge stranded shielded cable.

D. All digital outputs shall be wired using 18 gauge stranded wire.

E. All wiring in mechanical rooms, walls shall be installed in EMT conduit. Concealed conduit and wiring is required in all finished spaces.

F. Power Supplies:

1. Transformers – Each w/ low voltage fuse holder/disconnect.
2. Actuators and relays shall use separate transformers from those powering microprocessor control panels.
3. Transformers shall be sized for a minimum of 150% of the connected load.

G. Convenience Outlet:

1. 110vac combination outlet w/ switch to kill 110vac to panel.
2. Switched 110vac to panel is fused before transformers (after outlet).

3. Provide at all control panels excepting those for terminal equipment (exclude VAV boxes, reheats, cabinet heaters, fan coils, etc.)

H. Wiring Panduit:

1. Wire ducts around exterior of panel for cables entering panel.
2. Wire ducts as necessary to route hookup wires from terminals to controllers and other devices.

I. Panel Construction (sized to provide 25% future expansion w/ removable back panel):

1. Indoors – Johnson M8100 series
2. Outdoors – Hoffman fiberglass Nema 4x

J. Wire Labeling:

1. All DDC system wiring shall be individually labeled and permanently tagged at both ends of the conductors, including within all junction boxes between panels.
2. All submittal and as-built drawings shall reflect the field installed wire tag numbers.
3. All wire numbers shall be unique throughout the system installation.

3.05 DDC EQUIPMENT

A. All components shall be installed in protective enclosures. All wiring within the DDC enclosure shall be number coded. Both the enclosure and the controller shall be properly grounded in accordance with manufacturer's recommendation. Documentation shall be firmly attached to the enclosure within a plastic envelope. Documentation shall state point-to-point termination detail, description of each individual point, location of power source for the controller and ID number or address within the network.

B. All DDC Controllers shall be mounted on walls within equipment rooms, custodial closets or electrical rooms. Only application-specific controllers for VAV boxes, rooftop units or package units may be mounted on the equipment.

3.06 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate work of others. Controls system installer shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.07 PROTECTION

A. Controls system installer shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

B. Controls system installer shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.08 COORDINATION

A. Site:

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance:

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
2. Train Test and Balance Contractor to use control system interface tools.
3. Provide a qualified technician to assist with testing and balancing of all air handling equipment and terminal units.
4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

C. Life Safety:

1. Duct smoke detectors required for air handler shutdown are provided and installed by others. Interlock smoke detectors to air handlers for shutdown as specified Sequence of Operations for HVAC Controls.

D. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows:

1. Each supplier of a controls product shall configure, program, start up, and test that product to meet the required sequences of operation regardless of where within the contract documents those products are described.
2. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.

3. Controls system installer shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.09 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Independently support all temperature control wiring from other systems. Do NOT support from conduits, piping or hangers for equipment.

C. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

D. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

E. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

F. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.10 FIELD QUALITY CONTROL

A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Continually monitor field installation for code compliance and workmanship quality.

C. Contractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

3.11 COMMUNICATION WIRING

A. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

B. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

C. Verify entire network's integrity following cable installation using appropriate tests for each cable.

D. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

E. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

F. Label communication wiring to indicate origination and destination.

G. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.12 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft of sensing element for each 4 ft^2 of coil area.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. All sensors to be mounted on externally insulated ductwork or plenums shall be provided with standoff brackets. Insulation and vapor barriers shall be carried continuously beneath the sensor enclosure.

J. Differential Air Static Pressure:

1. Supply Duct Static Pressure. Pipe duct pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
2. Return Duct Static Pressure. Pipe duct pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover. Outdoor port shall be protected from intrusion by insects or debris.
4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
5. Air pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.13 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.14 ACTUATORS

A. General. Mount actuators and adapters according to manufacturer's recommendations.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
2. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° opens position, manually close the damper, and then tighten linkage.
3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
4. Provide necessary mounting hardware and linkages for actuator installation.
5. Actuator torque shall match damper manufacturer specified torque allowance to achieve low leakage rating.
6. Maximum 16 square feet per damper actuator.

C. Valve Actuators. Connect actuators to valves with adapters approved by actuator manufacturer.

3.15 SMOKE DAMPER AND FIRE/FAN SHUTDOWN

A. Division 16 "Electric" to provide a signal to stop air handling unit fans and close air handling unit smoke dampers upon activation of the fire alarm system. Wiring to be directly to the motor starter. An end switch shall prevent the operation of the air handling unit fans until its corresponding smoke dampers are open.

B. Division 16 "Electric" shall also provide a signal to the DDC control system that the fire alarm system is activated.

3.16 LOW AND HIGH LIMIT SAFETY FUNCTIONS

A. Provide for all supply fan units. Wiring to be directly to the motor starter. High limit controller (firestat) shall be located in the unit discharge, set at 180oF and prevent the fan from operating until reset. High limit shall alarm DDC system. Low limit shall be strung on the discharge face of heating coils OR upstream face of cooling coils set at 37oF. Low limit shall: prevent the fan from operating, set heating coils to full heat operate coil pumps, fully close the outside air damper, fully close the relief air dampers, open return air damper, and alarm DDC system until reset.

3.17 WARNING LABELS

A. Affix permanent warning labels to equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows:

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows:

C A U T I O N
This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.18 IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 2 in. of termination.

B. Permanently label or code each point of field terminal strips to show instrument or item served.

C. Label control panels with minimum ½ in. letters on laminated plastic nameplates.

D. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

E. Label room sensors related to terminal boxes or valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Label identifiers shall match record documents.

3.19 OPERATOR INTERFACE

A. Standard Graphics. Provide graphics as specified. Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List / diagram. Point information on graphics shall dynamically update.

B. Install and troubleshoot software and functions (including operating system software, operator interface database) on existing operator interface.

C. Provide logical descriptions and engineering units on all data displays. Example: percentage position shall be easily discernable as percent open or closed.

3.20 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification in addition to testing specified elsewhere in this section.

1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.
2. Complete approved checklists and forms for each system as part of system demonstration. Submit documents at least 30 days prior to scheduled testing for approval.
3. Demonstrate actual field operation of each sequence of operation. Provide at least two persons equipped with two-way communication (if required). Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
4. Demonstrate compliance with sequences of operation through each operational mode.
5. Demonstrate complete operation of operator interface.
6. Demonstrate each of the following:
    a. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
    b. Building fire alarm system interface.
    c. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the

points list provided with each sequence of operation.. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.

7. Tests that fail to demonstrate proper system operation shall be repeated, at the contractor's expense, after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance:

1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control, such as seasonal requirements or construction progress issues. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved.

3.21 CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent area.

APPENDIX A – GLOSSARY OF TERMS
Terms used within the Specification Text:

- Advanced Application Controller (AAC): A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

- Application Specific Controller (ASC): A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

- BACnet/IP: An approved BACnet network type which uses an Ethernet carrier and IP addressing.

- BACnet MS/TP: An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

- BACnet over ARCNET: An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

- Building Controller (BC): A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

- Direct Digital Control (DDC): A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

- PICS - Protocol Implementation Conformance Statement: A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

- Smart Actuator (SA): An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

- Smart Sensor (SS): A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)

- Web services: Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

Terms used within the Sequences of Operation:

- adj: Adjustable by the end user, through the supplied user interface.

- AI, AO, etc. (Column Headings on Points List).

- AI = Analog Input. A physical input to the control module.
  AO = Analog Output. A physical output from the control module.
  AV = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.
  BI = Binary Input. A physical input to the control module.
  BO = Binary Output. A physical output from the control module.
  BV = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
  Sched = Schedule. The control algorithm for this equipment shall include a user editable schedule.
  Trend. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)
  Alarm. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

  Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

- Occupant Override Switch, or Timed Local Override: A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time. When the override time expires, the zone returns to its unoccupied state.

- Occupant Setpoint Adjustment: A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

- Optimal Start-Up: A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied. In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint. The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity. A distributed system must use Run on Request with Optimal Start. (See below.)

- Requested, or Run on Request: A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule. The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment. For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller. The run on request

algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

- Trim and Respond, or Setpoint Optimization: A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint. For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

APPENDIX B – ABBREVIATIONS

The following abbreviations may be used in graphics, schematics, point names, and other UI applications where space is at a premium:

Abbreviation	Description
AC	Air Conditioning
ACU	Air Conditioning Unit
AHU	Air Handling Unit
AI	Analog Input
AO	Analog Output
AUTO	Automatic
AUX	Auxiliary
BI	Binary Input
BO	Binary Output
C	Common
DA	Discharge Air
EA	Exhaust Air
EF	Exhaust Fan
EVAP	Evaporators
HOA	Hand / Off / Auto
HTEX	Heat Exchanger
HW	Hot Water
HWP	Hot Water Pump
HWR	Hot Water Return
HWS	Hot Water Supply
MAX	Maximum
MIN	Minimum
NC	Normally Closed
NO	Normally Open
OA	Outdoor Air
PIU	Power Induction Unit
RA	Return Air
RF	Return Fan
RH	Relative Humidity
SA	Supply Air
SF	Supply Fan
SP	Static Pressure
TEMP	Temperature
UH	Unit Heater
W/	with
W/O	without

END OF SECTION

SECTION 230963

GAS MONITORING SYSTEMS AND ACCESSORIES

PART 1 – GENERAL

1.01 WORK INCLUDED

A. The Contractor shall provide labor, materials, equipment, services and warranty for complete installation, startup and commissioning of gas detection system(s) and accessories as required in the Contract Documents. Provide wiring and conduit required to connect devices furnished as a part of, or integral to the gas detection system(s). Provide wiring in accordance with the requirements specified in the National Electrical Code. Provide all devices required for proper system operation including detectors, transformers, transmitters, relays, and control modules. Provide complete wiring and terminations. Provide all components, whether specifically described or necessary to create a coherent system, encompassing all combined intents of design, drawings, specifications, addenda, and professional quality of work.

B. Provide a complete installation of a refrigerant leak detection system including a main control panel, sensors and audible/visual alarm devices and emergency break glass switches that are linked to a Building Automation System (BAS).

C. The gas detection system(s) shall be as indicated on the project documents, point lists, drawings and as described in these specifications. The scope of work shall include a complete and working system including all engineering, programming, controls, and installation materials, commissioning, start-up, training, and final project documentation and warranty.

D. The system shall include, but not be limited to, the following:

1. Display of refrigerant gas concentration.
2. Ability to modify alarm set points.
3. Daisy-chain capability.
4. Automatic and manual fan start/stop.
5. Display of alarm status.

E. The gas detection system shall be provided to monitor the levels of specific gas in designated areas of the facility and interface with the control system for the purposes of protecting occupants and controlling the exhaust air fan.

F. The refrigerant leak detection system design shall consist of diffusion type sensors and a control unit. Sample draw systems with sample tubing are unacceptable.

G. Free-standing panels shall be supported from “Unistrut”, securely fastened to walls.

H. Power for gas detection control panels shall come from designated panels on the electrical drawings. Wiring shall be by this contractor, panel breaker to be supplied by Division 26.

I. Coordinate all work with Division 26, “Electrical”.

J. Provide interface with Building Automation System to control operation of HVAC equipment in response to gas detection levels as per the sequence of operation in Section 230993.

1.02 WORK NOT INCLUDED

A. Power wiring for motors, motor starters and associated with it power starting and control equipment, as well as the motor starters (except in the case of equipment specified to have packaged controls/starters) are included in Division 26, “Electrical”, unless otherwise called for.

B. HVAC control system to operate HVAC equipment in response to gas detection levels is included in Division 23 Controls (Specification Section 230923).

1.03 SUBMITTALS AND SHOP DRAWINGS

A. Product Data: Submit for approval the manufacturer’s technical product data for each component furnished as part of the gas detection system. Data shall include dimensions, capacities, performance characteristics, electrical requirements, and material finishes. Data shall also include installation and start-up requirements.

B. Shop Drawings: Before commencing any work or ordering any materials, submit for approval drawings detailing the following:

1. Complete shop drawings of the gas detection system(s) for electrical services; including equipment cuts, schematic diagrams, layout drawings; a written sequence of operation indicating the function of each device; and connections to equipment furnished by others. Submittal shall indicate each item by its nomenclature, as used in the schematic diagrams, and the sequence of operation shall clearly indicate its function.
2. Show all gas detection equipment and indicate the function of each item.
3. Schematics shall not be “typicals” but shall show the specific equipment for the application.

1.04 ACCEPTABLE MANUFACTURERS

A. Provide a complete gas detection system as manufactured by one manufacturer and as specified herein and/or indicated on the drawings.

1. The gas detection system shall be designed by the equipment manufacturer.

1.05 QUALITY ASSURANCE

A. Acceptable Products: All products shall be proved to be functional and suitable in accordance with this specification for a period of warranty commencing on the day of transfer of completed project to the Owner. Demonstration of such warranty may be required prior to the submittal approval.

B. Contractor Qualifications: The Contractor shall be factory-authorized by the respective manufacturer to provide pertinent installation and service.

C. Field Representation: The Contractor shall staff the project with a field representative who has been factory-trained in the installation, programming and commissioning of the equipment specified.

D. Coordination of work during construction:

1. Contractor shall protect work installed by other trades.
2. The Contractor shall coordinate its work with other trades.
3. The Contractor shall promptly correct all work that Owner finds as defective or failing to conform to the Contract Documents.
4. The Contractor shall bear all cost of correcting of work found defective as described above.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver products in factory-fabricated containers. Deliver pipe and tube with factory-applied plastic end-caps on each length.

B. Store products in original wrapping and protect from dirt and damage. Store piping and tube inside. Where necessary to store outside, elevate well above grade and enclose with waterproof wrapping.

C. Handle products carefully to avoid damage. Do not install damaged products.

1.07 OPERATION AND MAINTENANCE MANUALS

A. Upon completion of installation and prior to the training, provide manuals containing the following information:

1. Installation and Service Manuals for all products and components.
2. Calibration, Maintenance and Troubleshooting Procedures for all installed equipment and components that have built-in calibration features.
3. List of locations of all enclosures, controllers, sensors, transformers and other components.
4. As-built Drawings with all modifications, changes and wiring details that depict actual installation. These shall include all final controller and device names, wire tags etc.

5. Sequence of Operation – Describing in detail the operation of every piece of equipment subject to control or the interface with the BAS and the specific information shared. Each section of the sequence should contain the following:

    a. Overview – Describes intent, what components are involved and provides a concise description of the equipment or system to be controlled.

    b. Alarm Modes – Describes operation of the system in the event of alarm condition and steps to restore system to normal operation. List all anticipated alarm conditions.

    c. Each component's individual sequence – Describes the detailed operation of each component and how it interacts with the entire system.

    d. Sections for each major piece of equipment - Contains the cut sheets for the controllers, custom programs, and relevant information pertaining to that piece of equipment. (i.e.: schedules for fan showing Equipment Tag Numbers, Controller, serial #, airflow, etc.).

    e. Wiring Details – Contains 8-1/2" x 11" drawings of all the wiring details shown throughout the set of drawings.

    f. Instrumentation Cut Sheets – Contains the Manufacturer's original cut sheets for all the instrumentation used on the job. (i.e.: transformers, enclosures, controllers, etc.).

    g. CAD Drawings – All drawings shall be provided in AutoCAD format (i.e.: each file format should have the ".dwg" extension). Drawing Sets consists of the following:

        (1) Systems Description Drawings – Shows the overview of the job and what is being controlled.

6. Within ten working days from the time of the final system commissioning, four (4) sets of Operation and Maintenance Manuals shall be submitted directly to the Owner/Engineer.

1.08 COMMISSIONING

A. Equipment Start-up: Upon completion of installation, all equipment shall be initially started and tested on site. Additionally perform the following:

1. Measure, calibrate and adjust all analog sensing inputs.
2. Verify that all timeclocking/ interlock functions are properly energizing the controlled device.
3. Confirm all alarms function properly and that intended responses are initiated.

B. Coordination: Work with the other contractors to provide proper and obstruction free component locations, and a complete system commissioning.

C. As-built Drawings: All drawings shall be reviewed after the final installation and corrected to provide accurate, as-built representation of the complete system.

D. Commissioning Report: A report shall be provide to the Engineer detailing the dates, times and person(s) performing the start-up. This report shall detail when and who performed the individual processes mentioned above.

E. Commissioning is considered completed only if the physical walk-through of the project, together by the Contractor and the Owner, was concluded and the complete set of required documentation has been transferred to the Owner. The Owner has no right to refuse or delay a reasonably scheduled walk-through meeting, during which time every major component shall be inspected if the Owner wishes so.

1.09 TRAINING

A. Provide system training for up to four (4) Owner selected personnel. The programs shall be by an experienced instructor, and shall be provided over 2 hours of time, to be scheduled fully at the convenience of the Owner. Training shall cover all aspects of installation, operations, and programming of the gas detection systems.

B. Included in the above training, the Contractor shall review the Operations and Maintenance manual(s) with the Owner. This session shall also include, but not be limited to:

1. Fundamental operation of the system.

2. Training on setpoint adjustment modifications.

1.10 WARRANTY

A. Warranty for the entire gas detection system shall commence upon completion of the system commissioning as specified. The warranty includes fine-tuning of all dynamic elements of the gas detection system to achieve reasonable, efficient and protection and operation.

B. Provide a one-year warranty on all controllers.

C. Provide a one-year warranty on all other components.

D. Disclose to Owner and accommodate longer warranty periods if provided by components manufactured at the time of purchasing.

PART 2 – PRODUCTS

2.01 EXPANSION UNIT

A. The controller shall provide a 4 -20 mA output signal (with an accuracy of +/- 3%) for each sensor corresponding to the measured refrigerant levels of each sensor. In the event of a sensor or controller malfunction, the controller shall energize an on board fault relay and turn on a fault indicator on the front panel.

B. The controller shall continuously display the specified refrigerant concentration of each sensor via an LCD display. The controller shall have a minimum of three levels of activation for each detected refrigerant level. There shall be 3 relays corresponding to

three alarm levels. The alarm A relay shall be energized and the first alarm (Alarm A) shall be initiated when the refrigerant concentration reaches or exceeds the programmed Alarm A level**.** Alarm A shall start the mechanical room ventilation equipment. The Alarm B relay shall be energized and the second alarm (Alarm B) shall be initiated when the refrigerant concentration levels reach or exceed the programmed Alarm B level. Alarm B shall energize an onboard red horn strobe unit attached to the controller or a remote red alarm horn strobe. All relays shall be form C, double pole double throw. Dry contacts shall be rated for 5 amps (resistive load) at 240 Vac.

C. The controller shall provide an audible alarm silence button on the front panel to silence the audible alarm but will automatically reset and sound again at the next alarm occurrence.

D. The controller shall be wall mount type with the following features:

1. Enclosure Type- The enclosure shall be NEMA 4 type. Access to the inside of the enclosure and wiring connections shall be through a front facing, full length door. The door shall have a window size sufficient to allow viewing of a 2 line by 20 character LCD display.

2. Enclosure Size- the enclosure shall be no more than 12 inches in any dimension.

3. Mounting Provisions – mounting brackets for the purpose of attaching the unit to a flat surface shall not be needed.

4. Front Panel Controls- a four button keypad and fan start stop and alarm silence buttons shall provide access to all monitor functions including display, calibration, set-up and diagnostics.

5. Front Panel Indicator Lights- Yellow (refrigerant vapor equal to or greater than AEL or TLV for specific refrigerant); Red (refrigerant vapor equal to or greater than STEL or 3 times the AEL/TLV for specific refrigerant).

6. Audible Alarm – A 65dBa (at 3 feet) audible alarm shall be internal to the controller; it shall sound when one of the pre-selected alarm conditions occurs.

7. No tools or special adapters shall be used for:

   a. Display of alarm set point level on front panel readout.

   b. Resetting any alarm set point.

   c. Zero and span calibration adjustments.

8. System Power Requirements – the system shall operate on 24Vac 2A max.

E. BACnet: The control panel shall enable BACnet communication through its BACnet output using BACnet/IP protocol over twisted-pair Ethernet cable.

2.02 EXPANSION UNIT REMOTE PANEL

A. The remote panel shall provide up to four relay inputs and visual indication of the gas concentration of the gas concentration.

B. In the event of a sensor, controller or remote panel malfunction, the remote panel shall energize an on board fault relay and turn on a fault indicator on the front panel.

C. The remote panel shall continuously display the specified refrigerant concentration of each sensor via an LCD display. The remote panel shall have a minimum of three levels of activation for each detected refrigerant level. There shall be 3 relays corresponding to three alarm levels. The alarm A relay shall be energized and the first alarm (Alarm A) shall be initiated when the refrigerant concentration reaches or exceeds the programmed Alarm A level**.** Alarm A shall start the mechanical room ventilation equipment. The Alarm B relay shall be energized and the second alarm (Alarm B) shall be initiated when the refrigerant concentration levels reach or exceed the programmed Alarm B level. Alarm B shall energize an onboard red horn strobe unit attached to the controller or a remote red alarm horn strobe. All relays shall be form C, double pole double throw. Dry contacts shall be rated for 5 amps (resistive load) at 240 Vac.

D. The remote panel shall provide an audible alarm silence button on the front panel to silence the audible alarm but will automatically reset and sound again at the next alarm occurrence.

E. The remote panel shall be wall mount type with the following features:

1. Enclosure Type- The enclosure shall be NEMA 4 type. Access to the inside of the enclosure and wiring connections shall be through a front facing, full length door. The door shall have a window size sufficient to allow viewing of a 2 line by 20 character LCD display.

2. Enclosure Size- the enclosure shall be no more than 12 inches in any dimension.

3. Mounting Provisions – mounting brackets for the purpose of attaching the unit to a flat surface shall not be needed.

4. Front Panel Controls- a four button keypad and fan start stop and alarm silence buttons shall provide access to all monitor functions including display, calibration, set-up and diagnostics.

5. Front Panel Indicator Lights- Yellow (refrigerant vapor equal to or greater than AEL or TLV for specific refrigerant); Red (refrigerant vapor equal to or greater than STEL or 3 times the AEL/TLV for specific refrigerant).

6. Audible Alarm – A 65dBa (at 3 feet) audible alarm shall be internal to the controller; it shall sound when one of the pre-selected alarm conditions occurs.

7. No tools or special adapters shall be used for:

   a. Display of alarm set point level on front panel readout.

   b. Resetting any alarm set point.

   c. Zero and span calibration adjustments.

8. System Power Requirements – the system shall operate on 24Vac 2A max.

F. BACnet: The remote control panel shall enable BACnet communication through its BACnet output using BACnet/IP protocol over twisted-pair Ethernet cable.

2.03 DETECTORS

A. Operating Principal: the principal of operation shall be non-dispersive infrared technology. Detector and associated monitoring system shall be continuously operating and monitoring for the specific refrigerant used in the chiller system or stored.

1. Detector sample: The detector shall be of diffusion type with no internal sample pump or filter.

2. Detector sensitivity: The detector shall be capable of monitoring over a range of 0-1000 ppm with a resolution of 1 ppm.

3. Detector accuracy: The detector shall be capable of maintaining a response of ±8% @ range of 500 ppm.

4. Temperature: The system shall operate over a range of 32ºF to 104 ºF.

5. Environmental conditions: The system shall be compatible with the humidity, barometric pressure and voltage fluctuation of the operating environment.

6. Stability: The 30 day zero and span drift shall be less than 1% F.S. without the aid of automatic or manual recalibration. The system shall not employ any type of auto-zero techniques in order to maintain stability. The use of fresh air sources or scrubbers as zero reference is not permitted.

7. Calibration – The system must provide a menu driven method of checking both zero and span calibrations. Any adjustments must be made through the front panel keyboard.

8. Maximum distance between the sensor and controller shall not exceed 200 ft.

9. Maximum System Maintenance Requirements – The detectors shall require no periodic maintenance other than yearly zero and span checking with calibrated zero and span gas. Periodic checking or adjustments of the unit shall be capable of being accomplished by one person at the unit location.

10. The detectors shall be located where the refrigerant is used and/or stored in accordance with the parameters listed below. The alarms shall be activated in accordance with the following parameters:

Toxic Gases	1st alarm setpoint (TLV-TWA)	2nd alarm setpoint (TLV-STEL)	3rd alarm setpoint	Mounting Height	Coverage
Carbon Monoxide (CO)	25 ppm	200 ppm	225 ppm	5 ft AFF	20 ft
Refrigerants	250 ppm	500 ppm	900 ppm	1 ft AFF	1 per chiller

2.04 ACCESSORIES

A. Strobe & Horn: Strobe and horn may be integral to the controller or remote mounted. The remote mounted unit shall be rated at 85dba at 10 ft The integral horn strobe unit shall be rated at 90dba at 3 ft.

B. Emergency break glass switches: Provide emergency break glass manual switches.

C. Self Contained Breathing Apparatus: Provide two Self Contained Breathing Apparatus (SCBA) with wall- mounted cabinets. Mount cabinets outside of, but close to the chiller room.

2.05 MANUFACTURERS

A. Design Equipment: Honeywell Analytics.

B. Acceptable Makes: Honeywell, Thermo Fisher Scientific, Scott Health & Safety, Sierra Monitor Corporation.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install the gas detection system complete, including but not limited to sensors, audible alarms, panels, power and control wiring, as indicated in the Contract Documents, as recommended by the manufacturer of the equipment in the User's Manual and in compliance with local codes and the authority having jurisdiction.

B. Install low voltage control conduit and wiring from sensors to control panel as per the Contract Documents and as recommended by the manufacturer of the equipment.

1. Low voltage conduit and wiring are specified in Division 26: Electrical.

C. For mechanical room applications, provide a control panel within the mechanical room and a remote control panel outside the mechanical room at each entrance.

D. The system shall be installed with strict adherence to the manufacturer's guide lines.

E. Mount sensors where indicated on Drawings and in accordance with the table below:

Gas-specific sensor	Mounting Height
Refrigerants	1 ft AFF

F. Gas sensors shall be strategically located throughout the facility as shown on the Contract Documents. Each detector shall cover a maximum area as indicated in the table below:

Mechanical Room / Boiler Room Refrigerant Leak Applications

Gas-specific sensor	Coverage
Refrigerants	20 ft / 1250 ft^2

G. Fans and motors are specified in other sections.

3.02 ELECTRICAL WIRING

A. Refer to specification section 230514 – Electric Wiring.

3.03 ELECTRIC / ELECTRONIC CONTROL SYSTEM

A. Contractor shall provide and distribute electrical power from an “Emergency” power panel to all control equipment requiring same, and install a control system consisting of standalone electronic devices meeting the requirements of this section.

1. Provide power and control transformers, fused disconnects, contactors, wiring and control components to achieve the specified function.

2. Coordinate all power requirements with Division 26.

3. Where there is an existing electric/electronic control system connected to a source of emergency power, this Contractor may use and extend the existing system, provided that the resulting total electrical load including all new controls, does not exceed the capacity of the existing system.

3.04 SEQUENCES OF OPERATION (TO BE PROVIDED AS PART OF THE BMS SYSTEM)

A. Refrigerant detection system: Monitor the refrigerant leak sensor. Upon detection of a leak, sound audible alarm located in space, and secondary alarm outside space, send alarm to the operator work station, start the refrigerant leak exhaust fan, shut down all boilers and water heaters.

B. Refrigerant Monitoring System and Associated Equipment:

1. The refrigerant monitor shall provide an alarm relay output which energizes when the monitor detects a refrigerant level at or above the threshold limit value (TLV) or allowable exposure limit (AEL). This relay shall be used to initiate the following events:

a. Energize a yellow light on the monitoring device and a second light on the remote annunciator panel(s) outside the entrance(s) to the chiller room to provide an additional warning. This signal shall be sent to the DDC system where an alarm message will be generated.

b. Energize a yellow light on the monitoring device and a second light on the remote annunciator panel(s) outside the entrance(s) to the chiller room to provide an additional warning. This signal shall be sent to the DDC system where an alarm message will be generated.

2. The refrigerant vapor monitor shall provide a second-level alarm relay output which energizes when the monitor detects a refrigerant level at or above the short term exposure limit (STEL) or 3 times the allowable exposure limit (AEL). This relay shall energize a red light and sound an audible alarm on the monitoring device in the equipment room and at the remote annunciator panel(s). This alarm signal must be audible in all parts of the chiller room above the normal

equipment room sound level, and be consistent with the other building alarms used to signal mandatory evacuation.

3. The refrigerant vapor monitor shall provide a failure relay output, separate from those described above, that energizes when the monitor detects a fault in its operation. Examples of faults include low air flow through the monitor, circuit failure, and a saturated or absent sensor signal. This output shall signal an alarm condition to the DDC system so that the monitor can be checked and returned to operation.

4. The following features shall be provided at the central control for interface with the DDC system:

   a. The refrigerant monitor shall provide an analog output (0-10 vDC) that corresponds to the level of refrigerant detected by the monitor. This signal shall be connected to the DDC system where it will be used to trend the refrigerant level in the chiller room. Any increase in the level shall trigger an informational diagnostic indicating that the refrigeration system should be checked for leaks.

   b. The DDC system shall monitor the alarm status of the refrigerant monitor and provide an alarm condition for each of the following: monitor malfunction, refrigerant alarm triggered at the AEL/TWA for the refrigerant in use, and refrigerant alarm triggered at three times the AEL/TWA for the refrigerant in use.

   c. The DDC system shall be tied to the chiller room ventilation system to provide control of both normal and purge ventilation. This control shall be in parallel to the primary control of the fans by the refrigerant monitor.

3.05 START-UP TESTING

A. The gas detection system shall be inspected and commissioned on site by a factory-trained and authorized technician representing the manufacturer. A factory generated certification document shall be presented certifying the operation of the detection system and the alarm system. A test report shall be submitted to the Engineer.

B. Submit six (6) copies of operations and maintenance manuals. Manuals shall be bound with index, tabs, and include the following:

   1. Equipment submittals.
   2. Operating and maintenance instruction sheets and parts list.
   3. Design Data sheets.
   4. Contact person for more information.

3.06 CLEANUP

A. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.

3.07 PROTECTION

A. Protect the work of this section until substantial completion.

3.08 COMMISSIONING

A. After installation, test and calibrate equipment by manufacturer's certified service technician to demonstrate operation of functions described above under Sequences of Operation.

B. Provide testing kits (including gas bottles) for testing and calibration by Commission forces.

END OF SECTION

SECTION 230993

SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related work as required in the Contract Documents.

B. All parameters and set points provided shall be user adjustable and optimized during system startup and specified seasonal tuning of the system operation.

1.02 SUBMITTALS

A. See section 230923 for submittal requirements.

1.03 REFERENCED SECTIONS

A. Refer to Section 230923 for a glossary of terms and abbreviations list.

B. Refer to Division 23 for specifics on equipment and requirements.

1.04 SEQUENCE OF OPERATIONS

A. Hot Water System:

1. General:

a. The hot water system consists of one steam to hot water converter with steam valves arranged for 1/3 - 2/3 operation and primary and back-up hot water pumps. The system is DDC controlled using electric actuation.

b. The system operates as follows (All suggested set points and settings are adjustable.

2. Occupied Mode:

a. The heating system enable point is controlled either manually by the operator or by a program function (i.e., Time-Of-Day). If the heating system enable point is on and the outdoor air temperature is below 65°F, the lead hot water pump starts. At proof of flow, the converter steam valves operate. If after 2 minutes (adj.) the flow switch has not been proved, lead pump stops, an alarm is generated, and second pump starts. If after 2 minutes (adj.) the flow switch has not been proven, the second pumps stop, and a critical building alarm is generated.

b. The supply hot water set point is maintained by modulating the converter steam valves. The hot water supply set point is reset based on outdoor air temperature. When the outdoor air temperature is 0°F, the set point is 180°F (adj.) and when the outdoor air temperature is 60°F, the set point is 120°F (adj.).

c. The hot water pump de-stages and the converter steam valves close when the outdoor air temperature rises above 68°F (adj.).

3. Pumping Operation:

a. In the event of a failure of the on line (lead) pump, the lag pump shall be enabled and a critical building alarm generated at all operator interfaces.

b. The lead and lag pump shall automatically rotate for run hour equalization

c. The pump speed shall be operated based upon a variable pressure algorithm to maintain loop differential pressure:

1. Whenever a pump is in operation, the heating system pressure control set point shall be reset between pressure P1 and P2. P1 is defined as the pressure necessary to circulate minimum flow with all valves closed to heating (only 3-way valve bypass flow). P2 is defined as the pressure necessary to obtain design flow rate with all valves open.
2. On system shutdown (heating pumps disabled), the startup system pressure shall be set to low set point level of P1.
3. When the system enters heating mode (heating pumps enabled), the control system shall continuously monitor the position of the heating valves serving all connected HVAC equipment.
4. If any valve is open beyond 95% the loop pressure shall be increased at a rate of 0.5 psig/3 minutes (up to a maximum level of P2) until such a time that no valve is open beyond 95%.
5. If all valves close below 85% open, the loop pressure shall be decreased at a rate of 0.5 psig/3 minutes until such a time that at least one valve is open greater than 85%.

4. Alarms:

a. All alarms and alarm levels shall be generated at all operator interfaces.

b. Hot water pump failure.

c. HX water temperature set points, supply and return low/high limits.

d. Pump VFD or operating failure.

e. Low / high loop differential pressure.

B. Chiller/Tower System

1. General:

a. The chilled water system consists of an indoor chiller, and roof mounted open cooling tower, condenser water pump, and chilled water pump.

b. Chiller shall utilize it's on board unit controller for staging of the chiller and chiller pump operation.

2. Condenser Water Control:

a. The condenser water system shall stage to maintain the chilled water loop supply temperature set point at 45°F (adj.).

b. The DDC system shall continuously monitor the outdoor air wet bulb temperature and continuously reset the chilled water loop supply temperature set point in response to this reading.

c. When the outdoor air wet bulb temperature is above 73°F, the condenser water supply temperature set point shall be 85°F. When the outdoor air wet bulb temperature is below 65°F, the condenser water supply temperature set point shall be 75°F.

d. The chilled water loop supply temperature set point shall be a straight line reset between these points. Temperature set points and reset ratios shall be adjustable and optimized during the system commissioning for best system operational efficiency.

3. Tower Operational Set Points:

a. Tower bypass valve open at 80°F; close at 76°F

b. Tower lead loop pump on at 80°F; off at 76°F

c. Tower fan on at 84°F; modulate fan speed to maintain 84°F; off 80°F

d. Open fill valve as needed to maintain water in the sump.

e. DDC shall monitor the temperature of the basin water, and if the temperature of the water falls below 50°F (adj.) the DDC shall initiate the heaters. Once the temperature of the basin has risen above the set point for a period of 5 minutes (adj.) the basins heaters shall disable.

4. Condenser Loop Water Treatment:

a. The tower pump shall be exercised at minimum for a period of 1 hour a day, unless tower basin has been drained. Condenser water system non-chemical water treatment requires minimum circulation to the system to prevent biological growth. In the event that the tower is not in operation during the schedule exercise period, the bypass valve shall be opened. By-pass valve shall remain open for the duration of the exercise period, unless there is a call for cooling. If there is a call for cooling, the tower shall return to normal operation. If tower is in operation during time of exercise, the exercise shall be by-passed.

b. The system shall monitor the conductivity of the cooling tower water non-chemical water treatment system, through the non-chemical water treatment controller.

5. Cooling Tower Sweeper System

   a. The DDC system shall monitor the status of the cooling tower sweeper system and notified the operator if the system fails to operate on call for sweep.

6. Chilled Water Pumping System

   a. General:

      (1) The chilled water pump shall be configured to control off of variable pressure algorithm as described in 1.04.B.6.g.

   b. Occupied Mode:

      (1) When the outdoor air temperature is above the occupied cooling lockout temperature (T1), the cooling mode shall be enabled.
      (2) When the outdoor air temperature falls below T1 – 2.0° the cooling system shall shut down.

   c. Unoccupied Mode:

      (1) When any air handling system enters night setback condition and the outdoor air temperature is above the cooling lockout temperature, the cooling shall be enabled. Once in cooling mode the system shall remain as such for a minimum of 10 minutes before cooling mode is disabled.

   d. Cooling Mode Start-Up:

      (1) When the system enters cooling mode, the cooling pump shall be enabled.

      (2) The plant chilled water valve shall modulate to maintain loop temperature control set point

   e. Cooling Mode Shutdown:

      (1) The plant chilled water valve shall modulate closed.

      (2) The chilled water pump shall operate for a minimum of 5 minutes after the plant CWS control valve is commanded closed and the chilled water supply temperature rises above 50°F

   f. Failure Mode:

      (1) In the event that the pump fails to operate in either occupied or unoccupied mode a critical building alarm shall be provided to the operator’s console.

   g. Loop Pressure Control – Variable Pressure Pumping:

(1) Whenever the system pump is in operation, the building chilled water system control set point shall be reset between pressure P1 and P2. P1 is defined as the pressure necessary to circulate minimum flow with all valves closed to heating (only 3-way valve bypass flow). P2 is defined as the pressure necessary to obtain design flow rate with all valves open.

(2) On system shutdown the startup system pressure shall be set to low set point level of P1.

(3) When the system enters cooling mode, the system shall continuously monitor the position of all connected cooling control valves. If any valve is open beyond 95%, the loop pressure shall be increased at a rate of 0.5 psig/3 minutes (up to maximum level of P2) until such time that no valve is open beyond 95%. If all valves close below 85% open, the loop pressure shall be decreased at a rate of 0.5 psig/3 minutes until such a time that at least one valve is open greater than 85%

h. Cooling Water Temperature Reset:

(1) The CWS temperature set point shall be continuously reset against outdoor air temperature. When the outdoor air temperature is below 60°F, the set point shall be 50°F. When the outdoor air temperature is 80°F, the loop set point shall be 44°F.

C. Variable Volume Air Handling Unit (AHU-1, 2, 4, and 5)

1. General:

a. Variable volume system with supply fan and return/relief fan, chilled water cooling coil, steam preheat coil with face and bypass damper, and economizer.

b. All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.

2. Start-up:

a. When initiated by the DDC system, the supply and return fan's variable speed drives shall be enabled. After proof of operation, the fans shall ramp to set point and the PID loops for the cooling coil, heating coil, and economizer shall be enabled.

3. Shutdown:

a. When initiated by the DDC system or triggered by a safety device, the air handler shall shut down. Both fans shall be disabled. After a programmable time delay (initially 30 seconds) the economizer dampers shall position to 100% return air and the relief air dampers shall close.

b. If the outdoor air is above 40°F, the cooling coil control valve shall close. Otherwise, the chilled water valve shall be positioned to a fixed position of 50% (adj.) to coil. An alarm shall be generated the cooling coil leaving water temperature falls below 40°F, and the cooling coil valve shall be opened 100%.

c. If the outdoor air temperature is above 40°F, the preheat coil valve shall close. If the outdoor air temperature falls below 40°F, the preheat coil valve shall modulate to maintain the temperature at the mixed air sensor above 60°F.

4. Cooling Coil Operation:

a. Mechanical cooling (chilled water) shall be locked out at any time the plant chilled water valve is locked out.

b. Subject to startup and shutdown sequences and outdoor air lockout temperature, the cooling coil shall modulate to maintain coil leaving air temperature at set point based on a reset schedule of 60°F at 10°F outdoor air, 53°F at 80°F outdoor air.

c. When the CWR temperature is below 40°F, the cooling valve shall open.

d. If the CWR temperature drops below 34°F, the unit shall be shut down and a critical alarm shall be generated.

5. Economizer Operation:

a. The economizer (OA and RA dampers) shall modulate in sequence with the cooling valve to maintain cooling coil supply air temperature, subject to comparative enthalpy (OA vs. RA conditions), an outdoor air lockout temperature of 65°F, and a mixed air low limit of 50°F.

b. Whenever the economizer is locked out due to outdoor air conditions, the economizer shall modulate for calculated minimum ventilation air flow.

c. Whenever the economizer is operating, at no time shall the outside air flow rate be allowed to drop below the calculated minimum ventilation rate.

d. As any space or return air CO_2 sensor reading increases from 800PPM to 1000PPM, the air handler calculated minimum outdoor air intake volume shall be increased from the DCV minimum to the scheduled minimum outdoor air quantity per the HVAC schedules.

6. Heating Coil Operation:

a. The preheat coil valve shall remain fully closed whenever the outdoor air temperature is above 50°F.

b. Whenever the unit is operating and the temperature is below 50°F, the preheat coil shall modulate in sequence with the economizer to maintain leaving air temperature set point without overlap.

c. When the outdoor air temperature is below 35°F (adj.) the control valve shall modulate fully open, and the face and bypass damper shall modulate the airflow over the coil to maintain the temperature downstream of the coil at the coil discharge air temperature.

7. Relief/Exhaust Damper Operation:

a. The relief/exhaust damper shall modulate to maintain pressure set point in the return air compartment ahead of the relief/exhaust damper. The set point shall operate on a reset schedule, initially 0.05" w.c. (adj.) at unit minimum outdoor air flow and 0.1" w.c. (adj.) at unit maximum outdoor air flow, to be optimized during air balance to achieve required relief air rates.

8. Supply Fan Speed Modulation:

a. The supply fan shall modulate to maintain duct supply air pressure set point at the remotely located supply air duct pressure sensor.

b. The DDC system shall poll all connected VAV terminals once every 5 minutes (adj.) for their current damper calculated damper positions.

c. If any damper is more than 95% open, the duct static pressure set point shall be automatically incremented up by 0.1" w.c. (adj.) each polling interval (up to a maximum determined during air balance to be adequate to serve all terminals at 100% flow).

d. If all dampers are less than 85% open, the duct static pressure set point shall be automatically incremented down 0.1" w.c. (adj.) each polling interval (down to a minimum determined during air balance to be adequate to serve all terminals at minimum flow).

9. Return Fan Speed Modulation:

a. The return fan air flow shall track the supply fan air flow at a calculated differential through modulation of the variable speed drives. The baseline tracking differential shall be determined during air balancing to achieve required pressurization relative to adjacent areas with the kitchen exhaust fans and makeup air systems off. The operating tracking differential shall be calculated based upon this value PLUS the tracking differential described under part 12 of this sequence.

10. Safeties:

a. The air handling unit shall be equipped with static pressure safeties and smoke detectors in the return ductwork, and a freezestat downstream of the cooling coil.

b. All safety devices shall be hard wired in series through the "drive inhibit" (or safety interlock if available) VFD inputs of both supply and return fans to shut them down immediately on safety trip.

c. An auxiliary contact on all devices shall be monitored individually to provide specific alarm information at the operator's console.

d. On trip of any safety device, all PID controlled items (cooling coil) shall automatically enter shutdown mode, and the VFD PID loops for the fans shall modulate down to minimum speed. On manual (field) reset of the safety device(s), the fan PID loop shall ramp up, followed by the loops controlling the balance of the air handling system in the order described in the startup sequence.

e. Programming shall preclude the "wind up" of PID loops during shutdown conditions.

D. Single Zone Variable Volume Air Handling Unit (AHU-3):

1. General:

a. Single zone, variable volume system with supply fan and return/relief fan, chilled water cooling coil, steam preheat coil with face and bypass damper, and economizer.

b. All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.

2. Start-up:

a. When initiated by the DDC system, the supply and return fan's variable speed drives shall be enabled. After proof of operation, the fans shall ramp to set point and the PID loops for the cooling coil, heating coil, and economizer shall be enabled.

3. Shutdown:

a. When initiated by the DDC system or triggered by a safety device, the air handler shall shut down. Both fans shall be disabled. After a programmable time delay (initially 30 seconds) the economizer dampers shall position to 100% return air and the relief air dampers shall close.

b. If the outdoor air is above 40°F, the cooling coil control valve shall close. Otherwise, the chilled water valve shall be positioned to a fixed position of 50% (adj.) to coil. An alarm shall be generated the cooling coil leaving water temperature falls below 40°F, and the cooling coil valve shall be opened 100%.

4. Cooling Coil Operation:

a. Mechanical cooling (chilled water) shall be locked out at any time the plant chilled water valve is locked out.

b. Subject to startup and shutdown sequences and outdoor air lockout temperature, the cooling coil shall modulate to maintain coil leaving air temperature at set point based on a reset schedule of 60°F at 10°F outdoor air, 53°F at 80°F outdoor air.

c. When the CWR temperature is below 40°F, the cooling valve shall open.

d. If the CWR temperature drops below 34°F, the unit shall be shut down and a critical alarm shall be generated.

5. Economizer Operation:

a. The economizer (OA and RA dampers) shall modulate in sequence with the cooling valve to maintain cooling coil supply air temperature, subject to comparative enthalpy (OA vs. RA conditions), an outdoor air lockout temperature of 65°F, and a mixed air low limit of 50°F.

b. Whenever the economizer is locked out due to outdoor air conditions, the economizer shall modulate for calculated minimum ventilation air flow.

c. Whenever the economizer is operating, at no time shall the outside air flow rate be allowed to drop below the calculated minimum ventilation rate.

d. As any space or return air CO_2 sensor reading increases from 800PPM to 1000PPM, the air handler calculated minimum outdoor air intake volume shall be increased from the DCV minimum to the scheduled minimum outdoor air quantity per the HVAC schedules.

6. Heating Coil Operation:

a. The preheat coil valve shall remain fully closed whenever the outdoor air temperature is above 50°F.

b. Whenever the unit is operating and the temperature is below 50°F, the preheat coil shall modulate in sequence with the economizer to maintain leaving air temperature set point without overlap.

c. When the outdoor air temperature is below 35°F (adj.) the control valve shall modulate fully open, and the face and bypass damper shall modulate the airflow over the coil to maintain the temperature downstream of the coil at the coil discharge air temperature.

7. Relief/Exhaust Damper Operation:

a. The relief/exhaust damper shall modulate to maintain pressure set point in the return air compartment ahead of the relief/exhaust damper. The set point shall operate on a reset schedule, initially 0.05” w.c. (adj.) at unit minimum outdoor air flow and 0.1” w.c. (adj.) at unit maximum outdoor air flow, to be optimized during air balance to achieve required relief air rates.

8. Supply Fan Speed Modulation:

a. The supply fan shall modulate to maintain space temperature subject to requirements of part b.

b. The DDC system shall monitor the speeds of KEF-1, KEF-2, and KEF-3 and shall set the minimum airflow of the unit to 20% of the total air exhausted by the 3 fans.

9. Return Fan Speed Modulation:

a. The return fan air flow shall be set at the supply air flow minus the 20% of the air flow of KEF-1, KEF-2, and KEF-3.

10. Safeties:

a. The air handling unit shall be equipped with smoke detectors in the return ductwork, and a freezestat downstream of the cooling coil.

b. All safety devices shall be hard wired in series through the “drive inhibit” (or safety interlock if available) VFD inputs of both supply and return fans to shut them down immediately on safety trip.

c. An auxiliary contact on all devices shall be monitored individually to provide specific alarm information at the operator’s console.

d. On trip of any safety device, all PID controlled items (cooling coil) shall automatically enter shutdown mode, and the VFD PID loops for the fans shall modulate down to minimum speed. On manual (field) reset of the safety device(s), the fan PID loop shall ramp up, followed by the loops controlling the balance of the air handling system in the order described in the startup sequence.

11. Programming shall preclude the “wind up” of PID loops during shutdown conditions.

E. VAV Terminal Control

1. Pressure independent application specific controller with integral differential pressure sensor for connection to manufacturer provided air flow probe. Convert differential pressure to CFM. Calibrate during air balance procedures.

2. Cooling operation - Controller shall modulate air flow from minimum to maximum per the equipment schedule to maintain cooling space temperature set point. Where separately indicated, use the cooling minimum and maximum air flow values.

3. Heating operation – Modulate the reheat valve at the heating set point to maintain heating space temperature set point. Where separately indicated, modulate air flow in sequence from the heating minimum to heating maximum cfm in sequence with the valve. Leaving air temperature to be limited to a value of 20°F above occupied heating space temperature set point.

4. Provide a 24v electric damper actuator. The actuator shall have a visual position indicator and be field reversible for the type of terminal application. The stroke time shall be 75-150 seconds with adequate torque for smooth operation. The actuator shall be NEMA type 2 with a flammability rating conforming to UL 94.

The actuator shall be maintenance free and have a minimum life span of 60,000 cycles. Actuator shall be Bellimo NM24-1US, or equal.

5. Provide power transformers for controller and actuator suitable for 120v, 1ph input power. Multiple boxes (approximately 6-8) may be powered off of one terminal unit transformer through a low voltage power loop. Coordinate final requirements for power wiring with Division 26.

6. Provide wall mounted space sensors where indicated.

7. Provide CO2 sensors where indicated directly connected to the associated VAV box controller.

8. Zones configured with a CO_2 sensor shall provide the following local demand controlled ventilation sequence. The space CO_2 set point is 700 ppm. As the CO_2 rises from 700 to 800 ppm, the VAV terminal heating / cooling minimum air flow set point shall be reset from the scheduled DCV minimum air flow to the scheduled cooling maximum air flow.

9. VAV2-5 and VAV2-8 shall provide make-up air when the kitchen hoods are in use.

   a. The DDC system shall poll KEF-4 and KEF-5, if the fans are in operation, the minimum airflow of VAV2-5 shall be set at the airflow of KEF-5 plus 20% of the airflow of KEF4.

   b. The DDC system shall poll KEF-6 and KEF-7, if the fans are in operation, the minimum airflow of VAV2-8 shall be set at 20% of the airflow of KEF-6 and KEF-7.

F. Kitchen Hood Exhaust Systems:

1. General:

   a. Kitchen hood exhaust systems consist of an exhaust fan, a make-up air unit and a, or a group of, exhaust hoods. Make-up air units may serve hoods in a different arrangement than the exhaust fans.

   b. Kitchen hood exhaust systems shall be controlled by the M.A.R.V.E.L. kitchen control system, with integration into the building management system. The following shall apply to each kitchen hood exhaust system:

      (1) During the user defined occupied period, if the kitchen hood exhaust system is locally initiated, the make-up air unit and kitchen exhaust fan shall initiate.
      (2) At the user defined setback time, if any kitchen hood exhaust system is operating, the associated kitchen exhaust fan and make-up air unit shall de-energize, and the outside air damper on the make-up air unit shall close.
      (3) There shall be a manual override at the exhaust hood, which will operate the system outside of the occupied period, for 45 minutes (adj.)

2. Kitchen Exhaust Fans:

   a. Exhaust fans shall be controlled by the M.A.R.V.E.L. kitchen control system. Refer to drawing M305, M306, and M307 for further information.

3. Make-up Air Units

   a. Start-up:

      (1) When initiated by the M.A.R.V.E.L. kitchen control system, the enable command shall open the outside air damper. The end switch shall complete the VFD enable circuit, and the supply fan shall start.

   b. Occupied Mode:

      (1) When the day and time fall within the specified occupied schedule, the system will enter occupied mode.

   c. Occupied Heating Mode:

      (1) The heating coil valve shall remain fully closed whenever the outdoor air temperature is above 65°F.

      (2) Whenever the unit is operating and the temperature is below 50°F, the preheat coil shall modulate to maintain leaving air temperature set point.

      (3) When the outdoor air temperature is below 35°F (adj.) the control valve shall modulate fully open, and the face and bypass damper shall modulate the airflow over the coil to maintain the temperature downstream of the coil at the coil discharge air temperature.

   d. Unoccupied Mode:

      (1) The unit shall be off, subject to space override.

   e. Supply Fan Speed Control:

      (1) The DDC system shall monitor the 'Total Hood CFM' via BACnet from the associated M.A.R.V.E.L. kitchen control system.
      (2) The VFD shall modulate to deliver 'Total Hood CFM'.
      (3) The DDC system shall poll the M.A.R.V.E.L. system for the value of 'Total Hood CFM' every 10 seconds (adj.).

   f. Safeties:

      (1) The air handling unit shall be equipped with a freezestat downstream of the coil. Safety devices shall be hard wired in series through the "drive inhibit" (or safety interlock if available)

VFD inputs of supply fan to shut it down immediately on safety trip.

G. Exhaust Fans:

1. General:

a. Each fan shall be able to be individually scheduled and have independent start/stop control.

b. The fan is wired normally open, and fails off.

c. The exhaust air damper is normally closed. Fan shall energize when damper end switch is proven. Enable command opens the damper. The fan shall start by interlock of the damper end switch to the starter circuit.

2. Common Mode Control:

a. When the fan is off, the exhaust air damper shall fail to normally closed position.

3. Operation:

a. EF-1: The fan shall run continuously and its associated damper shall open.

b. EF-2: Shall operate when initiated by the refrigerant monitoring system.

c. EF-3, EF-6, EF-7, EF-8: Fan shall initiate when the local space temperature set point is exceeded (initially set at 82°F, adjustable). Fan shall run until space temperature set point is satisfied for a period of 2 minutes (adj.), Fan shall have a built in delay of 3 minutes between de-energizing and energizing.

d. EF-4 for be locally initiated when the lighting circuit is completed. Fan shall not be monitored by the BMS.

e. DEF-1 and DEF-2 shall be imitated locally by the user.

4. Unoccupied Mode:

a. EF-1 shall be off.

b. All other fans do not have an unoccupied setting.

H. Fin Tube Radiation/Radiant Ceiling Panel/Panel Radiation:

1. General:

a. Fin tube associated directly with an area VAV box shall be interlocked to and controlled by that VAV box controller. Replication of space temperature sensors is not required. The fin tube and reheat coil shall operate in sequence to maintain space conditions, with the fin tube as

first stage. PI algorithm shall be employed for this sequencing. Temperature staging offset is not acceptable.

b. The fin tube radiation is controlled by an application specific DDC controller using electronic actuation. The space served by the radiation/convector is controlled in Occupied and Unoccupied modes as follows:

2. Occupied:

a. The controller monitors the room temperature sensor and modulates the heating valve to maintain the space temperature at set point.

3. Unoccupied:

a. The radiation/convector is controlled using the unoccupied space temperature set point. The controller may reset to the Occupied mode for a predetermined time period upon a signal from the control system or manually at the room sensor

I. Chilled Beams:

1. General:

a. Chilled beams located in first floor West corridor and second floor West corridor. Chilled beams on each floor include a dedicated constant volume VAV box, and a 2 position control valve.

b. The chilled beams are provided with a dedicated chilled water loop with a pump and a 3-way mixing valve.

2. Pumping System:

a. The DDC system shall monitor the position of the chilled beam control valves. If any of the valves are open, the pump shall operate. If the valves are all closed, the pump shall de-energize.

b. When the pump is in operation, the 3-way mixing valve shall modulate to maintain a Chilled Beam Loop Supply Temperature of 56°F (adj.)

3. Occupied (Cooling):

a. The DDC system shall monitor the temperature of the secondary air entering the chilled beam. If the secondary air temperature exceeds the set point of 76°F (adj.) for a period of 3 minutes the control valve shall open.

a. When the secondary air temperature falls below the set point for a period of 3 minutes, the control valve shall close.

4. Occupied (Heating):

a. Control valve shall modulate to maintain space temperature set point

5. Unoccupied:

   a. Unit shall maintain a set back temperature of 60°F (adj.).

   b. Unoccupied cooling is not available.

6. Safeties:

   a. The DDC System shall monitor the position of the control valve on the radiant ceiling panel in the associated corridor. If the control valve for the radiant ceiling panel is open, the DDC shall not allow the cooling valve on the chilled beam to open.

7. Alarms:

   a. If the drain pan sensor is activated, the cooling control valve shall close and an alarm shall be generated at the operator's workstation indicating a clogged drain.

J. Unit Heater/Cabinet Unit Heater:

1. General:

   a. The Unit Heater (UH/CUH) is controlled by an application specific DDC controller using electric actuation. The space served by the UH is controlled in Occupied and Unoccupied modes as follows:

2. Occupied:

   a. The UH fan operates on call for heat. The controller monitors the room temperature sensor and modulates the heating valve to maintain the space temperature at set point.

3. Unoccupied:

   a. The UH is controlled using the Unoccupied space temperature set point. The UH fan is off when the space is satisfied. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system or manually at the room sensor.

K. Walk-in Freezer/Cooler:

1. The DDC system shall monitor the temperature in the walk-in freezer/cooler.

2. If the temperature in a cooler rises above a user defined level initially set at 45°F (adj.), a building alarm shall be generated.

3. If the temperature in a freezer rises above a user defined level initially set at 30°F (adj.), a building alarm shall be generated.

L. Lighting Control:

1. Lighting in the corridors shall be controlled by the DDC system:

   a. At the start of a user defined occupied period, the DDC shall be responsible for turning on the corridor lighting. At the end of the user defined occupied period, the DDC shall be responsible for turning off the lighting in the corridors.

   b. If at any outside of the user defined occupied range, the local override is initiated, the corridor lighting shall operate for a timed period of 30 minutes (adj.).

2. The site lighting shall be controlled by the DDC system:

   a. At the start of a user defined enable period, the DDC shall be responsible for turning on the site lighting. At the end of the user defined enable period, the DDC shall be responsible for turning off the site lighting.

   b. A photocell located on the roof of the building shall override the user defined enable period, should site lighting be required outside of the user defined enable period.

PART 2 – PRODUCTS

2.01 Not Used

PART 3 – EXECUTION

3.01 Not Used

END OF SECTION

SECTION 23 1123

FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

1.3 SUBMITTALS

A. Product Data: For each type of the following:

1. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
2. Dielectric fittings.

B. Welding certificates.

C. Field quality-control reports.

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. All work under this section shall be performed by a contractor who is prequalified and preapproved for such work by the natural gas utility company.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.6 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Architect and Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Architect's written permission.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.

    b. Stainless-steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Stainless-steel bolts, washers, and nuts.
    e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Transition Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    b. Outlet shall be threaded or flanged or suitable for welded connection.
    c. Bridging sleeve over mechanical coupling.
    d. Factory-connected anode.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
4. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Dresser Piping Specialties; Division of Dresser, Inc.
2) Smith-Blair, Inc.

b. Stainless-steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Stainless-steel bolts, washers, and nuts.
e. Factory-installed anode for steel-body couplings installed underground.

2.2 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.3 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig (862 kPa).
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Lee Brass Company.
    b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).
7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Flowserve.
    b. Homestead Valve; a division of Olson Technologies, Inc.
    c. McDonald, A. Y. Mfg. Co.
    d. Milliken Valve Company.
    e. Mueller Co.; Gas Products Div.

f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.4 DIELECTRIC UNIONS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Capitol Manufacturing Company.
2. Central Plastics Company.
3. Hart Industries International, Inc.
4. McDonald, A. Y. Mfg. Co.
5. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
6. Wilkins; Zurn Plumbing Products Group.

B. Minimum Operating-Pressure Rating: 150 psig.

C. Combination fitting of copper alloy and ferrous materials.

D. Insulating materials suitable for natural gas.

E. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

F. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.

c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

G. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.
b. Calpico Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.5 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earthmoving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

3.4 VALVE INSTALLATION

A. Install underground valves with valve boxes.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

C. Install anode for metallic valves in underground PE piping.

3.5 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.

5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.6 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

3.7 LABELING AND IDENTIFYING

A. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.8 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
c. Topcoat: Exterior alkyd enamel (flat).
d. Color: Gray.

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:

1. PE pipe and fittings joined by heat fusion; service-line risers with tracer wire terminated in an accessible location.
2. Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.11 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

A. Underground:

1. NPS 2 (DN 50) and Smaller: Bronze plug valves.
2. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated plug valves.

END OF SECTION 23 11 23

SECTION 232000

PIPING SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

B. Provide all chemical treatment required for piping systems each time an individual system is drained and then refilled as a result of work performed under this contract.

1.02 SUBMITTALS

A. Submit a schedule of pipe materials, fittings and connections by piping system.

B. Submit grooved mechanical connection system.

C. Submit refrigerant piping diagram.

D. Submit anchors, sleeves, hanger shields, and guides.

1.03 QUALITY ASSURANCE

A. Manufacturer: Provide domestically manufactured pipe, fittings and accessories.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver products in factory-fabricated containers. Deliver pipe and tube with factory-applied plastic end-caps on each length.

B. Store products in original wrapping and protect from dirt and damage. Store piping and tube inside. Where necessary to store outside, evaluate well above grade and enclose with waterproof wrapping.

C. Handle products carefully to avoid damage. Do not install damaged products.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe and fittings new and marked with manufacturer's name; complying with applicable ASTM and ANSI Standards.

2.02 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53, Schedule 40, or extra strong (Schedule 80) weight; black or galvanized finish as called for in Exhibit ‘A’ or as noted on drawings; ends chamfered for welding or roll grooved for grooved mechanical connections.

B. Fittings: Same material and pressure class as adjoining pipe.

1. Welded fittings: Factory forged, seamless construction, butt weld type, chamfered ends. Where branch connections are two or more sizes smaller than main size, use of "Weldolets," "Threadolets" or "Sockolets" is acceptable. Mitered elbows, "shaped" nipples, and job fabricated reductions are not acceptable unless specifically called for. Socket weld type, 2000 psi wp, where called for in Exhibit 'A'.

2. Screwed fittings: Cast or malleable iron, black or galvanized, as called for in Exhibit 'A'.

C. Flanges, Unions And Couplings:

1. Screwed connections:

a. Unions: ASA malleable cast iron, bronze to iron seat, 300 lb. wwp; for sizes 2 in. and smaller.

b. Flanges: Cast iron companion type; for sizes 2-1/2 in. and larger.

2. Welded connections:

a. Flanges: Welding neck type. Slip-on type shall not be provided except where called for and shall not be provided in conjunction with butterfly valves.

3. Grooved mechanical connections:

a. Couplings of malleable iron (ASTM A470) or ductile iron (ASTM A536) with painted coating designed for rolled grooved piping.

b. Gaskets suitable for water service -30^{o}F to 230^{o}F of EPDM, Grade E.

c. Bolts and nuts: Heat treated, hex head carbon steel (ASTM A183) cadmium plated or zinc electroplated.

d. Fittings: Elbows, tees, laterals, reducers, adapters as required. Same construction as couplings. The use of mechanical tees is permitted only when a branch size is two or more sizes smaller than the main size. Reducing couplings and segment-welded elbows are not acceptable.

e. Design equipment: Victaulic Rigid System, Style 07 couplings.

f. Make: Grinnell, Victaulic, Gruvlok.

D. Cleanouts, gauge and instrument connections, nipples and plugs, for adapting gauges and instruments to piping system shall be IPS brass.

E. Base Elbows:

1. Cast iron or steel type, flange connections; Crane 500 or equivalent. Made from welding elbows, with welded pipe support and steel base. Reducing elbows where necessary.

Elbow Size	Support Size	Base Plate
to 3 in.	1-1/4 in.	6 in. x 6 in. x 1/4 in.
4 in. and up	2-1/2 in.	8 in. x 8 in. x 1/4 in.

2. Anchor bolt holes in each corner of base for securely bolting to floor or concrete base; minimum 3/4 in. bolts.

2.03 COPPER PIPE AND SOLDER FITTINGS

A. Pipe: Hard temper, ASTM B88; Type K, L, M, or DWV, as called for in Exhibit 'A' or as noted on the Drawings. Soft temper only as called for in Exhibit 'A' or as noted on the Drawings. Plans show copper tube sizes.

B. Tees, Elbows, Reducers: Wrought copper or cast bronze as called for in Exhibit 'A' or as noted on the Drawings; solder end connections; ASTM B62, ANSI B16.22.

C. Unions and Flanges: 2 in. and smaller use unions, solder type, cast bronze, ground joint, 150 lb. swp; 2-1/2 in. and over use flanges, cast bronze, companion type, ASME drilled, solder connection, 150 lb. swp.

D. Solder Materials: No-lead solder, using alloys made from tin, copper, silver and nickel.

E. Make: Harris "Stay-Safe 50" and "Bright", Englehart "Silverbright 100", Willard Industries "Solder Safe (silver bearing), Canfield "Watersafe".

2.04 THERMOPLASTIC (PVC) PIPE AND FITTINGS

A. Interior Thermoplastic Sewer (PVC):

1. Pipe: ASTM D1784 material manufactured to ASTM D1785 standards. Seamless Schedule 40 polyvinyl chloride (PVC) Type 1, Grade 1. Socket type weld couplings ASTM D2466, DR with integral bell end for solvent cementing ASTM D2672. Solvent cement - ASTM D2564.

2. Fittings: Socket type cement weld fittings of same material and pressure class as adjoining pipe. ASTM D2466.

2.05 DIELECTRIC PIPE FITTINGS

A. Tensile strength, ASME B16.8 union 250 psi, or flange design, 175 psi, pressure rating, threaded or solder joint, constructed to prevent gasket from squeezing into internal opening.

B. Make: Capitol Manufacturing, Epco, Watts, Victaulic.

2.06 HANGERS, INSERTS AND SUPPORTS

A. Hangers, Inserts, Clamps: Carpenter and Patterson, Central Iron, Fee and Mason, ITT Grinnell.

B. Hangers:

1. Adjustable, wrought malleable iron or steel. Copper plated or PVC coated where in contact with copper piping. Cadmium plated or galvanized for exterior.

2. Adjustable ring type where piping is installed directly on hanger for piping 3 in. and smaller.

3. Adjustable steel clevis type for piping 4 in. and larger, and where insulation passes through hanger.

4. Steam (over 50 psi) piping, adjustable yoke pipe roller equivalent to Grinnell Figure #181.

5. Hangers sized to permit passage of insulation through the hanger for chilled water, refrigerant and steam (over 50 psi) piping.

6. Nuts and rods with electroplated zinc or cadmium (0.005 in. minimum) finish.

C. Hanger Shields:

1. Pre-insulated type:

a. Insulated pipes shall be protected at point of support by a 360^{o} insert of high density, 100 psi waterproofed calcium silicate, encased in a 360^{o} sheet metal shield. Insulation insert to be same thickness as adjoining pipe insulation and extend 1 in. beyond sheet metal shield.

2. Field-insulated type:

a. #18 USSG, galvanized steel shields, minimum 120^{o} arc. Provide temporary blocking between pipe and hanger to maintain proper spacing for insulation. Provide at all support points.

3. Shield Sizing:

Pipe Size	Shield Length	Minimum Gauge
Up to 3-1/2"	12 in.	18
4”	12 in.	16
Over 4”	12 in.	14

a. Hanger shield gauges listed are for use with band type hangers only. For point loading (roller support), increase shield thickness by one gauge, and length by 50%.

D. Spacing Schedule:

Pipe Size	Steel	Copper	PVC Plastic	Rod Size
½ to 1 in.	8 ft.	6 ft.	3 ft.	3/8 in.
1 ¼ to 2 in.	10 ft.	6 ft.	3 ft.	3/8 in.
2 ½ to 4 in.	12 ft.	10 ft.	4 ft.	1/2 in.
Over 4 in.	12 ft.	10 ft.	4 ft.	5/8 in.

E. Inserts: ITT Grinnell Fig. #281, maximum loading 1000 lbs., galvanized finish, and Fig. #285, maximum loading 400 lbs. Make: Globestrut, Grinnell, Unistrut.

F. Supports:

1. For weights under 1000 lbs.: "Drill-In" inserts equivalent to Phillips "Red Head," "U-Channel," "Unistrut," beam clamps or other structurally reviewed support. The factor of safety shall be at least four. Follow manufacturer's recommendations.

2. For weights above 1000 lbs.: Drill through floor slabs and provide flat flush plate welded to top of rod or provide additional "Drill-In" inserts and hangers to reduce load per hanger below 1000 lbs. The factor of safety shall be at least four.

3. For metal decks: Drill hole through for hanger rods and imbed a welded plate in concrete or use Phillips "Red Head" devices designed for this application, with a safety factor of four.

2.07 PIPING ACCESSORIES

A. Escutcheon Plates: Steel or cast iron polished chrome, split hinge type with setscrew, high plates where required for extended sleeves.

B. Pipe Guides: Cylindrical steel guide sleeve, proper length for travel, integral bottom base anchor; top half removable. Split steel spider to bolt to pipe, copper plated spider for copper pipe. Space between sleeve and spider to allow for insulation where required. Make: Anaconda, Flexonics, Pipe Shields, Keflex, or equal.

C. Anchors: Same material as pipe. Make: Keflex, Flexonics, Pipe Shields, or field constructed.

D. Flexible Expansion Loops: Same materials as pipe. Loop travel shall be +/-3" for all pipe sizes. Loops shall impart no thrust loads on anchors. Loops shall consist of two flexible sections of hose and braid, two 90^{o} elbows, and a 180^{o} return bend. Provide "nested" construction of loops when installed in multiples. Provide a pipe guide within four pipe diameters on each side of the loop. Support loops per manufacturer's recommendations. Loops shall be at 0" deflection at time of installation. Hose braid shall be stainless steel for steel loops, and bronze braid for sweat end copper loops. Make: Metraflex Metraloop.

2.08 SLEEVES

A. Standard Type:

1. Schedule 40 black steel pipe sleeves, two pipe sizes larger than the pipe, for structural surfaces (bearing walls, structural slabs, beams and other structural

surfaces) and where called for.

2. Schedule 40, PVC sleeves or sheet metal sleeves for nonstructural surfaces and existing construction. Sheet metal sleeves shall be 18 gauge minimum and braced to prevent collapsing.

B. Pre-Insulated Type:

1. Adjustable or fixed length metal cans, 24 gauge minimum, sized for 1 in. spacing between insulation and can. Insulation shall consist of a 360^{o} waterproofed calcium silicate insert sized to extend 1 in. beyond wall or floor penetration. Calcium silicate insert shall be same thickness as adjoining pipe insulation. Spacing between shield and can packed at each end with double neoprene coated rope positively fastened.

2.09 SEALING ELEMENTS

A. Waterproof Type:

1. Exterior walls, below grade, above floor: Synthetic rubber material with zinc plated bolts. Make: "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

2.10 FIRESTOP SYSTEM FOR OPENINGS THROUGH FIRE RATED WALL FLOOR ASSEMBLIES

A. Materials for firestopping seals shall be listed by an approved independent testing laboratory for "Through-Penetration Firestop Systems". The system shall meet the standard fire test for Through-Penetration Firestop Systems designated ASTM E814. Firestop system seals shall be provided at locations where piping passes through fire rated wall, floor/ceiling, or ceiling/roof assembly. Minimum required fire resistant ratings of the assembly shall be maintained by the Firestop System. Installation shall conform to the manufacturer's recommendations and other requirements necessary to meet the testing laboratory's listing for the specific installation.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install pipe, tube and fittings in accordance with recognized industry practices which will achieve permanently leak proof piping systems, capable of performing each indicated service without piping failure. Install each run with a minimum of joints and couplings, but with adequate accessible unions and flanges for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, with 1/16" misalignment tolerance.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as indicated or described by diagrams, details and notations or, if not otherwise indicated, run piping in the shortest route which does not obstruct usable space or block access for servicing the building and equipment. Hold piping close to walls, overhead construction, columns and other structural and permanent enclosure elements of the building. Limit clearance to 1.0" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Wherever possible, in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as indicated.

C. Space pipe supports, arrange reducers, and pitch piping to allow air to be vented to system high points and to allow the system to be drained at the low points, and wherever required to permit complete draining of all lines.

D. Make all changes in size and direction of piping with fittings, except for soft copper tubing, use tubing bender.

E. Install piping to valves, strainers, pumps and other equipment at full line size. Where reduction or increase in size is required, make it with a fitting at the equipment connection.

F. Air Vents: Provide manual air vents at high points in piping system and where indicated on the drawings.

G. Drain Valves: Provide manual drain valves at low points in piping system and where indicated on the drawings.

3.02 EQUIPMENT AND SYSTEMS

A. Equipment and systems in accordance with laws, codes, and provisions of each applicable section of these specifications. Accurately establish grade and elevation of piping before setting sleeves. Install piping without springing or forcing (except where specifically called for), making proper allowance for expansion and anchoring. Arrange piping at equipment with necessary offsets, unions, flanges, valves, to allow for easy part removal and maintenance. Offset piping and change elevation as required for coordination with other work. Avoid contact with other mechanical or electrical systems. Provide adequate means of draining and venting units, risers, circuits and systems. Conceal piping unless otherwise called for. Ream pipes after cutting and clean before installing. Cap or plug equipment and pipe openings during construction. Install piping

parallel with lines of building, properly spaced to provide clearance for insulation. Make changes in direction and branch connections with fittings. Do not install valves, unions and flanges in inaccessible locations. Provide trap seal of adequate depth on drain pans.

3.03 WATER SYSTEMS

A. Top connection for upfeed, bottom or side connection for downfeed. Grade off-level; up in direction of flow and down toward drain.

3.04 STEAM AND CONDENSATE PIPING

A. Install with bottom of pipes in line. Connections from top of mains or headers unless otherwise called for. Drip ends of mains and at low points where condensate may collect. Make counterflow piping one pipe size larger than vertical pipe. Provide 2 in. x 6 in. (minimum) deep capped scale pocket at ends of steam mains, drip points, and return ends of steam coils.

B. Grade:

1. Steam mains, branches and connections to equipment: down 1 in. in 20 ft.

2. Coil connections necessarily grading opposite to steam flow: up 1/4 in. per ft.

3. Condensate mains, branches, and runouts, and drip lines: down 1 in. in 10 ft.

4. Wet returns: down to low point, use tees instead of ells.

5. Pumped condensate piping: just off level down to drain points.

3.05 HANGERS, INSERTS AND SUPPORTS

A. Piping shall not be supported by wires, band iron, chains, vertical expansion bolts or from other piping. Support each pipe with individual hangers from concrete inserts, welded supports, or beam clamps of proper configuration and loading design requirements for each location. Trapeze hangers are acceptable for racking of multiple pipes of 1-1/2" or less in size. Follow manufacturer's safe loading recommendations. Suspend with rods of sufficient length for swing and of size as called for, using four nuts per rod. Provide additional rust proofed structural steel members, where required for proper support. Provide oversized hangers where insulation/supports must pass between pipe and hanger. Hangers, when attached to joists, shall only be placed at the top or bottom chord panel point. Only concentric type hangers are permissible on joists; "C" type not permitted on joists. Provide riser clamps for each riser at each floor.

3.06 PIPE CONNECTIONS

A. Solder Connections: Utilize non-acid flux and clean off excess flux and solder.

B. Threaded Connections: Clean out tapering threads, made up with pipe dope; screwed until tight connection. Pipe dope must be specific for each application.

C. Dielectric Pipe Fittings: Provide dielectric unions in both open and closed type piping system (heating water, chilled water, domestic water, etc.) at all locations where dissimilar metals are to be joined.

D. Grooved Mechanical Joints: Pipe shall be prepared in accordance with the latest Victaulic Grooving Specifications (ref. Victaulic PB137), using Victaulic Vic-Easy Grooving tools. Pipe shall be checked to be sure it is free of indentations, projections, weld seams or roll marks on the exterior of the pipe over the entire gasket seating area. Pipe ends are to be square cut. Victaulic lubricant shall be applied to gasket and/or pipe ends and housing interiors to eliminate pinching the gasket.

3.07 WELDING

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded piping shall be fabricated by certified welder. Contractor shall submit proof of current certification of each welder, if requested by Owner. Use full length pipe where possible; minimum distance between welds shall be 18 in. on straight runs. Welds must be at least full thickness of pipe with inside smooth and remove cutting beads, slag and excess material at joints; chamfer ends. Minimum gap 1/8 in., maximum 1/4 in., for butt welds. Overlaps on

position and bench welds to be not less than 3/4 in. One internal pass and one external pass minimum required on slip-on flanges. Do not apply heat to rectify distorted pipe due to concentrated welding; replace distorted pipe. Welding is prohibited in existing building, except in the following areas: boiler rooms, mechanical rooms, crawl spaces and roof decks. When welding galvanized pipe, apply cold galvanizing on joint after welding.

3.08 HANGER SHIELDS

A. Pre-insulated type or field-insulated type at Contractor's option.

B. Provide for all chilled water and all "non-direct" connection supports.

3.09 SLEEVES

A. Provide for pipes passing through floors, roofs/decks, walls or ceilings. Not required for floors which are core-drilled, except where floor is waterproofed.

B. Pre-insulated type: Required for chilled water and steam (over 50 psi) piping.

C. Standard type: Provide for piping as noted above. Extend 1/8 in. above finished floor in finished areas. In above grade mechanical rooms and other areas with floor drains; use steel pipe sleeves projecting 2 in. above floor. Sleeves shall be as small as practical, consistent with insulation, to preserve fire rating. Fill abandoned sleeves with concrete. Where necessary for pipes to pass through ducts, air chambers or built-up housings and approved by Engineer, provide rubber grommet seals.

D. Roof/deck penetrations: Provide sleeve and deck sealing for watertight installation per detail on Contract Documents.

E. Provide a 0.16 inch thick smooth aluminum jacket over insulated pipes where they pass through sleeves.

3.10 ANCHORS AND GUIDES

A. Provide piping system anchors and guides as shown on the plans, and as recommended by the expansion joint/loop manufacturer. Where an anchor is shown at a change in piping direction, it shall fully control movement in all three axes. In lieu of a single anchor fabricated for two directional pipes, two (2) individual anchors may be provided.

3.11 SLEEVE PACKING

A. Seal void space at sleeves as follows:

1. Interior locations: Firmly pack with fiberglass and caulk.

2. Exterior walls and below grade cored holes: Use sealing element.

3. Fire rated, partitions and floor slabs: Use fire rated sealing elements, materials and methods. Provide per manufacturer's instructions to maintain firestop.

4. Waterproofed floors: Use waterproof sealing element, device, or compound.

3.12 ESCUTCHEON PLATES

A. Provide polished chrome escutcheon plates for exposed piping passing through floors, walls or ceilings, except in Boiler, Fan and Mechanical Rooms.

3.13 CLEANING HOT AND CHILLED WATER SYSTEMS

A. Provide temporary bypasses and/or pumps and pump connections as required to circulate the new piping system or segment without cross contamination of other existing or already cleaned systems.

B. Provide circulating pumps with “startup” fine mesh (1/8” or less) strainer screens during cleaning process.

C. After each closed system has been tested and thoroughly flushed, introduce Sodium Carbonate (one lb. for each 30 gallons).

D. Provide chemical feed tank similar to Calgon #20 Micromet and connect across pump outlet valve, or as called for, with three-valve bypass. Provide temporary meter or other means of determining amount of water in system.

E. Operate pumps and arrange control system so that all control valves are open. Fill, vent and circulate system with this solution, while raising to design temperature.

F. Remove, clean and/or replace air vents, strainers, and check valves, which do not function properly.

G. After cleaning strainers, circulate for additional time, then clean strainers again; repeat until strainers are found clean and system runs visibly clear without any signs of sediment. Drain and refill system.

H. Notify Owner's Representative before starting Work. Pumps shall not be operated continuously until system is flushed and strainers cleaned.

I. Water Treatment:

1. After system cleaning, furnish report of water test to determine quality.

2. Provide complete water treatment facilities to Owner, including water analysis, feed equipment, metering equipment, pumps, and chemical, obtained from Calgon, Vulcan, Bird Archer, Heating Economy Service, Inc., Mogul, Garratt-Callahan Company, Metropolitan, or Allen-Murray.

3. Recommendations for water treatment shall be reviewed by Owner's Representative before systems are placed into service.

4. Add water treatment as necessary to prevent deterioration of piping system and equipment due to oxygen, acid, scaling.

5. Water treatment shall be deemed complete when circulation has been established throughout, and water runs clear and clean from deposits and discoloration. Submit typewritten letter to inform Owner's Representative upon completion of the Work.

3.14 CLEANING STEAM HEATING SYSTEM

A. Waste returns to sewer until condensate is clean, but not more than 48 hours. Make and remove temporary pipe connections as required. Pipe to nearest waste point. Clean system until strainers are found clean. Temper with domestic water to keep waste below 140^{o}F.

B. Coordinate all equipment operation with Owner's Representative. Verify that no debris is collecting in strainers. Repeat cleaning of strainers until no further debris is noted.

3.15 TESTS

A. Test piping and accessories before insulation, connecting to existing piping, and concealment. Repeat as many times as necessary to prove tight system. Notify Owner's Representative at least seven days in advance of each test. Isolate valves and equipment not capable of withstanding test pressures. Make leaks tight; no caulking permitted. Remove and replace defective fittings, pipe or connections. Furnish necessary pumps, gauges, equipment, piping, valving, power and labor for testing. Certify that test have been successfully completed.

B. Schedule Of Test Requirements:

1. Hot, chilled, condenser, and domestic water: Hydrostatic, 100 psig at high point of system; two hours duration.

2. Vent, drain, overflow and condensate drain: Hydrostatic, maintain 10 feet head of water above highest point of section being tested for six hours.

3. Steam (50 psi and lower), drip and condensate piping: 125 psig hydrostatic pressure; two hours duration.

4. Steam (over 50 psi), drip, and condensate piping: Hydrostatic test, 1-1/2 times working pressure; two hours duration.

5. Tests: No change in pressure under stable temperature conditions.

6. Equipment: Test at working pressures.

3.16 CONNECTIONS TO SPECIAL EQUIPMENT

A. Steam Kettles: Kettles shall be furnished and set in place by the kitchen equipment contractor. This contractor shall make connection to kettle with low pressure steam piping as shown on the contract documents.

B. Dishwasher: Dishwasher shall be furnished and set in place by the kitchen equipment contractor. This contractor shall make connection to Dishwasher with low pressure steam piping as shown on the contract documents.

C. This Contractor shall closely coordinate piping connections to equipment with other trades.

D. Control valves, individual pressure reducing valves and thermostatic traps for sterilizing equipment provided by equipment manufacturer.

E. This Contractor shall provide necessary piping, valves, strainers, and fittings.

3.17 PIPE LINE SIZING

A. Pipe sizes called for shall be maintained. Pipe size changes shall be made only as reviewed by Owner's Representative. Where discrepancy in size occurs, the larger size shall be provided.

Exhibit 'A' – Piping Materials (HVAC)
Notes are at the end of Exhibit 'A'

Service	Pipe Materials	Fittings	Connections
Hot water heating	Schedule 40, black steel	Malleable iron and butt weld	2 in. and smaller screwed 2-1/2 in. and larger welded SEE NOTE 1
Hot water heating (Optional)	Schedule 40, black steel	Grooved, rigid couplings	Mechanical with gasket SEE NOTE 2
Hot water heating (Optional)	Type L copper	Wrought copper or cast bronze, solder end	No-lead solder
Chilled water	Schedule 40, black steel	Butt weld and malleable iron	2-1/2 in. and larger welded or flanged 2 in. and smaller screwed SEE NOTE 1
Chilled water (Optional)	Type L copper	Wrought copper or cast bronze solder end	No-lead solder
Chilled water (Optional)	Schedule 40, black steel	Grooved, rigid couplings	Mechanical with gasket SEE NOTE 2
Vent, Drain, Overflow, Coil Condensate	Schedule 40, galvanized steel or Type M copper	Cast iron drainage type or wrought copper	Threaded or solder
Coil condensate drain (optional)	Schedule 40, PVC	Socket type PVC	Socket weld cement
Steam up to 50 psi	Schedule 40, black steel	Butt weld, malleable iron	2-1/2 in. and larger welded or flanged 2 in. and smaller screwed SEE NOTE 1
Steam over 50 psi	Schedule 40, black steel	1-1/4 in. and larger butt weld, 1 in. and smaller socket weld	Welded and flanged SEE NOTE 1
Condensate and drip lines	Schedule, 80 black steel	Extra strong, butt weld and malleable iron	2-1/2 in. and larger welded or flanged 2 in. and smaller screwed

Pumped condensate (50 psi and lower)	Schedule 80, black steel	Malleable iron	Screwed
Condenser water	Schedule 40, black steel (outside piping shall be galvanized or painted per job requirements)	Butt weld, malleable iron,	2-1/2 in. and larger welded and flanged 2 in. and smaller screwed,
Condenser water (optional)	Schedule 40, black steel (outside piping shall be galvanized or painted per job requirements)	Grooved, rigid couplings	Mechanical with gasket
Spray water	Schedule 40, galvanized steel	Galvanized iron	Screwed
Domestic water	Type L copper	Solder end	No-lead solder

NOTES FOR EXHIBIT "A":

NOTE 1: Screwed piping permitted in Crawl Spaces, Mechanical Rooms and Boiler Rooms.

NOTE 2: Grooved piping systems are only allowed in mechanical rooms and penthouses.

END OF SECTION

SECTION 232023

PUMPS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required, for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Shop drawings and performance curves, on pumps and pump accessories. Clearly indicate which equipment is being submitted.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Pumps shall be non-overloading over their entire performance range with motors capable of running continuously without undue noise, heating, or sparking. Impellers statically and dynamically balanced. Mechanical seals for closed systems, shall be constructed of carbon rings with ceramic mating seat up to 220^{o}F. Packing type seals for open systems only. Materials suitable for water pressures, temperature and conditions for each application. Tapped discharges and suction connections for gauges, vent and drain. With trimmed impeller if required to meet initial delivery requirements. Factory service engineer or machinist must check each pump alignment before pump is started. Include the cost of checking and start-up in pump quotation.

2.02 IN-LINE CENTRIFUGAL PUMPS

A. Designed for continuous operation between 40^{o} and 250^{o}F.

B. In-line, split coupled, single stage, bronze fitted construction.

C. All pump internals shall be capable of being serviced without disturbing piping connections.

D. Replaceable shaft sleeves at the seal.

E. Enclosed type impeller, keyed to the shaft and secured by a locking cap screw.

F. Factory guaranteed operating performance.

G. Design equipment: Bell & Gossett

H. Make: Armstrong, Bell & Gossett, Taco, Grundfos.

2.03 BASE MOUNTED, END SUCTION TYPE

A. Designed for continuous operation between 40^{o} and 250^{o}F. Single stage, end suction, bronze fitted, with cast iron volute for service to 175 psi wp. Enclosed, bronze impeller mounted on a hardened, alloy steel shaft with regreasible ball bearings.

B. Pump shall be direct connected to the drive motor by means of a rubber insert, flexible coupling with guard.

C. Pump and motor shall be mounted on a groutable structural steel main-frame with welded cross members.

D. Design equipment: Bell & Gossett.

E. Acceptable Make: Armstrong, Bell & Gossett, Taco.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Adjust flow rate (gpm) of each pump to capacity called for on schedule, re-adjust during balancing. Install in-line pumps in locations shown, supported independently of piping, using hangers on both pump flanges.

B. Level base so that pump and pump casing are not strained. Align pumps as directed by the manufacturer. After pumps have been aligned, install dowels to prevent shifting. Fill base with concrete through grouting holes provided in baseplate. Contractor responsible for accurate size of base and exact location of mounting bolts. Contractor responsible for trouble resulting from poor pump alignment. Provide concrete base pad for each base mounted pump.

C. Base mounted end suction pumps shall be provided with inlet suction diffusers. Pipe suction diffuser blow-off (full line size with ball valve) to nearest floor drain. Provide start-up strainers for first 48 hours of operation. Replace after completion of start-up period. Base mounted, double suction type pumps shall have piping arranged so that there is a minimum of eight pipe diameters of straight pipe at the pump suction connections. Where this cannot be maintained due to field conditions, the Contractor shall notify the Engineer immediately, before beginning piping work. Determine exact height of bases required for base mounted elbows; shim to match mounting height of base elbow with inlet and outlet of pump. Provide vibration absorber between pump outlet and inlet and base-mounted elbow.

END OF SECTION

SECTION 232133

WATER SYSTEMS SPECIALTIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit shop drawings on water system specialties.

1.03 GENERAL REQUIREMENTS

A. Equipment and accessories shall be rated for a minimum of 125 psi wwp, and 250^{o}F temperatures. Manufacturer's written installation procedures shall become a part of these specifications.

B. Provide equipment, piping, valves, fittings, switches, and miscellaneous equipment necessary and required for the complete installation.

PART 2 - PRODUCTS

2.01 HEAT EXCHANGERS

A. Shell and Tube Type:

1. Constructed and stamped ASME Code, 125 psi wwp design, 250 psi test. Removable head and tube bundle, steel shell and baffles with mounting saddles. 3/4" o.d., #20 BWG copper tubes, U-bend construction, 5 ft./second maximum tube velocity, fouling factor 0.0005.

2. Design Equipment: Bell & Gossett.

3. Make: Armstrong, Bell & Gossett, Taco.

2.02 EXPANSION TANKS AND ACCESSORIES

A. Steel tanks, 125 psi wwp, ASME construction per ASME Section VIII. Div. 1, with reinforced openings of size and location as required. Red oxide coating outside and final exterior coat of paint; factory applied. Tank shall contain a heavy duty rubber bladder which is replaceable and removable for inspection. The tank shall be capable of full acceptance of the tank volume when tank is void of air.

B. Design Equipment: Bell & Gossett.

C. Make: Armstrong, Bell & Gossett, Taco.

2.03 AIR REMOVAL ASSEMBLY

A. Air removal assembly, full size of piping, welded steel construction having flanged connections, perforated air collector tube, built-in removable strainer w/blow-down connection**,** and dished steel divider to direct water through strainer.

B. Maximum pressure drop 3.0 ft. or less.

C. Design Equipment: Armstrong.

D. Make: Armstrong, Bell & Gossett, Taco.

2.04 AIR ELIMINATING SUPPLY FITTING

A. Designed to eliminate air from supply water; located in supply header from heat generating devices; flanged or screwed.

B. Design Equipment: Bell & Gossett.

C. Make: Armstrong, Bell & Gossett, Taco.

2.05 MAKE-UP WATER VALVES

A. Brass with built-in strainer and anti-siphon check valve. Equal to Bell & Gossett No. 7.

2.06 SUCTION DIFFUSER

A. Cast iron body, 125 lb. working pressure, 250^{o}F operating temperature. Type X (for closed systems) cylinder orifice in steel with start-up strainer with bronze mesh and inlet vanes in steel construction. Type Y (for open systems) cylinder orifice in stainless steel without strainer and inlet vanes in steel construction. Angle type body with inlet vanes and combination diffuser-strainer orifice cylinder with 3/16 in. diameter openings. Disposable fine mesh start-up strainer to be removed after 30 days of operation. Permanent strainer free area not less than five times section area of pump connection with blow-down connection and magnetic trap. Adjustable support foot.

B. Maximum pressure drop 3.0 ft. or less.

C. Design Equipment: Bell & Gossett.

D. Make: Armstrong, Bell & Gossett, Taco.

2.07 STRAINERS

A. Cast semi-steel body or cast iron construction for steel piping and bronze body construction for copper piping; equipped with removable, monel or stainless steel water screen; maximum pressure drop 2 psi with free area at least four times area of pipe. Provided with blow-off outlet.

B. "Y" Type.

C. Design Equipment: Mueller.

D. Make: Elliot, Illinois, Keckley, Mueller, Webster, Victaulic.

2.08 MULTI-PURPOSE VALVE

A. To serve as system balancing device, shutoff valve and check valve constructed with linear contoured disc and calibrated adjustment feature. Installed in vertical position, stem up. Cast iron body, 125 psi wwp, 300^{o}F.

B. Maximum pressure drop 5.0 ft. or less.

C. Design Equipment: Bell & Gossett.

D. Make: Bell & Gossett, Taco.

2.09 AUTOMATIC AIR VENTS

A. Inverted ball type automatic vent trap, 150 psi rating, Sarco 13W.

B. Make: Armstrong, Hoffman, Sarco.

2.10 PUMP AND COIL FLEXIBLE CONNECTORS

A. Carbon steel flanges welded to carbon steel stub ends with annular close pitch stainless steel hose with stainless steel braid for coils. Keflex type KFCS, or equal.

B. Construction same as above for pump applications. Keflex type KSSPC, or equal.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Obtain detailed instructions from each manufacturer for proper method of installation.

B. Equipment and systems shall be installed in accordance with manufacturer’s installation instructions.

C. Provide all control wiring. Wiring shall meet the requirements of Specification Section 230514, and the equipment supplier’s wiring diagram.

3.02 HEAT EXCHANGERS

A. Install so that tube bundle or plates can be readily removed for maintenance. Support on angle steel frame, floor mounted or wall mounted, or on concrete housekeeping pad, as designated on drawings.

3.03 EXPANSION TANKS

A. For compression tanks pitch connection to heating system 1” in 5 ft. minimum up toward tank. Provide shutoff valve in piping connection to system and 3/4" hose end drain valve on tank. Provide supporting steelwork, hangers, and suspension racks. Provide water make-up connection, petcocks and tank fitting.

B. For expansion tanks, provide 4” housekeeping pad with length and width greater than 1.2 times the maximum diameter of the tank. Provide pitch connection to heating system 1” in 5 ft. minimum up toward system. If connection must rise towards tank, provide automatic air vent at high point. Provide shutoff valve in piping connection to system and 3/4" hose end drain valve on tank. Provide water make-up connection to air separator. Air separator shall have automatic air vent.

3.04 SYSTEM FILLING

A. After cleaning, fill each system from low point:

1. With pumps off, vent mains, risers, runouts, and units, working consecutively from low to high point in building. Obtain approximately 2 psi at highest point. Obtain proper air cushion in compression tanks.

3.05 AIR VENTING

A. Provide one of the following vents at points in piping system where air may collect.

1. Manual vent assembly consisting of: 1-1/4” x 6” air collection chamber, 1/4" brass globe valve in accessible location, install hose connection on valve outlet.

2. Automatic vent with air chamber.

B. Equipment Vents:

1. When equipment is above mains: Connect runouts or risers to upper quadrant or top of mains. Install vent assembly concealed within enclosure, consisting of 1” diameter by 4” to 6” long air collection chamber with 1/4" soft copper tube to manual valve. Mount securely near bottom of enclosure, but not fastened to enclosure. For individual units such as, radiators, fan convectors and units with return grilles: Provide screwdriver operated manual valve, operated from discharge grille or access door. Drill enclosure and position valve for operating without removing enclosure.

2. When equipment is below mains: Connect piping runouts or risers to bottom or lower quadrant of mains. Vent assembly not required in unit. Provide means of purging and draining each unit if required. Use tees instead of ells at low point of runouts.

3.06 AIR REMOVAL ASSEMBLY

A. Provide supports and provide blow-down with hose end drain valve full size of opening.

3.07 MAKE-UP WATER VALVES

A. Provide for each system, with 3/4 in. globe valve, bypass connection, and check valve downstream of bypass connection. Set valves to provide 2 psi at high point of system. Provide pressure gauge assembly.

3.08 STRAINERS

A. Provide where called for. Provide valved dirt blow-down connection for strainers, size 6 in and larger. Equip with quick opening hose end valve, and brass plug.

3.09 SUCTION DIFFUSERS

A. Provide at inlet to base mounted pump.

B. Pipe suction diffuser blow-off connection (full line size with ball valve) to nearest floor drain.

C. Provide support under suction diffuser. Suction diffuser shall not be supported by the pump casing.

END OF SECTION

SECTION 232223

CONDENSATE PUMP AND RECEIVER UNIT

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Condensate pump and receiver unit.

B. Control panel schematic wiring diagram.

PART 2 - PRODUCTS

2.01 CONDENSATE PUMP AND RECEIVER UNIT

A. Provide a Duplex condensate pump and elevated receiver unit consisting of a cast iron receiver, close coupled two stage centrifugal pumps and control cabinet.

1. Pumps shall be close coupled two stage centrifugal pumps permanently aligned and flange mounted to receiver. Bronze impeller, with stainless steel shaft and bronze wear rings. Mechanical seals suitable for 250^{o}F operation. Pump shall be capable of delivering its full rated capacity at 210^{o}F and two (2) ft. NPSH.

B. Factory wired and assembled mounted on a common steel base designed to raise the receiver 24” above the pump suction.

C. Provide with inlet strainer, dial thermometer, dial pressure gauge on pump discharge, water level gauge. Suction isolation valves on duplex units, High level water alarm with silencing button.

D. Unit manufacturer shall provide a completely packaged prewired NEMA 2 control cabinet with piano hinged door enclosing the following:

1. Combination magnetic starters for each pump (each having 3 overload relays) with fused disconnects and cover interlocks.

2. Electrical alternator.

3. "Auto-Off Hand" selector switches for each pump.

4. Numbered terminal strip.

5. Fused control circuit transformer for each circuit when the motor voltage exceeds 230 volts.

6. All Control Cabinet components shall be U.L. Listed or recognized components. The control panel assembly shall be listed by Underwriters' Laboratories, Inc. All interconnecting wiring between the pump, controls and control panel shall be in liquid tight flexible conduit. Each pump control circuit shall be completely independent of the other. The electrical alternator shall (A) change the operating sequence automatically after each cycle, (B) provide simultaneous operation under peak load conditions and (C) operate the second pump automatically, should the active pump or its controls fail.

E. Design Equipment: Bell & Gossett.

F. Make: Bell & Gossett, Dunham-Bush, Shipco.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set on 4” high concrete base.

B. Installation shall be in accordance with manufacturer's recommendation and as per submitted wiring diagrams.

C. Provide silent check valve and flow balancer in each pump discharge.

END OF SECTION

SECTION 232233

STEAM SPECIALTIES AND ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 GENERAL REQUIREMENTS

A. Steam specialties shall be of one manufacture, insofar as possible. Straight-through, angle or offset body to suit job conditions. Steam specialties designed to withstand 125 psi steam pressure without damage, but with openings sized for operating steam pressure.

1.03 SUBMITTALS

A. Submit shop drawings on steam specialties and accessories. Schedule of equipment, capacities, and pressure drops.

1.04 MAKE

A. Design Equipment: Sarco, unless otherwise called for.
B. Armstrong, Dunham-Bush, Hoffman, Illinois, Sarco.

PART 2 - PRODUCTS

2.01 TRAPS

A. Determine maximum condensing rate by multiplying operating condensing rate by the following multipliers:

1.	Heat exchangers	x 2.0
2.	Coils handling outside air	x 2.5

B. Select each trap in accordance with manufacturer's published recommendations for maximum efficiency, handling air, noncondensable gases, and maximum condensate loads given at minimum available pressure.

C. Thermostatic Traps: Cast brass bodies, angle, offset or vertical pattern. Brass cap, union nut and nipple. Duplex diaphragm or bellows type. Stainless steel conical or ball shaped valve piece to provide positive and tight closure. Stainless steel or brass removable seats and valve. Bellows to withstand 50 psi pressure.

D. Float and Thermostatic Traps: Cast iron body with drain tapping. Readily accessible to operating mechanism without disturbing pipe connections. Stainless steel or brass float and renewable seat. Thermostatic bypass. Designed to withstand 50 psi.

E. Bucket Traps: Open or inverted bucket type. Stainless steel buckets. Drain tapping on body, cast iron or semi-steel body. Valve and seat shall be of renewable stainless steel. Valve and seat shall be water sealed during trap operation. Trap shall be capable of withstanding freezing and thawing. Designed for maximum working pressure of at least 150 psi and 500^{o}F. Continuous thermostatic air venting.

F. Thermodynamic Trap: Trap shall be all stainless steel construction, disc type, suitable for installation in horizontal position. Integral seat design with hardened disc and seating surfaces. Trap suitable for operation between 3.5 to 600 psig. Provide with insulcap on all installations where ambient operating temperature is below 65^{o}F.

2.02 STRAINERS

A. Steam and Condensate Strainers: High strength cast iron body, 125 psi pressure. Monel or stainless steel removable perforated screens. Screwed body type, 2” and smaller. Flanged body type, 2-1/2” and larger. Screen suitable for steam service. 0.045” diameter holes, 233 per sq. in. Free area strainer, minimum four times area of pipe size with blow-off and plug.

2.03 VACUUM BREAKERS

A. Adjustable type.

B. Design Equipment: Hoffman No. 62.

2.04 FLASH TANKS

A. Closed type, welded steel construction, tested and stamped in accordance with Section 8D of ANSI/ASME Boilers and Pressure Vessels Code for 125 psig working pressure; cleaned, prime coated and supplied with steel support legs. Construct with nozzles and tappings for installation of accessories and piping connections.

B. Size: 34” height, 14” diameter, 2” vent, 2” drain.

C. Design Equipment: Penn Separator

D. Acceptable Manufacturers: Penn, Wendland, Wilson

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install traps with unions. All traps, other than radiation traps, installed with maximum drip leg to maintain "dry" conditions in equipment and piping, using capped dirt leg of adequate length. Provide thermostatic traps (0 to 15 psi) on return connection to each steam unit less than 10 MBH, and where called for. Provide float and thermostatic traps (15 psi to 20 in. vacuum), and as called for. Return end of each steam unit larger than 10 MBH. Where required to raise low pressure steam mains to clear obstructions, provide drip trap at low point and connect.

B. Provide bucket traps for medium pressure steam systems and drip points, and where called for.

1. Provide for service:

    a. At return end of all medium pressure steam heating coils.

    b. Hot water heat exchanger.

C. Strainers: Full size of pipe to control valve and/or trap. Ahead of each float and thermostatic trap. EXCEPTION! No strainer required ahead of trap if one provided ahead of control valve.

D. Vacuum Breakers: Provide on discharge side of each control valve.

END OF SECTION

SECTION 232236

STEAM PRESSURE REDUCING VALVES AND RELIEF VALVES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Reducing valve station and accessories.

B. Pressure relief valves.

PART 2 - PRODUCTS

2.01 PRESSURE REDUCING VALVES

A. Cast iron body, 250 lbs., 450^{o}F ASA construction, up to 2 in. screwed connections, 2-1/2 in. and up, flanged connections, 450^{o}F temperature, single seated, stainless steel diaphragm, guides and seat ring.

1. Self-operated type with pilot.
2. Pilot valve shall be separate from main valve and connected to it by unions or integrally mounted pilot. Pilot seats shall be protected by built-in strainer screens.
3. Parts shall be easily accessible without removing valve from the line.
4. Valve to close on pilot failure.
5. No springs in the path of the steam.
6. No stuffing boxes or bellow seals.

B. Design Equipment: Hoffman.

C. Make: Fisher, Hoffman, Spence.

2.02 NOISE SUPPRESSER

A. Flanged connections, welded steel construction, 150 lb. construction, twenty-five (25) lb. saturated steam service.

B. Effective over 400-12,000 Hz. range and selected so as to obtain 20 dB sound pressure level reduction.

C. Deflector assembly and acoustic packing of corrosion resistant material.

D. Compatible with pressure reducing valve.

E. Make: Same as pressure reducing valve.

2.03 PRESSURE RELIEF VALVES

A. Side outlet ASME tested, rated, certified, stamped and with try lever.

1. Inlet and outlet manifolds if more than one valve is required for service.
2. Size to relieve full heating capacity as required by ASME Code.

B. Design Equipment: Kunkle.

C. Make: Consolidated, Spence, Kunkle.

PART 3 - EXECUTION

3.01 PRESSURE REDUCING VALVES

A. Provide gate valve and strainer upstream of reducing valve, same size as upstream piping.

B. Install with upstream and downstream straight pipe lengths per manufacturer's recommendations.

3.02 PRESSURE RELIEF VALVES

A. Provide on downstream side of pressure reducing valve.

B. Route relief valve discharge pipe out thru roof or wall as shown on drawings.

1. Pipe size shall be at least the size of the relief valve discharge outlet. Where multiple relief valves are connected together the common pipe shall have a free area equal to the sum of the individual relief valves.
2. Provide drip pan elbow at heel of vertical riser.
3. Insulate pipe where same passes through roof to prevent melting roof tar.

3.03 NOISE SUPPRESSER

A. Provide at pressure reducing valves where sound pressure level 3 ft downstream of the valve and 3 ft from the pipe surface is above 50 dB. Install in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 232513

WATER TREATMENT FOR CLOSED LOOP SYSTEMS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents. Contractor provide the following at a minimum:

1. Chemical treatment test equipment must be Chemet Kit K-6720.
2. HVAC water treatment chemicals.
3. Water filtration units for HVAC recirculation system.
4. Written report each visit including cleanout of the system and 12 regular service visits during the year.

B. Provide all chemical treatment required for piping systems each time an individual system is drained and then refilled as a result of work performed under this contract.

1.02 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets, standard schematic drawings, specifications and installation instructions for the chemical feeders and accessories.

B. Operation and Maintenance Data: Provide one copy of written instructions, framed under rigid plastic, on the procedures, tests required and dosages to be used for the chemical treatment of the system.

1.03 RELATED SECTIONS

A. Testing, Adjusting and Balancing: Section 230593.

B. Piping Systems and Accessories: Section 232000.

C. Valves: Section 230523.

1.04 MAINTENANCE

A. Extra Materials: Before final payment, deliver a one year supply of water treatment chemicals to the Owner's Representative at the Site.

PART 2 - PRODUCTS

2.01 SIDE STREAM FILTER

A. Side stream filter shall be used to filter suspended solids and feed chemical into the system.

B. Floor mounting housing with filter cartridges for removing particles from water.

C. The unit will have the inlet piped to the discharge of the pump, and the discharge to the suction of the pump

D. Sock: Replaceable and of shape to fit the housing. Must supply 10 – 5 micron and 10 – 1 micron filter bags at start of cleanout.

E. Acceptable Manufacturers: Knight, Rosedale, Shelco.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install side stream filter, complete with valves and piping, as indicated on the drawings.

3.02 CLEANING PROCEDURES

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to the operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at the project site, HVAC system equipment material characteristics and functional performance characteristics, and operating personnel capabilities.

C. Closed hydronic systems for hot water heating shall have the following water qualities:

1. pH of 9.5 to 10.5.
2. “P” Alkalinity: maintain a value within 100 – 250 ppm.
3. Molybdate to maintain a value within 100 – 120 ppm as MoO_4 in the system.
4. Have yellow metal inhibitor, sodium tolyltriazole, a 2 – 3 ppm in the system.

D. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.

E. Cleanout Procedures:

1. System cleanout shall be with a surfactant type dispersant designed to keep suspended solids dispersed and the same time passivate both mild steel and copper alloys.

2. During system clean and passivation all zone valves or any other control areas must be forced open. A minimum of 24 hours will be maintained during the cleaning.

3. Flushing of the system will be for a duration of 24 hours at a controlled rate by bleeding the top of the system to the sewer. After the period a soap test will be performed by shaking a sample in a glass jar. If soap bubbles appear then continued flushing must be done until all traces of soap are gone. At that time, 5 micron filters will be used for a duration of 24 hours, until they are clean. Final, 1 micron, filters shall be used for a duration of one year.

END OF SECTION

SECTION 232516

WATER TREATMENT FOR COOLING TOWER

PART 1 - GENERAL

1.01 INCLUDED WORK

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTALS

A. Submittals shall be made on all water treatment equipment.

1.03 GENERAL REQUIREMENTS

A. The chemicals supplied shall meet Federal, State and Local regulations pertaining to pollution.

B. Provide water treatment feeding equipment, piping, valves, fittings, switches, and miscellaneous equipment necessary and required for the complete installation.

C. Provide complete water treatment facilities to the Owner including raw water analysis, necessary chemicals, test equipment, reagents, and a one year service contract consisting of at least monthly visits to the site during the cooling season.

D. Water treatment manufacturer shall furnish a one year supply of water treatment.

E. Corrosion control chemicals shall limit corrosion to 5 mpy (by test) for mild steel and 0.2 mpy (by test) for yellow metals using approved N.A.C.E. procedures.

1.04 SYSTEMS DESCRIPTIONS

A. Water treatment for the cooling water tower water shall consist of the addition of chemicals for the control of scale and corrosion by automatic control in proportion to the amount of make-up water; and the bleed off of tower water based upon conductivity.

B. Microbiocides for algae control shall be introduced into the system automatically based on ORP set point from the controller.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Water treatment equipment including chemicals furnished, shall be provided by Feedwater Treatment Systems, GE Betz, Garrett-Callahan Company, or approved equal.

2.02 PIPE AND FITTINGS

A. Pipe and fittings for treatment injection including valves, shall be Schedule 80 PVC plastic pipe. The water treatment equipment manufacturer shall furnish suitable injection assemblies for installation at each location where chemicals are introduced to the system.

2.03 WATER METERS

A. Water meters shall be rotating disc, volumetric, positive displacement type with an impulse contactor to provide one impulse per 10 gallons of make-up water to the tower.

B. Design Equipment: Walchem WRM series

C. Acceptable Manufacturers: Neptune, Walchem, Niagara.

2.04 COOLING TOWER BLEED AND FEED CONTROL

A. Controller to be equal to a Walchem WDT410-1N9-RV and incorporate the following features:

1. Linear conductivity control with set point, test, calibrate and range selector. Range 50-1000 mmhos or 500-10,000 (field selectable). Provide conductivity meter display on controller face.
2. Unit to be temperature compensated between 40^{o} - 130^{o}F.
3. Accuracy to be $\pm$ 5% over entire range w/99.8% linearity.
4. Probe shall have carbon element and PVC body with integral T/C element. Conductivity probe shall be compatible with controller.
5. Provide T2 option with counter (0-100 adj.), reset type timer (0-10 min. adj.), and controls for timer adjustment, counter adjustment, treatment pump MOA.
6. ORP control for Bromine addition.
7. Alarm output relay to BMS for low conductivity, high conductivity, and no flow.
8. Flow meter input, able to accept flow meter provided.

B. Acceptable Manufacturers: Chemteck, Vector Industries, Precision

2.05 BROMINE FEEDER

A. Feeder for the introduction of chemicals shall suit the requirements of the application.

B. Heavy gauge carbon steel, coated with chemical resistant epoxy powder coating. Feeder tested a minimum pressure of 200 psi.

C. Design Equipment: Vector Industries Biomate model 2000-50 with 0.75” Flow Meter Valve Kit

D. Acceptable Manufacturers: Chemteck, Vector Industries, Precision.

2.06 MISCELLANEOUS ACCESSORIES

A. Solenoid valve for automatic blow-down, weatherproof if outdoors, Belimo, or approved equal.

B. SS Corporation stop or check valve for each system.

C. Ball flow indicator of required size and flow, SK Instruments, or approved equal.

2.07 CHEMICAL TREATMENT

A. The chemical for water treatment shall:

1. Be non-toxic at use concentration.
2. Not use an alkaline (non-acid) environment.
3. Suspend or disperse particles to allow removal.
4. Not contain chromate inhibitors.
5. Molybdate & TTA specific for both ferrous and yellow metal.

B. Bromine will be the primary Biocide.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Equipment and systems shall be installed in accordance with manufacturer's installation instructions.

B. Plastic piping shall be properly supported and be located to prevent damage from normal service work in the area.

C. Wiring shall meet the requirements of Specification Section 230514, and the equipment supplier's wiring diagram.

3.02 TESTING AND START-UP SERVICE

A. The Contractor shall provide the services of water consultant to supervise installation of chemical feed equipment, start-up of chemical treatment, and instruct operation personnel orally and in writing in the performance of the control tests and their interpretation and to supervise through periodic visits, the progress of the water treatment program.

1. Field Service Engineer assigned to this job shall be thoroughly trained in the field of water treatment for at least two years.

B. Water Consultant shall have a complete analytical laboratory for the analysis of water and waterformed deposits.

C. Test Kits:

1. Molybdate test kit equal to Chemet K-6702 and one year supply of reagents.
2. Bromine test kit equal to Chemet K-1610 and one year supply of reagents.

END OF SECTION

SECTION 233000

SHEET METAL AND DUCTWORK ACCESSORIES

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services required for the complete installation designed in Contract Documents.

1.02 RELATED SECTIONS

A. 018121 – Indoor Air Quality Management during Construction.

1.03 QUALITY ASSURANCE

A. Ductwork shall be fabricated and installed in compliance with latest edition of the following standards:

1. SMACNA Duct Construction Standards - Metal and Flexible Ductwork.
2. SMACNA Duct Liner Application Standard.
3. Plans and Specifications which exceed the requirements in any of the referenced standards.

B. All sheet metal shall be fabricated and installed by an experienced Contractor specializing in this type of Work.

1.04 SUBMITTALS

A. Shop drawings of all sheet metal equipment being provided. Submit a complete shop standard manual including construction details for all shop fabricated materials.

B. Ductwork detail drawings.

1.05 DUCTWORK SHOP DRAWINGS

A. Prepare minimum 1/4 in. scale drawings:

1. Constructed from actual field inspections and measurements so as to assure a complete job.
2. Incorporating dimensions of actual equipment proposed for use on the project.
3. Showing adequate sections, elevations, and plan views and indicating the bottom of ductwork elevations from the finished floor.
4. Indicating all volume dampers, damper access doors, air balance test plugs, and other accessories required for a complete project.

B. Call to the attention of the Engineers, immediately, any major deviations from the Contract Drawings which must be made. All deviations shall be documented in writing.

C. Submit roof, wall and floor opening dimensions and locations shown on shop drawings.

D. Submit prints to each Contractor of other trades for review for interferences and coordination with their work.

1.06 DAMPERS

A. Provide volume dampers in ductwork at all air outlets, diffusers, grilles. Dampers shall not be provided at the air outlets unless specifically noted on plan.

PART 2 – PRODUCTS

2.01 DUCTWORK MATERIALS

A. Unless otherwise called for, provide materials in accordance with Exhibit I.

2.02 DUCTWORK LEAKAGE, SEALING AND PRESSURE CLASSIFICATION

A. All ductwork shall be constructed for a minimum pressure class of 2 in. w.g. unless stated otherwise.

B. SMACNA duct sealing classification shall be used for duct systems using the following criteria:

1. Seal Class A.

C. Ductwork Sealant:

1. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL-181A, and appropriately marked according to system type.
2. Tapes and mastics used to seal flexible air ducts and flexible air connectors shall be listed and labeled in accordance with UL-181B, and appropriately marked for system type.

D. SMACNA Duct Leakage Classification shall be used for duct systems using the following criteria:

1. Leakage Class 6 for round metal ductwork.
2. Leakage Class 12 for square and rectangular metal ductwork.

2.03 SQUARE AND RECTANGULAR DUCTWORK

A. Transverse and longitudinal duct seams reinforcement shall conform to appropriate tables and figures per SMACNA Velocity -Pressure Classification for duct construction.

1. Transverse joints shall be sealed with duct joint sealants. "Ductmate" or "Nexus" 4-bolt connection systems may be used in lieu of standard construction.

2. Field assembled longitudinal seams shall be sealed with duct sealant.

B. Corner closures shall be required as described and illustrated by SMACNA Duct Construction Standards.

C. Throat radius on all elbows shall not be less than dimension of duct in plane of radius. Where this cannot be maintained, use shorter radius with internal guide vanes, or square elbow with turning vanes.

D. Bracing and hanging of ductwork shall be per SMACNA Standards for size and system class of ductwork being used.

E. Any transformations shall not reduce the ductwork cross-sectional area. Maximum angle in straight duct, 20^{o} for diverging flow and 30^{o} for contraction flow. Transformation from square to round or flat oval seams welded or brazed.

2.04 ROUND DUCTWORK

A. Manufactured of galvanized steel ASTM A527, gauges per SMACNA Duct Construction Standards, spiral lock-seam or longitudinal fusion-welded, as called for in Exhibit I.

B. All spiral duct shall have locked seams so made as to eliminate leakage under pressure for which this system has been designed. Longitudinal seams duct shall have fusion-welded butt seams.

C. No stovepipe will be allowed.

D. Round ductwork fittings:

1. All fittings fabricated Per SMACNA Standards for round and flat-oval ductwork.
2. Fittings shall have continuous, welded seams.
3. 90^{o} tees shall be conical type. 90^{o} tees and 45^{o} laterals up to and including 12 in. diameter tap size shall have a radiused entrance into the tap, produced by machine or press forming. The entrance shall be free of any restrictions.
4. Round taps off the bottom of rectangular ducts down to diffusers shall be made with a 45^{o} square to round shoe-tap.

E. Elbows:

1. Diameters 3” through 8”: Two-section stamped and continuously welded elbows.
2. Over 8”: Gored construction with seams continuous welded. Less than 35^{o} - two gores, 36^{o} to 71^{o} - three gores, over 71^{o} - five gores.
3. Fabricated to a centerline radius of 1.5 times the cross-section diameter.

F. Joints:

1. Pipe-to-pipe joints shall be by the use of sleeve couplings, reinforced by rolled beads.

2. Pipe-to-fitting joints shall be by slip-fit of projecting collar of the fitting into the pipe.

3. Insertion length of sleeve coupling and fitting collar shall be 2".

2.05 TURNING VANES

A. Provided in square elbows as shown on contract drawings. Vanes for ducts with areas greater than 100 sq. in. shall be "double" type having dimensions and spacing as detailed.

1. Make: Elgen, or contractor fabricated.

2.06 DAMPERS IN DUCTWORK

A. Blade type volume dampers: Constructed per SMACNA, one gauge heavier than duct material, securely fastened to 3/8 in. sq., cold rolled steel operator rod. Provide multi-blade dampers above 12 in. duct diameter in width or depth. Where multi-blade dampers are required, they shall be equal to Ruskin Model CD35. Provide quadrant locking handle on air volume dampers.

B. Fire and Smoke Dampers: See "Fire and Smoke Dampers" Section 233316.

C. Automatic Air Dampers: Furnished as part of "Control Systems" Section 230923 installed by this Contractor.

2.07 FLEXIBLE DUCTWORK

A. Shall be constructed in compliance with NFPA Bulletin 90A, and UL Standard 181, Class I Air Duct:

1. Consisting of corrosion resistant galvanized steel helix mechanically locked to fabric. Fabric to be a trilaminate of aluminum foil, fiberglass and aluminized polyester.

2. Factory applied, 1" fiberglass exterior insulation, sheathed in a seamless reinforced exterior vapor barrier jacket.

3. Flexible ductwork shall be rated for 12" w.g. positive pressure, 5500 fpm, operating temperature range -20^{o}F to 250^{o}F.

B. Design Equipment: Flexmaster Type 3.

C. Make: Clevaflex, Flexmaster, Genflex, Thermaflex.

2.08 FLEXIBLE CONNECTIONS TO FANS AND EQUIPMENT

A. Materials for flexible connections shall be fire retardant, water and mildew resistant, and comply with UL Standard 214:

1. Systems up to 2" w.g. s.p.: approximately 20 oz. of fabric per sq. yd. Ventfabrics, Inc., "Ventfab".

2. Systems greater than 2” w.g. s.p., and watertight systems: Of heavy glass fabric, double neoprene coated, approximately 30 oz. per sq. yd. Ventfabrics Inc., "Ventglas".

2.09 ACCESS DOORS

A. In Ductwork: Shall be double panel construction, 1” rigid insulation when in insulated ducts; SMACNA construction, hinged type. Double cam type only acceptable where hinged type will not fit and if approved by engineer. Same metal as duct, or factory fabricated. Doors airtight to fit system static pressure, minimum size 16” x 12”.

B. When Installed In Kitchen Hood Exhaust Systems: Shall be in accordance with NFPA 96, latest edition, grease tight bolted and flanged.

C. When installed in intake or exhaust plenums, access doors will be sized to allow for full access to plenum.

D. Where plenums are greater than 4 feet wide or deep, the access door is to be at least 2 ft. wide by 4 ft. tall to allow for personnel entry.

E. Door Hardware:

1. Hinges: Minimum of two per door, at least 1-1/2” long by 1/8” thick, spaced no more than 2 ft. apart and no more than 1/4 of the door size from top to bottom of door. Maximum 4” length, 6 ft. door, for larger doors, length equal to 1/12 door height.

2. Latches: As manufactured by Ventfabrics, Inc. or equivalent. Metal window sash latch not acceptable.

a. Access doors up to 2” w.g.: Ventlok #100/#102.

b. Walk-in doors up to 2” w.g.: Ventlok #260.

c. Access or walk-in above 2” w.g.: Ventlok #310.

F. Make: Air Balance, Ruskin, Ventlok, Elgen.

2.10 INSTRUMENT TEST HOLES

A. Suitable for insertion pitot tubes and other test instruments:

B. Fabricated with heavy screw cap and gasket.

C. With sufficient extension to accommodate exterior insulation where required.

D. Make: Ventlok #699.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Equipment and systems shall be installed in accordance with local and state codes and regulations having jurisdiction.

B. Install all ductwork concealed and tight to the structure above unless noted otherwise on shop drawings. Fabricate only after the approval of shop drawings, and in locations to avoid interference. Ductwork installed without approved shop drawings, which requires removal/modification and/or reinstallation due to conflicts or improper installation shall be repaired at no cost to the Owner.

C. Sizes given on contract drawings are inside dimensions. Keep openings closed with protective caps or blanks during construction to prevent entrance of dirt and debris.

D. Provide sheet metal sleeves at each floor and wall duct opening.

E. Extend access openings, damper rods and levers, to outside of external insulation make systems airtight.

F. No piping, conduit or other obstruction to airflow is permitted in ductwork. Provide with airtight streamlined sleeve, soldered or brazed joint between sleeve and ductwork. Increase size of ductwork to maintain proper cross-sectional area.

G. Provide necessary openings, sleeves, hanger inserts, framing, chases, and recesses, not provided by other trades.

H. Exposed exhaust or return registers and grilles shall be flush with face of duct; exposed supply registers and grilles shall be mounted outside airstream with 45^{o} shoe-tap extension collars.

I. Provide sleeves for ducts passing through walls or floors. Use 14 gauge sleeve with framing through structural surfaces; 18 gauge sheet metal for other cases. Set sleeves 4” above finished floor in Mechanical Rooms, seal watertight to floor.

3.02 FLEXIBLE CONNECTIONS

A. Provide flexible connections for the intake and discharge connections of duct connected to fans and air handling equipment:

1. Round connections made with adhesive and metal drawbands with ends tightly bolted.

2. Rectangular connections made with material securely held in grooved seam between flanges, tightly clipped or riveted on 6” centers.

B. Connections made with a minimum of 2” space between duct and equipment collars, installed in line, and with 1” excess material folded so as not to interfere with airflow through connection.

3.03 FLEXIBLE DUCTWORK

A. Joints made with Minnesota 3M adhesive applied to duct end or collar.

B. Duct slid on depth of collar and 2” on duct end and secured with sheet metal screws and drawband, Wraplock 5900.

C. Maximum length 36”.

D. Maximum one 90^{o} angle bend from ductwork to outlet.

3.04 TURNING VANES

A. Install only in square elbows of equal dimensions.

B. Use large size vanes, 2-1/4" spacing when ducts are 20" or wider.

C. Secure vane runners to duct with spot welding, riveting or sheet metal screws.

D. When installing in ductwork with internal insulation:

1. Install runners in ductwork inside insulation and bolt through insulation and duct sides, welding bolts to insure rigid installation. Provide build-outs for duct Velocity-Pressure classes above 2" w.g.

3.05 INSTRUMENT TEST HOLES

A. Locate in the following locations:

1. Downstream of fan discharge
2. Downstream of exhaust duct
3. Downstream of fan inlet.

3.06 CLEANING DUCTWORK AFTER INSTALLATION

A. Clean rubbish and dirt from system before fans are turned on.

B. Keep openings closed during this construction period.

C. Pay damages resulting from dirt blown on painted or other finished surfaces.

D. Repair or replace damaged fan wheels, dampers, or other system parts damaged as a result of dirt.

E. Clean system as many times as required until the entire system is dirt-free.

F. Verification of System Cleanliness: The contractor shall demonstrate to the commissioning agent that the system is free of dirt and debris

3.07 INSTALLATION ROUND DUCTWORK

A. Use factory fabricated couplings for joints.

B. After the joint is slipped together, sheet metal screws are placed ½" from the joint bead for mechanical strength.

C. Sealer is applied to the outside of the joint and covering the screw heads.

D. Flanged joints shall be made with neoprene rubber gaskets.

3.08 TEST OF DUCTWORK

A. Conduct duct leakage tests per SMACNA "HVAC Air Duct Leakage Test Manual", latest edition. When leakage above stated limits occurs, ascertain location of leaks and repair as required. Repeat tests as required to obtain allowable leakage rates. Prepare a report similar to that suggested by SMACNA and submit for review. Duct testing shall be conducted in the presence of the Owner's Representative. The following ductwork shall be tested:

1. 25% of all supply and return ductwork, both upstream and downstream of VAV's

2. 50% of grease exhaust ductwork.

B. Ductwork not formally tested for leakage shall be checked and guaranteed to meet standards of SMACNA Seal and Leakage Classifications (seal Class A- 2" w.g. and above). Air balancing and testing shall be used to determine satisfactory operation of duct systems. Balancing reports indicating excessive leakage amounts shall be required to rebuild, repair or seal ductwork having excessive leakage.

3.09 DAMPERS AND AIR CONTROL DEVICES

A. Provide dampers necessary to permit proper balancing of air quantities. Comply with code requirements for smoke and fire control. Prevent introduction of uncontrolled outside air into building through roof and wall openings.

B. When dampers are installed in acoustically lined ductwork, install with insulated "build-outs" per SMACNA.

C. Install fire and smoke dampers in accordance with "Fire and Smoke Dampers" Section and applicable codes.

D. Install all dampers furnished as part of "Control Systems" Section.

3.10 ACCESS DOORS

A. Provide as required for maintenance and service access at:

1. Control dampers
2. Damper motors
3. Fire dampers for replacement of fire damper link
4. Smoke detectors
5. Control instruments
6. Fan bearings
7. Both inlet and outlet of terminal heating and/or cooling coils
8. Intake or exhaust plenums

B. Provide service openings in accordance and as required by NFPA 96 at 20 ft. intervals along horizontal ducts and at each vertical riser for kitchen hood exhaust.

3.11 DUCT SUPPORTS

A. Provide per SMACNA, same material as duct. Hanger bands to extend down sides and turn under bottom 2" Minimum two metal screws per hanger. Angle iron on larger duct. Spaced per building structural system but not greater than 8 ft. Provide extra support angles as required.

3.12 AIR AND WATERTIGHT METAL WORK

A. Where water or snow may accumulate and ductwork or where odors or corrosive gasses may collect, ductwork and plenums shall be made watertight by soldering, brazing or welding of joints. Grade ducts down toward waste points and/or toward louvers. Provide valve and drain piping from low point to waste point. The following ductwork shall be constructed air and watertight:

1. Kitchen range hood and exhaust ductwork.
2. Dishwasher hood and exhaust ductwork.
3. Intake and exhaust plenums.

B. Test for water-tightness: Before concealment, apply water by hose to check for leaks, witnessed by Owner's Representative.

3.13 SMOKE DETECTION

A. Smoke detectors shall be furnished by Division 26 "Electrical". This Contractor shall install detectors located in ductwork. Clearly indicate locations of smoke detectors on the sheet metal shop drawings.

B. Increase duct size at smoke detectors, where required for proper installation, per smoke detector manufacturer's recommendations. Coordinate minimum duct size required with Division 26 "Electrical".

EXHIBIT I - DUCTWORK MATERIALS
(Notes are at the end of Exhibit "I")

SERVICE	MATERIAL	SPECIAL REQUIREMENTS
Supply, return, vent, relief, and exhaust	Lock forming quality, galvanized steel ASTM 525	Joints and features as called for
Supply and return ductwork located outside the building envelope	Galvanized steel	Double wall construction with 1" insulation (refer to 230700) between walls. Inner wall lock forming joints, outer wall braze or weld water tight.
Dishwasher, exposed kitchen exhaust hood	Type 302 stainless steel, with No. 4 finish where exposed	Braze or weld watertight SEE NOTE 3
Concealed kitchen hood exhaust	16 gauge black steel	Joints welded, flanged and gasketed at connections to hood SEE NOTE 3
Air plenums at roof or wall, intake or exhaust	PVS, Type 302 stainless steel or galvanized steel	Braze or weld watertight. SEE NOTE 1 SEE NOTE 2
Accessories, dampers and air turns	Same or better as parent duct	------

NOTES FOR EXHIBIT I:

NOTE 1: Wall plenums that are likely to see moisture collection due to rain or snow are to be provided with a sloped floor and trapped drain to indirect waste connection.

NOTE 2: Wall plenums greater than 4 ft. wide are to have 16 gauge floor, reinforced to support maintenance or service personnel.

NOTE 3: For applications with reduced clearance to combustibles or with field-applied grease duct enclosures, fire rated duct insulation shall be applied, to comply with NFPA 96 and local codes. See Specification Section 230714. In these applications, both the duct and the fire rated duct insulation shall be tested and listed in accordance with ASTM E2336 and installed in accordance with the manufacturers' instructions and listing requirements.

END OF SECTION

SECTION 233316

FIRE AND SMOKE DAMPERS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Documents.

1.02 SUBMITTALS

A. Types, schedule of sizes, locations, and installation arrangements of all dampers.

B. Manufacturers UL listed installation details for each mounting arrangement.

1.03 QUALIFICATIONS

A. Provide Work in accordance with latest requirements of the New York State Building Code, NFPA 90A, NFPA 101 and UL 555 (Sixth Edition), UL 555S (Fourth Edition). Fire dampers shall be Underwriter's Laboratories classified.

B. All Dampers shall be rated for protection at 350°F. and shall be Leakage Class I.

C. Smoke dampers and operator assemblies shall be Underwriter's Laboratories classified as an assembly.

PART 2 – PRODUCTS

2.01 FIRE DAMPERS

A. Blade type damper of galvanized steel construction with fusible link, roll formed frame and stainless steel spring negator. UL listed and labeled.

B. 80% free area for velocities up to 2000 fpm.

C. Square, rectangular, round or oval duct connection as required by duct connections.

D. 1-1/2 hour rated dampers for two-hour rated walls.

E. Equipped with sleeve and slip joint connection or field installed sleeve and slip joint connection. See detail sheet on Contract Drawings.

F. Fusible link temperature rating of 165°F.

G. Design Equipment: Ruskin.

H. Make: Greenheck, National Controlled Air, Ruskin.

2.02 COMBINATION FIRE/SMOKE DAMPERS

A. Airfoil multi-blade type damper of aluminum construction suitable for installation in high velocity air systems up to 4000 fpm and 4 in. s.p. UL listed fusible link. Frame thickness 16 gauge minimum.

B. UL listed 120 volt electric motor operator. Operator to be mounted outside of the airstream. Power to open spring to close.

C. Square, rectangular or round as required. Duct transitions for dampers in oval ducts.

D. Class I leak rating of 4.0 cfm/ft^2 at 1" w.g.

E. Provide Out-of Wall style damper to suit project conditions.

F. Design Equipment: Ruskin.

G. Make: Greenheck, Air Balance, Ruskin.

PART 3 – EXECUTION

3.01 LOCATIONS

A. Provide fire dampers in floor openings, openings in two hour fire partitions and penetrations of one-hour rated walls which are used for air transfer only, and not ducted. Provide smoke dampers as called for in penetrations of smoke barriers.

3.02 INSTALLATION

A. Provide sleeves, angles, and access doors for installation in accordance requirements of NFPA, UL and damper manufacturer. Provide sheet metal access doors in ductwork for dampers and accessories. Provide ceiling or wall access doors for dampers and accessories. Division 26 "Electric" will provide signal wiring and power wiring for smoke dampers. Smoke detectors shall be furnished by Division 26 "Electric". Install detectors located in ductwork. Increase duct size at smoke detectors, where required for proper installation, per smoke detector manufacturer's recommendations. Coordinate minimum duct size and length required with Division 26 "Electric". Provide insulation end seal fittings for double wall ductwork where same connects to damper assembly.

3.03 CERTIFICATION

A. Contractor shall certify that dampers are accessible for servicing, are installed properly, and are operational. Submit three copies of signed certification to the Owner's Representative for review.

3.04 IDENTIFICATION

A. Provide damper tags and chart. Fasten tag to ductwork adjacent to the dampers. Number each damper and make chart listing.

1. Number
2. Location
3. Air system in which they are installed.

B. Submit three copies of chart to the Owner's Representative for review.

END OF SECTION

SECTION 233400

FANS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Drawings.

1.02 SUBMITTALS

A. Submittals shall include all fans, motors, drives, and accessories. Include all fan curves and fan operating point.

1.03 QUALITY ASSURANCE

A. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories shall be provided as called for or scheduled. All ratings shall be made in accordance with AMCA Standard 210. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. The manufacturer shall guarantee sound-power level ratings not exceeding those of the design equipment. All equipment shall be statically and dynamically balanced to acceptable tolerances with weights permanently fastened. Fan wheels shall be rebalanced in the field, if necessary.

B. Pressure Classification:

Maximum Total Static Pressure	Class
Up to 3-3/4" w.g.	I

C. Motors:

1. Motors shall be furnished with each fan of sizes scheduled. Refer to specification Section 230513 for acceptable motor manufacturers. All belt-driven fan motors shall be mounted on either an adjustable slide base or a pivoting base.

D. Drive Systems:

1. Provide fans with belt or direct drive systems as scheduled. V-belt drives as recommended by drive manufacturer, unless otherwise specified or scheduled.

   a. Below 10 hp: Size 150% of motor rating.

   b. 10hp & up: Size drive for 200% of motor rating.

   c. Motors 5 hp and larger shall be provided with a minimum of two matched belts. All belt sets shall be matched.

   d. Cast iron or cast steel pulleys.

   e. Provide a belt and shaft guards for each driven device. Provide openings in both the motor and fan sections of the guard so that the motor and fan speeds can be checked without removing the belt guard.

f. For belt driven devices, provide factory installed automatic belt tensioner to maintain proper belt tension.

E. Motor Pulleys:

1. Adjustable type to produce 15% speed change above and below scheduled fan speed.

2. 5 hp & smaller: "A" section, 2.6 in. minimum pitch diameter.

3. 7-1/2 hp - 20 hp: "B" section, 4.6 in. minimum pitch diameter.

4. Drive ratio not over 4:1.

5. Vibration isolation for units shall be furnished by fan manufacturer unless otherwise noted. Where spring vibration isolators are used, they shall be guided spring type.

PART 2 - PRODUCTS

2.01 UTILITY FAN SETS

A. Utility set shall be a packaged type centrifugal fan and drive assembly. Airfoil blades as scheduled on Contract Drawings. Weatherproof hood, special bearings, and lubrication to withstand outdoor weather operation. Bearing mounting shall be adjustable and self-aligning, 50,000 B-10 life hours rated in accordance with AFBMA.

B. Shall be of airtight construction with the scroll panel material formed and embedded into the side panels or continuously welded heavy gauge steel. 500°F maximum operating temperature for a minimum of 4 hours.

C. Access door shall be bolted to the fan housing. Hinged doors are no acceptable.

D. Fan housing shall be provided with a 1-1/4” drain connection for removal of grease.

E. Design Equipment: Greenheck.

F. Acceptable Makes: Twin City, Cook, Greenheck.

2.02 CABINET FANS

A. Fan casings constructed of a minimum of 18 gauge steel reinforced and braced with angle framework for rigidity and to prevent vibration. Prime coated and painted with manufacturer's standard enamel finish. Ceiling suspended fans provided with bottom-mounted clip angles. Removable side panels for access to internal parts. Bearing mountings adjustable and self-aligning, 50,000 B-10 life hours, rated in accordance with AFBMA. Lubricating lines extended to outside of unit casing. Interior of fan section housing lined with 1/2" thick mat covered glass fiberboard meeting NFPA 90 Standards.

B. Design Equipment: Greenheck.

C. Make: Twin City, Cook, Greenheck.

2.03 ROOF FANS (DOME TYPE)

A. Centrifugal type fan wheel with backward curved blades. Spun aluminum housing. Fan enclosure with removable dome for access to motor, drive, bearings and fan wheel. Hinged at curb so that entire fan can be tilted upward for maintenance access to automatic dampers and damper motor. For belt driven units, the motor and drive shall be isolated from the airstream. The motor shall be mounted on an adjustable base. Permanently lubricated sealed motor bearings.

B. Fan Bearings: 50,000 B-10 life hours per AFBMA.

C. 1/2” x 1/2” aluminum mesh bird screen. Factory mounted and wired disconnect switch. Factory mounted and wired variable speed controller for all direct drive fans. Factory constructed roof curb.

D. Design Equipment: Greenheck.

E. Acceptable Make: Cook, Greenheck, Twin City.

2.04 ROOF FANS (LOUVERED PENTHOUSE TYPE)

A. Centrifugal type fan wheel with backward curved blades. Aluminum housing with stormproof louver blades. Minimum of 0.081 in., extruded of 6063T alloy, mitered and continuously welded at corners. Blades with integral stormproofing lip. Housing insulated with 1” mat faced fiberglass, mechanically fastened with stick pins, and sealed in place with mastic.

B. Hinged at curb so that entire fan can be tilted upward for maintenance access to automatic dampers and damper motor, with supporting bar. Factory constructed roof curb.

C. For belt driven units, the motor and drive shall be isolated from the airstream. The motor shall be mounted on an adjustable base. Permanently lubricated sealed motor bearings. Fan Bearings shall be 50,000 B-10 life hours per AFBMA.

D. Provide 1/2" aluminum mesh birdscreen on inside of each louvered wall. Provide unit with factory mounted and wired disconnect switch.

E. Design Equipment: Greenheck.

F. Acceptable Make: Cook, Greenheck, Twin City.

2.05 PROPELLER FANS

A. Heavy duty, direct or belt driven as scheduled. Square frame, welded steel construction with mounting flanges and baked enamel finish. Electric damper at wall. Die-formed steel or aluminum propeller. Aluminum for explosion-proof application. Provide guard for belts, pulleys and fan blades.

B. Design Equipment: Greenheck.

C. Acceptable Make: Twin City, Cook, Greenheck

PART 3 - EXECUTION

3.01 INSTALLATION OF EQUIPMENT

A. Provide equipment in accordance with manufacturer's instructions. All fans shall meet the intent of the system performance requirements. Provide rubber in-shear vibration isolation for all fans unless otherwise called for differently. Provide necessary supporting ironwork and platforms for equipment as detailed on the contract drawings. Provide guards for all exposed belts, shafts and fan wheels. Change pulley sizes or adjust sheaves as required to make systems deliver specified quantities of air as listed on the Contract Drawings.

3.02 SPARE PARTS

A. At the completion of the project, the contractor shall provide the Owner with one (1) spare set of belts for each belt driven fan. Belts shall be tagged by fan number.

END OF SECTION

SECTION 233600

VARIABLE AND CONSTANT VOLUME TERMINAL UNITS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Drawings.

1.02 SUBMITTALS

A. Submit terminal units by room number, maximum and minimum CFM, accessories, pressure drops, discharge and sound power data by octave band. Clearly indicate box sizes being proposed. Submit separately the controller and control interface devices being utilized.

PART 2 - PRODUCTS

2.01 TERMINAL UNITS

A. General Unit Construction:

1. Unit casing shall be constructed of 22 gauge welded galvanized steel. Each unit shall be internally lined with 1/2" minimum 1-1/2" lb/ft^3 fiberglass insulation which meets NFPA 90A and UL 181 erosion requirements and has a flame spread rating of 25 and a smoked developed rating of 50. Factory label each unit with size, location, minimum and maximum CFM, and calibration chart. Air terminal units shall be capable of operating 10 in. W.G. pressure maximum without damage.

2. Units to be certified under ARI Standard 880-87 Certification Program and carry ARI seal.

B. Control and Volume Regulating Devices:

1. Internal unit damper shall be constructed of galvanized steel with blade-end seals for tight shutoff (2% leakage) against a maximum of 3 in. w.g. Damper shall be mounted on a galvanized steel shaft extending through the unit on torque free bearings. Terminal shall be available with normally open or closed dampers as called for. Minimum and maximum air quantities shall be factory set, but may be held adjustable. Neither the radiated or discharge sound power levels shall exceed the ratings of design equipment as scheduled on the Contract Drawings.

C. Hydronic Reheat Coil:

1. Coil shall be factory installed on the terminal unit and shall be constructed of 1/2" copper tube with aluminum plate fins. Tested at the factory to 250 PSI hydrostatic pressure. Control valves shall be provided by the temperature control subcontractor as described in Section 230923. Output capacity and rows as scheduled on the Contract Drawings.

D. Terminal Volume Controller (Microprocessor Based):

1. Provide unit with air flow velocity and total pressure sensor suitable for up to 3000 fpm inlet velocity. Sensor shall be averaging type with multiple sampling points on cross grids. Pressure independent microprocessor based electronic controller shall modulate air flow to maintain space temperature.

2. Provide a 24 volt electric damper actuator. The actuator shall be reversible with a switch and have a visual position indicator. The stroke time shall be 75-150 seconds at 0-53 in-lbs torque. The unit shall have a 3 foot long plenum rated cable. The housing shall be NEMA type 2 with a flammability rating conforming to UL94. The actuator shall be maintenance free and have a minimum life span of 60,000 cycles. Actuator shall be Bellimo NM24-1US, or equal.

3. Provide factory-mounted transformers for controller and actuator suitable for 120 volt, 1 phase input power. Multiple boxes (approximately 6 to 8) shall be powered off of one terminal unit transformer through a low voltage power loop. Coordinate with the Control Contractor which terminal units require transformers.

4. Wall mounted thermistor type electronic space sensor provided by Control subcontractor unit manufacturer. Controller shall interface with the DDC control system to provide analog outputs for space temperature and air flow and accept analog inputs to position the actuator for warm-up or pull-down and change space temperature set-point for night set-back, set-up or occupancy sensor status. Controller shall sequence reheat coil and remote radiation to maintain space temperature.

5. The VAV box manufacturer shall provide the box, airflow sensor microprocessor based controller and damper actuator. The temperature control subcontractor shall ship the microprocessor based controller to the VAV box manufacturer's factory for mounting and calibration.

E. Design Equipment: Titus.

F. Acceptable Makes: Price, Titus, Trane.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Suspend terminal units from the building structural system independent of the ceiling system. If this cannot be accomplished, provide additional intermediate angle iron from which the units shall be suspended. Level each unit. Access to terminal unit controls shall be accomplished by remove of ceiling panels or through an access door. Coordinate locations of access doors.

END OF SECTION

SECTION 233623

CHILLED BEAMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Provide labor, materials, equipment and services as required for the complete installation as designed in the contract documents and per the General Conditions, Supplementary Conditions.

1.02 SUMMARY

A. Furnish and install active chilled beam units herein specified and as the lengths and quantities indicated on the Drawings.

1.03 REFERENCE STANDARDS

A. ASTM-653

B. ASTM-C1071-05

C. ASTM-E84 25/50

D. UL 94 V-0

E. UL 2043

F. UL 181

G. AHRI 410

H. ASHRAE 62-2010

1.04 SUBMITTALS

A. The following submittal data shall be furnished according to General Conditions and shall include, but not be limited to:

1. Performance Data:

a. Sensible cooling capacities based on room conditions.

b. Latent cooling capacities based on room conditions.

c. Primary, induced and total airflow rates.

d. Airside pressure loss.

e. Chilled and hot water flow rates.

f. Waterside pressure loss.

g. Supply air leaving temperature (primary + induced) in cooling and (where applicable) heating operation.

h. Sound pressure levels expressed in NC including 10 dB room absorption.

i. Sound power levels in octave bands.

j. Selection software used to predict active beam performance shall be provided along with verified unit performance test data by an independent testing laboratory.

2. Mechanical Data:

a. Unit weights and dimensions

b. Mounting bracket detail

c. Manufacturers recommendations for installation

1.05 WARRANTY

A. The manufacturer shall warranty the product for a minimum of one year from defects in manufacturing.

PART 2 – PRODUCTS

2.01 CONCEALED ACTIVE CHILLED BEAM UNITS

A. Concealed active chilled beam units shall be as indicated on the Mechanical and Architectural Drawings and shall meet the capacity and acoustical performance requirements specified and indicated on the schedule and Contract Documents. Cooling and heating performance data shall be based on the installation above a one or two way discharge diffuser with a maximum airflow resistance of 0.03 in H2O. Concealed active chilled beam performance data shall be verified by an independent test laboratory.

B. Concealed active chilled beams shall be designed to fit in the ceiling cavity mounted above a one or two way discharge linear diffuser (by Dadanco or others). All units shall consist of a casing, primary air plenum, water coil frame and mixing chamber manufactured from 20 GA G-60 galvanized sheet steel conforming to ASTM-653 standards. The primary air plenum shall deliver air through a series of induction nozzles and into a mixing chamber. Secondary air shall be drawn into the side of the unit through the vertically mounted water coil and combined with the primary air in the mixing chamber. A single oval air connection spigot shall be mounted on the side or at the end of the unit as indicated on the Drawings. All sheet metal joints in the primary air plenum and air connection spigot shall be sealed airtight. The overall height of the unit shall not exceed 11¾”.

C. Primary air shall be discharged into the mixing chamber through multi-lobed induction nozzles. The size and quantity of nozzles shall be selected to provide the primary and secondary airflows at the inlet static pressure and noise levels specified. Nozzles shall be manufactured from UL 94 V-0 flame retardant thermoplastic.

D. Concealed active chilled beams shall be fitted with a commissioning tube for measuring the static pressure differential between the primary air plenum and the room. Each unit shall be provided with an airflow calibration chart showing primary airflow rate for given nozzle configuration at different static pressures.

E. Secondary water coils shall be two or four pipe configuration as indicated on the schedules. The single vertically mounted coil shall be manufactured with ½“ seamless copper tubing with a minimum 0.016” wall thickness mechanically expanded into corrugated aluminum fins spaced at 12 FPI (fins per inch). Coils shall be fitted with a condensate pan manufactured from welded G-60 galvanized steel and powder coated black. The condensate pan shall be sloped at least 1/8” per foot in accordance with ASHRAE standard 62 and fitted with a plastic capped ½” O.D copper drain connection. Water velocity in the tubes shall be at least 50 FPM and not exceed 240 FPM. The coils shall have a maximum working pressure of no less than 300 PSI and be factory tested for leakage at 500 PSI. Coils shall be rated in accordance with AHRI standard 410. Coil connections shall be ½“ O.D. bare copper for field sweating to the water circuit. Water coils connection handing shall be as shown on the Drawings.

F. Concealed active chilled beams shall be delivered to site clean and flushed. Each unit shall be labeled with identification tagging and commissioning requirements for primary air and chilled water flow. Units shall be individually packaged in cardboard cartons and palletized on wooden skids.

G. The manufacturer shall provide the following options where marked on the Schedules and Drawings:

1. ½“ thick thermal insulation applied to the interior of the primary air plenum to prevent condensation forming on the outside of the unit casing and the interior surfaces of the primary air chamber. Thermal insulation shall be manufactured in accordance with ASTM C1071-05, UL-181 (Air Erosion) and ASTM E84 25/50 (flame spread and smoke density) standards.

2. Removable lint screen shall be installed on the face of the coil.

3. ½“ NPT male threaded connections fitted to the water coil, suitable for field connection to a ½“ NPT female flexible hose.

4. ½“ NPT female threaded connections fitted to the water coil, suitable for field connection to a ½“ NPT male flexible hose.

5. ½“ diameter 18” long flexible hoses comprising a PTFE lined hose with stainless steel wire braided jacket rated for a maximum operating pressure of not less than 500 PSI at 200°F. Hoses shall be 100% tested for leakage at 100 PSI.

2.02 MANUFACTURERS

A. Design Make: Dadanco

B. Acceptable Manufacturers: Dadanco, Krueger, Titus

PART 3 – EXECUTION

3.01 INSTALLATION

A. All active chilled beam units shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations and as indicated on the Drawings.

B. Active chilled beams shall be independently suspended from the structure at four points with either ⅜" diameter suspended rods or code approved suspension wire.

C. Air connections to the main primary air duct shall be made with flexible duct with all joints sealed and made airtight.

D. The piping system shall be flushed to remove all debris before connecting to the active chilled beams. Water connections shall be flexible hoses or hard connection using sweated fittings.

E. Flexible hoses shall comprise a PTFE lined hose with stainless steel wire braided jacket rated for a maximum operating pressure of not less than 500 PSI at 200°F.

3.02 MOCK-UP INSTALLATION

A. Prior to installation of multiple active chilled beam units, the Contractor shall install a sample unit as a mock-up generally representative of a typical active chilled beam and ceiling installation. The mock-up installation shall be complete with piping, ductwork and water valves. The mock-up installation shall be located in one of the typical areas of the project. The Contractor shall advise the Engineer and Owners representative after the mock-up is complete and arrange a suitable time for inspection and review to determine any changes and modifications that need to be made for the installation to be acceptable to the Engineer and Owner. The Contractor shall provide the required modifications and additional follow-up field inspections as required without additional cost to the Owner.

END OF SECTION

SECTION 233713

REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Registers/Grilles/Diffusers. Submit room schedule listing size, throw, direction of throw, accessories, finish, material type and color chart.

1.03 GENERAL REQUIREMENTS

A. Each manufacturer shall check noise level ratings for registers and diffusers to insure that the sizes selected will not produce noise to exceed 30 db, "A" scale, measured at occupant level; notify Owner's Representative of problems prior to shop drawing submittal.

B. Pressure drop, air flow and noise criteria selection are based on design equipment. Manufacturers not submitting design equipment must provide written certification in the front of submittal that equipment submitted has been checked against and performs equal to the design equipment.

1.04 REQUIREMENTS FOR REGISTERS

A. General:

1. A register is defined as a grille plus a volume damper.
2. Registers shall be installed "sight-proof" where possible, i.e., high wall register with horizontal blades inclined up, or along a wall with blades facing the wall.
3. Borders and frames shall be of same material as register face unless specified otherwise.

B. Mounting Frames:

1. Provide with screw holes in register face punched and countersunk at factory, and mounting frame drilled and tapped to suit. Sponge rubber gasket between frame and wall or ceiling for all surface mounted frames.
2. Frame shall be overlap type and shall be suitable for type of ceiling where register is to be installed.

C. Finishes:

1. Baked enamel (of colors as selected from the manufacturer's standard color chart).

D. Design Equipment: Price unless otherwise noted.

E. Make: Titus, Price, Tuttle and Bailey

1.05 REQUIREMENTS FOR DIFFUSERS

A. General:

1. Provide four way blow unless otherwise noted.
2. Where manufacturer's size recommendations require duct sizes or connections differing from design Contractor shall provide at no change in Contract price.
3. Provide square to round neck transitions as required.
4. Provide sponge rubber gasket for all surface mounted frames.

B. Finishes:

1. Baked enamel (of colors as selected from the manufacturer's standard color chart).
2. Suitable for recessed mounting unless otherwise indicated. Frame style shall be suitable for type of ceiling in which diffuser is to be installed.

C. Design Equipment: Price unless otherwise noted

D. Make: Titus, Price, Tuttle and Bailey.

PART 2 - PRODUCTS

2.01 REGISTER TYPES

A. Type A (exhaust & return grilles):

1. Steel construction with 18 gauge frame and blades, with horizontal bars on a 3/4" spacing set at 35^{o} fixed deflection.
2. 1-1/4” wide flange.
3. The blades shall be parallel to the long dimension.
4. Model: Price model 535.

2.02 DIFFUSER TYPES

A. Type 1 (induction nozzle type):

1. 22 gauge steel construction, with face panel finished flush with ceiling system.
2. With optional directional air flow pattern controllers that are concealed behind the face or in the neck, as noted on plans.
3. Core shall be removable and securely held in place to the back pan without noise or vibration.
4. Horizontal air flow pattern.
5. Induction nozzles welded to each wing of the inner core. Nozzles shall be oriented at 45 degree angles in split opposite directions.
6. Panel size: 24" x 24", with square inlet as integral part of assembly. Provide with transition piece for attachment of round duct of diameter as noted on plans.
7. Model: Price model SMX.

B. Type 2 (perforated face diffuser):

1. Perforated air distribution face with minimum 51% free area. Face shall be removable with hinges connected to the back pan. Face shall be contracted of steel.
2. Heavy gauge steel back pan with connection collar as noted on drawings.
3. Size as noted on plans.
4. Model: Price model PDDR.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions. Rough-in or install per reflected ceiling plan or in locations instructed by Owner's Representative.

B. When the final connection to an exhaust or return grille is made, a 12” minimum height plenum box must be supplied to all grilles. Plenum dimensions shall match grille size.

END OF SECTION

SECTION 233726

LOUVERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Louvers including all blade types, finishes and arrangements.

B. Penthouses including materials, finishes and accessories.

C. Provide original color charts for selection of finish.

PART 2 - PRODUCTS

2.01 LOUVERS

A. Factory constructed aluminum louvers.

B. Provide mullions where blade lengths exceed 60 in.

C. With 1/2 " x 1/2" mesh, 14 gauge wire, aluminum birdscreen secured in removable frame, secured to back of louver.

D. Extruded sections 6063-T5 alloy, 0.081” minimum thickness, 6” deep, Double Drainable unless otherwise called for.

E. Sill extension and sill style as required by job conditions.

F. Standard anodized finish color as selected at review of submittal.

G. Size, type and free areas indicated in location as called for on the Contract Documents.

H. "Stormproof" design with special curb to trap rain.

I. One-piece structural head, sill, and jambs.

J. All stainless steel fasteners.

K. Design Equipment: Greenheck
.

L. Acceptable Make: Construction Specialties, Inc., Greenheck, Ruskin.

2.02 PENTHOUSES LOUVERED TYPE

A. Housing shall have heavy gauge extruded aluminum blades of the storm-proof style with corners mitered and welded.

B. Roof and curb caps shall be formed of heavy gauge aluminum with the entire assembly braced by interior upright angles at the corners and along the sides.

C. Provide unit with mill finish.

D. Provide 12" high, insulated, double wall curb.

E. Provide aluminum bird screen.

F. Design Equipment: Greenheck.

G. Acceptable Make: Penn Ventilator, Greenheck, Cook.

PART 3 - EXECUTION

3.01 GENERAL

A. Install louvers and penthouses as per manufacturer's recommendations.

3.02 LOUVERS

A. Size called for is approximate wall/or masonry opening size. Adjust slightly to suit construction or coursing (review architectural drawings or field conditions for rough opening sizes). Louvers will be installed by General Contractor, assisted by this Contractor. Deliver in ample time. Slope ductwork and plenum to louver weephole or provide drain.

END OF SECTION

SECTION 236416

WATER CHILLER

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

B. Compliance with Mechanical Refrigeration Safety Code, ANSI B9.1, latest edition.

C. Manufacturers' installation booklets, written instructions, and diagrams are hereby made part of this Contract.

1.02 REFERENCES

A. Comply with applicable Standards/Codes of ARI 550/590-98, ANSI/ASHRAE 15, ASME Section VIII, NEC, and OSHA as adopted by the State.Equipment shall meet efficiency standards of ASHRAE Standard 90.1.

1.03 SUBMITTALS

A. Submit shop drawings and product data in accordance with contract specifications.

B. Provide KW/Ton at 25%, 50%, 75% and 100% of rated capacity.

C. Submittals shall include the following:

1. Dimensioned plan and elevation view drawings, required clearances, and location of all field connections.
2. Summary of all auxiliary utility requirements such as electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
3. Single line schematic drawing of the field power hookup requirements, indicating all items that are furnished.
4. Schematic diagram of control system indicating points for field connection. Diagram shall fully delineate field and factory wiring.
5. Water chilling unit and accessories. Motor starter. Auxiliaries and accessories.
6. Installation manual .

1.04 START-UP AND INSTALLATION DATA

A. Manufacturer of refrigeration machine responsible for:

1. Furnishing complete installation drawings, templates, wiring diagrams and instruction manuals for the equipment. Manufacturer's "Installation Instructions," "Initial Start-Up Instructions" and "Service Instructions" plus catalog indicating wiring and piping shall become a part of the Contract Documents.

2. Two additional copies of above data for Owner.

3. Submitting drawings, either made especially for this job or distinctly modified for

same; errors resulting from use of standard factory drawings, responsibility of this Contractor.

4. Supervising and checking installation for compliance with manufacturer's recommendations.

5. Checking out machines and actual start-up of same.

6. Advising and assisting this Contractor in making final adjustments.

   a. Regulating flows of condenser water, chilled water, and oil cooler water.
   b. Provide for proper balance and most economical operation.
   c. Under actual load conditions equal to at least 75% design conditions.

7. Thoroughly instructing Owner's operating personnel in proper operation of equipment, provide one day minimum of instruction.

1.05 TRAINING

A. Provide two (2) hours of training for up to six (6) Owner selected personnel.

1.06 WARRANTY

1. Standard Warranty (Domestic): The refrigeration equipment manufacturer's warranty shall be for a period of one (1) year from the date of equipment start up, but not more than eighteen (18) months from date of shipment. It shall cover replacement parts (labor not included) having proven defective within the above period, excluding refrigerant.

2. Extended Compressor Warranty: Four (4) years, parts only (total of 5 years).

PART 2 - PRODUCTS

2.01 CENTRIFUGAL CHILLER

A. UNIT DESCRIPTION

1. Provide and install as shown on the plans factory assembled, factory charged, water-cooled scroll compressor packaged chillers in the quantity specified. Each chiller shall consist of multiple hermetic scroll compressors, multi-circuit brazed plate or shell-and –tube evaporator, shell-and-tube water-cooled condensers, control system and all components necessary for controlled unit operation. Refrigerant shall be R-410A. Each chiller shall be factory run-tested with water to verify full load operation. Operating controls and refrigerant charge shall be verified for proper operation and optimum performance. Units with remote evaporators or condensers shall be tested with a temporary hook-up to a factory evaporator or condenser. Any deviation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments.

B. DESIGN REQUIREMENTS

1. General: Provide a complete scroll packaged chiller as specified herein and as shown on the drawings. The unit shall be in accordance with the standards referenced in section 1.02 and any local codes in effect.

2. Performance: Refer to the schedule of performance on the drawings. Performance shall be in accordance with applicable ARI Standard.

3. Acoustics: Sound pressure levels for the unit shall not exceed the following specified levels. The manufacturer shall provide the necessary sound treatment to meet these levels if required. Sound data shall be provided with the quotation. Test shall be in accordance with ARI Standard 575.

SOUND DATA with compressor blankets								
Sound Pressure (at 1 meter) – octave band at center frequency (with sound insulation)								
63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	Overall
76	70	71	75	73	71	66	58	78
Sound Power – octave band at center frequency (with sound insulation)								
63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	Overall
84	78	79	83	81	79	74	66	86

C. CHILLER COMPONENTS

1. Compressors: The compressors shall be sealed hermetic scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads.

2. Evaporator: The evaporator shall be shell-and-tube construction, insulated with 3/4 inch (19mm) closed cell polyurethane insulation, and with 150 psi (1033kPa) water-side working pressure.

3. Condenser: Horizontal shell and finned tube type with steel shell and integral finned copper tubes rolled into steel tube sheets. The chiller shall be equipped with intermediate tube supports. Construct condenser in accordance with the requirements of ASME Section VIII Unfired Pressure Vessel Code and ANSI B9.1 Safety Code. It shall be designed for 232 psi (1599 kPa) water side working pressure and 450 psig (3104 kPa) refrigerant side pressure and be provided with ASME, ANSI B9.1 pressure relief valves.

4. Refrigerant Circuit: Each refrigerant circuit shall include a liquid line shutoff valve, replaceable core filter-drier, sight glass with moisture indicator, liquid line solenoid valve, thermal expansion valve, and insulated suction line.

5. Control Panel: The control panel shall contain a microprocessor controller providing operating and equipment protection controls plus motor starting equipment, factory wired, operationally tested, and ready for operation. Standard components shall include a control transformer with primary and secondary fusing, microprocessor transformers with integral fusing, compressor contactors,

circuit breakers, single-point wiring arrangement and switches for each circuit pumpdown and unit control power. The control panel shall have a hinged tool-locked door. The control system shall stage the compressors based on the leaving water temperature. Equipment protection devices controlled by the microprocessor include motor protection, high pressure, loss of refrigerant, loss of water flow, freeze protection, and low refrigerant pressure. Controls shall include auto/stop switch, chilled water setpoint adjustment, anti-recycle timer, and digital display with water temperature and setpoint, operating temperatures and pressures, and diagnostic messages.

a. The following features and functions shall be included:

(1) The LCD-type display shall have a minimum of 20 characters with all messages in plain English. Coded messages are not acceptable.
(2) Critical parameters shall have their own section of control and shall be password protected.
(3) Resetting chilled water temperature by a remote 4-20mA DC signal.
(4) A soft load function to prevent the system from operating at full load during the chilled water pulldown period.
(5) An electronic time clock to allow programming of a yearly schedule accommodating weekends and holidays.
(6) Auto restart after a power failure, not requiring external battery backup or auxiliary power for maintaining program memory.
(7) Shutdowns shall be date and time stamped with system temperatures and pressures recorded. A minimum of six previous occurrences shall be kept in a revolving memory.
(8) Start-to-start and stop-to-start timers to provide minimum compressor off-time with maximum motor protection.
(9) Capability of communication with a PC or remote monitoring through a twisted pair RS-232 interface.
(10) Lead/lag manually or automatically by compressor number of starts.
(11) Continuous diagnostic checks of unit to provide a pre-alarm signal in advance of a shutdown allowing time for remedial action to be taken.

b. The controller shall contain the following features as a minimum:

(1) Unit Enable Selection - Enables unit operation from local keypad, digital input, or BAS.
(2) Unit Mode Selection - Selects standard cooling, ice, glycol, or test operation mode.
(3) Analog Inputs - Reset of leaving water temperature, 4-20 mA
(4) Digital Inputs:

(a) Unit off switch
(b) Remote start/stop
(c) Flow switch
(d) Ice mode, converts operation and setpoints for ice production
(e) Motor protection

(5) Digital Outputs:

(a) Shutdown alarm; field wired, activates on an alarm condition, off when alarm is cleared.
(b) Evaporator pump; field wired, starts pump when unit is set to start

(6) Limit Alarms:

(a) Condenser pressure stage down, unloads unit at high discharge pressures.
(b) Low ambient lockout, shuts off unit at low ambient temperatures.
(c) Low evaporator pressure hold, holds stage #1 until pressure rises.
(d) Low evaporator pressure unload, shuts off one compressor.

(7) Shutdown Alarms:

(a) No evaporator water flow
(b) Low evaporator pressure
(c) High condenser pressure
(d) Motor protection system
(e) Outside ambient temperature
(f) Evaporator freeze protection
(g) Sensor failures

c. Equipment Protection - The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.

6. Optional Building Automation System (BAS) Interface:

a. The unit shall be equipped with an optional factory-installed BAS communication module. Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARKS ® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

(1) BACnet MS/TP master (Clause 9)
(2) BACnet IP, (Annex J)
(3) BACnet ISO 8802-3, (Ethernet)
(4) LONMARKS FTT-10A. The unit controller shall be LONMARKS® certified.

D. OPTIONS AND ACCESSORIES

1. The following options are to be included:

    a. Acoustical compressor blankets

    b. High short circuit current rating with single-point disconnect switch

    c. Phase and under/over voltage protection

    d. Ground fault protection.

    e. The unit shall be shipped with spring vibration isolators for field installation per plans.

E. Design Equipment: Dakin Applied

F. Make: Daikin Applied, York, Carrier

2.02 REFRIGERANT MONITORING SYSTEM AND ASSOCIATED EQUIPMENT

A. Each refrigerating system erected on the premises shall be provided with an easily legible, permanent sign - securely attached and easily accessible indicating:

1. The name and address of the installer.

2. The kind and initial charge of refrigerant.

3. The field test pressure applied.

B. Systems containing more than 110 pounds of refrigerant shall be provided with durable signs having letters not less than 0.5” in height, designating valves for controlling the refrigerant flow and switches for the ventilation.

C. Emergency shutdown procedures, including precautions to be observed in case of a breakdown or leak shall be posted outside of the machinery room, immediately adjacent to each door. These precautions shall address:

1. Instructions for shutting down the system in case of emergency.

2. The name, address and day and night telephone numbers for obtaining service.

3. The name, address and telephone number of the municipal inspection department having jurisdiction, as well as instructions to notify said department immediately in case of emergency.

D. One permanently mounted, continuously operating refrigerant vapor monitor shall be mounted in the equipment room to detect the leakage of refrigerant from locations where the refrigerant is either stored or in use. Refer to specification section 230963 – Gas Monitoring Systems and Accessories.

PART 3 - EXECUTION

3.01 STORAGE

A. After setting in place the unit shall be protected by a temporary canvas and wood frame to seal out moisture and dirt and shall also be set higher than surrounding floor; Contractor shall provide an electric heater or lamps to maintain at least 50^{o}F at all times.

3.02 INSTALLATION

A. Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents. Chiller manufacturer must approve the refrigerant piping design.

B. Adjust and level chiller in alignment on supports

C. Coordinate electrical installation with Division 26.

D. Coordinate controls with control contractor.

E. Provide all appurtenances required to ensure a fully operational and functional chiller.

3.02 THIS CONTRACTOR RESPONSIBLE FOR

A. Providing 4" concrete pad.

B. Obtaining installation and wiring diagrams, piping diagrams from manufacturer.

C. Setting refrigeration machine on proper vibration isolation equipment. Install precisely according to vibration isolator manufacturer's installation details, with spring type isolators.

D. Providing piping, valves and accessories to connect condenser and chilled water flow switches, oil cooler piping, purge condenser and other miscellaneous special devices or piping required for actual machines and tower selected; obtain exact requirements from manufacturer of equipment.

E. Provide thermometers and pressure gauges at all inlets and outlets.

F. Coordinating Work of other trades in area adjacent to machines to insure adequate clearances for operating and service, as well as tube pulling space.

G. Guaranteeing system, including refrigerant charge for one year from date of acceptance.

H. Prevention of freeze-up from any cause.

I. Insulate completely as recommended by manufacturer those areas of unit not factory insulated.

J. Installation of power and control wiring not installed by Division 26, "Electric".

3.03 PIPING CONNECTIONS

A. Use stainless steel braided type flexible connectors at condenser and chilled water connections.

B. Extend relief valve discharge to "out-of-doors" using two pipe sizes larger than relief valve. Use galvanized or copper pipe.

C. Verify chilled water IN and OUT, and condenser water IN and OUT before piping.

D. Provide means of completely draining and venting chilled water and condenser water parts and piping.

E. Install thermostat-thermometer wells, flow switches, pressure gauges, as directed by manufacturer.

F. Install all air vents, drain valves, controls, and auxiliary piping or accessories.

3.04 ELECTRIC WIRING

A. Division 26, "Electric", will provide all power wiring to chillers, cooling towers, and pumps.

B. Provide control wiring at chillers, interlocks to cooling tower, chilled water pumps, condenser water pumps, connections to thermostats, flow switches, pressure switches, control circuit transformer (with current breaker), oil heater and oil pump.

C. Provide transformers, switches, relays or other electrical equipment required for operation.

3.05 START-UP AND TESTING

A. Provide testing, and starting of machine, and instruct the Owner in its proper operation and maintenance.

B. Ensure proper charge of refrigerant and oil.

C. Submit test and start-up reports to the Owner's Representative. Manufacturer shall provide parts list and provide written maintenance procedure.

D. Division 23 and the unit supplier shall cooperate with the Commissioning Agent during commissioning testing.

END OF SECTION

SECTION 236513

COOLING TOWERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTALS

A. Cooling tower unit and accessories.

B. Sweeper system and accessories.

C. Non-Chemical Water Treatment system and accessories.

1.03 START-UP AND INSTALLATION DATA

A. Manufacturer of cooling tower responsible for:

1. Furnishing complete installation drawings, templates, wiring diagrams and instruction manuals for the equipment. Manufacturer's "Installation Instructions," "Initial Start-Up Instructions" and "Service Instructions" plus catalog indicating wiring and piping shall become a part of the Contract Documents.

2. Two additional copies of above data for Owner.

3. Submitting drawings, either made especially for this job or distinctly modified for same; errors resulting from use of standard factory drawings, responsibility of this Contractor.

4. Supervising and checking installation for compliance with manufacturer's recommendations.

5. Checking out towers and actual start-up of same.

6. Advising and assisting this Contractor in making final adjustments.

   a. Regulating flow of condenser water.

   b. Provide for proper capacity control and most economical operation.

   c. Under actual load conditions equal to at least 75% design conditions.

7. Cooling tower shall be provided with the following parts only warranty:

   a. Entire unit: One (1) year from start-up, not to exceed eighteen (18) months from shipment.

b. Motor/Drive System: Five (5) year comprehensive warranty against materials and workmanship including motor, fan, bearings, mechanical support, sheaves, bushings and belt.

B. Installing contractor shall be responsible for providing one year free service and guarantee from date of final acceptance.

1.04 QUALITY ASSURANCE

A. Test and certify cooling tower thermal performance according to CTI Standard 201.

B. Test and certify cooling tower sound performance according to CTI ATC-128.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Furnish and install as shown on the plans an induced draft, counterflow, factory-assembled, industrial duty, cooling tower.

B. IBC Compliance: The unit structure shall be designed, analyzed, and constructed in accordance with the latest edition of the International Building Code (IBC) Regulations for seismic loads up to 1 g and wind loads up to 60 psf

C. The casing shall be constructed of heavy gauge G-235 hot-dip galvanized steel for long life and durability. The cold water basin shall be constructed of type 316 stainless steel.

D. Standard basin accessories shall include bypass, overflow, makeup and drain connections, removable stainless-steel strainer, electronic water level control and electric basin heaters.

E. Fan Motor(s):

1. Motors shall conform to the requirements of Section 230513 - Motors.

2. Motors shall be inverter capable, premium efficient, TEAO or TEFC.

3. Motor(s) shall be mounted on an adjustable base which is accessible from the outside of the unit for service.

F. Drive:

1. Drive: Power Band Belt designed for 150% of the motor nameplate HP.

2. Belt: Mutli-groove, solid back V-belt type neoprene reinforced with polyester cord.

3. Sheaves: Aluminum alloy if located inside the airstream.

G. Axial Propeller Fans:

1. Axial propeller, one piece heavy duty FRP hub and blade construction.

2. Galvanized steel closely fitted fan cowl with venturi air inlet for maximum fan efficiency, covered with a heavy gauge hot dip galvanized steel fan guard.

3. Maximum sound pressure level of 70 dB(A) measured at 5 feet above the fan discharge during full speed operation in accordance with CTI Standard ATC-128.

H. Fan Shaft Bearings:

1. Heavy duty, self-aligning pillow block bearings with lubrication lines extended to side access door. Minimum L10 life for bearings shall be 75,000 hours. Provide extended grease lines and fittings.

I. Fan Drive Warranty (Parts Only):

1. Motor/Drive System: Five (5) year comprehensive warranty against materials and workmanship including motor, fan, bearings, mechanical support, sheaves, bushings and belt.

J. Fill Media:

1. PVC; resistant to rot, decay and biological attack; formed, cross-fluted bonded together for strength and durability in block format for easy removal and replacement; suitable for use as a working surface; self-extinguishing with flame spread rating of 5 per ASTM E84-81a; able to withstand continuous operating temperature of 130°F; and fabricated, formed and installed by the manufacturer to ensure water breaks up into droplets.

K. Cold Water Basin:

1. Collection Basin Material shall be constructed of type 316 stainless steel.

2. Removable stainless-steel strainer with openings smaller than nozzle orifices.

3. Joints: Bolted and sealed watertight or welded.

L. Water Distribution System:

1. The spray header and branches shall be constructed of Schedule 40 PVC pipe for corrosion resistance and shall have a steel connection to attach the external piping.

2. The spray header and branches shall be removable for cleaning purposes.

3. Nozzles shall be non-clogging, ABS Plastic, threaded into branch piping.

M. Eliminators:

1. Shall be constructed of the same material as the Fill media.

2. Maximum drift rate shall be 0.001% or less of the recirculating water rate.

N. Louvers:

1. Air Inlet Louver Screens shall be formed PVC mounted in Type 316 stainless steel frames for easy removal; designed "Sight Tight" to completely block direct sunlight from entering and water from splashing out of the cooling tower.

O. Additional Accessories:

1. Provide full size bypass connection in tower basin with diffuser hood.

2. Water Level Control: Provide a 5-probe electronic water level control package shipped loose for field installation by installing contractor. Package shall include high/low alarm contacts, probe assembly, PVC standpipe, and slow-operating, normally closed, solenoid valve.

3. Vibration Cutout Switch: Provide a mechanical switch in NEMA 4 enclosure to de- energize fan motors if excessive vibration. Field wiring by installing contractor required.

4. Sweeper Piping: Provide factory installed sump sweeper piping with high flow educator nozzles.

5. Service Platform & Ladder: Provide an external service platform with ladder and safety cage shipped loose for field installation by installing contractor.

6. Motor Davit: Provide a mechanical jib-boom assembly to facilitate removal of larger fan section components.

P. Design Equipment: EVAPCO UT.

Q. Acceptable Make: Baltimore Air Coil, EVAPCO, Marley.

2.02 PACKAGED BASIN SWEEPING SOLID SEPARATION SYSTEM

A. Primary Purpose – The system shall remove unwanted solids from a cooling tower basin using a centrifugal-action vortex separator. The liquid-solids separation system shall help prevent particle fouling of the cooling system's components, reduce maintenance and servicing routines, maintain optimum energy efficiency of the heat exchange process, limit blow down practices help to control harmful bacteria growth in the basin/sump. Fluid viscosity must be 100 SSU or less.

B. A completely assembled package shall be supplied for the isolated recirculation and particle separation/filtration of the fluid in the cooling tower basin in order to prevent troublesome accumulation of solids in the tower basin. Flow through the separator package shall be continuous, without interruption for the periodic evacuation of separated solids. Sweeper piping shall be factory installed in the basin of the cooling tower by the cooling tower manufacturer. Field piping between the tower basin and the solid separation system shall be provided by the installing contractor. Placement of the separator package's inlet and outlet within the basin shall be strategically determined and supplemented where necessary with specific flow enhancement/agitation devices known as Hydroboosters.

C. System Performance Requirements:

1. Testing Requirements – Each unit shall be tested by the manufacturer prior to shipment to ensure it conforms to stated operating specifications.

2. Independent Testing Laboratory – Performance of said products must be verified by published results from an independent and identified testing laboratory. Standard test protocol of upstream injection, downstream capture, and separator purge recovery is allowed with 50-200 mesh particles to enable effective, repeatable results. Single pass test performance must not be less than 95% removal. Model tested must be of same flow-design as specified unit

D. Solids Removal Effectiveness:

1. In Recirculating Systems - 98% performance is predictable to as fine as 40 microns (given solids with a specific gravity of 2.6), with correspondingly higher aggregate performance percentages (up to 90%) of solids as fine as 5 microns.

E. Construction:

1. The separator package -- Shall provide for initial pre-straining prior to pump suction, followed by direct pumping through a specific centrifugal-action solids-from-liquid separator and immediate return of flow to the HydroBoosters. Separated solids shall be purged periodically to desired disposal with an automatic purge valve.

2. Strainer - Cast-iron housing; manual-cleaning; 9/32-inch minimum mesh rating; stainless steel basket.

3. Pump - End-suction, single stage; TEFC motor; cast iron housing; iron impeller; bronze shaft sleeve; silicon carbide mechanical shaft seal; flooded suction required.

4. Separator - Centrifugal-action design, incorporating a true tangential inlet and mutually tangential Swirlex internal accelerating slots, employed to promote the proper velocity necessary for the removal of the separable solids. The internal accelerating slots shall be spiral-cut for optimum flow transfer, laminar action and particle influence into the separation barrel. The separator's internal vortex shall allow this process to occur without wear to the accelerating slots. Separated particle matter shall spiral downward along the perimeter of the inner separation barrel, in a manner which does not promote wear of the separation barrel, and into the solids collection chamber, located below the vortex deflector plate. The separator shall be of unishell construction with SA-36, SA-53B or equivalent quality carbon steel, minimum thickness of .25 inches.

5. Automatic Purge Valve - An electrically-actuated valve shall be programmed at appropriate intervals and duration in order to efficiently and regularly purge solids from the separator's collection chamber. Valve body shall be bronze. Valve ball shall be stainless steel with Teflon seat.

6. Inlet and Outlet – Shall be grooved couplings.

7. Purge Outlet – Shall be threaded with a screw-on flange.

8. Piping -- Schedule 40 galvanized carbon steel.

9. Electrical Control -- IEC starter with overload module; HOA selector switch; NEMA-4x enclosure; re-set/disconnect/trip switch; 120 volt, single phase control voltage; CSA-approved.

10. Valves -- Ball valves on purge line for isolation of purging equipment and inlet/outlet valve kit shipped loose for field installation by installing contractor.

11. Skid Plate -- Stainless steel, 3/16-inch minimum thickness.

12. Paint Coating – Shall be oil-based enamel.

F. Purging:

1. Evacuation of separated solids shall be accomplished automatically, employing a motorized ball valve with integrally-equipped programming for controlling the frequency and duration of solids purging.

G. Manufacturers:

1. Design Equipment: LAKOS Filtration Systems.

2. Acceptable Manufacturers: LAKOS, BAC, TH Industrial Solutions

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions as shown on the drawings.

B. Provide all required supports, attachment devices, and accessories needed to insure stable, quiet operation.

C. Contractor shall field install cooling tower and specified accessories complete and functional as per manufacturer’s recommendations, including but not limited to: ladder, gate, railing, cage, motor, fan collar and guard, basin heater, basin heater controls, basin water level controls, and make-up valve.

D. Contractor shall field install sweeper system complete and function as per the manufacturer’s recommendations.

E. Provide representative of manufacturer for installation supervision and start up.

END OF SECTION

SECTION 237313

AIR HANDLING UNITS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Documents.

B. Coordinate work performed under this section with work performed under the separate installation contract.

1.02 REFERENCES

A. AMCA Standard 99: Standards Handbook.

B. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans.

C. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings.

D. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans.

E. AMCA Standard 500:Test Methods for Louvers, Dampers and Shutters.

F. ARI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil.

G. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

H. ASHRAE/ANSI Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.

I. UL Standard 1995: Heating and Cooling Equipment.

J. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.

1.03 QUALIFICATIONS

A. Manufacturer shall be a company specializing in the design and manufacture of commercial / industrial custom HVAC equipment. Manufacturer shall have been in production of custom HVAC equipment for a minimum of 5 years.

B. Each unit shall bear an ETL or UL label under UL Standard 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.

C. Units must comply with the ‘Made in America’ regulation.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under the supervision of the owner.

1.05 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 1.

B. Submittals shall include the following:

1. Dimensioned plan and elevation view drawings, including motor starter and control cabinets, required clearances, and location of all field connections.
2. Summary of all auxiliary utility requirements such as: electricity, water, compressed air, etc. Summary shall indicate quality and quantity of each required utility.
3. Ladder type schematic drawing of the power and ancillary utility field hookup requirements, indicating all items that are furnished.
4. Manufacturer's performance of each unit. Selection shall indicate, as a minimum, the following:
    a. Input data used for selection.
    b. Model number of the unit.
    c. Net capacity.
    d. Rated load amp draw.
    e. Noise levels produced by equipment.
    f. Fan curves.
    g. Approximate unit shipping weight.

1.06 OPERATION AND MAINTENANCE DATA

A. Include data on design, inspection and procedures related to preventative maintenance. Operation and Maintenance manuals shall be submitted at the time of unit shipment.

1.07 TRAINING

A. Provide two (2) hours of training for up to six (6) Owner selected personnel.

1.08 WARRANTY

A. The complete unit shall be covered by a parts warranty issued by the manufacturer covering the first year of operation. This warranty period shall start upon receipt of start-up forms for the unit or eighteen months after the date of shipment, whichever occurs first.

B. The installing contractor shall provide labor warranty during the unit's first year of operation

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Furnish and install where shown on the plans, mechanical frame style air handling units with construction features as specified below. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Air handling units shall be of the following basic design:

1. AHU-1: Single tunnel air handling unit with inlet section, return fan array, economizer/mixing section, filter section consisting of MERV-8 pre-filter and MERV-13 final filter, steam heating coil with face and bypass dampers, chilled water coil, supply fan array and discharge section. Collars for ductwork connection shall be located on same side (for supply, return, outside air, and relief) opposite coil connections and access doors.

2. AHU-2: Dual tunnel air handling unit with inlet section, return fan array, and economizer/mixing section in bottom tunnel, and filter section consisting of MERV-8 pre-filter and MERV-13 final filter, steam heating coil with face and bypass dampers, chilled water coil, supply fan array and discharge section located in top tunnel. Collars for ductwork connection shall be located on long sides of unit as shown on plan with supply connections located on both sides of the unit.

3. AHU-3: Dual tunnel air handling unit with inlet section, return fan array, and economizer/mixing section in bottom tunnel, and filter section consisting of MERV-8 pre-filter and MERV-13 final filter, steam heating coil with face and bypass dampers, chilled water coil, supply fan array and discharge section located in top tunnel. Collars for ductwork connection shall be located on long sides of the unit as shown on plan with supply and return connections located on same side of the unit as coil connections, opposite of outside air and relief duct connections.

4. AHU-4: Dual tunnel air handling unit with inlet section, return fan array, and economizer/mixing section in bottom tunnel, and filter section consisting of MERV-8 pre-filter and MERV-13 final filter, steam heating coil with face and bypass dampers, chilled water coil, supply fan array and discharge section located in top tunnel. Collars for ductwork connection shall be located on long sides of unit as shown on plan with supply and return connections located on both sides of the unit.

5. AHU-5: Single tunnel air handling unit with inlet section, return fan array, economizer/mixing section, filter section consisting of MERV-8 pre-filter and MERV-13 final filter, steam heating coil with face and bypass dampers, chilled water coil, supply fan array and discharge section. Collars for ductwork connection shall be located as shown on plan with outside air and relief connections on log side opposite the coil connections and access doors, return and supply connections on the ends of the unit.

6. MUA-1 – 4: Make-up air units shall consist of angled filter section, steam heating coil with face and bypass damper, supply fan and discharge section. Duct connections shall be on the ends of the units.

C. Each size fan to be supplied shall be tested in the manufacturer's laboratory under simulated installation conditions. Ratings based on test, not on interpolated or extrapolated calculation. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. Guaranteed sound power level ratings not exceeding those of design equipment or as scheduled.

D. Classification:

Maximum Total S.P.	Class
Up to 3-3/4 in. WG-STD	I
Up to 6-3/4 in. WG-STD	II

2.02 AIR HANDLING UNITS

A. General:

1. Provide factory-fabricated air handling units with capacity as indicated on the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer.

2. Units shall be completely assembled. Multiple sectioned units shall be shipped as a single factory assembled piece (except where shipping limitations prevent) de-mounted into modular sections in the field by the contractor. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by the contractor.

3. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARI 410.

4. All electrical components and assemblies shall comply with NEMA standards.

5. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.” Units shall comply with NFPA 70, “National Electrical Code,” as applicable for installation and electrical connections of ancillary electrical components of air handling units.

6. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors.

7. Operation and maintenance manuals shall be furnished with each unit. Units shall be UL or ETL listed.

8. Units shipped in multiple sections shall be engineered for field assembly. The 4” base frame shall have integral lifting lugs. The lifting lugs shall be fabricated from structural steel with an appropriate rigging hole. Lifting lugs shall be located at the

corner of each section (and along the sides if required) and sized to allow rigging and handling of the unit. All gasket and necessary assembly hardware shall ship loose with unit. Junction boxes with a factory supplied numbered terminal strip shall be supplied at each shipping split for reconnection of control wiring.

9. Unit perimeter base shall be completely welded and fabricated using heavy gauge structural steel tubing. Bolted bases are not acceptable. C-Channel cross supports shall be welded to perimeter base steel tubing and located on maximum 24" centers to provide support for internal components. Base rails shall include lifting lugs welded to perimeter base at the corner of the unit or each section if de-mounted. Entire base frame is to be painted with a phenolic coating.

10. Internal walk-on floor shall be 16 ga galvanized steel. The outer sub-floor of the unit shall be made from 20 ga galvanized steel. The floor cavity shall be spray foam insulated with floor seams gasketed for thermal break and sealed for airtight construction.

11. Where access is provided to the unit interior, floor openings shall be covered with walk on phenolic coated steel safety grating. Single wall floors with glued and pined insulation and no sub floor are not acceptable. Base frame shall be attached to the unit at the factory.

12. The construction of the air handling unit shall consist of a 1" x 2" steel frame with formed 3", 20 ga galvanized steel double wall construction. The exterior casing panels shall be attached to the gasketed 1" x 2" steel frame with corrosion resistant fasteners.

13. All casing panels shall be completely removable from the unit exterior without affecting the unit's structural integrity.

14. The air handling unit casing shall be of the "no-through-metal" design. The casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there's no path of continuous unbroken metal to metal conduction from inner to outer surfaces.

15. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection, additional internal reinforcing is required. All panel seams shall be caulked and sealed for an airtight unit.

16. Leakage rates shall be less than 1% at design static pressure or 9" W.C. whichever is greater. The unit exterior shall be polyester resin coated to meet or exceed ASTM B-117 salt spray resistance at 95F. 2500 hrs.

17. Entire unit to be insulated with a full 3" (R-12.5) thick non-compressed fiberglass insulation. The insulation shall have an effective thermal conductivity (C) of .24 (BTU in./sq.ft. °F) and a noise reduction coefficient (NRC) of 0.70 / per inch thick (based on a type "A" mounting).

18. The coefficients shall meet or exceed a 3.0 P.C.F. density material rating. Insulation shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88) and meet NFPA 90A and 90B.

19. All insulation edges shall be encapsulated within the panel. All perforated sections shall have Micromat® or equal insulation with non-woven mat facing, 5000 fpm rating and non-hygroscopic fibers as manufactured by Johns Manville or approved equal.

20. The units shall be equipped with a solid double wall insulated (same as the unit casing), hinged access doors as shown on the plans. The doorframe shall be extruded aluminum, foam filled with a built in thermal break barrier and full perimeter gasket. The door hinge assembly shall be completely adjustable die cast stainless steel. There shall be a minimum of two heavy duty handles per door. Provide ETL, UL 1995, and CAL-OSHA approved tool operated safety latch on all fan section access doors

    a. Access shall be provided at a minimum to: Fans, Filters, Economizer, Coils (both upstream and downstream), and to any electrical device.

B. Fan Section:

1. Make-Up Air Units:

    a. SWSI direct drive fans: Fan shall be single width single inlet plenum fan as indicated on the schedule.

    b. Fan blades shall be hollow airfoil in shape, welded to the center and wheel side plates. Fan bearings shall be heavy duty, self-aligning, type with full contact on shaft.

    c. Bearings shall be selected for a minimum L-10 life (100,000) hours at maximum horsepower and operating speed for the classification. Rigid support for the inlet bearing must be removable for access to the wheel. Inlet cone shall be precision spun.

    d. The fan shall be rated in accordance with AMCA 210 for performance and AMCA 300 for sound.

    e. Motors shall conform to specification section 230513 - Motors.

2. Indoor Air Handling Units:

    a. Multiple fan array systems for both supply and return fan systems. The system shall include multiple, direct driven, plenum fans constructed per AMCA requirements for the duty specified class III as required. Class I fans are not acceptable.

    b. Fans shall be rated in accordance with and certified by AMCA for performance. All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed.

    c. The fan array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed.

    d. Each fan/motor cube or cell shall include a minimum 10 gauge, G 90 Galvanized steel intake wall, .100 aluminum spun fan inlet funnel, and an 7 gauge HR steel (painted) motor support plate rail and structure.

e. All motors shall be standard foot mounted type TEAO selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2.

f. Motors shall meet the requirements of specification section 2301513 – Motors and be specifically design for use in multiple fan arrays that operate at varying synchronous speeds as driven by an approved VFD.

g. Motor HP shall not exceed the scheduled HP as indicated in the AHU equipment schedule(s).

h. Steel cased motors and/or ODP motors are not acceptable.

i. All motors shall include permanently sealed (L10-400,000 hr) bearings and AEGIS™ shaft grounding to protect the motor bearings from electrical discharge machining due to stray shaft currents.

j. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of .03" per second peak, filter in (.55mm per second peak, filter in).

k. The fan array shall consist of multiple fan and motor "cubes" or "cells", spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein.

l. In order to assure uniform velocity profile in the AHU cross section, the fan cube dimensions must be variable, such that each fan rests in an identically sized cube or cell, and in a spacing that must be such that the submitted array dimensions fill a minimum of 90% of the cross sectional area of the AHU air way tunnel.

m. There shall be no blank off plates or "spacers" between adjacent fan columns or rows to position the fans across the air way tunnel. The array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit to equal the specified cooling coil and/or filter bank face velocity by +/- 10% when measured at a point 36" from the intake side of the fan array intake plenum wall, and at a distance of 72" from the discharge side of the fan array intake plenum wall.

n. Each individual cube or cell in the multiple fan arrays shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan or multiple fans become disabled.

o. The system effects for the back flow prevention device(s) shall be included in the criteria for TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals.

p. Submitted AHU performance that does not indicate allowance for system effects for the back flow prevention device(s) and the system effect for the fan and motor enclosure in which each fan is mounted , will be returned to the contractor disapproved and will need to be resubmitted with all of the requested information included for approval.

q. Damper data must be for the specific purpose of preventing back flow in any disabled fan cube and that is mounted directly at the inlet of each fan. AHU Manufacturers that do not manufacture the fans being

submitted on must provide certified performance data for fans as installed in the AHU unit with Back Draft damper effects included. At the sole discretion of the engineer, such performance testing may be witnessed by the engineer and/or the owner's representative.

r. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of .022" per second peak, filter in (.55mm per second peak, filter in).

s. All fan and motor assemblies with 27" dia. and less shall be balanced to meet or exceed the G .55 residual unbalance. Fan and motor assemblies submitted for approval incorporating larger than 10 HP motors shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .022" per second peak filter in (.55 mm per second peak, filter in).

t. Fan arrays that meet the balancing specification do not require spring isolation.

u. Copies of the certified balancing reports shall be provided with the unit O&M manuals at the time of shipment. Submittals that do not include a statement of compliance with this requirement will be returned to the contractor without review.

3. Each fan system for MUA & AHU shall be individually wired to a control panel containing a single VFD as the primary VFD and a backup VFD wired in bypass. VFDs shall conform to specification section 260485.

4. Each VFD shall be sized for the total connected HP for all fan motors contained in the fan array.

5. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements.

6. The multiple fan array electrical panel shall include system optimization controls to actively control fan speed and to enable and disable fans in the multiple fan array. The number of active fans in the array shall be automatically determined, and the speed of the enabled fans shall be adjusted to produce the required coincidental flow and pressure at the perimeter boundary of the unit at substantially peak efficiency.

7. The system optimization controls shall continuously monitor required flow and pressure and shall automatically optimize the operating array configuration and speed for peak efficiency. System optimization controls shall be provided that will interface with, and be compatible with the BMS.

8. It is the responsibility of the contractor to assure that the fan system optimization controls are compatible with the BMS system.

9. System optimization controls shall be provided by the AHU unit manufacturer to assure single source responsibility for fan volume controls, and shall require only an input control signal from the controls installer for SP or flow for proper operation of the system optimization controls.

10. The AHU unit manufacturer shall provide a single communication interface with the BAS and shall coordinate with the controls installer to make sure that all necessary data points are communicated.

11. Each fan & motor assembly shall be removable through a 24" wide, free area, access door located on the discharge side of the fan wall array without removing the fan wheel from the motor. All fan/motor access doors shall open against pressure

12. All motors in the fan array shall be provided with individual Motor Protection for thermal overload protection. All motor circuit protectors can be located in starting device enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the fan array. Provide remote indication by means of aux contacts wired in series.

C. Steam Heating Coil Sections with Face and Bypass Damper:

1. The coil ratings shall be certified in accordance with ARI 410 standards.

2. The coil shall consist of an integral series of finned heating elements and element by-pass with interlocked dampers.

3. The coil shall be a non freeze design.

4. The coil shall be capable of maintaining constant discharge air temperatures regardless of variations in the entering air temperature, with full steam pressure on the coil at all times.

5. Coils shall be designed for service up to 200 PSIG and 400 deg F. Coils shall be factory tested at 300 PSIG air under water.

6. The heating elements shall consist of patterned 0.0075 thick aluminum plate fins applied to 5/8" OD, 0.035" wall thickness seamless copper tubes.

7. The finned elements shall be secured to a carbon steel header by means of a silver brazed joint. The supply/return header(s) shall be enclosed within the coil casing at the base of the unit and not exposed to the air stream. Elements shall be arranged in a vertical position with the supply and return connections located at the bottom of the unit, thus allowing for unrestricted expansion and contraction at the opposite end.

8. Casings shall be minimum 12 GA galvanized steel, braced and flanged (punched if necessary for duct or wall mounting). End casings shall have smooth, embossed tube holes to avoid abrasion during expansion and contraction.

9. Dampers shall be wrap around "clamshell" design. Dampers shall be minimum 16 GA galvanized steel with aluminum hinges & stainless steel pins. Interconnecting bars shall be stainless steel. Operator lever arms shall be welded to a common shaft for permanent alignment with pivots on bronze oilite bearings. The electric operator shall connect to the damper linkage via threaded ball joint rod ends.

10. Manufacturer Aerofin, Marlo, Wing.

D. Chilled Water Cooling Coil Section:

1. All coil assemblies shall be leak tested under water at 315 PSIG and performance is to be certified under ARI Standard 410. Coils exceeding the range of ARI standard rating conditions shall be noted.

2. Cooling coils shall be mounted on stainless steel support rack to permit coils to slide out individually from the unit. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout.

3. Water coils shall be constructed of seamless copper tubing mechanically expanded into fin collars. All fins shall be continuous within the coil casing to eliminate carryover inherent with a split fin design. Fins are die formed Plate type.

4. Headers are to be seamless copper with die formed tube holes.

5. Connections shall be male pipe thread (MPT) Schedule 40 Red Brass with 1/8" vent and drain provided on coil header for coil drainage. All coil connections shall be extended to the exterior of the unit casing by the manufacturer.

6. Coils shall be suitable for 250 PSIG working pressure. Intermediate tube supports shall be supplied on coils over 44" fin length with an additional support every 42" multiple thereafter.

7. Water coils shall have the following construction:

   a. 5/8" o.d. x .020" wall copper tube

   b. 0.028 return bends.

   c. 0.008" aluminum fins.

   d. 16 gauge stainless steel casing.

8. Drain Pan:

   a. IAQ style drain pans shall be provided under all cooling coils. The drain pan shall be fabricated from 16 gauge 304 stainless steel.

   b. All pans are to be triple pitched for complete drainage with no standing water in the unit.

   c. Pans shall be insulated minimum 3-inch with welded corners.

   d. Stainless steel, 1-1/4” MPT drain connection extended to the exterior of the unit base rail.

E. Filters:

1. Provide filters of the type indicated on the schedule.

2. Factory fabricated filter sections shall be of the same construction and finish as the unit. Face loaded pre and final filters shall have Type 8 frames as manufactured by BLC, FARR or equal.

3. Filter racks over 72" in length shall require an angle center reinforcement support.

4. Side service filter racks shall be fabricated from no less than 16 gauge galvanized steel and include hinged access doors as indicated on unit drawings.

5. Internal blank-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters.

6. Filter Gauge: Each Filter bank shall be furnished with Dwyer Series 2000 filter gauge or equal.

   a. MERV 8 Pleated PreFilters– 2” filters as specified on schedule. The filters shall be as manufactured by AAF, FARR or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters.

   b. MERV 13 Rigid Final filters - 12” deep filters as specified on the schedule. The filters shall be listed as Class II under UL Standard 900. The filters shall be as manufactured by AAF, FARR or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters.

F. Dampers:

1. Class 1 rated, ultra low leak dampers (less than 3 cfm/sq ft. @ 1” w.g.).

2. Dampers shall have extruded aluminum airfoil blades. The damper blade shall incorporate santoprene rubber edge seals and zinc plated or stainless steel tubular steel shaft for a non-slip operation.

3. Shaft bearings shall be spherical – non corrosive nylon.

4. Damper jamb seals shall be UV rated, nylon glass reinforced or stainless steel spring arcs designed for a minimum air leakage and smooth operation.

5. Damper linkage shall be concealed within a 16 gauge galvanized steel frame.

6. Temtrol TD-6, Ruskin CD-50 or approved equal.

2.03 ELECTRICAL POWER AND CONTROLS

A. All electrical and automatic control devices not previously called out or listed below are to be furnished and installed in the field by others.

B. All wiring shall be (75°C) Insulated copper wires.

C. The unit shall feature a mounted permanent nameplate displaying at a minimum the manufacturer, serial number, model number and current and amps voltage. The unit must have an ETL or UL Listing and bear the appropriate mark.

D. Conduit shall consist of a combination of EMT or flexible metal conduit as required. Liquidtite flexible metal conduit may be used outside the air tunnel for wet locations.

E. Provide a VFD panel with main disconnect for each unit. Furnish electromechanical starters for all auxiliary electric motors required. Starter shall include overload protection

devices in each of 3 phases. Contactors for electromechanical starters shall be UL.

F. Unit Convenience Features:

1. Each serviceable section shall be equipped with a vapor- proof 100 watt service light with guard.

2. Furnish a 120 volt GFI duplex convenience outlet on the exterior of the unit control panel

2.04 MANUFACTURERS

A. Design Equipment: Temtrol.

B. Acceptable Manufacturers: Temtrol, Innovent, Ingenia.

1. Contractor must be certain that equipment submitted fits properly into indicated space conditions, same as design equipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide equipment in accordance with manufacturer's recommendations and compatible with intent of the respective system performance requirements. Provide vibration isolators in accordance with manufacturer's recommendations, and as called for. Provide necessary steel supporting framework for equipment requiring same. Braced against swaying. Provide guards for exposed belts, shafts or fan wheels. Change pulley sizes as many times as necessary, as part of Contract, to make systems deliver specified quantities of air.

B. Pipe cooling coil pan drains to nearest floor drain. Trap offset dimension and trap seal depth shall be as per the air handling unit manufacturer’s recommendations.

C. Division 23 and unit supplier shall cooperate with the Commissioning Agent during final commissioning testing.

END OF SECTION

SECTION 238116

SPLIT SYSTEM AIR CONDITIONER

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide all labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Split system air conditioner, Manufacturer's wiring diagrams, Refrigerant piping schematics showing accessories.

1.03 GENERAL REQUIREMENTS

A. Provide units to fit intended use and location as indicated:

1. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories as scheduled and/or as necessary to obtain required results and allow for proper maintenance.

2. Unit capacities to be ARI, ASHRAE and AMCA rated.

3. Each size fan to be supplied shall be tested in the manufacturer's laboratory under simulated installation conditions. Ratings based on test, not on interpolated or extrapolated calculation.

4. Guaranteed sound-power level ratings not exceeding those of design equipment.

B. Motors:

1. Furnished by equipment manufacturer.

2. Horsepower as scheduled and type as required for each location and service.

3. Motors shall comply with requirements of Section 15A018, "Motors".

PART 2 - PRODUCTS

2.01 AIR HANDLING UNIT

A. Units shall be completely factory assembled including coil, condensate drain pan, fan, motor, filters and controls in an insulated casing. Units shall be UL listed and C.S.A. certified. Forward curved, dynamically and statically balanced fan with 3 speed direct drive. Fan motor bearing shall be permanently lubricated.

B. Units shall have sheet metal and steel frame construction and shall be painted with an enamel finish. Casing shall be insulated and knockouts shall be provided for electrical power and control wiring.

C. Unit shall have a single refrigerant circuit controlled by a flow control check valve (FCCV). Aluminum fin surface shall be mechanically bonded to 3/8 inch OD copper tubing. Coils shall be factory pressure and leak tested. Filters shall be one inch low velocity semi-permanent type.

2.02 CONDENSING UNIT

A. The condensing unit shall be fully charged from the factory for up to 10 feet of piping. The unit must be designed to operate at outdoor ambient temperatures as high as 115^{o}F. The unit shall be UL listed. Unit casing shall be constructed of heavy gauge, galvanized steel and painted with a weather-resistant powder paint finish.

B. Refrigeration system controls include condenser fan and compressor contactor. High and low pressure controls shall be inherent to the compressor. A factory installed liquid line dryer shall be standard. The compressor shall feature internal over temperature and pressure protection, total epoxy dipped hermetic motor windings, thermostatically controlled sump heater, centrifugal oil pump, and internal spring mounts to reduce vibration and noise. The coil shall be continuously wrapped, corrosion resistant all aluminum with minimum brazed joints. The coil shall be 3/8 inch O.D. seamless aluminum glued to a continuous aluminum fin. The coil shall be protected on all four sides by louvered panels.

2.03 MANUFACTURERS

A. Design Equipment: Mitsubishi.

B. Acceptable Make: Mitsubishi, LG, Daiken.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions and so as to be compatible with intent of the respective system performance requirements.

B. Hang unit in strict accordance with manufacturer's instruction.

C. Pipe coil pan drains to nearest floor drain and/or as indicated on Plans. Equip with P-trap.

D. Provide refrigerant piping and accessories to air cooled condensing unit as recommended by equipment manufacturer.

END OF SECTION

SECTION 238210

HYDRONIC GRAVITY HEATING EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit shop drawings on gravity heating equipment with color selection chart. Clearly indicate which equipment is being submitted.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All equipment shall be free from expansion, noises and strains. Exposed parts to be cleaned and parkerized or phosphate coated before prime coating or baked enameling. Finish colors as selected from manufacturers standard colors during the submittal process. Factory-boxed and tagged by room numbers. Access doors shall be provided in cabinet at locations of valves, flow balancers and air vents. Verify at site, the space available for each piece of equipment. Top of heating unit enclosures shall be at least 1 in. below top of windowsill. Bottom of heating unit enclosures, unless otherwise called for, approximately 6 in. above floor and above the base molding. Refer to Owner's representative at once, any correction, discrepancy or suggested change in size or location. This Contractor responsible for proper location and size of recesses. Coordinate dimensions from floor to bottom of recess with other trades. Provide framing in recess and shims, if required.

2.02 CONVECTORS

A. Heating Elements:

1. Seamless copper tubes, nonferrous fins, with cast iron headers.

2. Tubes mechanically expanded to fin collars for permanent metal-to-metal contact.

3. Top and bottom header connections at both ends; plug unused openings.

B. Cabinets and Enclosures:

1. Cold rolled furniture steel, constructed of minimum 20 gauge stock.

   a. Exposed corners and edges rounded.

2. Shower and Drying Room enclosures, all parts nonferrous and non-corrosive. Bolts and fasteners nonferrous.

3. Return grilles for all units except those which are wall hung.

4. Provide cam type catches on access doors. Access doors are not required on convectors with hinged-type mounting of cabinet front panel.

C. Recessed or semi-recessed units:

1. 14 gauge front and sides, 20 gauge back.

2. Fronts over 48” in length, shall have reinforcing members welded to back of front plate.

D. Wall hung type:

1. Sloping top.

2. 14 gauge, one-piece front; 20 gauge back, 16 gauge sides.

3. Enclosures over 36 in. in length to have reinforcing members welded to back of cover. Submit details for approval.

E. Dampers:

1. Provide in locations where automatic control is not installed.

2. Worm gear type nonferrous construction with two dissimilar metals and 1-1/2” diameter knurled aluminum knob.

F. Design Equipment: Rosemex.

G. Acceptable Make: AAF, Airtherm, Dunham-Bush, Rosemex, Sterling, Trane, Vulcan.

2.03 FIN RADIATION - HEAVY DUTY SECURITY TYPE

A. General Requirements:

1. Complete enclosure, continuous supporting channel backplate, heating element, hangers and accessories, as specified and shown on the Contract Drawings.

2. Enclosures to run from wall-to-wall unless otherwise called. Provide necessary corner pieces, end caps, column enclosures, butt trims, wall sleeves, with access doors. Do not leave any enclosure installed without an end trim piece.

B. Heating Element:

1. Hot Water System: Seamless copper tube with non ferrous fins, 125 lbs. minimum hydrostatic test pressure. .020" tube wall thickness, minimum. .020" fin thickness, minimum.

2. Tube mechanically expanded to fin collars for permanent metal to metal contact.

3. Properly support with pitch adjustment. Silent element and pipe support. Locate a maximum of 2'-0" apart. Support shall allow for lateral movement for expansion and contraction of heating equipment.

C. Enclosures:

1. Enclosure fronts, 14 gauge steel.

a. Sloping top with 1/8" diameter perforations on 3/16" centers. Enclosure shall have partial perforations at inlet and outlet.

b. Edges and corners rounded. Individual sections not over 6 ft.

c. Factory finished coat of baked enamel in a color selected by Architect.

2. Support channel partial backplate and supports, 14 gauge:

a. Securely fasten to wall.

b. Enclosure front braced by internal channel braces.

c. No sheet metal screws or other fastening devices shall be visible.

d. Provide wall brackets or stiffening supports adjacent to each joint and at least every 18”.

e. Field cut hole in enclosure bottom for upfeed piping.

D. Accessories:

1. Access panel at both ends of the enclosure.

E. Design Equipment: Rittling.

F. Make: Sterling, Vulcan, Shaw-Perkins.

2.04 FIN RADIATION

A. General Requirements:

1. Complete enclosure, continuous supporting channel backplate, heating element, hangers and accessories, as specified and shown on the Contract Drawings.

2. Enclosures to run from wall-to-wall unless otherwise called. Provide necessary corner pieces, end caps, column enclosures, butt trims, wall sleeves, with access doors. Do not leave any enclosure installed without an end trim piece.

B. Heating Element:

1. Hot Water System: Seamless copper tube with non ferrous fins, 125 lbs. minimum hydrostatic test pressure. .020" tube wall thickness, minimum. .020" fin thickness, minimum.

2. Tube mechanically expanded to fin collars for permanent metal to metal contact.

3. Properly support with pitch adjustment. Silent element and pipe support. Locate a maximum of 2'-0" apart. Support shall allow for lateral movement for expansion and contraction of heating equipment.

C. Enclosures:

1. Enclosure fronts 14 gauge furniture steel.

   a. Sloping top with stamped grille. Extruded aluminum anodized grille as scheduled on drawings.

   b. Edges and corners rounded. Individual sections not over 6 ft. No exposed areas shall have sharp edges.

   c. Mechanically fastened to wall bracket.

   d. Continuous interlocking slip joint fit between adjoining covers. Finish shall match enclosure fronts along entire male and female sides.

   e. Enclosure accessories shall fit tight to wall at sides, in back plate at top and extend back and mechanically screw to wall at bottom.

2. Support channel full backplate partial backplate with top wall gasket and supports:

   a. 18 gauge securely fasten to wall.

   b. Enclosure front braced by internal channel braces. Minimum on either side of joint seam.

   c. No sheet metal screws or other fastening devices shall be visible.

   d. Provide wall brackets or stiffening supports adjacent to each joint and at least every 16 in., maximum 24" O.C.

3. Top of cover rest on backplate only and not between wall and backplate.

4. Accessories:

   a. Pedestal brackets or bottom panel when required for style.
   b. With worm gear driven discharge damper and knurled aluminum knob.

D. Fin radiation scheduled as bare element shall be supported with manufacturer’s brackets with cradle attached to partial wall brackets.

E. Design Equipment: Rosemex.

F. Make: Rosemex, Sterling, Trane, Vulcan, Rittling.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each unit isolated with shut-off ball valves to permit servicing. Provide flow balancer for each unit as detailed. Provide trap for each unit as detailed. Contractor responsible for correct end connections and arrangements. Arrange piping accessories and valving fully accessible for servicing. Enclosures fastened to structure with screws or bolts, no nailing allowed. Fasten at 6 in. O.C. Provide air collecting chamber and manual vent on return end of each heating unit on all upfeed hot water installations.

END OF SECTION

SECTION 238230

PANEL RADIATION

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit shop drawings on gravity heating equipment with color selection chart. Clearly indicate which equipment is being submitted.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All equipment shall be free from expansion, noises and strains. Exposed parts to be cleaned and parkerized or phosphate coated before prime coating or baked enameling. Finish colors as selected from manufacturer's standard colors during the submittal process. Factory-boxed and tagged by room numbers. Access doors shall be provided in cabinet at locations of valves, flow balancers and air vents. Verify at site, the space available for each piece of equipment. Top of heating unit enclosures shall be at least 1 in. below top of windowsill. Bottom of heating unit enclosures, unless otherwise called for, approximately 6 in. above floor and above the base molding. Refer to Owner's representative at once, any correction, discrepancy or suggested change in size or location. This Contractor responsible for proper location and size of recesses. Coordinate dimensions from floor to bottom of recess with other trades. Provide framing in recess and shims, if required.

2.02 PANEL RADIATORS

A. Wall hung type:

1. Radiators manufactured of cold rolled low carbon steel, fully welded and consisting of header pipes at each end, connected by flat oval water tubes.

2. Tube wall thickness shall be Standard Pressure – 0.048" minimum.

3. Radiator header pipes shall be square, 0.109" min. wall thickness and include all necessary supply, return, and air vent connections. Internal baffling is required on installations with same end return.

4. Piping connections shall be 1/2" NPT taper threaded sockets, located in side positions. Air vent connections to be 1/8" NPT taper threaded sockets.

5. Working pressure of all headers and tubing to be Standard Pressure – 56 psi max (Factory tested at 74 psi) Radiator expansion shall not exceed 0.016" per linear foot at 215°F.

6. Radiators to be phosphatized and primed with flat white baked enamel.

7. Radiators shall be finish painted with gloss baked enamel, for a total paint thickness of 2 to 3 mils (0.002” to 0.003”).

8. Color of the finish painting shall be as scheduled or selected by the Architect.

B. Hangers:

1. Securely fasten to or in wall, as required.

2. Wall blocking as necessary for proper radiator mounting.

3. Horizontal and vertical adjustment.

4. Suitable for wall furrings as required.

5. Furnished by radiation manufacturer.

6. Hangers fastened only by 1/2" hook bolts set in masonry.

7. Lag bolts not acceptable.

8. Submit for approval.

C. Design Equipment: Rittling.

D. Make: Runtal, Dunham-Bush, Rittling.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each unit isolated with shut-off ball valves to permit servicing. Provide flow balancer for each unit as detailed. Provide trap for each unit as detailed. Contractor responsible for correct end connections and arrangements. Arrange piping accessories and valving fully accessible for servicing.

B. Standard Installation

1. Installation per manufacturer’s written recommendations.

C. Curved Installation:

1. Minimum of twice the number of hangers required for straight installation per manufacturer’s written recommendations.

END OF SECTION

SECTION 238231

RADIANT CEILING PANEL

PART 1 – GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit shop drawings on radiant panel heating equipment with color selection chart. Clearly indicate which equipment is being submitted. Provide 12" long sample showing face pattern, tubing in place, cross channels and clips in place.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All equipment shall be free from expansion, noises and strains. Exposed parts to be cleaned and parkerized or phosphate coated before prime coating or baked enameling. Finish colors as selected from manufacturers standard colors during the submittal process. Factory-boxed and tagged by room numbers. Verify at site, the space available for each piece of equipment. Refer to Owner's representative at once, any correction, discrepancy or suggested change in size or location.

B. All panels shall fit into 24” x 24” ceiling grid pattern.

2.02 RADIANT PANELS

A. General Requirements:

1. Provide complete system including all required accessories for installation without visible warp or deflection.

2. Enclosures to run continuous unless otherwise called. Size to accommodate thermal movement of the radiant system.

B. Modular (size as scheduled) Panels in Ceiling Systems:

1. Aluminum face plate (.040" thick minimum).

2. Copper tubing with .020" wall thickness 0.50” ID, metallurgically bonded to face plate.

3. Panel weight 1.5 lbs/ft. maximum.

4. Provide 1" thick unfaced fiberglass insulation on concealed face of panel.

C. Radiant panels shall be installed according to the manufacturer's recommendations for security installations.

D. Design Equipment: Rittling

E. Make: Airtex, Aerotech, Rittling.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each unit isolated with shut-off ball valves to permit servicing. Provide flow balancer for each group if 24 x24 sections, 4 max to a group as detailed. Contractor responsible for correct end connections and arrangements. Arrange piping accessories and valving fully accessible for servicing.

B. Connections to piping mains shall be made with Type "C" soft copper to avoid imposing thermal expansion stress of piping onto radiant panel system.

C. Main hot water system shall be flushed completely prior to flowing water through panel systems.

END OF SECTION

SECTION 238239

UNIT HEATERS AND CABINET UNIT HEATERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Specification addresses unit construction of hot water unit heaters, steam unit heaters, and hot water cabinet unit heaters.

B. Provide labor, materials, equipment and services as required for the complete installation and related work as shown on the Contract Documents.

1.02 SUBMITTALS

A. Unit heaters and cabinet unit heaters.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Free from expansion and contraction noises and strains. Fan speed shown on Schedule shall not be exceeded. Each piece of equipment factory-boxed and tagged by room number. Cabinet unit heaters and unit heaters shall have baked enamel finish with color selected by the Architect from manufacturer's standard colors. Rating in accordance with standard test codes adopted jointly by IUGA and ASHRAE.

2.02 UNIT HEATERS

A. General:

1. Ceiling suspended.

2. Access for servicing the heating element, motors, and controls.

3. Horizontal discharge units with adjustable horizontal and/or vertical outlet vanes.

4. Vertical units with adjustable outlet louvers or diffusers.

B. Fan and Motor:

1. Statically and dynamically balanced.

2. Motor shall be totally enclosed and designed for continuous operation. Lubrication shall be sealed-in, permanent type.

3. Unit mounted low voltage thermostat. Provide transformer.

C. Steam/Hot Water Heating Element:

1. Serpentine coil, copper tube, aluminum fins, back or side connections to fit headroom requirements.

2. Aquastat on return side to prevent fan operation when heat is not available.

D. Design Equipment: Sterling.

E. Acceptable Makes: Sterling, Rittling, Vulcan.

2.03 CABINET UNIT HEATERS

A. General:

1. Rough-in dimensions must not exceed those of design equipment.

B. Cabinet:

1. Front and exposed parts, 16 gauge furniture steel, all others, 18 gauge steel.

2. Fronts shall be removable for access to interior parts.

3. Recessed or semi-recessed equipment to have four-side overlap, trim strips not acceptable.

C. Fan and Motor:

1. Fans, forward curved, centrifugal type, direct drive from motor shafts.

2. Driven by totally enclosed motor with overload protection and lifetime lubrication.

a) Integral manual motor starter.

3. Shall be quiet in operation, not to exceed 45 db measured 5 ft. away, at high speed.

4. Three speed accessible fan selector switch.

5. Unit mounted low voltage thermostat. Provide transformer.

6. Permanent filter.

D. Hot Water Heating Element:

1. Nonferrous construction, copper tube, aluminum fins.

2. Multipass serpentine design for high temperature drop.

3. Aquastat on return side to prevent operation when heat is not available.

E. Design Equipment: Sterling.

F. Acceptable Makes: Sterling, Rittling, Vulcan.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Provide equipment in accordance with manufacturer's printed instructions. Report untrue walls before installation. Report cases where clearance below suspended heaters is less than 7-1/2 ft. Provide clearance for piping and conduit. Support units independent of piping. Support units from building structure, with screws or bolts, no nailing allowed. Be responsible for proper location and size of recesses. Coordinate installation of recessed or semi-recessed equipment in recesses. Provide framing in recess and shims. Use sponge rubber gasket air-seal between front enclosure and wall.

B. Provide valves and accessories and arrange to permit servicing. Coordinate correct end connections and coil arrangements.

END OF SECTION