SECTION 230500 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, tools, materials, accessories, parts, transportation, taxes, and related items, essential for installation of the work and necessary to make work, complete, and operational. Provide new equipment and material unless otherwise called for. References to codes, specifications and standards called for in the specification sections and on the drawings mean, the latest edition, amendment and revision of such referenced standard in effect on the date of these contract documents. All materials and equipment shall be installed in accordance with the manufacturer's recommendations.

1.2 LICENSING

A. The Contractor shall hold a license to perform the work as issued by the authority having jurisdiction.

B. Plumbing contract work shall be performed by, or under, the direct supervision of a licensed master plumber.

C. Electrical contract work shall be performed by, or under, the direct supervision of a licensed electrician.

1.3 PERMITS

A. Apply for and obtain all required permits and inspections, pay all fees and charges including all service charges. Provide certificate of approval from the Authorities Having Jurisdiction prior to request for final payment.

B. Provide electrical inspection certificate of approval from Middle Department Inspection Agency, Commonwealth Inspection Agency, or an Engineer approved Inspection Agency prior to request for final payment.

1.4 CODE COMPLIANCE

A. Provide work in compliance with the following:

1. 2020 Building Code of New York State.
2. 2020 Fire Code of New York State.
3. 2020 Plumbing Code of New York State.
4. 2020 Mechanical Code of New York State.
5. 2020 Fuel Gas Code of New York State.
6. 2020 Property Maintenance Code of New York State.
7. 2020 Energy Conservation Code of New York State

8. Accessible and Usable Buildings and Facilities, ICC A117.1 (2009).
9. New York State Department of Labor Rules and Regulations.
10. New York State Department of Health.
11. 2017 National Electrical Code (NEC).
12. Occupational Safety and Health Administration (OSHA).
13. Local Codes and Ordinances.
14. Life Safety Code, NFPA 101.

1.5 GLOSSARY

ACI	American Concrete Institute
AGA	American Gas Association
AGCA	Associated General Contractors of America, Inc.
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AFBMA	Anti-Friction Bearing Manufacturer's Association
AMCA	Air Moving and Conditioning Association, Inc.
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASTM	American Society for Testing Materials
AWSC	American Welding Society Code
AWWA	American Water Works Association
FM	Factory Mutual Insurance Company
IBR	Institute of Boiler & Radiation Manufacturers
IEEE	Institute of Electrical and Electronics Engineers
IRI	Industrial Risk Insurers
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association

NYS/DEC	New York State Department of Environmental Conservation
SBI	Steel Boiler Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UFPO	Underground Facilities Protective Organization
UL	Underwriter's Laboratories, Inc.
OSHA	Occupational Safety and Health Administration
XL - GAP	XL Global Asset Protection Services

1.6 DEFINITIONS

Acceptance	Owner acceptance of the project from Contractor upon certification by Owner's Representative.
As Specified	Materials, equipment including the execution specified/shown in the contract documents.
Basis of Design	Equipment, materials, installation, etc. on which the design is based. (Refer to the article, Equipment Arrangements, and the article, Substitutions.)
Code Requirements	Minimum requirements.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
Coordination Drawings	Show the relationship and integration of different construction elements and trades that require careful coordination during fabrication or installation, to fit in the space provided or to function as intended.
Delegated-Design Services	Performance and Design criteria for Contractor provided professional services. Where professional design services or certifications by a design professional are specifically required of a Contractor, by the Contract Documents. Provide products and systems with the specific design criteria indicated. If criteria indicated is insufficient to perform services or certification required, submit a written request for additional information to the Engineer. Submit wet signed and sealed certification by the licensed design professional for each product and system specifically assigned to the Contractor to be designed or certified by a design professional. Examples: structural maintenance ladders, stairs and platforms, pipe anchors, seismic compliant system, wind, structural supports for material equipment, sprinkler hydraulic calculations.
Equal, Equivalent, Equal To, Equivalent To, As Directed and As Required	Shall all be interpreted and should be taken to mean "to the satisfaction of the Engineer".
Exposed	Work not identified as concealed.
Extract	Carefully dismantle and store where directed by Owner's Representative

	and/or reinstall as indicated on drawings or as described in specifications.
Furnish	Purchase and deliver to job site, location as directed by the Owner's Representative.
Inspection	Visual observations by Owner's site Representative.
Install	Store at job site if required, proper placement within building construction including miscellaneous items needed to affect placement as required and protect during construction. Take responsibility to mount, connect, start-up and make fully functional.
Labeled	Refers to classification by a standards agency.
Manufacturers	Refer to the article, Equipment Arrangements, and the article, Substitutions.
Prime Professional	Architect or Engineer having a contract directly with the Owner for professional services.
Product Data	Illustrations, standard schedules, performance charts, instructions, brochures, wiring diagrams, finishes, or other information furnished by the Contractor to illustrate materials or equipment for some portion of the work.
Provide (Furnish and Install)	Contractor shall furnish all labor, materials, equipment and supplies necessary to install and place in operating condition, unless otherwise specifically stated.
Relocate	Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use.
Remove	Dismantle and take away from premises without added cost to Owner, and dispose of in a legal manner.
Review and Reviewed	Should be taken to mean to be followed by "for the limited purpose of checking for conformance with information given and the design concept expressed in the Contract Documents".
Roughing	Pipe, duct, conduit, equipment layout and installation.
Samples	Physical full scale examples which illustrate materials, finishes, coatings, equipment or workmanship, and establishes standards by which work will be judged.
Satisfactory	As specified in contract documents.
Shop Drawings	Fabrication drawings, diagrams, schedules and other instruments, specifically prepared for the work by the Contractor or a Sub-contractor, manufacturer, supplier or distributor to illustrate some portion of the work.
Site Representative	Owner's Inspector or "Clerk of Works" at the work site.
Submittals Defined (Technical)	Any item required to be delivered to the Engineer for review as requirement of the Contract Documents. The purpose of technical submittals is to demonstrate for those portions of the work for which a submittal is required, the manner in which the Contractor proposes to conform to the information given and design concepts expressed and required by the Contract Documents.

1.7 SHOP DRAWINGS/PRODUCT DATA/SAMPLES

A. Provide submittals on all items of equipment and materials to be furnished and installed. Submittals shall be accompanied by a transmittal letter, stating name of project and contractor, name of vendor supplying equipment, number of drawings, titles, specification sections (name and number) and other pertinent data called for in individual sections. Submittals shall have individual cover sheets that 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. Individual piecemeal or incomplete submittals will not be accepted. Similar items, (all types specified) shall be submitted at under one cover sheet per specification section (e.g. valves, plumbing fixtures, etc.). Number each submittal by trade. Indicate deviations from contract requirements on Letter of Transmittal. Submittals will be given a general review only. Corrections or comments made on the Submittals during the review do not relieve 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. If submitting hard copies, submit four (4) copies for review.

B. If submittals are to be submitted electronically, all requirements in Item A apply. Submittals shall be emailed in PDF format to specific email address provided by the Construction Manager, General Contractor, Architect or Project Manager. Name of project shall be in subject line of email. Send emails to mealbasubmittalclerk@meengineering.com.

C. Refer to Division 01 for additional requirements.

1.8 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 required to provide safe conditions for all workmen and site visitors.

1.9 EQUIPMENT ARRANGEMENTS

A. The contract documents are prepared using one manufacturer as the Basis of Design, even though other manufacturers' names are listed. If Contractor elects to use one of the listed manufacturers other than Basis of Design, submit detailed drawings, indicating proposed installation of equipment. Show maintenance clearances, service removal space required, and other pertinent revisions to the design arrangement. Make required changes in the work of other trades, at no increase in any contract. Provide larger motors, feeders, breakers, and equipment, additional control devices, valves, fittings and other miscellaneous equipment required for proper operation, and assume responsibility for proper location of roughing and connections by other trades. Remove and replace doorframes, access doors, walls, ceilings, or floors required to install other than Basis of

Design. If revised arrangement submittal is rejected, revise and resubmit specified Basis of Design item which conforms to Contract Documents.

1.10 SUBSTITUTIONS

A. If Contractor desires to bid on any other kind, type, brand, or manufacture of material or equipment than those named in specifications, secure prior approval. To request such approval, Contractor shall submit complete information comparing (item-for-item) material or equipment offered with design material or equipment. Include sufficient information to permit quick and thorough comparison, and include performance curves on same basis, capacities, power requirements, controls, materials, metal gauges, finishes, dimensions, weights, etc., of major parts. If accepted, an addendum will be issued to this effect ahead of bid date. Unless such addendum is issued, substitution offered may not be used.

1.11 UTILITY COMPANY SERVICES

A. Division 26 shall make arrangements with National Grid for electric service to the Owner's distribution equipment. Provide underground or overhead electric service as called for and transformers, meter sockets or meter compartments as required by the Utility Company. Coordinate all activities between the Owner and Utility Company. The installation of the electric service shall comply with the published Utility Company standards

B. Division 22 shall make arrangements with National Grid for gas service to the Owner's distribution system. Provide service to the building as required by the Utility Company. Coordinate all activities between the Owner and Utility Company. The installation of the gas service shall comply with the published Utility Company standards

1.12 ROUGHING

A. The Contract Drawings have been prepared in order to convey design intent and are diagrammatic only. Drawings shall not be interpreted to be fully coordinated for construction.

B. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, interferences, etc. Make necessary changes in contract work, equipment locations, etc., as part of a contract to accommodate work to avoid obstacles and interferences encountered. Before installing, verify exact location and elevations at work site. DO NOT SCALE plans. If field conditions, details, changes in equipment or shop drawing information require an important rearrangement, report same to Owner's Representative for review. Obtain written approval for all major changes before installing.

C. Install work so that items both existing and new are operable and serviceable. Eliminate interference with removal of coils, motors, filters, belt guards and/or operation of doors. Provide easy, safe, and code mandated clearances at controllers, motor starters, valve access, and other equipment requiring maintenance and operation. Provide new materials, including new piping and insulation for relocated work.

D. Coordinate work with other trades and determine exact route or location of each duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Obtain from Owner's Representative exact location of all equipment in finished areas, such as thermostat, fixture, and switch mounting heights, and equipment mounting heights. 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.

E. Before roughing for equipment furnished by Owner or in other Divisions, obtain from Owner and other Divisions, 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. For equipment and connections provided in this contract, prepare roughing drawing as follows:

1. Existing Equipment: Measure the existing equipment and prepare for installation in new location.

2. New Equipment: Obtain equipment roughing drawings and dimensions, then prepare roughing-in-drawings. If such information is not available in time, obtain an acknowledgement in writing, then make space arrangements as required with Owner's Representative.

1.13 COORDINATION DRAWINGS

A. Before construction work commences, Divisions for all trades shall submit coordination drawings in the form of CAD drawing files, drawn at not less than 1/4 in. scale. Such drawings will be required throughout all areas, for all Contracts. These drawings shall show resolutions of trade conflicts in congested areas. Mechanical Equipment Rooms shall be drawn early in coordination drawing process simultaneous with all other congested areas. Prepare Coordination Drawings as follows:

1. Division 23 shall prepare the base plan CAD coordination drawings showing all ductwork, all pertinent heating piping, and equipment. These drawings may be CAD files of the required Ductwork Shop Drawings. The drawings shall be coordinated with lighting fixtures, sprinklers, air diffusers, other ceiling mounted items, ceiling heights, structural work, maintenance clearances, electric code clearance, reflected ceiling plans, and other contract requirements. Reposition proposed locations of work after coordination drawing review by the Owner's Representative. Provide adjustments to exact size, location, and offsets of ducts, pipes, conduit, etc., to achieve reasonable appearance objectives. Provide these adjustments as part of contract. Minor revisions need not be redrawn.

2. Division 23shall provide CAD files and submit the base plan CAD Coordination Drawings to all Divisions.

3. Divisions 21 and 22 shall draw the location of piping and equipment on the base plan CAD Coordination Drawings, indicating areas of conflict and suggested resolutions.

4. Divisions 26, 27 and 28 shall draw the location of lighting fixtures, cable trays, and feeders over 1-1/2 in. on the base plan CAD Coordination Drawings, indicating areas of conflict and suggested resolution.

5. The General Construction Trade shall indicate areas of architectural/structural conflicts or obstacles on the CAD Coordination Drawings, and coordinate to suit the overall construction schedule.

6. The General Construction Trade shall expedite all Coordination Drawing work and coordinate to suit the overall construction schedule. In the case of unresolved interferences, he shall notify the Owner's Representative. The Owner's Representative will then direct the various trades as to how to revise their drawings as required to eliminate installation interferences.

7. If a given trade proceeds prior to resolving conflicts, then if necessary, that trade shall change its work at no extra cost in order to permit others to proceed with a coordinated installation. Coordination approval will be given by areas after special site meetings involving all Divisions.

B. The purpose of the coordination drawing process is to identify and resolve potential conflicts between trades, and between trades and existing or new building construction, before they occur in construction. Coordination drawings are intended for the respective trade's use during construction and shall not replace any Shop Drawings, or record drawings required elsewhere in these contract documents.

1.14 EQUIPMENT AND MATERIAL 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. Potable water systems and equipment shall be built according to AWWA Standards.

4. Gas-fired equipment and system shall meet AGA Regulations and shall have AGA label.

5. Fire protection equipment shall be UL listed and FM approved.

B. Exterior and wet locations shall utilize materials, equipment supports, mounting, etc. suitable for the intended locations. Metals shall be stainless steel, galvanized or with baked enamel finish as a minimum. Finishes and coatings shall be continuous and any surface damaged or cut ends shall be field corrected in accordance with the manufacturer's recommendations. Hardware (screws, bolts, nuts, washers, supports, fasteners, etc.) shall be:

1. Stainless steel where the associated system or equipment material is stainless steel or aluminum.

2. Hot dipped galvanized or stainless steel where the associated system or equipment is steel, galvanized steel or other.

1.15 CUTTING AND PATCHING

A. Each trade shall include their required cutting and patching work unless shown as part of the General Construction Contract. 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.

1.16 PAINTING

A. Paint all insulated and bare piping, pipe hangers and supports exposed to view in mechanical equipment rooms, penthouse, boiler rooms and similar spaces. Paint all bare piping, ductwork and supports exposed to the out-of-doors with rust inhibiting coatings. Paint all equipment that is not factory finish painted (i.e. expansion tanks, etc.).

B. All painting shall consist of one (1) prime coat and two (2) finish coats of non-lead oil base paint, unless otherwise indicated herein. Provide galvanized iron primer for all galvanized surfaces. All surfaces must be thoroughly cleaned before painting. Review system color coding prior to painting with the Owner's Representative or Architect.

C. All items installed after finished painting is completed and any damaged factory finish paint on equipment furnished under this contract must be touched up by the Contractor responsible for same.

D. Include painting for patchwork with color to match adjacent surfaces. Where color cannot be adequately matched, paint entire surface. Provide one (1) coat of primer and two (2) finish coats or as called for in the Specifications.

E. All primers and paint used in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

F. Refer to Division 9 - Finishes, for additional information.

1.17 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.

1.18 CHASES

A. New Construction:

1. Certain chases, recesses, openings, shafts, and wall pockets will be provided as part of General Construction Trade. Mechanical and Electrical trades shall provide all other openings required for their contract work.

2. Check Architectural and Structural Design and Shop Drawings to verify correct size and location for all openings, recesses and chases in general building construction work.

3. Assume responsibility for correct and final location and size of such openings.

4. Rectify improperly sized, improperly located or omitted chases or openings due to faulty or late information or failure to check final location.

5. Provide 18 gauge galvanized sleeves and inserts. Extend all sleeves 2 in. above finished floor. Set sleeves and inserts in place ahead of new construction, securely fastened during concrete pouring. Correct, by drilling, omitted or improperly located sleeves. Assume responsibility for all work and equipment damaged during course of drilling. Firestop all unused sleeves.

6. Provide angle iron frame where openings are required for contract work, unless provided by General Construction trade.

1.19 PENETRATION FIRESTOPPING

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 "Penetration Fire-Stop Systems". The system shall meet the requirements of "Fire Tests of Penetrations 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. Plastic pipe/conduit materials shall be installed utilizing intumescent collars.

6. Provide a submittal including products intended for use, manufacturer's installation instructions, and the UL details for all applicable types of wall and floor penetrations.

7. Fire-stopping products shall not be used for sealing of penetrations of non-rated walls or floors.

B. Acceptable Manufacturers:

1. Dow Corning Fire-Stop System Foams and Sealants.

2. Nelson Electric Fire-Stop System Putty, CLK and WRP.

3. S-100 FS500/600, Thomas & Betts.

4. Carborundum Fyre Putty.

5. 3-M Fire Products.

6. Hilti Corporation.

1.20 NON-RATED WALL PENETRATIONS

A. Each trade shall be responsible for sealing wall penetrations related to their installed work, including but not limited to ductwork, piping, conduits, etc. See individual specification sections for requirements.

1.21 SUPPORTS

A. Provide required supports, beams, angles, hangers, rods, bases, braces, and other items to properly support contract work. 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.

B. For precast panels/planks and metal decks, support mechanical/electrical work as determined by manufacturer and the Engineer. 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.

C. For finished areas without a finished ceiling system such as classrooms, offices, conference rooms, etc., where decking and structure is exposed, and ductwork/piping/conduit is exposed: All mounting brackets, channel support systems and mounting hardware for ductwork, piping, lighting, etc. shall be concealed and approved by the Architect/Engineer prior to the installation. AirCraft cable style hanging for ductwork is required. It is recommended that room mockups be done and receive Architect/Engineer approval prior to proceeding with installation.

D. Equipment, piping, conduit, raceway, etc. supports shall be installed to minimize the generation and transmission of vibration.

E. Materials and equipment shall be solely supported by the building structure and connected framing. Gypboard, ceilings, other finishes, etc. shall not be used for support of materials and equipment.

1.22 ACCESS PANELS

A. Provide access panels for required access to respective trade's work. Location and size shall be the responsibility of each trade. Access panels provided for equipment shall provide an opening not smaller than 22 in. by 22 in. Panels shall be capable of opening a minimum of 90 degrees. Bear cost of construction changes necessary due to improper information or failure to provide proper information in ample time. Access panels over 324 square inches shall have two cam locks. Provide proper frame and door type for various wall or ceiling finishes. Access panels shall be equal to "Milcor" as manufactured by Inland Steel Products Co., Milwaukee, Wisconsin. Provide General Construction trade with a set of architectural plans with size and locations of access panels.

1.23 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. Bases 4 in. high (unless otherwise indicated); shape and size to accommodate equipment. Provide anchor bolts in equipment bases for all equipment provided for the project, whether mounted on new concrete bases or existing concrete bases.

1.24 HVAC EQUIPMENT CONNECTIONS

A. Contractor is responsible for draining, filling, venting, chemically treating and restarting any systems which are affected by work shown on the Contract Documents unless specifically noted otherwise.

B. Provide final 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 drain connections extended to floor drains.

C. 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.

1.25 PLUMBING EQUIPMENT CONNECTIONS

A. Contractor is responsible for draining, filling, venting, chemically treating and restarting any systems which are affected by work shown on the Contract Documents unless specifically noted otherwise.

B. Provide roughing and final connections to all equipment. Provide loose key stops, sanitary "P" traps, tailpiece, adapters, gas or air cocks, and all necessary piping and fittings from roughing point to equipment. Provide installation of sinks, faucets, traps, tailpiece furnished by others. Provide cold water line with gate valve and backflow prevention device at locations called for. Provide continuation of piping and connection to equipment that is furnished by others. Provide relief valve discharge piping from equipment relief valves.

C. Provide valved water outlet adjacent to equipment requiring same. Provide equipment type floor drains, or drain hubs, adjacent to equipment.

D. Install controls and devices furnished by others.

E. Refer to Contract Documents for roughing schedules, and equipment and lists indicating scope of connections required.

F. Provide for Owner furnished and Contractor furnished equipment all valves, piping, piping accessories, traps, pressure reducing valves, gauges, relief valves, vents, drains, as required.

1.26 ELECTRICAL EQUIPMENT CONNECTIONS

A. Provide complete power connections to all electrical equipment. Provide control connections to equipment. Heavy duty NEC rated disconnect ahead of each piece of equipment. Ground all equipment in accordance with NEC.

B. Provide for Owner furnished and Contractor furnished equipment all power wiring, electric equipment, control wiring, switches, lights, receptacles, and connections as required.

1.27 STORAGE AND PROTECTION OF MATERIALS AND EQUIPMENT

A. Store Materials on dry base, at least 6 in. aboveground 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.

B. Refer to Division 01 for additional information.

1.28 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.

1.29 OWNER INSTRUCTIONS

A. Before final acceptance of the work, furnish necessary skilled labor to operate all systems by seasons. Instruct designated person on proper operation, and care of

systems/equipment. Repeat instructions, if necessary. Obtain written acknowledgement from person instructed prior to final payment. Contractor is fully responsible for system until final acceptance, even though operated by Owner's personnel, unless otherwise agreed in writing. List under clear plastic, operating, maintenance, and starting precautions procedures to be followed by Owner for operating systems and equipment.

1.30 OPERATION AND MAINTENANCE MANUALS

A. Submit by email (preferred) or digital media, thru the normal project submittal process. Include a copy of each final approved Shop Drawing, wiring diagrams, piping diagrams, spare parts lists, final testing and balancing report, as-built drawings and manufacturer's instructions. Include typewritten instructions, describing equipment, starting/operating procedures, emergency operating instructions, summer-winter changeover, freeze protection, precautions and recommended maintenance procedures. Include name, address, and telephone number of installing contractor and of supplier manufacturer Representative and service agency for all major equipment items. Provide a table of contents page and dividers based upon specification section numbers. Submit in a compiled and bookmarked PDF format as outlined below.

B. Provide content for Operation and Maintenance Manuals as specified in individual Specification Sections, and as reviewed and approved at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. Engineer and Commissioning Agent will comment on whether content of operation and maintenance submittals is acceptable.

2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

C. Submit Operation and Maintenance Manuals in the following format:

1. Submit by uploading to web-based project software site, or by email to Architect, as a formal project submittal in conformance with the project specific submittal procedures. Enable reviewer comments on draft submittals.

2. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.

3. File Names and Bookmarks: Bookmark individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in the table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

D. Initial Manual Submittal: Submit draft copy of each manual at least 30 days before commencing Owner training. Engineer and Commissioning Agent will comment on whether general scope and content of manual are acceptable.

E. Final Manual Submittal: Submit O&M manual in final form prior to requesting inspection for Substantial Completion and at least 2 weeks before commencing Owner training. Engineer and Commissioning Agent will return copy with review comments.

1. Correct or revise O&M manual to comply with Engineer's and Commissioning Agent's comments. Submit copies of each corrected manual within 2 weeks of receipt of Engineer's and Commissioning Agent's comments.

F. Refer to Division 01 for additional requirements.

1.31 RECORD DRAWINGS

A. The Contractor shall obtain at his expense one (1) set of construction Contract Drawings, (including non-reproduction black and white prints or electronic files) for the purpose of recording as-built conditions.

B. The Contractor shall perform all survey work required for the location and construction of the work and to record information necessary for completion of the record drawings. Record drawings shall show the actual location of the constructed facilities in the same manner as was shown on the bid drawings. All elevations and dimensions shown on the drawings shall be verified or corrected so as to provide a complete and accurate record of the facilities as constructed.

C. It shall be the responsibility of the Contractor to mark EACH sheet of the contract documents in red and to record thereon in a legible manner, any and all approved field changes and conditions as they occur. A complete file of approved field sketches, diagrams, and other changes shall also be maintained. At completion of the work, the complete set of red marked contract documents, plus all approved field sketches and diagrams shall be submitted to the engineer and used in preparation of the record drawings.

D. A complete set of red marked contract drawings shall be submitted, at one time, as the "Record" set. If there are no changes to a specific drawing, the contractor shall indicate "NO CHANGES" on that drawing. ALL drawings shall be included in the "Record" set.

E. The complete set of red marked Contract Documents or electronic files shall be certified by the Contractor as reflecting record conditions and submitted to the engineer for review.

F. The Contractor shall have the marked up set scanned, if they are not already electronic files, and then submit them to the Engineer as the "Record Set".

G. Refer to Division 01 for additional requirements.

1.32 FINAL INSPECTION

A. Upon completion of all Engineering Site Observation list items, the Contractor shall provide a copy of the Engineering Site Observation Report back to the Engineer with each items noted as completed or the current status of the item. Upon receipt, the Engineer will schedule a final review.

1.33 COMMISSIONING

A. Refer to General Commissioning Requirements in Division 01 for additional requirements.

1.34 TEMPORARY HEATING AND COOLING

A. Refer to the General Conditions of the Contract for Construction and Supplemental General Conditions.

1.35 MAINTENANCE OF HVAC SYSTEMS DURING TEMPORARY USE PERIODS

A. Provide each air handling system with a set of prefilters in addition to the permanent filters. Furnish four sets of prefilters for each system for use when system is operated for temporary heating or cooling. During such use, change prefilters as often as directed by Owner's Representative. Provide MERV-8 filters in all open ended ducts, return grilles and registers to keep dust out of ductwork. Change as often as necessary. Remove all such temporary filters upon completion. Use supply fans only. Do not operate return fans.

B. Blank-off outside air intake opening during temporary heating period. Install first set of permanent filters and prefilters.

C. Adjust dampers on supply system.

D. Set all heating coil control valves for manual operation.

E. Do not install any grilles or diffusers at room terminal ends of ducts until permission is given.

F. Assume responsibility for systems and equipment at all times, even though used for temporary heat or ventilating. Repair or replace all dented, scratched or damaged parts of systems prior to final acceptance.

G. Remove concrete, rust, paint spots, other blemishes, then clean.

H. Just prior to final acceptance, remove used final filter and install new set. Deliver all unused sets of prefilters to the Owner and obtain written receipt. Properly lubricate system bearings before and during temporary use. Maintain thermostats, freeze stats, overload devices, and all other safety controls in operating condition.

1.36 TEMPORARY FACILITIES

A. Refer to the Division 1 Sections, General Conditions and Supplemental General Conditions.

1.37 TEMPORARY LIGHT AND POWER

A. Refer to the Division 1 Sections, General Conditions and Supplemental General Conditions.

1.38 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.

1.39 SYSTEM START-UP AND TESTING

A. Prior to commencement of work, the Division(s) effecting such system shall survey all building mechanical, plumbing, fire protection and electrical systems and components and make written notice to the Owner's Representative regarding any damage, missing items and/or incomplete systems. Prior to the conclusion of this project, the Contractor shall verify with the Owner's Representative that all building systems have been returned to their original conditions.

1.40 TRANSFER OF ELECTRONIC FILES

A. M/E Engineering, P.C. will provide electronic files for the Contractor's use in the preparation of sheetmetal shop drawings, coordination drawings, or record drawings related to the project, subject to a and the following terms and conditions:

1. The Contractor shall submit a formal request for electronic drawing files on the M/E Engineering, P.C. website, by utilizing the following website link: http://www.meengineering.com/contact-pages/contractor-request.

2. M/E Engineering, P.C. makes no representation as to the compatibility of these files with the Contractor's hardware or the Contractor's software beyond the specific release of the referenced specifications.

3. M/E Engineering, P.C. can only provide CAD files of M/E/P/FP drawing levels for which we are the Engineer of Record. CAD files of Architectural backgrounds, reflected ceiling plans, structural plans, etc. must be obtained separately from the Architect of Record.

4. Data contained on these electronic files is part of M/E Engineering, P.C.'s instruments of service shall not be used by the Contractor or anyone else receiving data through or from the Contractor for any purpose other than as convenience in the preparation of shop drawings for the referenced project. Any other use or reuse by the Contractor or by others will be at the Contractor's sole risk and without liability or legal exposure to M/E Engineering, P.C. The Contractor agrees to make no claim and hereby waive, to the fullest extent permitted by law, any claim or cause of action of any nature against M/E

Engineering, P.C., its officers, directors, employees, agents or sub-consultants which may arise out of or in connection with the Contractor's use of the electronic files.

5. Furthermore, the Contractor shall, to the fullest extent permitted by law, indemnify and hold harmless, M/E Engineering, P.C. from all claims, damages, losses and expenses, including attorney's fees arising out of or resulting from the Contractor's use of these electronic files.

6. These electronic files are not contract documents. Significant difference may arise between these electronic files and corresponding hard copy contract documents due to addenda, change orders or other revisions. M/E Engineering, P.C. makes no representation regarding the accuracy or completeness of the electronic files the Contractor receives. In the event that a conflict arises between the signed contract documents prepared by M/E Engineering, P.C. and electronic files, the signed contract documents shall govern. The Contractor is responsible for determining if any conflicts exist. By the Contractor's use of these electronic files the Contractor is not relieved of the Contractor's duty to comply with the contract documents, including and without limitation, the need to check, confirm and coordinate all dimensions and details, take field measurements, field verify conditions and coordinate the Contractor's work with that of other contractors for the project.

1.41 ENERGY INCENTIVES

A. The Contractor, his Subcontractors and Suppliers shall provide to the Owner all paperwork necessary to support the Owners pursuit of incentives related to energy conservation as offered by the utility company or state sponsored incentive programs. This shall include at a minimum, receipts, and quantities and data sheets for energy efficient equipment such as: lighting, motors, variable frequency drives, etc.

END OF SECTION

SECTION 230504 - ELECTRIC WIRING

PART 1 - GENERAL

1.1 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".

1.2 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 control/starters), are included in Division 26, "Electrical", unless otherwise called for.

1.3 QUALIFICATIONS

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

1.4 SUBMITTALS

A. Provide complete wiring diagrams for equipment systems. Deliver wiring diagrams to proper trades in time for roughing of conduit, equipment connections, and avoid delay in construction schedule. Wiring diagrams and roughing information to be wired as part of the Work of Division 26, "Electrical", shall be clearly indicated.

PART 2 - PRODUCTS

2.1 PRODUCTS

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

PART 3 - EXECUTION

3.1 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.

3.2 WIRING FOR CONTROL SYSTEMS

A. Provide motor control and temperature control wiring for equipment. All wiring shall be in conduit, unless otherwise noted. Refer to Section 260501 for type of conduit to be used in specific applications. Provide 18 in. length flexible conduit at motors and devices subject to vibration. Conduit 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. All temperature control wiring shall be plenum rated type, meeting the requirements of NEC Article 300.

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

D. 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 50 volt and under shall:

1. Be adequately supported using bridle rings spaced a maximum of 3 ft. on centers or other approved method when installed horizontally above accessible ceilings or run exposed in unfinished areas.

2. Be installed in conduit when run in wall cavity or surface metal raceway where no access is available to wall cavity, in finished areas.

3. Be installed in conduit when installed vertically in Mechanical/Utility Rooms from panels and devices up to above ceiling, or 10 ft. above finished floor if no ceiling.

4. Be installed in conduit in all cases not specifically covered by the above cases, or where subject to physical damage.

3.3 EQUIPMENT WIRING

A. Provide power and control wiring between sections of electrical 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".

3.4 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 suitably 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 insulated, ring spade terminal for all control wires. Cables and wires shall be neatly bundled and lashed with nylon cable straps.

END OF SECTION

SECTION 230513 - MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 SUBMITTALS

A. Submit manufacturer's product data on all motors.

B. Product Data: For each motor, provide dimensions; mounting arrangements; frame type, enclosure type, location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings and characteristics.

C. Motor Performance Data: For each motor, include the following manufacturers' data:

1. Motor Performance: Percent Efficiency, Power Factor, Torque, RPM, Duty Rating and Design Category.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Motor manufacturer shall be based and headquartered in the United States of America and shall design and manufacture motors in the United States.

2. Motor manufacturer shall have over fifteen (15) years-experience in the motor industry and shall maintain active company-wide quality assurance program.

3. Motor manufacturer shall maintain an authorized service center within 60 miles of the project site, capable of providing training, parts and emergency maintenance and repairs.

B. Motor performance shall be warranted against material and workmanship defects by manufacturer's limited warranty and service policy for the period of at least 18 months from the day of shipment from the factory or the manufacturer's warehouse.

1. Premium efficiency motors shall be warranted for 36 months.

2. Severe duty motors (as applicable) shall be warranted for 60 months.

3. Extended warranty shall be offered for certain products or as agreed by additional terms and specified elsewhere.

PART 2 - PRODUCTS

2.1 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.

   a. In compliance with NEMA Standards, wound specifically for nameplate voltage, and selected for appropriate duty and environment.

   b. 1.15 minimum service factor at rated voltage and frequency. 1.0 service factor for inverter duty motors.

   c. Bearings: Bearings shall have a rated fatigue life of L-10 (B-10) of 150,000 hours for direct-coupled applications and 50,000 hours for belted applications minimum. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG 1-14.43. The calculation will be determined from the pulley centerline being at the end of the motor shaft.

   d. V-belt connected motors with adjustable slide rail bases and pulleys.

   e. Motors shall have Class F insulation system, with Class B temperature rise, insulation meeting NEMA MG 1 Part 31. Maximum allowable motor temperature rise for open drip-proof (ODP) or totally enclosed fan cooled (TEFC) type at 1.15 service factor shall be 105°C above 40°C ambient with a total temperature rating of 155°C.

   f. NEMA locked rotor kVA code as required to match unit equipment torque characteristics.

   g. Single-phase motors shall be capacitor start, induction run, or split phase type.

   h. Polyphase motors shall be constant speed, squirrel cage, unless otherwise specified.

   i. Nameplates shall have as a minimum, all information as described in NEMA Standard MG-1-20.60. Motor nameplate shall be mounted on enclosure with stainless steel fastening pins.

2. Motors for use with adjustable speed drive applications shall be premium efficiency inverter duty rated in accordance with NEMA and be capable of a 20:1 turndown.

   a. These motors shall meet NEMA corona inception voltage requirements, withstanding peak voltages up to 1600 volts, and be manufactured in accordance with NEMA MG 1 Part 30 and 31.

   b. All motors controlled by adjustable speed drives shall be equipped with circumferential micro-fiber shaft grounding rings to provide protection from electrical bearing damage, to meet NEMA MG 1, 31.4.4.3. Provide AEGIS Bearing Protection Ring Kit (or equal), installed in accordance

with the manufacturer's recommendation. For motors controlled by adjustable speed drives and 50hp or greater the motor shall have a ceramic electrically insulating bearing assembly on the opposite end of the grounding brushes.

3. EC Motors:

   a. The motor shall be DC rated with permanent magnet rotor and automatically resetting integral overload protection.

   b. The unit shall meet the scheduled voltage, phase, control and other requirements indicated.

   c. Input Control: The unit shall have the following control features as a minimum:

      1) Packaged Unit controls: DDC input to include start/stop/status/general trouble.

      2) External Control: Minimum of Modbus and/or BACnet digital start/stop, digital trouble, 0-10VDC and 4-20mA speed control input.

   d. Unit insulation shall be Class H.

   e. Electrical termination lugs shall be suitable for the intended feed circuit.

   f. Ratings shall be 90% minimum power factor and 10% maximum total harmonic distortion.

   g. Speed control suitable for 100% to 10% operational capability.

   h. Fully programmable and reviewable settings and parameters.

   i. Suitable for operation at ambient conditions of 32 to 104 degrees F.

   j. The power circuiting shall be separated from the low voltage control circuiting.

   k. Output parameters where indicated:

      1) Speed.

      2) Trouble indication.

      3) Overload indication.

4. Three phase motors rated 1 HP and greater shall be copper winding, re-lubable ball bearings, 1.15 service factor (1.0 service factor for inverter duty motors), premium efficiency, 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 as follows; per NEMA MG 1 Part 12, Table 12-12, nominal minimum efficiencies:

MINIMUM NOMINAL FULL-LOAD MOTOR EFFICIENCY						
HP	ODP MOTORS (RPM)			TEFC MOTORS (RPM)		
	1200	1800	3600	1200	1800	3600
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
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	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4

5. 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

6. Motor Application; Provide the following enclosure types unless noted otherwise:

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

7. Acceptable Manufacturers: Motors need not all be of the same manufacturer. Subject to the requirements of this section provide products by the following:

a. General Electric Energy & Saver NEMA Premium Efficiency/(ODP); General Electric X$D Ultra NEMA Premium Efficiency (TEFC).

b. Century/A.O. Smith Speed Plus

c. Baldor-Reliance Super E.

d. Lincoln Ultimate E CTAC.

e. Marathon XRI.

f. Siemens GO100A.

g. Nidec Motor Co. (U.S. Motors) Premium Efficient.

PART 3 - EXECUTION

3.1 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 230516 - VIBRATION ABSORBERS,EXPANSION COMPENSATORSAND [EXPANSION JOINTS

PART 1 - GENERAL

1.1 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.

1.2 SUBMITTALS

A. Submit product data on items provided for each piece of equipment.

B. Submit detailed fabrication drawings for all field fabricated anchors.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Vibration Isolation for Piping: Section 230548 - Vibration Isolation of Mechanical Systems.

B. Anchors and Guides: Section 232010 - Piping Systems and Accessories.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION FOR PIPING

A. Pipe runs connected to mechanical equipment should be mounted on steel spring and/or elastomer isolators as called for in "Vibration Isolation" Section.

2.2 VIBRATION ABSORBERS

A. Metal Bellows Type: Manufactured of stainless steel convoluted metal bellows with 150# ASA drilled carbon steel flanges. The bellows are to be filled with silicone rubber and the integral gaskets shall be vulcanized to the flanges surface. Absorbers shall be pressure tested at 225 psi and suitable for 300° operating temperature.

B. Design Equipment: Thermo Tech, Inc.

C. Make: Hyspan, Flexhose, Thermo Tech Inc.,

2.3 EXPANSION COMPENSATORS - TWO-PLY BRONZE BELLOWS

A. 3/4 in. through 3 in. installed in copper lines, 1-1/2 in. compression stroke, 1/2 in. extension stroke. 300 psi working pressure at 600°F. Metal enclosure over bellows with anti-torque device, bronze construction, threaded or solder ends.

B. Design Equipment: Keflex Model 7Q or 7QT.

C. Make: Flexonics, Hyspan, Keflex, Metraflex, Flexhose

2.4 EXPANSION COMPENSATORS - TWO-PLY STAINLESS STEEL

A. 3/4 in. through 3 in. installed in steel lines, two-ply stainless steel bellows, 1-1/2 in. compression stroke, 1/2 in. extension stroke. 300 psi working pressure at 600°F. Metal enclosure over bellows with anti-torque device, steel construction, threaded or flanged ends.

B. Design Equipment: Keflex Model 7Q-MPT or 7QFL.

C. Make: Flexonics, Hyspan, Keflex, Metraflex, Flexhose

2.5 RADIATION GUIDES AND ANCHORS

A. For use with expansion compensators (see above) within fin radiation enclosures.

B. Two piece full circumference nylon guide, bolted to "L" bracket. Keflex Model CTG, Tri-State Industries A-Series or equal.

C. Two piece, bolted copper tube anchor and "L" bracket. Keflex Model CTA, Tri-State Industries C-Series or equal.

2.6 EXTERNALLY PRESSURIZED EXPANSION JOINTS

A. Expansion joints shall be of the pack-less type, leak proof, maintenance-free, all welded construction with multi-ply bellows and a full protection shroud capable of withstanding the full design pressure.

B. The system pressure shall be external to the bellows element.

C. The expansion joint shall have internal/external guides to prevent the bellows from being subjected to movement for which it is not designed to accommodate.

D. All expansion joints shall have an integral internal liner.

E. End fittings shall be welded end suitable for mating pipe.

F. The outer liner shall have a drain port.

G. The bellows element shall be corrugated from multi-ply laminated tubes of Type 300 Series stainless steel suitable for the application.

H. The internal liner and external shroud shall be carbon steel pipe of thickness capable of withstanding full design pressure.

I. Design Equipment: Keflex Model EPEJ.

J. Make: Flexonics, Metraflex, Flexhose, Keflex.

2.7 FLEXIBLE EXPANSION LOOPS

A. Provide flexible expansion loops of size and type as shown on the drawings, which will provide a flexible pipe loop that will absorb and compensate multi-plane movements simultaneously as well as reduce piping stress.

B. Materials of construction and end fittings type shall be consistent with pipe material and equipment/pipe connection fittings.

C. Flexible loops shall consist of two (2) flexible sections of hose and braid, two (2) 90° elbows and a 180° return assembled in such a way that the piping does not change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located a t the bottom of the 180° return, and a drain/air release plug.

D. Flexible loops shall impart no thrust loads to system support anchors or building structure. Loops shall be installed in a neutral, pre-compressed or pre-extended condition as required for the application.

E. Provide nested construction loops when installed in multiples. For steam service, loops must be installed with flexible legs horizontal to prevent condensate build up.

F. Provide guides and anchors as specified.

G. Loops shall be at 0 in. deflection at time of installation based upon 50°F ambient temperature. If the installation temperature is to be below 50°F, it is the Contractor's responsibility to review the installation with the Engineer before proceeding.

H. Make: Metraflex Co., or equal.

2.8 FLEXIBLE EXPANSION LOOPS

A. Provide flexible expansion loops of size and type as shown on the drawings, which will provide a flexible pipe loop that will absorb and compensate multi-plane movements simultaneously as well as reduce piping stress.

B. Materials of construction and end fittings type shall be consistent with pipe material and equipment/pipe connection fittings.

C. Construction to be 3 equal length sections of annular corrugated 321 stainless steel (or bronze) close-pitch hose with stainless steel (or bronze) overbraid that will absorb or compensate for pipe movements in all 6 degrees of freedom (3 coordinate axes, plus rotation above those axes) simultaneously.

D. The corrugated metal hose, braid(s) and a stainless steel ring-ferrule/band (material gauge not less than .048 in.) must be integrally seal welded using a 100% circumferential, full penetration TIG welds. End fittings shall be selected per application. Fittings must be attached using 100% circumferential TIG weld or oxyacetylene process with phos-copper filler.

E. Pre-manufactured flexible loops shall have UL 536 listing when handling flammable and combustible gases and liquids at pressures not exceeding 175 psi at ambient temperature.

F. Braided stainless steel Tri-Flex Loops must be suitable for operating temperatures up to 850°F (455°C). Braided bronze Tri-Flex Loops must be suitable for operating temperatures up to 400°F (204°C).

G. Tri-Flex Loop must be designed for pressure testing to 1.5 times their maximum rated working pressure and a minimum 4:1 (burst to working) safety factor.

H. Each braided Tri-Flex Loop shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.

I. Tri-Flex Loops shall be prepared for shipment using a cut-to-length metal shipping bar, tacked securely between the elbows of the two parallel legs, to maintain the manufactured length during shipping. Shipping bar must be removed prior to system start-up.

J. The pre-manufactured flexible loop shall be installed following the manufacturer's printed installation instructions, unless otherwise noted.

K. A hanger assembly kit shall be provided with each loop. Kit shall include two (2) UL listed seismic wire cables (13 ft. long), two (2) universal restraint clips, and four (4) zinc plated copper oval sleeves. Wire cable shall conform to the requirement of ASCE guidelines (pre-stretched and permanent end fittings maintained a breakstrength safety factory of two). A Felco Model C7 cable cutter and #1-3SBHS crimping tool shall also be included for proper assembly of hanging kit components.

L. Warranty:

1. Tri-Flex Loop must have a three (3) year full replacement warranty when installed in accordance with all specifications and installation instructions as described in the Flex-Hose Tri-Flex Loop Installation and Maintenance Instructions.

M. Make:

1. Tri-Flex Loop as manufactured by Flexhose or equivalent.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Equipment installed in accordance with the manufacturer's installation instructions.

B. Piping shall be properly anchored to control the direction of expansion and guided at the entrance to expansion devices.

C. Expansion compensators and joints are sized based upon an ambient temperature of 50°F at the time of installation. If the installation temperature is to be below 50°F, it is the Contractor's responsibility to review the installation with the Engineer before proceeding.

D. Provide piping system anchors and guides as shown on the plans. Where an anchor is shown at a change in piping direction, it shall fully control movement in both directions.

In lieu of a single anchor fabricated for two directional control, two (2) individual anchors may be provided.

END OF SECTION

SECTION 230519 - GAUGES AND THERMOMETERS

PART 1 - GENERAL

1.1 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.

1.2 SUBMITTAL

A. Submit product data for gauges, thermometers and thermowells.

PART 2 - PRODUCTS

2.1 WATER PRESSURE GAUGES

A. Construction to be Bourdon tube type; 4-1/2 in. diameter minimum, dial face, **[** stamped stainless steel, replaceable glass lens, with snap-on rings. Phosphor bronze tube, 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; equipped with bronze pulsation dampener or snubber.

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

2.2 PIPING SYSTEM THERMOMETERS

A. Industrial type, plastic, aluminum or steel case, glass or plastic front, non-toxic organic liquid filled, red reading column, white or silver V-shaped scale, black numerals. Union flange mounted, separable socket with thermowell, extension necks where required; range as called for service. Universal adjustable type, 9 in. scale. For installation in hot water systems, graduations of 2°F., accurate to within 1°F. For installation in water systems where the maximum temperature is less than 120°F, graduations of 1°F, accurate to within 1/2°F.

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

2.3 DIGITAL LIGHT POWERED THERMOMETER

A. High impact ABS case. Range for -40° to 300°F 3/8 in. LCD display. Accuracy of 1% of reading or 1°F, whichever is greater. 1/10° resolution. Internal potentiometer for recalibration. 10 LUX rating. 10 second updates. Ambient operating range of -30° to 140°F. Glass passivated thermistor sensor. Industrial glassstem assembly. Provide suitable thermowell.

B. Make: Weiss, Winters.

2.4 PRESSURE/TEMPERATURE TEST PLUGS

A. 1/4 in. NPT plug shall be capable of reading either a pressure or temperature. 1/8 in. o.d. dual seal core of Nordel 275°F with zero leakage from vacuum to 500 psig.

B. Test kit consisting of: one 2-1/2 in. test gauge 0-100 psi, one gauge adapter 1/8 in. probe, and two 5 in. stem pocket testing thermometers - one 0° to 220° and one 25° to 125°F.

C. Makes: Peterson Equipment Company, Sisco P/T plugs.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide where called for in the drawings and as noted below.

B. All gauges and thermometers shall be provided with pressure and temperature ranges appropriate for the system in which they are installed. Select to operate in the middle third of the range under normal operating conditions. Gauges and thermometers shall be suitable for the environment of their installed location, and if installed outdoors shall be acceptable for operation down to an ambient temperature of -20°F.

3.2 WATER PRESSURE GAUGES

A. Heating water and chilled water coils: 0 to 60 psi range.

B. Provide 1/4 in. ball valve in each pump inlet and outlet tapping, or in piping adjacent to same. Range 30 in. vacuum to 100 psi.

C. Heat exchangers: 0 to 60 psi range.

D. Compression tanks: 0 to 100 psi range.

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

3.3 THERMOMETERS

A. Provide thermowells mounted in oversize tee, or elbow if necessary, to provide as little restriction as possible to fluid flow. Provide thermometer stems and thermowell depths of proper length to allow accurate reading. Locate adjacent to control sensing equipment. Install and adjust angles so as to be easily read from floor.

B. Cooling Coil: Inlet and outlet; range 20° to 120°F.

C. Chillers : Supply and return; range 20° to 120°F.

D. Boiler: Inlet and outlet; range 30° to 300°F.

E. Hot Water Zone: Supply and return pipe; range 30° to 300°F.

F. Snow Melting: Supply and return; range 0° to 160°F.

G. Heating Coil: Inlet and outlet; range 0° to 220°F.

3.4 TEST PLUG

A. Provide test plugs at locations as called for. END OF SECTION

SECTION 230523 - VALVES

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 SUBMITTAL

A. Submit product data for valves and accessories.

PART 2 - PRODUCTS

2.1 VALVES

A. General: Valves shall have following requirements:

1. Working pressure stamped or cast on bodies.

2. Stem packing serviceable without removing valve from line.

3. Valves on insulated services shall have handle extensions so that the handle is fully beyond the insulation jacketing.

4. Where possible, all valves of like type shall be of a single manufacturer.

B. Acceptable Manufacturers:

1. Gate, Globe, and Check Valves: Apollo, Hammond, Milwaukee, Nibco, Watts, Victaulic.

2. Ball Valves: Apollo, Hammond, Jamesbury, Milwaukee, Watts, Nibco, Victaulic.

3. Butterfly Valves: Apollo, DeZurik, Jamesbury, Keystone, Milwaukee, Watts, Nibco, Victaulic.

4. High Performance Butterfly Valves: Keystone, Bray, Velan, Milwaukee.

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

C. Gate Valves:

1. 2-1/2 in. and Larger: Iron body, bronze solid wedge disc. OS&Y, flanged ends, rising stem, bolted bonnet, 125 lb. SWP, Milwaukee F-2885A.

2. 2 in. and Smaller: Bronze body, bronze solid wedge disc, rising stem, threaded or union bonnet, threaded ends, 125 SWP, Milwaukee 1152.

D. Globe Valves:

1. 2-1/2 in. and Larger: Iron body, bronze solid wedge disc, 125 SWP, flanged ends, bolted bonnet, Milwaukee F-2981-A.

2. 2 in. and Smaller: Bronze body, renewable composition or bronze disc, union bonnet, rising stem, threaded ends, 150 SWP, Milwaukee 590.

E. Check Valves:

1. 2-1/2 in. and Larger: Iron body, cast iron disc with bronze disc face rings and bronze seat ring, bolted flange cap, flanged ends, 125 SWP, Milwaukee F-2974-A.

2. 2 in. and Smaller: Bronze, swing check, threaded ends, 125 SWP, Milwaukee 1509.

3. Silent Check Valves, 2 in. and Smaller: Renewable seat, bronze body with bronze trim and stainless steel spring, 125 lb. SWP. Apollo 61-500 Series.

4. Silent Check Valves, 2 in. and Larger: Cast iron body, 304 stainless steel seat, disc, spring, bushing and screw, 125 lb. SWP. Milwaukee 1400.

5. Grooved End Spring-Loaded Check Valves:

a. 2 in. through 3 in.: Ductile iron body, stainless steel disc and spring, brass shaft, nickel-plated seat, 365 psi CWP. Victaulic Series 716H.

b. 4 in. through 12 in.: Ductile iron body, EPDM coated ductile iron disc, stainless steel spring and shaft, welded-in nickel seat, 300 psi CWP, Victaulic Series 716 or 779 with venture taps.

c. 14 in. through 24 in.: Ductile iron body, dual disc design, stainless steel disc, spring and shaft, EPDM seat bonded to the valve body, 230 psi CWP. Victaulic Series W715.

F. Ball Valves for Water Service:

1. For chilled and hot water systems 3 in. and under: Bronze body with hardened chrome-plated brass ball, [glass reinforced or carbon impregnated PTFE seats, full porting, 600 lb., W.O.G., adjustable packing gland, insulated handle, screwed or soldered ends, blowout proof stem. Provide handle extension on insulated services.

2. Grooved end valves for chilled, hot and condenser water systems 1-1/2 in. through 6 in. ductile iron body, chrome plated carbon steel ball and stem, standard port, blowout proof, 800 psi CWP, lever handle or gear operator with hand wheel. Victaulic Series 726.

3. Provide extended operations handle on non-thermal conductive material and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

G. Ball valves for low pressure condensate systems. Same as above except with Type 316 stainless steel ball and stem. Rated for 150 lb. saturated service, Watts B6000SS.

H. Ball Valves for Steam Service:

1. Valve shall be suitable for 250 psi steam service, standard port with blowout proof stem.

2. Body: Two-piece stainless steel.

3. End Connections: Threaded or socket weld.

4. Ball: 316 SS.

5. Stem: 316 SS.

6. Seat: Glass reinforced or carbon impregnated PTFE.

7. Packing: Glass reinforced or carbon impregnated PTFE.

8. Actuator: 304 stainless steel lever, with handle extension for insulation.

9. Manufacturer: Conbraco Apollo 76-100-64.

10. Provide extended operations handle on non-thermal conductive material and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, with tee handle.

I. Valves for Gauges and Instruments:

1. 1/4 in., bronze body, hardened chrome plated brass ball, glass reinforced carbon impregnated seats, standard porting, 400 lb. W.O.G., adjustable packing gland, screwed ends, tee handle, Watts B6000TH.

J. Grooved Butterfly Valves for Water Service:

1. Bi-directional bubble tight shutoff against working pressure of 300 psi.

2. Body: Grooved type, coated ductile iron.

3. Disc: Nickel coated ductile iron.

4. Seat: EPDM; pressure responsive in sizes through 12 inch.

5. Stem: Stainless steel with EPDM seals. Stem shall be offset from the disc centerline to provide complete 360 degree circumferential seating.

6. Operators: Valves up to 6 in. with lever operators; valves 8 in. and larger with heavy duty manual gear actuators.

7. Victaulic VIC-300 Master Seal (2 in. to 12 in.).

8. Victaulic VIC-AGS (14 in. to 24 in.).

K. Lug Type Butterfly Valves for Water Service:

1. Rated for working pressure 200 psi, bi-directional dead end service, bubble-tight.

2. Body: Lug type, cast iron ASTM A126, or ductile iron.

3. Disc: Aluminized bronze.

4. Seat: EPDM, resilient seat. Rated to 250ºF.

5. Stem: 316 or 416 stainless steel. Single offset.

6. Operator: Lockable Lever for sizes through 6 in. Manual hand wheel gear actuator for sizes 8 in. and larger.

7. Milwaukee CL223E (2 in. - 6 in.), CL323E (8 in. and larger), or Watts BF-03.

L. Butterfly Valves for Low Pressure Steam (under 15 psig):

1. 100% bi-directional bubble tight shutoff and throttling service against listed working pressure of 285 psi, ANSI Class 150.

2. Body: Carbon steel ASTM A216 WCB, body to have internally cast travel stops.

3. Disc: 316 stainless steel mounted with corrosion resistant bearings.

4. Seat: Replaceable resilient seat constructed of RTFE suitable for temperatures to 500°F at 100 psig.

5. Stem: 17-4 PH stainless steel. Adjustable PTFE packing.

6. Stem and disc shall be double offset design.

7. Operators: Valves up to 6 in. with lockable lever operators; valve 8 in. and larger with heavy duty manual hand wheel gear actuators.

8. Seat Working P/T Rating: 100 psig @ 500°F minimum.

9. Body Working P/T Rating: 285 psig @ 100°F minimum.

10. Keystone K-Lok, Figure 362.

M. Butterfly Valves for High Pressure Steam:

1. Valves suitable for high pressure steam service to 600°F, metal-to-metal seated and bi-directional bubble tight service. Valve shall be ANSI 150 rated and triple offset design.

2. Body: Carbon steel ASTM A216 WCB.

3. Body Seat: Stellite gr.21 welded overlay.

4. Disc: ASTM A216 WCB nickel plated.

5. Seal Ring: Duplex SS UNS S31803 and graphite.

6. Shaft: ASTM A182 F6a C13.

7. Packing: Graphite.

8. Bearing: AISI 304 nitride.

9. Actuator: Heavy-duty manual hand wheel gear actuator for all sizes. Provide chain wheel gear actuators and chain on all valves located greater than 8 ft. above the floor.

10. Manufacturer: Vanessa QTF/150/CS.

N. Gas Valves:

1. 2-1/2 in. and Larger: Manual actuated with level actuators bolted gland type, short pattern, lubricated plug type, 175 lb. WOG, flanged, Nordstrom, Fig. #143, UL listed.

2. 2 in. and Smaller: AGA/CGA and UL/FM listed for natural and LP gas, forged brass full port, threaded ends, Watts FBV Series.

O. Hose Thread Drain Valves:

1. Ball valve, bronze body, hardened chrome ball with hose thread end, cap and chain.

P. Fusible Link Valves:

1. Level type gate valve for emergency closing of oil supply line. Spring-operated, self closing type, with spring and 165°F fusible link. Bronze valve with malleable iron handle. Port full line size. Preferred Utilities Type 110.

Q. Liquid or Vacuum Relief Valves:

1. Bronze base and bronze working parts except steel cadmium-plated springs; suitable for pressure up to 250 psi; non-pop valve suitable for use on boiler feed pump discharge, Lunkenheimer #658.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

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

2. Provide at major building and systems 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 fan convectors, room units, terminal units, or other similar apparatus may be inside cabinet or at connection to branch mains where accessible.

5. Locate valves with handles at horizontal position when 5 ft. or more above the floor, for greater visibility and easier use. Otherwise, locate valves with handles at or above horizontal position. Swing check valves in upright position only.

6. Butterfly valves may be used for water service over 2 in. unless otherwise noted.

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

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

END OF SECTION

SECTION 230525 - HYDRONIC COIL PIPING PACKAGE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide Hydronic Coil Piping Packages as shown on drawings and as specified herein.

B. Type, size, and rating compatible with intended service.

C. Suitable for use in Chilled Water and Hot Water Systems.

1.2 SUBMITTALS

A. Submittals shall include the following:

1. Drawing of coil package showing product arrangement with end connection type and size listed. Components shall be clearly labeled.

2. Written description of all components provided in package.

3. Manufacturer's system component specifications.

4. Computer generated, job specific package schedule indicating package part number, end connection size and types, control valve Cv, flow cartridge spring range, design flow rate, and location tag for each coil package.

1.3 DELIVERY, STORAGE, AND HANDLING

A. All equipment provided under this specification shall be shipped to the job site clearly labeled for intended use and in shrink-wrapped plastic per coil assembly. Manufacturer shall factory mount actuators (supplied by others) to actuated ball valve prior to shrink-wrap and shipment.

B. Manufacturer's representative shall coordinate with valve actuator supplier to develop common schedule of actuator type, size, and location. This schedule will be used by coil piping package factory to mount actuators prior to shrink-wrap and shipping.

1.4 WARRANTY

A. Manufacturer shall warrant all components for eighteen (18) months from date of final acceptance. The flow limiting cartridge shall be warranted by manufacturer for no less than five (5) years from date of final acceptance.

B. Manufacturer shall provide replacement flow limiting cartridges (installation by others) at no charge for up to 10% of total quantity of purchased packages in the event that flow conditions (gpm) are modified by Engineer after packages have shipped to the jobsite.

1.5 ACCEPTABLE MANUFACTURER

A. Griswold "Automizer" CPP-2A (Basis of Design).

B. Griswold PIC-V.

C. Delta Controls "Auto Touch".

D. Belimo "PICCV".

E. FCI - Delta P Valve.

F. Danfoss/Nexus Coil Pak

G. Flow Design/IMI

H. Victaulic Koil-Kit Coil Pack.

PART 2 - PRODUCTS

2.1 COMBINATION VALVES (RETURN SIDE) 10 GPM AND BELOW

A. Combination valve shall include a flow limiting cartridge, actuated ball valve, and manual isolation ball in a single valve housing to prevent opportunity for leakage with union end connection. Separate assembled components shall not be acceptable.

B. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

C. Valve shall have a union end connection that includes a factory installed manual air vent to allow for venting of the coil or heat pump.

D. Automatic Flow Limiting Cartridge (FLC):

1. FLC shall automatically control flow rates with ±5% accuracy over an operating pressure differential range of at least 14 times the minimum required for control. Three (3) operating pressure ranges shall be available with the minimum range requiring no more than 2 PSID to actuate the mechanism.

2. Valve internal control mechanism shall consist of a stainless steel one-piece cartridge with segmented port design and full travel linear coil spring. Plated steel cartridges shall not be acceptable.

3. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and system shall be standard.

4. Manufacturer shall be able to provide certified independent laboratory tests verifying accuracy of performance.

E. Actuated Ball Valve:

1. Valve ball shall consist of chemically plated nickel brass.

2. Actuator stem shall be removable/replaceable without removing valve from line.

3. Manufacturer shall be able to provide ball insert to make flow control equal percentage. Insert shall be constructed of a glass-filled polymer.

4. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals to allow for a minimum close-off pressure of 100 psi with 35 in.-lbs. of torque for 1/2 in. to 2 in. sizes.

5. Actuator shall provide minimum torque required for full valve shutoff position.

6. Coordinate specific details of actuator with BMS provider. BMS provider shall mount and wire actuators in the field.

F. Control Valves: All pressure independent valves for individual coil control shall be provided as part of Hydronic Coil Piping/Hose Kit Packages as specified herein. Control valve actuators will be supplied and installed by the pressure independent valve manufacturer. The Controls Contractor is responsible for wiring and testing the valve actuators.

G. Isolation Ball Valve:

1. Valve shall include a 600 WOG manual isolation ball valve.

2.2 COMBINATION VALVES (RETURN SIDE) LARGER THAN 10 GPM

A. The modulating control valves shall be pressure independent.

B. The pressure independent modulating control valve shall include a pressure compensating cartridge, actuated ball valve, and manual isolation ball in a single valve housing.

C. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

D. Valve shall have a fixed end or union end connection with factory installed air vent to allow for venting of the coil or heat pump.

E. The control valve shall accurately control the flow from 0 to 100% full rated flow.

F. A flow tag shall be furnished with each valve.

G. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Belimo, ELO Drive, Honeywell, Invensys, Johnson Controls, KMC, Neptronics, or Siemens.

H. The actuator and plate can be rotated after mounting.

I. Pressure Compensating Cartridge (PCC):

1. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.

2. The operating pressure range shall be available with the minimum range requiring 5.8 PSID to actuate the mechanism.

3. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.

4. Valves shall include an accessible/replaceable cartridge.

5. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.

J. Actuated Ball Valve:

1. Valve ball shall consist of chemically plated nickel brass or stainless steel.

2. Actuator stem shall be removable/replaceable without removing valve from line.

3. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with ±5% accuracy.

4. Valve shall have EPDM O-rings behind the seals to allow for a minimum close-off pressure of 100 psi with 35 in.-lbs. of torque for 1/2 in. to 2 in. sizes.

5. Actuator shall provide minimum torque required for full valve shutoff position.

K. Isolation Ball Valve:

1. Valve shall include a 600 WOG manual isolation ball valve.

2.3 COMBINATION VALVE (SUPPLY SIDE)

A. Combination valve shall include a manual isolation ball and integrated strainer, including drain valve with 3/4 in. hose connection with cap, in a single valve housing to prevent opportunity for leakage. Separate assembled components shall not be acceptable. Dual pressure/temperature test valve shall be standard.

B. Valve housing shall consist of forged brass rated at no less than 360 psi at 250°F.

C. Valve shall have one (1) fixed end and one (1) union end connection.

D. Integrated Strainer:

1. Shall be 20 mesh stainless steel and can be removed from housing without disturbing pipe connections for inspection or replacement.

2. Drain valve shall consist of nickel-plated ball in a brass housing rated for 275 psi at 250°F.

E. Isolation Ball Valve:

1. Valve shall include a 600 WOG manual isolation ball valve.

2.4 SUPPLY/RETURN HOSES (AS REQUIRED)

A. All hoses shall be equipped with swivel end connections at terminal unit. All end connections shall be crimped to meet standard pressure ratings. Serrated/slip fit connections shall not be acceptable.

B. Flame Retardant Hoses:

1. Hose material shall be stainless steel braided over a synthetic polymer liner.

2. Hoses shall meet or exceed the ASTM D380-00 standard.

3. Hoses shall meet or exceed flame retardant testing per standards per ANSI/UL 723, NFPA 255, UBC 42-1, and ASTM E84-00.

C. Insulated Hoses:

1. Hose materials shall be high quality polyethylene pipe insulation over a stainless steel braided inner core.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's recommendations and instructions.

END OF SECTION

SECTION 230530 - ROOF CURBS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation of roof curbs as shown in Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230550 - Wind Restraint for HVAC Systems.

B. Section 230529 - Seismic and Wind Restraint for Mechanical Systems.

1.3 SUBMITTALS

A. Typical detail and schedule for equipment. Details shall include cross-sectional view illustrating clearly the type of curb being submitted, i.e. double wall insulated, with or without cant.

PART 2 - PRODUCTS

2.1 ROOF CURBS AND PIPE/DUCT/EQUIPMENT SUPPORTS

A. Basis of Design: Subject to compliance with requirements of this section, provide Roof Products and Systems Corp. (RPS) or comparable product by one of the following:

1. RPI (Roof Products Inc.)
2. ThyCurb
3. Greenheck

B. Configuration: Coordinate curb type with roof deck construction and insulation thickness.

1. Self-flashing without cant strip, with mounting flange (RPS Series 2A).
2. Built-in cant and mounting flange (RPS Series 3A).
3. Built-in raised cant and mounting flange (RPS Series 4A).

C. Provide wind restraint as called for in Item 1.2 above.

2.2 FAN CURBS/DUCT CURBS

A. Double wall, 1-1/2 in. minimum thickness, fully insulated in the interior cavity with rigid insulation. Curb constructed of galvanized steel, 1-1/2 in. 3# density insulation with continuous welded corner seams and painted at all welds. 20 gauge up to 36 in., 18 gauge 38 to 72 in., 16 gauge over 72 in. in any dimension.

B. Kitchen exhaust fan curbs shall be 24 in. high with hinges and service hold-open chain or cable; all other fan curbs shall be 18 in. high or as otherwise noted on the drawings.

C. Provide curb with adhesive backed closed cell foam gasket on the top edge to make airtight seal between curb and ventilator, fan, or air handling unit. Gasketing for kitchen exhaust fan curbs shall be woven ceramic gasket tape rated for the operating temperature.

D. Options:

1. Insulated curb extension with damper tray to allow access door for damper maintenance; access door shall be 10 in. high.

2. Sound Curb: Curb with sound-absorbing insulation.

3. Solid platform.

4. Vented Curb: Unlined with louvered vents in vertical sides. (kitchen exhaust only)

E. Basis of Design: RPS - RC Roof Curbs.

2.3 CURB ADAPTER - TRANSITION/EXTENSION

A. Curb adapter/extension for equipment requiring a curb connection equal, larger or smaller than an existing curb.

B. 18 gauge galvanized steel, double walled construction. 1-1/2 in. minimum thickness rigid insulation. Fully welded construction and painted at all welds. Neoprene gasket.

C. Basis of Design: RPS - CE-1 (equal) or CA-1 (larger) or CA-2 (smaller).

2.4 EQUIPMENT SUPPORTS

A. Double wall, minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds. Constructed of heavier gauge steel where standard rail cannot support unit weight. Provide with top cap counter flashing. Width to be 5-1/2 inches.

B. Basis of Design: RPS - Equipment Rail ER2.

2.5 DUCT SUPPORTS

A. Double wall, minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds. Constructed of heavier gauge steel where standard curb cannot support unit weight. Provide with top cap counter flashing. Width to be 5-1/2 inches.

B. Duct mounting pedestal shall consist of a support rail 12 in. longer than the duct width for single duct support, with a single galvanized steel slide channel equal in length to the equipment rail attached to galvanized steel "U" shaped mounting brackets secured to the side of the equipment rail with lag bolts. The duct mounting slide assembly shall be

sized to suit the duct supported and fabricated of galvanized steel and shall have galvanized 18 in. long continuous threaded rods to allow 12 in. vertical adjustment, and lateral adjust spacer bracket for 12 in. horizontal adjustment.

C. Basis of Design: RPS - Duct Mounting Pedestal.

2.6 PIPE SUPPORTS

A. Same construction as "Equipment Supports". Provide with full length steel bracket, U bolts and accessories as required to secure piping to the pipe support as detailed on Contract Drawings.

B. Basis of Design: RPS - Pipe Mounting Pedestal Model ER.

2.7 PIPE CURB ASSEMBLY - PIPE PORTAL

A. Fully insulated with rigid 1-1/2 in. 3# density insulation. Minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds.

B. Acrylic coated ABS rib reinforced curb cover and integral counter flashing, size and number of pipe and conduit openings as required to suit job conditions.

C. EPDM protective rubber pipe boots and stainless steel clamps secured around each pipe individually. Curb provided with raised cant, flanged or recessed. Curb flange shall suit roof construction and type of insulation being applied.

D. Basis of Design: RPS - Pipe Portal Flashing System.

PART 3 - EXECUTION

3.1 GENERAL

A. Height as recommended by equipment manufacturer, not less than described in this specification. This Contractor shall be responsible for exact size, length, and location and shall set and secure each curb to the roof. Shim and level curb as required. Provide curb and supports for all roof-mounted equipment. All roof penetrations shall be made through an appropriate curb. All roof mounted equipment including fans, air handling units, etc, shall be set on an equipment support unless otherwise noted. Refer to Contract Drawings for details on plenums extending from curbs.

END OF SECTION

SECTION 230548 - VIBRATION ISOLATION OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Furnish and install vibration control devices, materials, and related items. Perform all work as shown on the Drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.2 **[RELATED SECTIONS**

A. **See Specification Section 230529 - Seismic [and Wind] Restraint for Mechanical Systems.**

OR

B. **See Specification Section 230550 - Wind Restraint for Mechanical Systems.]**

1.3 MATERIAL AND EQUIPMENT

A. All vibration isolation mounts shall be supplied by one of the following approved manufacturers:

1.	Mason Industries Inc. (Hauppauge, NY)	M.I.
2.	Kinetics Noise Control Inc. (Dublin, OH)	K.N.C.
3.	Vibration Mountings & Controls Group. (Butler, NJ)	VMC Group
4.	Vibration Eliminator Co. (Long Island City, NY)	V.E.C.

1.4 QUALITY ASSURANCE

A. Coordinate the size, location and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet the requirements stated herein even if not expressly specified or shown on the Drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specification.

E. Should any rotating equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for re-balancing, realignment, or other remedial work required to reduce noise and vibration levels.

Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of work, the Architect or the Architect's Representative shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.5 SUBMITTALS

A. Refer to related sections elsewhere for procedural instruction for submittals.

B. Before ordering any products, submit shop drawings of the items listed below. The shop drawings must be completed when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal.

C. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.

D. Detailed selection data for each vibration isolator supporting equipment, including:

1. The equipment identification mark.

2. The isolator type.

3. The actual load.

4. The static deflection expected under the actual load.

5. The specified minimum static deflection.

6. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.

7. Special details necessary to convey complete understanding of the work to be performed.

E. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATOR TYPES

A. General:

1. All springs installed out-of-doors shall be zinc electroplated or powder-coated after fabrication. Hardware and other metal parts shall be cadmium-plated or

galvanized. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.

2. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.

3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.

4. Static deflection of isolators shall be as provided in the EXECUTION section and as shown on the Drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.

B. Type FSN (Floor Spring and Neoprene):

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1 (one). All mounts shall have leveling bolts. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is used, grommets shall be provided for each bolt hole in the base plate. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum bearing plate shall be used between the friction pad and the NO isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, beating plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.

2. Type FSN isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from Type NP or approved equal:

a.	Type SLF	M.I.
b.	Type FDS	K.N.C.
c.	Series A	VMC Group

C. Type FSNTL (Floor Spring and Neoprene Travel Limited):

1. Spring isolators shall be freestanding and laterally stable. Spring diameter shall not be less than 0.8 of the compression height of the spring at the rated load. Spring shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts. All mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4 in. shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.

2. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is use, grommets shall be provided for each bolt hole in the base plate.

3. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum bearing plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, bearing plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.

4. Type FSNTL isolators shall be one of the following products, with the appropriate neoprene pad (if used) selected from Type NP or approved equal:

   a. Type SLR M.I.

   b. Type FLS K.N.C.

   c. Series AWR VMC Group

D. Type FN (Floor Neoprene):

1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

2. Type FN isolators shall be one of the following products or approved equal:

   a. Type ND M.I.

   b. Type RD K.N.C.

c. Series RD VMC Group

E. Type NP (Neoprene Pad):

1. Neoprene pad isolators shall be one layer of 1/4 in. to 3/8 in. thick ribbed or waffled neoprene. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

2. Type NP isolators shall be one of the following products or approved equal:

a. Type W M.I.

b. Type NPS K.N.C.

c. Series Shear Flex VMC Group

F. Type DNP (Double Neoprene Pad):

1. Neoprene pad isolators shall be formed by two layers of 1/4 in. to 3/8 in. thick ribbed or waffled neoprene, separated by a galvanized steel, stainless steel or aluminum plate. If the isolator is outdoors, the plate shall not be made of galvanized steel. These layers shall be permanently adhered together. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

2. Type DNP isolators shall be formed from one of the following products or approved equal:

a. Type WSW M.I.

b. Type NPS K.N.C.

c. Series Shear Flex VMC Group

G. Type HSN (Hanger Spring and Neoprene):

1. Vibration isolator hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole size shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Alternatively, other provisions shall be made to allow for a 30° arc of movement of the bottom hanger rod without contacting the isolator housing. Spring diameter shall not be less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3 in. minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.

2. Type HSN isolators shall be one of the following products or approved equal:

a. Type 30N M.I.

b. Type SRH or SFH K.N.C.

c. Type RSH or RFH VMC Group

H. Type HN (Hanger Neoprene):

1. Vibration isolator hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck brushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30° arc before contacting the hanger housing.

2. Type HN isolators shall be one of the following products or approved equal:

a. Type HD M.I.

b. Type RH or FH K.N.C.

c. Type RHD or RFD VMC Group

2.2 EQUIPMENT BASES

A. Type BSF (Base-Steel Frame):

1. Steel base frames shall consist of structural steel section sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame shall be at least 1/10 the longest dimension of the base and not less than 6 in. The base footprint shall be large enough to provide stability for supported equipment.

2. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

3. Type BSF bases shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:

a. Type WFSL M.I.

b. Type SFB or SRB K.N.C.

c. Series WFB VMC Group

B. Type BIB (Base-Inertia Base):

1. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lb./cu. ft.) and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base that will not twist, rack, deform, deflect, or crack in any manner that would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the inertia base and not less than 6 in. The base footprint shall be large enough to provide stability for supported equipment. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

2. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer.

3. Frame and reinforcement for Type BIB bases shall be one of the following products or approved equal:

a. Type KSL M.I.

b. Type CIB-L or CIB-H K.N.C.

c. Series WPF VMC Group

2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1/2 in. to 3/4 in. larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend 1 in. beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 in. of the ends of the sleeve. The remaining 1/4 in. space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through the sleeve without contacting the sleeve. Refer to details on Drawings.

2.4 RESILIENT LATERAL SUPPORTS

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN that are specifically designed to provide resilient lateral bracing of ducts or pipe.

B. Resilient lateral supports shall be one of the following products or approved equal:

1.	Type ADA	M.I.
2.	Type RGN	K.N.C.
3.	Type MDPA	VMC Group

2.5 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be heavy glass fabric, double neoprene coated, approximately 30 oz. per sq. yd. The clear space between connected parts shall be a minimum of 3 in. and the connection shall have a minimum of 1.5 in. of slack material. Materials for flex connection shall be fire retardant, water and milder resistant, and comply with UL standard 214.

B. Flexible duct connections shall be one of the following products or approved equal:

1. Ventfabrics, Inc. "Ventglass".

[DESIGNER NOTE: TYPICAL USE BRAIDED HOSE FLEXIBLE PIPE CONNECTIONS UNLESS DOUBLE SPHERE ARE REQUIRED BY AN ACOUSTICIAN, OR REPLACING EXISTING IN KIND.]

2.6 FLEXIBLE PIPE AND PUMP CONNECTIONS (DOUBLE SPHERE)

A. Flexible pipe connections shall be fabricated of multiple plys of nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongating, transverse, and angular movements. The flexible connections shall be selected and specifically fitted, if necessary, to suit the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.

B. Connectors for pipe sizes 2 in. or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

C. Flexible pipe connections shall be one of the following or approved equal:

1.	Type Twin Sphere	Metraflex
2.	Type MFTNC or MFTFU	M.I.

2.7 FLEXIBLE PIPE AND PUMP CONNECTIONS (BRAIDED STAINLESS STEEL)

A. Braided stainless steel pump and pipe connector(s) shall be constructed of annular corrugated stainless steel close-pitch hose with stainless steel overbraid. The corrugated metal hose, braid(s) and a stainless steel ring-ferrule/band (material gauge not less than .048 in.) shall be integrally seal-welded using a 100% circumferential, full-penetration TIG weld. Fittings shall be attached using a 100% circumferential TIG weld.

B. Braided stainless steel pump and pipe connector(s) must be suitable for operating temperatures up to 850°F. The rated working pressure of the braided metal hose must have a minimum 4:1 safety factor.

C. Each braided stainless steel connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.

D. Braided stainless steel connectors shall carry a three (3) year warranty when installed in accordance with all specifications and installation instructions as described by the manufacturer.

E. End fittings shall be flat-faceplate steel flanges with 150# ANSI drilling, and outside diameter, carbon steel MPT ends, flanged by Schedule 40 grooved ends or increasing ends.

F. Acceptable Manufacturers: Flexhose Pumpsaver or equivalent Keflex, Metraflex, Mason-Mercer.

2.8 THRUST RESTRAINTS

A. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be pre-compressed at the factory to allow for a maximum of 1/4 in. movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable. The assembly shall be furnished complete with rods and angle brackets for attachment to both equipment and the adjacent fixed structural anchor. The thrust restraints shall be installed on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable. The holes in the spring restraint brackets through which the restraint rods pass must be oversized to prevent contact between the brackets and rods.

B. Thrust restraints shall be one of the following products or an approved equal:

1.	Type WB	M.I.
2.	Type HSR	K.N.C.
3.	Type HTR	VMC Group

2.9 GROMMETS

A. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate, and shall be sized so that they will be loaded within the manufacturer's recommended load range.

B. Grommets shall either be custom made by combining a neoprene washer and sleeve, or be one of the following products or an approved equal:

1.	Type Isogrommets	MBIS, Inc. (Bedford Heights, OH)

2.	Type WB	Barry Controls (Brighton, MA)
3.	Type HG	Mason Industries Inc., (Hauppauge, NY)

2.10 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the non-setting sealants indicated below:

1.	Acoustical sealant	D.A.P.
2.	BR-96	Pecora
3.	Acoustical sealant	Tremco
4.	Acoustical sealant	U.S.G.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:

1. Refer to the PRODUCTS section of this specification for vibration isolation devices identified on the Drawings or specified herein.

2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment:

1. Unless otherwise shown or specified on Drawings, all floor-mounted major equipment shall be set on 6 in. high concrete housekeeping pads.

2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as specified hereunder.

3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the Drawings.

4. **[Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment and as indicated on Drawings in the positions shown on the Drawings.]**

5. Electrical connections to vibration-isolated equipment shall be flexible, as called for in the electrical portion of the specification.

6. Thrust restraints shall be installed on all suspended fans and on all floor-mounted fans developing 4 in. or more of static pressure, unless the horizontal component

of the thrust force can be demonstrated to be less than 10% of the equipment weight.

C. Equipment Vibration Isolation Schedule:

TYPE	VIBRATION ISOLATOR TYPE	MINIMUM STATIC DEFLECTION (In.)	EQUIPMENT BASE
Centrifugal Chiller	FSNTL	**[.75]**	----
Air Handling Units	FSN	**[2.5]**	BSF
Cooling Towers	FSNTL	**[2.5]**	----
Base Mounted Pumps (Note 1)	FSN	**[.75]**	BIB
Inline Pumps	HSN	**[.75]**	----
Boilers	DNP	**NA**	----
Inline Fans	HSN	**[1.5]**	----
Air Compressor	FN	**[.4]**	----

NOTE 1: Equipment base and vibration isolators can be deleted where pumps are provided on slabs on grade and if pumps are placed on concrete inertia slab isolated from surrounding floor slab.

[DESIGNER NOTE: MINIMUM STATIC DEFLECTION IS A DESIGNER CHOICE. SEE 1995 ASHRAE HVAC APPLICATIONS, PAGE 43.35, TABLE 42. USE 1 IN. RATED TO OBTAIN 0.75 IN. MINIMUM. USE 3 IN. RATED TO OBTAIN 2.5 IN. MINIMUM.]

D. Miscellaneous Mechanical Equipment:

1. Miscellaneous pieces of mechanical equipment such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks and expansion tanks which are connected to isolated piping systems shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for .01 in. static deflection) unless their position in the piping system requires a higher degree of isolation as called for under "Pipe Isolation".

E. Pipes:

1. All chilled water, condenser water, hot water, steam main and engine exhaust piping shall be isolated from the building structure within the following limits:

   a. Within mechanical rooms.

   b. Within 50 ft. total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.).

   c. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.

   d. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2 in., Type FSN or Type

HSN isolators shall be used. When the required static deflection is less than or equal to 1/2 in., Type FN or Type HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or Type HN achieving at least 1/4 in. static deflection.

e. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.

f. Pipes penetrating the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.

g. **[Provide flexible pipe connections as called for under "Major Equipment" above and wherever shown on the Drawings.]**

3.2 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.

2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolators:

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.

2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.

3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.

4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.

5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.

6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360° about the rod axis without contacting any object.

7. Parallel running pipes may be hung together on a trapeze, **[when allowed by Section 232010]** that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and un-isolated pipes on the same trapeze.

8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.

9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.

10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 in. clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.

11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitable rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements, and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.

2. Unless otherwise indicated, there is to be a minimum operating clearance of 1 in. between steel rails, steel frame base or inertia bases and the floor beneath the equipment. The isolator mounting brackets shall be positioned and the isolators adjusted so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:

1. Sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. **[Flexible Pipe Connections:**

1. **Install flexible pipe connections in strict accordance with the manufacturer's instructions.]**

F. Thrust Restraints:

1. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraints shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Grommets:

1. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

H. Resilient Penetration Sleeve/Seals:

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

END OF SECTION

SECTION 230550 - WIND RESTRAINT FOR HVAC SYSTEMS

[EDITORS NOTE: ANY CHANGES MADE TO THIS SECTION SHOULD ALSO BE MADE TO SECTIONS 220550 & 260550 WIND RESTRAINT… AND SECTION 210529/220529/230529/260529 SEISMIC AND WIND RESTRAINT]

[DESIGNER NOTE: USE THIS SECTION ONLY IF THERE IS NO SEISMIC COMPONENT. COORDINATE WITH OTHER TRADES THAT HAVE ROOF MOUNTED EQUIPMENT SO THIS SECTION IS APPLIED ACROSS ALL TRADES. IF THERE IS A SEISMIC COMPONENT, THE SEISMIC RESTRAINT SPEC ALREADY COVERS WIND RESTRAINTS.]

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Support and brace mechanical and electrical systems, as called for, to resist directional wind forces (lateral, longitudinal and vertical).

1.2 APPLICABLE CODES AND STANDARDS

A. Provide work in compliance with the following codes and standards:

[DESIGNER NOTE: FOR PROJECTS IN NEW YORK PERMITTED AFTER 5/12/2020, THE 2020 BC/EBC/MC/FGC OF NYS SHOULD BE SELECTED. FOR PROJECTS OUTSIDE NY VERIFY IF THE AHJ WILL ENFORCE THE 2015 IBC/IEBC/IMC/IFCG OR THE 2018 VERSIONS (OR ANOTHER CODE) AND EDIT SECTIONS 1 THRU 3 BELOW ACCORDINGLY.]

1. **[2015 International Building Code] [2020 Building Code of New York State]** (Section 1609 and 1613).

2. **[2015 International Mechanical Code] [2020 Mechanical Code of New York State]** (Section 301, Item 301.15).

3. American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures with Supplement No. 1 - Standard ASCE/SEI **[7-10] [7-16]**.

[DESIGNER NOTE: ASCE 7-16 IS REFERENCED IN THE 2020 BCNYS WHILE ASCE 7-10 IS REFERENCED IN THE 2015 IBC; VERIFY THAT THE PROPER VERSION IS REFERENCED BASED ON THE CODE THAT IS BEING ENFORCED BY THE AHJ]

1.3 QUALITY ASSURANCE

A. General:

1. The contractor shall provide Professional Engineer stamped and signed engineering calculations and details of wind restraint systems to meet total design lateral force requirements for support and restraint of mechanical systems. Engineer shall be licensed to practice in the state in which the project is located.

2. The wind restraint engineering calculations and details shall provide the quantity of attachments and size/type of attachments for the mounting of an equipment curb or support rail to the building structure, and for attachment of the equipment or system to the equipment curb or support rail. It is not the intent for manufactured equipment curbs or support rails to be certified by their respective manufacturers, nor is it the intent for them to be certified by the Professional Engineer who is providing the wind restraint calculations and connection methodology.

[DESIGNER NOTE: ALL ROOF MOUNTED EQUIPMENT LOCATIONS, WEIGHTS AND SIZES MUST BE PROVIDED TO THE ARCHITECT'S STRUCTURAL ENGINEER DURING DESIGN IN ORDER TO ACCOMMODATE THE DESIGN OF SUPPLEMENTAL STEEL FOR FULL PERIMETER ANCHORING AS REQUIRED FOR PROPER WIND RESTRAINT. PROVIDE EQUIPMENT CURB CUTS TO FACILITATE THE STRUCTURAL ENGINEER'S SUPPLEMENTAL STEEL DESIGN.]

3. Systems requiring wind restraint including, but not limited to:

   a. Cooling towers.
   b. Closed circuit evaporative coolers.
   c. Air handling units.
   d. Exhaust fans.
   e. Stair pressurization fans.
   f. Exterior generator exhaust stacks.
   g. Louvered intake or relief penthouses
   h. Hooded intake or relief ventilators.
   i. Supply fans.
   j. Air cooled chillers.
   k. Condensing units.
   l. Ductwork.
   m. Piping.
   n. Boiler flues.
   o. Fluid coolers.
   p. Roof curbs and pipe/duct/equipment supports associated with any of the equipment listed above.

[DESIGNER NOTE: EDIT/ADD TO LIST ABOVE AS NECESSARY.]

1.4 SUBMITTALS

A. Submit wind force level (Fp) calculations from applicable building code. Submit pre-approved restraint selections, installation details, and plans indicating locations of restraints.

B. Calculations, plans, restraint selection, and installation details shall be stamped and signed by a professionally licensed engineer experienced in wind restraint design.

C. Submit manufacturer's product data.

D. For each piece of equipment that requires wind restraint as outlined in this section, include the following:

1. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity and locate and describe mounting and anchoring provisions.

2. Anchorage: Provide detailed description of equipment anchorage devices on which the calculations are based and their installation requirements. Identify anchor bolts, studs and other mounting devices. Provide information on the size, type and spacing of mounting brackets, holes and other provisions.

E. The Contractor shall provide photographs of the installed roof mounted equipment, showing the fully installed wind restraint anchoring, prior to the roofing material installation, as a formal submittal for verification that the work has been completed.

PART 2 - PRODUCTS

2.1 CODE INFORMATION

A. This project is subject to the wind bracing requirements of the codes listed above. The following criteria are applicable to this project:

1. Basic Design Wind Speed (V): **[115 mph.] [120 mph.] [ ]**

2. Risk Category: **[II] [III] [IV]**

3. Exposure Category: **[B] [C] [D]**

4. Height and Exposure Adjustment Coefficient: **[ ] [N/A - Building height is less than 60 ft.]**

[DESIGNER NOTE: ALL BRACKETED INFORMATION ABOVE SHOULD BE PROVIDED BY ARCHITECT/STRUCTURAL ENGINEER AND SAVED IN THE JOB FILE.]

2.2 WIND BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Design analysis shall include calculated dead loads, wind loads, and capacity of materials utilized for the connection of the equipment or system to the structure.

2. Analysis shall detail anchoring methods, fastener sizes and spacing, etc.

3. All wind restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 2.1.

B. Friction from gravity loads shall not be considered resistance to wind forces.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wind Restraint of Piping:

1. All restraint systems shall be installed in strict accordance with the wind restraint design submittal.

2. Installation of restraints shall not cause any change in position of equipment or piping, resulting in stresses or misalignment.

B. Wind Restraint of Ductwork and Equipment:

1. All restraint systems shall be installed in strict accordance with the wind restraint design submittal.

2. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the restraint systems.

3. Installation of restraints shall not cause any change in position of equipment or ductwork, resulting in stresses or misalignment.

4. Exhaust fans with hinge kits shall have wind restraint fasteners installed on the hinged side, same as the three (3) non-hinged sides.

5. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

6. Do not install any equipment or duct that makes rigid connections with the building unless isolation is not specified.

7. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

END OF SECTION

[Wind Checklist

1. Wind restraints are required for all equipment exposed to the wind as covered by the following language in the 2020 New York State Building Code or 2015 International Building Code, Section 1609 Wind Loads Item 1609.1. "*Buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures."*

2. Coordinate with Architect to determine the following information about the building:

a. Basic Design Wind Speed (V): [115 mph.] [120 mph.] [ ]

b. Risk Category: [II] [III] [IV]

c. Exposure Category: [B] [C] [D]

d. Height and Exposure Adjustment Coefficient: [ ] [N/A - Building height is less than 60 ft.]

3. In general, the wind restraining equipment will be the same as the seismic restraining equipment. The purpose of this spec section is to identify the parameters by which the contractor must select and certify that equipment. The specific equipment to be restrained would be dictated by the prevailing Code.

4. In the individual spec sections for each piece of equipment that requires wind supports, add a reference back to this specification section (230550) for additional submittal and shop drawings requirements.

Submittal Reminder: When the wind restraint submittal is received, share it with the Structural Engineer for their review as well.]

SECTION 230553 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 QUALIFICATION

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

1.3 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 an 8-1/2 in. x 11 in. (minimum) indicating valve number, location, and valve function. Submit schedule of pipe, equipment and name identification for review before stenciling or labeling.

1.4 MAKES

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

PART 2 - PRODUCTS

2.1 GENERAL

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

B. All adhesives used for labels in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

2.2 PIPING IDENTIFICATION

A. Identification Types:

1. Pressure Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers complying with ANSI/ASME A13.1. Provide a 360° wrap of flow arrow tape at each end of pipe label.

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

3.

O.D. Pipe or Covering	Letter Size
3/4 in., 1 in., 1-1/4 in.	1/2 in.
1-1/2 in., 2 in.	3/4 in.
2-1/2 in. and over	1 in.

B. Lettering:

1. Piping labeling shall conform to the following list:

Pipe Function	Identification
Pumped Condensate	PC
Heating Water Supply	HWS
Heating Water Return	HWR
Chilled Water Supply	CWS
Chilled Water Return	CWR
Glycol Supply	GS
Glycol Return	GR

2.3 VALVE IDENTIFICATION

A. Valve Tags:

1. Standard brass valve tags, 2 in. diameter with 1/2 in. high numerals. Identify between heating and plumbing services with 1/4 in. letters above the valve number. Lettering to be stamped and in-filled black. Seton, or equal.

a. Valve-tag Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Chart:

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

2. Valve chart to include as a minimum, valve #, valve size, valve type, valve service description, valve location.

2.4 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, phenolic (micarta) labels for mechanical engraving, 1/8 in.**]** thick, and having predrilled holes for attachment hardware.

2. Letter Color: White.

3. Background Color: Black.

4. Maximum Temperature: Able to withstand temperatures up to 160 F.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 in. by 3/4 in.

6. Minimum Letter Size: 1/4 in. for name of units if viewing distance is less than 24 in., 1/2 in. for viewing distances up to 72 in., and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 in. x 11 in. bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

D. Provide for the following equipment:

1. Air handling units

2. Pumps

3. Chillers

4. Heat exchangers

5. Condensate pumps

2.5 ABOVE CEILING EQUIPMENT LOCATOR

A. 3/4 in. diameter adhesive stickers placed on ceiling grid. Color coded. Provide for the following:

1. Fire dampers/smoke dampers - RED

2. Plumbing valves - BLUE

3. HVAC valves - ORANGE

4. VAV boxes or reheat coils - GREEN

5. Fans - YELLOW

6. Pumps - BLACK

PART 3 - EXECUTION

3.1 GENERAL

A. Provide valve tags for all valves provided on project, except for service valves at terminal equipment.

B. Provide equipment tags for all equipment listed above.

C. Provide above ceiling equipment locator stickers on ceiling grid for all equipment listed above.

D. Provide piping identification with directional flow arrows for all piping on project, at maximum intervals of 20 ft. 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

1.1 WORK INCLUDED

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

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

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

1. Supply air systems, all pressure ranges; including constant volume and variable volume systems.

2. Return air systems.

3. Exhaust air systems; including kitchen exhaust systems.

4. Hydronic systems; including constant flow and variable flow systems.

5. Laboratory Fume Hoods.

D. This Section does not include:

1. Testing boilers and pressure vessels for compliance with safety codes;

2. Specifications for materials for patching mechanical systems;

3. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.

4. Requirements and procedures for piping and ductwork systems leakage tests.

1.2 SUBMITTALS

A. Provide information in report form listing items required by specifications. Results shall be guaranteed. Contractor shall be subject to recall to site to verify report information before acceptance of the report by the Owner's Representative.

B. Strategies and Procedures Plan: Within thirty (30) days of Contractor's Notice to Proceed, submit testing and balancing strategies and step-by-step procedures as specified in Section 3.1.B, "Preparation", and consistent with those listed in Part 3 of this specification.

C. System Readiness Checklists: Within thirty (30) days of Contractor's Notice to Proceed, AABC agency shall provide system readiness checklists as specified in Section 3.1.C,

"Preparation", to be used and filled out by the installing contractors verifying that systems are ready for Testing and Balancing.

D. Examination Report: Provide a summary report of the examination review required in Section 3.1.D to the Engineer, documenting issues that may preclude the proper testing and balancing of the systems.

E. Certified report format shall consist of the following:

1. Title sheet with job name, contractor, engineer, date, balance contractor's name, address, telephone number and contact person's name and the balancing technician's name.

2. Individual test sheets for air handlers, terminal units, air distribution, exhaust fans, duct traverses, pumps, air handling coils, reheat coils, radiation, convectors, cabinet unit heaters and unit ventilators.

3. Manufacturer's pump and fan curves for equipment installed with design and actual operating conditions indicated.

4. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".

1.3 DEFINITIONS

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

1. The balance of air and water distribution;

2. Adjustment of total system to provide design quantities;

3. Electrical measurement;

4. Verification of performance of all equipment and automatic controls.

B. Test: To determine quantitative performance of equipment.

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

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

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

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

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

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

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

J. Branch Main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.4 QUALIFICATIONS

A. Follow procedures and methods published by one or more of the following:

1. Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).

2. Individual manufacturer requirements and recommendations.

B. Maintain qualified personnel at project for system operation and trouble shooting. TAB contractor shall change sheaves and perform mechanical adjustments in conjunction with balancing procedure.

C. Balancing contractor shall be current member of AABC or NEBB.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in the *AABC National Standards for Total System Balance.*

1.5 GENERAL REQUIREMENTS

A. Before concealment of systems visit the job site to verify and advise on type and location of balancing devices and test points. Make changes as required to balance facilities.

B. Place systems in satisfactory operating condition.

1. Adjusting and balancing shall be accomplished as soon as the systems are complete and before Owner takes possession.

2. Prior to balancing, adjust balancing devices for full flow; fill, vent and clean hydronic systems, replace temporary filters and strainers.

3. Initial adjustment and balancing to quantities as called for or as directed by the engineer, to satisfy job conditions.

4. All outdoor conditions (Db, Wb, and a description of the weather conditions) at the time of testing shall be documented in the report.

5. Provide sheaves and belts as required to meet system performance requirements for all belt-driven fan motors 10 HP and greater. Adjust and align sheaves to obtain proper settings and operation. Verify motors are not overloading.

6. Installing contractor shall replace balancing cocks, flow balancers and dampers in new systems that cannot be manipulated to satisfy balancing requirements.

7. Identify flow balancers, balancing cocks and dampers in existing systems that cannot be manipulated to satisfy balancing requirements.

8. Traverse main ducts to determine total system air quantities after all outlets have been set prior to final adjustment if the system does not meet design requirements. A sum of room CFM's is not acceptable.

9. If duct construction and/or installation prohibits proper traverse readings, provide coil measurements at main coils and/or fresh air intake traverse with units operating in 100% outside air mode (where applicable).

1.6 CONTRACTOR RESPONSIBILITIES

A. Provide Testing and Balancing agency one complete set of contract documents, change orders, and approved submittals in digital and hard copy formats.

B. Controls contractor shall provide required BAS hardware, software, personnel and assistance to Testing and Balancing agency as required to balance the systems. Controls Contractor shall also provide trending report to demonstrate that systems are complete.

C. Coordinate meetings and assistance from suppliers and contractors as required by Testing and Balancing agency.

D. Provide additional valves, dampers, sheaves and belts as required by Testing and Balancing agency.

E. Flag all manual volume dampers with fluorescent or other high-visibility tape.

F. Provide access to all dampers, valves, test ports, nameplates and other appurtenances as required by Testing and Balancing agency.

G. Installing contractor shall replace or repair insulation as required by Testing and Balancing agency.

H. Have the HVAC systems at complete operational readiness for Testing and Balancing to begin. As a minimum verify the following:

1. Airside:

a. All ductwork is complete with all terminals installed.

b. All volume, smoke and fire dampers are open and functional.

c. Clean filters are installed.

d. All fans are operating, free of vibration, and rotating in correct direction.

e. ASD start-up is complete and all safeties are verified.

f. System readiness checklists are completed and returned to Testing and Balancing agency.

2. Hydronics:

a. Piping is complete with all terminals installed.

b. Water treatment is complete.

c. Systems are flushed, filled and air purged.

d. Strainers are pulled and cleaned.

e. Control valves are functioning per the sequence of operation.

f. All shutoff and balance valves have been verified to be 100% open.

g. Pumps are started, and proper rotation is verified.

h. Pump gauge connections are installed directly at the pump inlet and outlet flange or in discharge and suction pipe prior to any valves or strainers.

i. ASD start-up is complete and all safeties have been verified.

j. System readiness checklists are completed and returned to Testing and Balancing agency.

I. Promptly correct deficiencies identified during Testing and Balancing.

J. Maintain a construction schedule that allows the Testing and Balancing agency to complete work prior to occupancy.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Provide tools, ladders, recording meters, gauges, thermometers, velometers, anemometers, Pitot tubes, inclined gauge manometers, magnehelic gauges, amprobes, voltmeters, psychrometers and tachometers required.

B. Instrumentation Calibration: Calibrate instruments at least every six (6) months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine Bid Documents and submittals and notify Owner's Representative and Engineer of any questions regarding balancing.

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper Testing and Balancing of systems and equipment.

2. Examine the approved submittals for HVAC systems and equipment.

3. Examine equipment performance data including fan and pump curves.

B. Prepare a Testing and Balancing Strategies and Procedures Plan that includes:

1. Equipment and systems to be tested.

2. Strategies and step-by-step procedures for balancing the systems.

3. Instrumentation to be used.

4. Sample forms with specific identification for all equipment.

C. Prepare system-readiness checklists, as described in the *AABC National Standards for Total System Balance,* for use by contractors in verifying system readiness for Testing and Balancing. These shall include, at a minimum:

1. Airside:

a. All ductwork is complete with all terminals installed.

b. All volume, smoke and fire dampers are open and functional.

c. Clean filters are installed.

d. All fans are operating, free of vibration, and rotating in correct direction.

e. Permanent electrical power wiring and ASD start-up is complete and all safeties are verified.

f. Automatic temperature-control systems are operational.

g. Ceilings are installed.

h. Windows and doors are installed.

i. Suitable access to balancing devices and equipment is provided.

j. Equipment and duct access doors are securely closed.

2. Hydronics:

a. Piping is complete with all terminals installed.

b. Water treatment is complete.

c. Systems are flushed, filled and air purged.

d. Strainers are pulled and cleaned.

e. Control valves are functioning per the sequence of operation.

f. All shutoff and balance valves have been verified to be 100% open.

g. Pumps are started and proper rotation is verified.

h. Pump gauge connections are installed directly at the pump inlet and outlet flange or in discharge and suction pipe prior to any valves or strainers.

i. Permanent electrical power wiring and ASD start-up is complete and all safeties are verified.

j. Suitable access to balancing devices and equipment is provided.

D. Examine construction and notify Owner's Representative and Engineer of outstanding issues related to balancing, as part of "Examination Report" submittal.

1. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas.

2. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean permanent filters are installed, and controls are ready for operation.

3. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected, configured by the controls contractor and functioning.

4. Examine strainers to verify that Mechanical Contractor has replaced startup screens with permanent screens and that all strainers have been cleaned.

5. Examine two-way valves for proper installation and function.

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

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

8. Examine air vents to verify that mechanical contractor has removed all air from all hydronic systems.

9. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, weld-o-lets, and manual volume dampers prior to pressure testing. Note the locations of devices that are not accessible for testing and balancing.

3.2 TESTING OF AIR/WATER SYSTEMS

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. 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 insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and function.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. 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 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.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to sheaves sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. 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 that no overload will occur. Measure

amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

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

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

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

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

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

1. Set outside-air dampers at minimum, and return-and exhaust-air dampers at a position that simulates full-cooling load.

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

3. Measure total system airflow. Adjust to within indicated airflow.

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

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

   a. If air outlets are out of balance at minimum airflow, report the conditions but leave outlets balanced for maximum airflow.

6. 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 constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that the adequate static pressure is maintained at the most critical unit.

8. Record the final fan performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.

3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow.

6. Measure static pressure at the sensor.

7. 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 constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils and heat exchangers. Obtain approved submittals and any manufacturer-recommended testing procedures. Cross check the summation of required coil and heat exchanger gpms with pump design flow rate.

B. Verify that hydronic systems are ready for testing and balancing:

1. Check liquid level in expansion tank and verify that tank is set to specified pressure for system fill and expansion.

2. Check that makeup water has adequate pressure to highest vent.

3. Check that control valves are in their proper positions.

4. Check that air has been purged from the system.

5. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

6. Verify that motor starters are equipped with properly sized thermal protection.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.

b. Measure flow by main flow meter, if installed.

c. If main flow meter is not installed, determine flow by pump total dynamic head (TDH) or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves or fittings.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.

c. Convert pressure to head and correct for differences in gauge heights.

d. On single stage centrifugal pumps, verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

e. With all valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.

2. Adjust main and branch balance valves for design flow.

3. Re-measure each main and branch after all have been adjusted if requested by Engineer.

C. Adjust flow measuring devices installed at terminals for each space to design water flows.

1. Measure flow at all terminals.

2. Adjust each terminal to design flow.

3. Re-measure each terminal after all have been adjusted, if requested by Engineer.

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

5. Perform temperature tests after all flows have been balanced, if requested by Engineer.

D. For systems with pressure-independent valves at the terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after all flows have been verified.

E. For systems without pressure-independent valves or flow measuring devices at the terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.

2. If balanced by coil pressure drop, perform temperature tests after all flows have been verified, if requested by Engineer.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.

2. Re-measure all final pump operating data, TDH, volts, amps, static profile.

3. Mark all final settings.

G. Verify that all memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential pressure (DP) sensor is located per the Contract Documents.

2. Determine if there is diversity in the system.

B. For systems with no diversity:

1. Follow procedures outlined for constant-flow hydronic systems.

2. Prior to verifying final system conditions, determine the system DP setpoint.

3. If the pump discharge valve was used to set total system flow with ASD at 60 Hz, at completion open discharge valve 100% and allow ASD to control system DP setpoint. Record pump data under both conditions.

4. Mark all final settings and verify that all memory stops have been set.

C. For systems with diversity:

1. Determine diversity factor.

2. Simulate system diversity by closing required number of control valves, as approved by the design Engineer.

3. Follow procedures outlined for constant flow hydronic systems.

4. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance the terminals that were just opened.

5. Prior to verifying final system conditions, determine the system DP setpoint.

6. If the pump discharge valve was used to set total system flow with ASD at 60 Hz, at completion open discharge valve 100% and allow ASD to control system DP setpoint. Record pump data under both conditions.

7. Mark all final settings and verify that all memory stops have been set.

D. For systems with pressure-independent valves at the terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after all flows have been verified.

3.10 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

A. Measure, adjust and record the airflow of each kitchen hood. For kitchen hoods designed with integral make-up air, measure and adjust the exhaust and make-up airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.

1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.

2. Recommend means to adjust airflow to achieve design values where exhaust fans serve multiple hoods.

3. Installing contractor shall provide recommendations as required by Engineer.

B. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.

1. Check duct slopes as required.

2. Verify that duct access is installed as required.

3. Perform a light test or an approved equivalent test method to determine that all welded and brazed joints are liquid tight. Test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire section of ductwork to be tested. The lamp shall be open as to emit light equally in all directions perpendicular to duct walls. Test every joint in the entire duct system, including the hood-to-duct connection. Ductwork may be tested in sections provided that every joint is tested.

4. Verify that point of termination is as required.

5. Verify that duct air velocity is within the range required.

6. Prior to concealment of any portion of the grease-duct system, perform a duct leakage test in the presence of the code official.

7. Verify that duct is within a fire-rated enclosure.

C. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.

2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 in. between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.

3. Field test the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns

to achieve optimum results. The field test shall be conducted with all appliances under the hood at operating temperatures, with all sources of outdoor air providing make-up air for the hood operating, and with all sources of recirculated air providing conditioning for the space in which the hood is located operating.

D. Report deficiencies.

3.11 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: Zero to plus 10 percent.

2. Air Outlets and Inlets: Plus or minus 10 percent.

3. Minimum Outside Air: Zero to plus 10 percent.

4. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

5. Heating-Water Flow Rate: Plus or minus 10 percent.

6. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.12 FINAL TEST AND BALANCE REPORT

A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the Testing and Balancing process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. All measurements and test results that appear in the reports must be made on site and dated by the technicians or Test and Balance Engineers.

B. The report must be organized by systems and shall include the following information as a minimum:

1. Title Page:

a. AABC or NEBB Certified Company Name.

b. Company Address.

c. Company Telephone Number.

d. Project Identification Number.

e. Location.

f. Project Architect.

g. Project Engineer.

h. Project Contractor.

i. Project Number.

j. Date of Report.

k. Certification Statement.

l. Name, Signature, and Certification Number.

2. Table of Contents.

3. National Performance Guaranty.

4. Report Summary:

a. The summary shall include a list of items that do not meet design tolerances, with information that may be considered in resolving deficiencies.

5. Instrument List:

a. Type
b. Manufacturer
c. Model
d. Serial Number
e. Calibration Date

C. Required air side data - Test, adjust and record the following:

1. Motors:

a. RPM
b. BHP
c. Full load amps
d. Sheave sizes, number and size of belts
e. Shaft diameter
f. Complete nameplate data

2. Fans:

a. Cfm
b. RPM
c. Suction static pressure
d. Discharge static pressure
e. Sheave sizes, number and size of belts, key sizes, shaft, diameter
f. Complete nameplate data
g. Sketch of system's inlet and outlet connections
h. Location of test port

3. Duct: Traverse Zones:

a. Cfm
b. Static Pressure

4. AHU - Fan coil units, heat pumps, unit ventilators (In both minimum O.A. and economizer modes):

a. Minimum outdoor air Cfm
b. Total discharge and return Cfm
c. Static profile thru unit
d. Complete nameplate data

5. Coil:

a. Entering air temperature (DB/WB)
b. Leaving air temperature (DB/WB)
c. Static differential
d. Face velocity and area
e. Cfm
f. Complete nameplate data

6. Registers/Grilles/Diffusers:

a. Cfm
b. Set, adjust and record air flow pattern

7. Filter Banks:

a. Nameplate data
b. Static pressure drop

D. Required Fluid Data: Test, adjust and record the following:

1. Heat Transfer Devices: Including, but not limited to air handlers, convectors, fin tube radiation sections, unit ventilators, fan coils, cabinet heaters, unit heaters, heat pumps, heat exchangers.

a. GPM (coil and bypass)
b. Entering water temperature
c. Leaving water temperature
d. Water pressure drop
e. Complete nameplate data
f. Refrigerant suction pressure and temperature

2. Pumps:

a. Check rotation
b. GPM
c. Pump off pressures (suction and discharge)
d. Running suction pressure
e. Running discharge pressure
f. Running load amps

g. RPM - motor
h. Complete nameplate motor and pump
i. Marked up pump curve illustrating final operating conditions

3. Boilers:

a. GPM
b. Entering water temperature and pressure
c. Leaving water temperature and pressure
d. Complete nameplate data
e. **[Leaving steam pressure]**

4. Heat Exchanger:

a. GPM
b. Entering water temperature and pressure
c. Leaving water temperature and pressure
d. Complete nameplate data
e. **[Entering steam pressure]**

5. Chillers - (Evaporator and Condensing Sections):

a. GPM
b. Entering water temperature and pressure
c. Leaving water temperature and pressure
d. Complete nameplate data
e. **[Entering steam pressure]**

E. The final test and balance report shall be provided as a formal project submittal for review by the Engineer of Record.

END OF SECTION

SECTION 230710 - INSULATION

PART 1 - GENERAL

1.1 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.

1.2 SUBMITTAL

A. Submit product data, product description, manufacturer's installation instructions, types and recommended thicknesses for each application, and location of materials.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230533 - Electric Heat Tracing for HVAC Piping.

B. Section 230710.50 - Removable Insulation Blankets.

C. Section 232010 - Piping Systems and Accessories.

D. Section 233100 - Sheet Metal and Ductwork Accessories Construction.

PART 2 - PRODUCTS

2.1 GENERAL

A. Insulation, jackets, adhesive, and coatings shall comply with the following:

1. Treatment of jackets or facing for flame and smoke safety must be permanent. Water-soluble treatments 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, when tested in accordance with ASTM E84.

3. Asbestos or asbestos bearing materials are prohibited.

4. Comply with 2020 Energy Conservation Construction Code of New York State.

5. All adhesives, coatings and sealants used for insulation in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

6. Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least two (2) years prior to bid opening. Provide insulation systems in accordance with the approved MICA or NAIMA Insulation Standards.

7. Insulation shall be clearly marked with manufacturer's name, identification of installed thermal resistance (R) value, out-of-package R value, flame spread and smoke developed indexes in accordance with Energy Code requirements.

2.2 ACCEPTABLE MANUFACTURERS

A. Fiberglass: Knauf/Manson, Johns Manville, Owen-Corning, Certainteed. (Board, Blanket and Liner)

B. Polyisocyanurate: Dow Trymer 2000XP, HyTherm.

C. Calcium Silicate: Industrial Insulation Group (ILG).

D. Flexible Elastomeric: Armacell, K-Flex.

E. Adhesives, Coatings, Mastics, Sealants: Childers, Foster.

2.3 PIPE INSULATION (RIGID FIBERGLASS TYPE)

A. Product meeting ASTM C 547, ASTM C 585, and ASTM C 795; rigid, molded, noncombustible.

B. 'K' Value: ASTM C 335, 0.23 at 75°F mean temperature installed value. Maximum Service Temperature: 1000°F.

C. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C 1136 Type I, secured with self-sealing longitudinal laps and butt strips.

D. Field-Applied PVC Fitting Covers with Flexible Fiberglass Insulation: Proto Corporation 25/50 or Indoor/Outdoor, UV-resistant fittings, jacketing and accessories, white or colored. Fitting cover system consists of pre-molded, high-impact PVC materials with blanket type fiberglass wrap inserts. Blanket fiberglass wrap inserts shall have a thermal conductivity ('K') of 0.26 at 75°F mean temperature. Closures to be stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

2.4 PIPE INSULATION (RIGID POLYISOCYANURATE TYPE)

A. Preformed Rigid Polyisocyanurate Insulation: Cellular foam complying with ASTM C591, rigid molded, non-combustible. 2 lb./ft^3 nominal density. Maximum thermal conductivity (k) shall be 0.19 BTU-in/ft^2 hr. °F at 75°F mean temperature. Maximum Service Temperature; 300°F.

B. Vapor Retarder Jacket; Dow Saran Vapor Retarder Film and Tape.

C. Covering Jacket; White Kraft outer surface bonded to aluminum foil and reinforced with fiberglass yarn.

2.5 FLEXIBLE TYPE INSULATION

A. Flexible Elastomeric Thermal Insulation: Closed-cell, foam material. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Maximum thermal conductivity (k) shall be 0.25 BTU-in/ft^2 hr. °F at 75°F mean temperature. Adhesive: As recommended by insulation material manufacturer.

B. Insulation shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 as tested by ASTM E 84 and CAN/ULC S-102, "Method of Test for Surface Burning Characteristics of Building Materials".

2.6 CALCIUM SILICATE

A. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

2.7 DUCT INSULATION

A. Duct insulation shall have a thermal resistance (R) value identification mark by the manufacturer applied no less than every 10 ft., as per Energy Code requirements.

B. Flexible Fiber Glass Blanket:

1. Product meeting ASTM C 553 Types I, II and III, and ASTM C 1290; Greenguard compliant.

2. 'K' Value of 0.27 at 75°F mean temperature. Maximum Service Temperature (Faced): 250°F.

3. Vapor Retarder Jacket: FSK conforming to ASTM C 1136 Type II. Provide ASJ jacket for ductwork to be painted.

4. Installation: Maximum allowable compression is 25%. Securement: Secured in place using outward cinching staples in combination with appropriate pressure-sensitive aluminum foil tape. Coat taped seams with glass fabric and vapor barrier coating.

5. Density: 0.75 or 1.0 PCF. See Exhibit II for the thickness requirement at each density.

C. Rigid Fiber Glass Board:

1. Product meeting ASTM C 612 Type IA and IB.

2. 'K' Value of 0.23 at 75°F mean temperature. Maximum Service Temperature: 450º F.

3. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, or FSK or PSK conforming to ASTM C 1136 Type II. Provide ASJ jacket for ductwork to be painted.

4. Securement: Secured in place using adhesive and mechanical fasteners spaced a minimum of 12 in. on center with a minimum of 2 rows per side of duct. Insulation shall be secured with speed washers and all joints, breaks and punctures sealed with appropriate pressure-sensitive foil tape. Coat taped seams with glass fabric and vapor barrier coating.

   a. Concealed Areas: Minimum 3 lb./ft.^{3}.

   b. Exposed Areas: 6 lb./ft.^{3} minimum density for duct less than 8 ft. - 0 in. above finished floor.

D. Kitchen Hood Exhaust Duct Wrap: John Mansville Firetemp Wrap, Certainteed FlameChek, Unifrax FyreWrap or approved equal. Wrap shall be compliant with ASTM E2336 Fire Resistive Duct Enclosure System, fully tested against internal grease ducts fires (ASTM E-2336), external fires (ASTM E 119/UL263), through penetration insulated duct fires (ASTM 814/UL1479), wall fires (ASTM E 119), and surface burning (ASTM E 84/UL723). Wrap for grease duct applications shall use two layers of 1-1/2 in. wrap. The interior layer is applied with a butt joint. The second layer is offset a minimum of six inches from the initial layer. It is applied with an overlap of three inches and the insulated duct is banded with stainless steel straps.

E. Polyisocyanurate Board: Closed cell polyisocyanurate core bonded to a triple laminated foil facing on both sides. Comply with ASTM C1289 Type I Class I. "K" value: 0.17 BTU in/(hr. sq.ft. degree F) at 75 deg. F.

2.8 EQUIPMENT INSULATION

A. Rigid Fiber Glass Board:

1. Product meeting ASTM C 612 Type IA and IB.

2. Concealed Areas:

   a. Density: Minimum 3 PCF.

   b. 'K' Value of 0.23 at 75°F mean temperature. Maximum Service Temperature: 450°F.

   c. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, or FSK conforming to ASTM C 1136 Type II.

3. Exposed Areas:

   a. Density: Minimum 6 PCF

   b. 'K' Value: ASTM C 177, 0.22 at 75°F mean temperature.

B. Foam Board. Polyisocyanurate core. Foil faced on one side and opposite side faced with white acrylic coated embossed aluminum, 4-mil. equal to "Dow Chemical Thermax Heavy Duty".

2.9 FIELD-APPLIED JACKETS

A. Piping:

1. PVC Pipe Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming. Adhesive: As recommended by insulation material manufacturer. PVC Jacket Color: White.

2. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003-alloy, and H-14 temper. Finish and Thickness: Corrugated finish, 0.010 inch thick. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

3. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch thick; and factory cut and rolled to indicated sizes. Moisture Barrier: 3-mil- thick, heat-bonded polyethylene and kraft paper. Elbows: Gore type, for 45- and 90-degree elbows in same material, finish, and thickness as jacket. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.

4. Alumaguard Jacketing: Self adhesive, 60 mil thick, rubberized bitumen, foil faced membrane. Polyguard Products, Inc. Alumaguard 60, or equal.

5. Venture Guard Jacketing: 26.6 mil thick, Hypalon self adhesive membrane. Venture Tape Corp. Venture Guard, or equal.

B. Ductwork:

1. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section. Finish: Cross-crimp corrugated or stucco embossed finish. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.

2. Stainless-Steel Jacket: Deep corrugated sheets of stainless steel complying with ASTM A 666, Type 304 or 316; 0.10 inch thick; and roll stock ready for shop or field cutting and forming to indicated sizes. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.

3. Alumaguard Jacketing: Self adhesive, 60 mil thick, rubberized bitumen, foil faced membrane. Polyguard Products, Inc. Alumaguard 60, or equal.

4. Venture Guard Jacketing: 26.6 mil thick, Hypalon self adhesive membrane. Venture Tape Corp. Venture Guard, or equal. To be used on the bottom surface of rectangular ducts greater than 24 in. wide, due to lesser jacket weight that will avoid sagging issues over time.

2.10 COATINGS, MASTICS, ADHESIVES AND SEALANTS

A. Vapor Barrier Coatings: Used in conjunction with reinforcing mesh to coat insulation on below ambient services temperatures. Permeance shall be no greater than 0.08 perms at 45 mils dry as tested by ASTM F1249. Foster 30-65 Vapor Fas; Childers CP-34, or approved equal.

B. Lagging Adhesives: Used in conjunction with canvas or glass lagging cloth to protect equipment/piping indoors. Foster 30-36 Sealfas; Childers CP-50AMV1 Chil Seal, or approved equal.

C. Weather Barrier Mastic: Used outdoors to protect above ambient insulation from weather. Foster 46-50 Weatherite; Childers CP-10 Vi Cryl, or approved equal.

D. Fiberglass Adhesive: Used bond low density fibrous insulation to metal surfaces. Shall meet ASTM C916 Type II. Foster 85-60; Childers CP-127, or approved equal.

E. Elastomeric Insulation Adhesive: Used to bond elastomeric insulation. Foster 85-75; Childers CP-82, or approved equal.

F. Elastomeric Insulation Coating: Water based coating used to protect outside of elastomeric insulation. Foster 30-65, Childers CP-34 or approved equal.

G. Insulation Joint Sealant: Used as a vapor sealant on below ambient piping with polyisocyanurate and cellular glass insulation. Foster 95-50; Childers CP-76, or approved equal.

H. Metal Jacketing Sealant: Used as a sealant on metal jacketing seams to prevent water entry. Foster 95-44; Childers CP-76, or approved equal.

I. Reinforcing Mesh: Used in conjunction with coatings/mastics to reinforce. Foster Mast A Fab; Childers Chil Glass #10, or approved equal.

2.11 MATERIALS AND SCHEDULES

A. See Exhibits at the end of this section.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards.

B. Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation. No glass fibers shall be exposed to the air.

C. All pipe and duct insulation shall be continuous through hangers, walls, ceiling and floor openings, and through sleeves, unless not allowed by Fire Stop System. Refer to Section 230500 "Basic Requirements" for Fire Stop Systems.

D. Provide thermal insulation on clean, dry surfaces and after piping, ductwork and equipment (as applicable) have been tested. Do not cover pipe joints with insulation until required tests are completed.

E. All cold surfaces that may "sweat" must be insulated. Vapor barrier must be maintained; insulation shall be applied with a continuous, unbroken moisture and vapor seal. All hangers, supports, anchors, or other projections that are secured to cold surfaces shall be insulated and vapor sealed to prevent condensation. Cover valves, fittings and similar items in each piping system with insulation as applied to adjoining pipe run. Extra care must be taken on piping appurtenances to insure a tight fit to the piping system. For piping systems with fluid temperatures below ambient, all vapor retarder jacket (ASJ) seams must be coated with vapor barrier coating. All associated elbows, fittings, valves, etc. must be coated with vapor barrier coating and reinforcing mesh to prevent moisture ingress. Valve extension stems require Elastomeric insulation that is tight fitting to the adjoining fiberglass system insulation. Pumps, strainers, air separators, drain valves, etc. must be totally encapsulated with Elastomeric insulation.

F. Items such as boiler manholes, handholds, clean-outs, ASME stamp, and manufacturers' nameplates, may be left un-insulated unless omitting insulation would cause a condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

G. Provide protective insulation as required to prevent personnel injury: Piping from zero to seven feet above all floors and access platforms including hot (above 140°F) piping and any other related hot surface.

H. All pipes shall be individually insulated.

I. If any insulation material has become wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site.

3.2 PIPE INSULATION

A. Insulate piping systems including fittings, valves, flanges, unions, strainers, and other attachments installed in piping system, whether exposed or concealed except within radiation enclosures.

B. Insulation installed on piping operating below ambient temperatures must have a continuous vapor retarder. All joints, seams and fittings must be sealed.

C. Hanger Shields: Refer to Section 232010 "Piping Systems and Accessories".

D. Metal shields shall be installed between hangers or supports and the piping insulation. Rigid insulation inserts shall be installed as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required.

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 Hamfab Co. "H" blocks per manufacturers recommended spacing between pipe and shield.

3. Tape shields to insulation.

E. Joints in section pipe covering made as follows:

1. All ends must be firmly butted and secured with appropriate butt-strip material. On high-temperature piping, double layering with staggered joints may be appropriate. When double layering, the inner layer should not be jacketed.

2. Standard: Longitudinal laps and butt joint sealing strips cemented with white vapor barrier coating, or factory supplied pressure sensitive adhesive lap seal.

3. Vapor Barrier: For cold services, Longitudinal laps and 4 in. vapor barrier strip at butt joints shall be sealed with white vapor barrier coating. Seal ends of pipe insulation at valves, flanges, and fittings with white vapor barrier coating. When using polyisocyanurate or cellular glass on below ambient piping/duct, seal all insulation joints with insulation joint sealant.

F. Fittings, Valves and Flanges:

1. Chilled Water: Flexiblefitting insulation of the same material and thickness as the adjacent pipe insulation. Vapor seal with two (2) coats of white vapor barrier coating.

2. Hot Services and Domestic Cold Water: Flexible insulation of the same material and thickness as the adjacent pipe insulation. Vapor seal domestic cold water with two (2) coats of white vapor barrier coating.

3. White PVC jacketing, with continuous solvent weld of all seams. Tape all fittings.

G. Flexible Pipe Insulation:

1. Split longitudinal joint and seal with adhesive.

2. Fittings made from miter-cut pieces properly sealed with adhesive, or ells may be continuous.

3. Where exposed outdoors, provide with Alumaguardjacketing.

H. For piping exposed to the elements, jacketing shall be **[aluminum] [stainless steel]** with a factory applied moisture barrier. Fitting covers shall be of similar materials. The insulation and jacketing shall be held firmly in place with a friction type Z lock or a minimum 2 in. overlap joint. All joints shall be sealed completely along the longitudinal seam and installed so as to shed water. All circumferential joints shall be sealed by use of preformed butt strips; minimum 2 in. wide or a minimum 2 in. overlap. Butt strips

shall overlap the adjacent jacketing a minimum 1/2 in. and be completely weather sealed. Jacket at ells and tees shall be mitered, or pre-manufactured fitting jackets shall be provided, with additional aluminum holding bands, as required. All joints shall be sealed watertight using specified metal jacketing sealant as recommended by the manufacturer.

I. Apply PVC jacket where indicated, with 1 in. overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.

J. Apply either aluminum or PVC jacketing to exposed insulated pipe, valves, fittings, and specialties, at an elevation of 8 feet or less above finished floor in mechanical/electrical rooms, penthouses, and services aisles/pipe chases. Fittings of aluminum-jacketed piping may be either aluminum or standard PVC fitting covers.

K. All exposed piping less than 8'-0" above finished floor in occupied spaces shall be insulated with polyisocyanurate insulation (for cold services) or calcium silicate (for hot services) and rigid fiberglass fittings. All exposed piping shall have a continuous 30 mil thick white PVC jacketing.

3.3 DUCTWORK INSULATION

A. Provide external thermal insulation for duct. Not required where ducts have internal acoustical insulation. 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 (2) rows per side. Secure insulation with washer clips. Self-adhesive clips are not acceptable. Staple all joints. Seal breaks and joints in vapor barrier with 4 in. wide matching tape and 4 in. glass-fab applied with specified vapor barrier coating. Apply tape over corner beading where exposed.

2. Flexible Blanket Type: Install Duct Wrap to obtain specified R-value using a maximum compression of 25%. Installed R-value shall be per energy code requirements. Firmly butt all joints. The longitudinal seam of the vapor retarder must be overlapped a minimum of 2 in. Where vapor retarder performance is required, all penetrations and damage to the facing shall be repaired using pressure-sensitive foil tape, and coated with vapor barrier coating prior to system startup. Pressure-sensitive foil tapes shall be a minimum 3 in. wide and shall be applied with moving pressure using a squeegee or other appropriate sealing tool. Closure shall have a 25/50 Flame Spread/Smoke Developed Rating per UL 723. Duct wrap shall be additionally secured to the bottom of rectangular ductwork over 18 in. wide using mechanical fasteners on 18 in. centers. Self-adhesive clips are not acceptable. Care should be exercised to avoid over-compression of the insulation during installation.

3. Kitchen Hood Exhaust Duct Wrap: Install duct wrap in strict accordance with the manufacturer's written installation methods.

4. Exterior Ductwork: Finish with an aluminumjacket. All joints shall be positioned so as to shed water; with a minimum 3 in. overlap, and completely weather sealed with specified metal jacketing sealant.

3.4 EQUIPMENT INSULATION

A. Apply insulation with joints firmly butted as close as possible to the equipment surface. Insulation shall be secured as required with adhesive, mechanical fasteners or banding material. Fasteners shall be located a maximum of 3 in. from each edge and spaced no greater than 12 in. on center.

B. Vapor retarders shall overlap a minimum of 2 in. at all seams and be sealed with appropriate pressure-sensitive tape and vapor barrier coating. All penetrations, facing damage, and mechanical fasteners shall be covered with a minimum 2 in. overlap of tape and vapor barrier coating.

C. Calcium Silicate Equipment Insulation: Secure blocks with galvanized steel bands, 12 in. O.C., then point with insulating cement. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white mastic coating. Leave ready for painting.

D. Fiberglass Equipment Insulation: Secure fiberglass with pins, studs, or clips. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white lagging adhesive/coating. Leave ready for painting.

E. Equipment insulation exposed to the elements shall be finished with minimum 0.030 in. thick outdoor weather able PVC, specified weather barrier mastic and glass cloth, or metal. All joints shall be positioned so as to shed water; with a minimum 3 in. overlap, and completely weather sealed.

F. For equipment insulation exposed in mechanical rooms or subject to mechanical abuse, finish with minimum 0.020 in. thick PVC Jacketing or metal. All other insulation shall be finished as appropriate for the location and service or as specified on the drawings.

EXHIBIT "I" - PIPE INSULATION MATERIALS

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Hot water and glycol/hot water (200°F and lower)	Glass fiber	1-1/2 in. and Larger: 2 in. 1-1/4 in. and Smaller: 1-1/2 in.	
Heat pump boiler water (from boiler to heat pump loop)	Glass fiber	1-1/2 in. and Larger: 2 in. 1-1/4 in. and Smaller: 1-1/2 in.	
Chilled water, glycol/chilled water	Glass fiber Flexible	1-1/2 in. and Larger: 1 in. 1-1/4 in. and Smaller: 1/2 in.	
Refrigeration Piping (Suction and liquid lines)	Flexible	1 in. and Larger: 1 in. 3/4 in. and Smaller: 1/2 in.	

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Outdoor Refrigeration Piping (Suction and liquid lines)	Flexible	1 in. and Larger: 1 in. 3/4 in. and Smaller: 1/2 in.	Insulation shall be provided with a UV resistant coating. **Cover with Alumaguard jacketing applied per manufacturer's recommendations**
Generator Exhaust	Calcium Silicate		
Concealed AC unit condensate drains	Flexible	All Sizes: 1/2 in.	
Piping in exterior walls, spaces, overhangs, attics, exterior, or where subject to freezing.		Insulate pipe with double the thickness called for above	

EXHIBIT "II" - DUCT INSULATION MATERIALS

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
HVAC Supply	Within mechanical rooms or exposed at 8 feet or less above finished floor: Rigid fiberglass	……..……..1-1/2 in.	Min. installed R value of 6
	Concealed: Flexible fiberglass	……..2 in. at 1.0 PCF or ……..2.2 in. at 0.75 PCF	Min. installed R value of 6
Supply or Return ducts in cold attic spaces or other un-conditioned spaces	Flexible fiberglass	……..……..…5 in	Min. installed R value of 12
Exhaust ducts in cold attic spaces or other un-heated spaces	Flexible fiberglass	……..……. 3 in	Min. installed R value of 8
Supply ducts, exposed within the conditioned space served	…….	…NOT INSULATED…	Does not include the associated supply ductwork within the Mechanical Room or supply duct to the conditioned space.
Interior ductwork indicated to be lined	…….	…NOT INSULATED…	……
Return and exhaust ducts within heated building envelope	…….	…NOT INSULATED…	……
Outside air ducts and plenums, connections and mixing boxes	Rigid fiberglass	……..……. 2 in.	Min. installed R value of 8

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
			Provide neat fit at intake plenum
Exhaust, relief or vent ducts and plenums	Exposed: Rigid fiberglass Concealed: Flexible fiberglass	……...……1-1/2 in. ……...……2 in.	Min. installed R value of 6 Insulate 15 ft. from exterior opening and plenums
Concealed kitchen hood exhaust	UL1978 Grease duct wrap	……Two (2) Layers @ 1-1/2 in.	
Outdoor Ductwork	Polyisocyanurate board Rigid Fiberglass	……...……..2-1/2 in. ……...……..3 in.	Min. installed R value of 12 Cover with Alumaguard jacketing applied per manufacturer's recommendations.
Field-fabricated boiler breeching	Calcium silicate	……...…….1-1/2 in.	

EXHIBIT "III" - EQUIPMENT INSULATION MATERIALS

[DESIGNER NOTE: WHEREVER POSSIBLE, SPECIFY OPTIONAL FACTORY INSULATION OF DEARATORS, CONDENSATE RECEIVERS, DHW HEATERS, CHILLERS, AND SIMILAR EQUIPMENT]

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Air removal assemblies and fabric filter assemblies	----------	SAME AS WATER PIPING	
Heating system expansion tanks and chemical feed tanks	----------	NOT INSULATED	----------
Cooling system expansion tanks and chemical feed tanks	----------	SAME AS WATER PIPING	----------
Chilled water pumps and cold heat exchangers	Flexible sheets of Elastomeric foam	…….…. 1 in.	Arrange for easy removal. Coat with white finish.
	Polyisocyanurate	…… 1 in.	Construct a "box-style" to cover with removable access sections where required. Seal all joints with manufacturer's

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
			recommended vapor barrier.

END OF SECTION

SECTION 230923 - BUILDING MANAGEMENT SYSTEM - DDC LOGIC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Drawings. Provide a complete Building Management System (BMS), to perform the functions described in this Section. All new equipment shall be compatible with the existing system. 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 and including 120 volts. Install wiring in accordance with requirements of "Electrical Wiring" in Section 230504, and the National Electrical Code. Provide all required devices for proper system operation, including special electrical switches, transformers, relays, pushbutton stations, etc.

1. All Actuation of valves and dampers shall be electric unless specifically called out elsewhere in the specifications or drawings.

B. The Mechanical Contractor shall be responsible to provide the services to develop the BMS System documentation, programming, installation of the equipment, and commissioning such that the project has a complete and workable Building Management System that is fully compliant with the requirements of this specification section.

C. The BMS System shall have the following capabilities as described in these specifications:

1. The network controllers and operator's workstations shall be connected directly to the Owner's Ethernet Network. The network controller shall also contain SNMP for integration to the Owner's Network Controllers System.

2. Off site access for Owner's personnel shall be provided and shall have full workstation capability from remote location. Identical graphical displays shall be provided for offsite access to match the displays at the on-site Operator's Workstation. Connection to the site shall be via a high speed Ethernet connection.

3. The Network Controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e. WEB browser), eliminating the need and reliance on any PC-based WEB server hardware or software.

4. The system shall be capable of sending both emails and text messages, and calling landline/cell phone numbers for alarms. A minimum of six (6) email addresses and phone numbers (for text and phone call messages) must be supported by the system. Coordinate with the Owner for email addresses, phone numbers and alarms.

5. All system variables in the temperature control system shall be Microsoft variables allowing them to be displayed and manipulated in other Microsoft products.

6. Network controllers shall all be flash upgradeable and not require changing chips for upgrades.

7. Short term logging of historical data shall be provided for every DDC input and output in the system. Each point shall be capable of being logged for a minimum of two (2) weeks.

D. The BMS shall consist of PC-based workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions. Further, the system shall be the backbone framework for the Security/Card Access/CCTV system through the front-end software.

E. The system shall consist of the following components:

1. Provide one (1) File Server, one (1) Operator Workstation Computer(s), and printer(s) as described in this specification. The Workstations shall be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third party front-end workstation software will be acceptable.

2. Provide Ethernet-based network controllers as described in this specification. Controllers shall connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others.

3. Provide the necessary quantity and types of standalone controllers to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each standalone controller shall operate completely standalone, containing all of the I/O and programs to control its associated equipment.

4. A high speed Ethernet connection to the site shall be used for offsite access to the site. Coordinate with the Owner's IT professionals for high speed system access and shall comply with Owner's requirements to maintain the level of security required by the Owner. Coordinate with Owner and provide VPN (Virtual Private Network) as required, to comply with the Owner's IT professionals requirements.

5. BACnet Protocol Integration - BACnet:

a. The neutral protocol used between systems will be BACnet over Ethernet and comply with ASHRAE BACnet standard 135-2003.

b. A complete Protocol Implementation Conformance Statement shall be provided for all BACnet system devices.

c. The ability to command share point object data, change of state data and schedules between the host and BACnet systems shall be provided.

1.2 QUALITY ASSURANCE

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

B. The BMS Contractor/Subcontractor shall have a minimum of five (5) years experience in systems of similar size, type and complexity installed within a 100 mile radius.

C. The BMS Contractor/Subcontractor shall have a local service department (within a 50 mile radius) and have available a minimum of three (3) 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 ten (10) years minimum from the date that the system is commissioned.

F. Electrical standards: Provide electrical products that comply with the following agency approvals:

1. UL 916; Energy Management Systems for Temperature Control components and ancillary equipment.

2. UL 873; Temperature Indication and Regulating Equipment.

3. FCC, Part 15, Subpart J, Class A Computing Devices.

G. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National codes.

1.3 ACCEPTABLE MAKES

A. The complete Building Management System is designed and based on that manufactured by **the following:** Acceptable Make: Andover, Siemens Building Technologies, Siebe Environment Controls, Johnson Controls, Automated Logic, Alertron.

1.4 SUBMITTALS

A. Submit for review, a brochure containing the following:

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

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

3. 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.

4. 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.

5. 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.

1.5 SCOPE OF WORK

A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, workstations, software, sensors, transducers, relays, valves, dampers, damper operators and other accessory equipment, along with a complete system of electrical interlocking wiring as required to fill the intent of the specification and provide for a complete and operable system.

B. The BMS Contractor/Subcontractor shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

C. All interlocking, wiring and installation of control devices associated with the equipment shall be provided under this Contract. The BMS Contractor/Subcontractor shall demonstrate the operation of the system to the Owner and prove that it complies with the intent of the drawings and specifications.

D. Provide services and manpower necessary for commissioning of system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative. Commissioning reports showing the testing of each DDC point on the system shall be submitted to the Engineer for review and approval upon completion of the commissioning process. Refer to the Commissioning Specification Section 019113.

1.6 WORK INCIDENTAL TO TEMPERATURE CONTROL CONTRACTOR

A. The BMS Contractor/Subcontractor shall furnish the following materials, installation by the HVAC Contractor:

1. For piping work:

a. Control valves in piping.

b. Immersion sensing wells in piping systems.

c. Valved pressure taps.

2. For sheet metal work:

a. All automatic dampers, the BMS Contractor/Subcontractor shall assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper and motors.

b. The HVAC Contractor shall provide access doors or other means of access through ducts or ceilings and walls for service and adjustment of controllers, valves, and dampers.

B. 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.

C. BMS Contractor/Subcontractor is responsible for providing 120 volt dedicated power to all DDC panels and operator workstations.

D. BMS Contractor/Subcontractor is responsible for providing 120 volt dedicated power and control transformers at all microprocessor based VAV terminal unit controllers laboratory control valves. As an option, provide control transformers sized to serve multiple VAV terminal unit controllers laboratory control valves. The Electrical Contractor is responsible for providing a junction box or boxes to obtain power, on a per floor basis. See electrical plans for locations.

E. BMS Contractor/Subcontractor is responsible for installing dedicated phone line for DDC system modems.

F. BMS Contractor/Subcontractor is responsible for providing Ethernet data drops at main building controller and at operator workstation.

1.7 CONTROL SYSTEM GUARANTEES

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. Provide one (1) year maintenance service of control components, to start concurrently with the guarantee specified above. Such service shall include software updates and 24 hour, 7 day emergency and seasonal inspection and adjustment of operating controls and replacement of parts or instruments found deficient and defective during this period.

C. Provide monitoring of the DDC system as soon as the system is operating and then for a minimum of one (1) year (24 hours/day, 7 days/week) after the acceptance date. A monthly report will be sent to the Owner with a description of general system status and any alarms or off-normal conditions.

D. Guarantee future availability of continuous, 24 hour, 7 day a week service for the systems through available maintenance contracts.

1.8 SYSTEM ADJUSTMENT AND CALIBRATION

A. When the Work has been completed, completely adjust and calibrate the control system. Review the operation of each system input and output, control loops and/or software routings, timing functions, operator entered constants and facilities management functions and observe that they perform their intended functions. Provide a complete values and points log, printed every hour, for one week to demonstrate control functions and programming. Provide one point log for summer operation and one winter. Points to be trended shall be selected by the Engineer. When above procedure has been completed and the control system is operating satisfactorily, submit a letter with one (1) copy of completed values and points log to the Owner's Representative advising them that the control system is 100% complete and operates in accordance with the Contract Documents.

B. After review and approval of points log by the Engineer, the BMS Contractor shall schedule a technician on site for field review of system components, operation and graphics as part of final system appearance.

1.9 INSTRUCTIONS TO THE OWNER'S REPRESENTATIVE

A. Provide competent control technicians to instruct the Owner's operating personnel and turn over three (3) copies of maintenance manual. Provide a total of **24** hours of instruction at the site, **16** hours during start-up and **8**after six (6) months. Instruction sessions shall be scheduled at the Owner's convenience and shall be limited to four (4) hours per session. The instructions shall include, but not be limited to, the following:

1. System Overview.

2. System Software and Operation:

a. System Access.

b. Software Features Overview.

c. Changing Setpoints and Other Attributes.

d. Scheduling.

e. Editing Programmed Variables.

f. Displaying Color Graphics.

g. Running Reports.

h. Workstation Maintenance.

i. Application Programming.

3. Operational sequences including start-up, shutdown, adjusting and balancing.

4. Equipment maintenance.

PART 2 - PRODUCTS

2.1 CONTROL DEVICES

A. Control Valves:

1. Sized by BMS Contractor/Subcontractor 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 10 ft. of head drop. Steam valves shall be sized for no more than a 5 psig pressure drop, or 30% (max.) of design steam pressure, whichever is smaller. Pressure drop for valves shall be submitted for review, including all CV values.

2. 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.

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

4. Electric Operators:

   a. 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.

B. Temperature Sensors:

1. All temperature devices shall use precision thermistors accurate to ± 0.36°F over a range of -30 to 230°F.

2. Standard space sensors shall be provided in an off white, or white, enclosure for mounting on a standard electrical box.

3. Provide manual adjustment slider with ± programmable scale. Programmable scale shall have the capability to be limited via the DDC System.

4. Provide a local LCD display for viewing the space temperature.

5. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors shall be used in air handling applications where the air stream temperature is consistent and is not stratified. Averaging sensors shall be employed in all mixing plenum and coil discharge

applications and in any other application where the temperature might otherwise be stratified. The averaging sensor tube shall contain at least four thermistor sensors.

6. Immersion sensors shall be employed for measurement of temperature in all chilled water, hot water and glycol applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250°F and 300 series stainless steel for all other applications.

C. Humidity Sensors:

1. Humidity sensors shall be polymer resistance type.

2. Duct sensors and Outdoor air humidity sensors shall have a sensing range of 5 to 95% RH with accuracy of +/ 3% RH. Sensors shall be suitable for ambient temperature conditions of -40 to 212°F.

D. Electric Thermostats:

1. Provide a low voltage thermostat for control of single zone heating and air conditioning unit as specified in the sequence of operation. Electric thermostats shall include a display of the current space temperature as well as a mechanism for adjusting the setpoint locally. Aquastats on unit heaters shall stop the fan when the water temperature is below 100°F.

E. Temperature Sensor, Humidistat Sensor or Thermostat Guards:

1. Provide heavy duty acrylic lockable guard to prevent damage and tampering.

F. Electric Operators (Damper):

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

G. Control (Motorized) Dampers:

1. Provide control dampers as shown on the drawings and diagrams, to meet the following minimum construction standards.

2. Leakage: Class 1, 4 CFM/sq. ft. at 1 in. W.C., tested per AMCA Standard 500-D-98 and AMCA Standard 511 and bearing AMCA's Certified Ratings for both air performance and air leakage.

3. Frame: 16 gauge galvanized steel structural hot channel with tabbed corners for reinforcement to meet 13 gauge criteria.

4. Blades: 14 gauge (equivalent thickness galvanized steel) roll forward air foil type for low pressure drop and low noise generation. Blades shall be parallel for two-position dampers and opposed, for modulating dampers.

5. Blade Seals: Ruskiprene, suitable for -72°F to +275°F mechanically locked into the blade edge.

6. Jamb Seals: Flexible metal, compression type.

7. Blade Axles: 1/2 in. plated steel hexagonal positively locked into the damper blade. Linkage conceded out of the air stream.

8. Bearings: Corrosion resistant, permanently lubricated stainless steel sleeve.

9. Dampers subject to corrosive fumes or humidity shall be constructed of stainless steel.

10. Dampers over 48 in. length and height shall be made in multiple sections.

11. Where damper sizes are not specifically indicated, they shall be sized by the Temperature Control Contractor. Maximum velocity shall be 1500 fpm and maximum pressure drop 0.1 in. w.g.

12. Where shown or required for proof of closure or open position, provide factory installed damper positioning switch package Ruskin Model SP-100.

13. Dampers shall be as manufactured by Ruskin CD60 Control Damper, or equivalent Tamco or Greenheck.

H. Pressure Sensors:

1. Air pressure or differential air pressure measurements in the range of 0 to 10 in. water column shall be accurate to ± 1% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Acceptable manufacturer shall be Setra model C-264.

2. Liquid pressure or differential liquid pressure measurements shall be accurate to ± 0.25% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Unit shall be provided with isolation and bypass manifold for start-up and maintenance operations. Acceptable manufacturer shall be Setra Model C-230.

3. Steam pressure measurements shall be accurate to ± 0.13% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Unit shall be provided with isolation and bypass manifold for start-up and maintenance operations. Acceptable manufacturer shall be Setra Model C-207.

4. Room pressure sensors shall be bi-directional, bleed airflow thermistor type. Sensor assembly shall contain three (3) individually wired, hermetically sealed bead-in-glass thermistors. The operating range shall be +3,000 FPM to -3,000 FPM, and device shall have an accuracy of ±2% of readings over the entire

operating airflow range. Acceptable manufacturer shall be Ebtron Model GTC116-B.

I. Current Measurement Devices:

1. Measurement of three-phase power shall be accomplished with a kW/kWh transducer. The instrument shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWh). Provide Veris Model 6000 Power Transducer or approved equal.

J. Carbon Dioxide Sensing Devices:

1. Space or outside air carbon dioxide (CO2) sensors shall be an infrared technology based detector, and shall contain an on board relay with field adjustable trip point and adjustable time delay. The sensor shall monitor CO2 over a range of 0 - 2000 PPM. Space CO2 sensors shall operate within the range of 32-122°F and 0-95% RH. Outside air CO2 sensors shall have an operation range of -40° to 122°F and 0-95% RH. The sensor shall have an accuracy of no more than 50 PPM in the expected range of measurement, and a drift of no more 20 ppm. The sensors shall be self-calibrating. Provide an LCD display for displaying PPM level and field adjustable settings. Greystone Product # CDD4 Series, Honeywell C7232, Siemens QPA20, GE Ventostat.

K. Combination CO_2, RH, Temperature Sensors

1. Provide BACnet combination CO2/RH/Temperature measuring devices for mounting where indicated on the plans.

2. Each BACnet combination sensor shall consist of an integrated system of three or more environment sensing functions in a wall mounted package, with an integral microprocessor-based design capable of operating at least two (2) independent sensor nodes per measurement location.

3. BACnet combination sensors shall have an environmental operating range of no less than 32 – 122° F (0 – 50° C) and 0 – 95% RH, non-condensing.

4. CO_2 Sensor Design and Performance:

a. CO_2 measurement shall be accomplished with Non-Dispersive Infrared (NDIR) technology using gold plated optics and diffusion sampling.

b. CO_2 measurement uncertainty shall be no greater than ±75 ppm (or ±7% of Reading <500 ppm and ±7.5% for 800 – 1,200 ppm) at 77° F (25° C) for a CO_2 measurement range of at least 400 – 2,000 ppm.

c. CO_2 measurement stability shall be <2% FS over the expected 15 year life of the typical sensor.

d. Each CO_2 sensor node shall be factory calibrated, shall automatically self-calibrate during operation and shall not require routine recalibration throughout its normal service life.

5. Relative Humidity (RH) Sensor Design and Performance:

a. Each RH sensor node shall measure ambient RH using planar laminated, electrolytic polymer capacitor technology.

b. RH measurement range shall be 0 – 100% RH, non-condensing.

c. RH measurement accuracy shall be ±2% from 20% – 80%RH at 77° F (25° C). Outside of this normal RH operating range, accuracy shall be ±3%.

d. RH output resolution shall be at least 0.4% of Reading.

6. Temperature Sensor Design and Performance:

a. Each temperature sensor node shall sense changes using integral bandgap voltage reference circuitry and perfectly proportional to absolute temperature (PTAT) ΔV technology.

b. Temperature measurement accuracy shall be equal to or greater than ±1.08° F at 77° F (±0.6° C at 25° C).

c. The operating temperature range shall be at least -58° F to 302° F (-50° C to 150° C).

d. Output resolution shall be at least 0.36° F (0.2° C).

7. Power, Connectivity and Communications:

a. The BACnet combination sensor shall be capable of communicating with other devices using an RS-485 standard interface and BACnet-MS/TP protocol, implemented as a Master.

1) Communication speed shall be field-selectable between 9.6, 19.2, 38.4 and 76.8 kBaud.

b. BACnet devices shall implement the open protocol in compliance of the requirements of ASHRAE Standard 135-2008 and all BACnet products shall be BTL Listed.

c. The BACnet combination sensor shall be capable of field set-up and configuration using a simple dip-switch interface.

d. The BACnet combination sensor shall operate on 24 VAC (22.8 to 26.4 VAC), 50/60Hz.

1) The combination sensor design shall include protection from over voltage, over current transients and power surges.

2) The combination sensor shall use "watch-dog" circuitry to assure automatic processor reset after power disruption, transients and brown-outs.

e. The BACnet combination sensor design shall be capable of communicating to the network if one of the sensor functions becomes faulty, and will continue to operate the remaining CO_2 or RH/Temp sensor nodes.

8. The BACnet combination sensor enclosure shall be a low profile wall mount type, compatible in size for mounting with a standard single-gang electrical box or for surface mount applications.

a. The sensors shall be installed at locations that are protected from weather and/or water.

9. The manufacturer's authorized representative shall review and approve wall-position placement for each measurement location indicated on the plans.

a. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's recommendations or requirements.

10. Acceptable manufacturer shall be Ebtron Model IAQ-300-N.

L. Airflow Stations (Thermal Dispersion Type):

1. Provide thermal dispersion airflow/temperature measurement device (ATMD) at each location indicated in specifications and control sequences.

a. Fan inlet measurement devices shall not be used unless indicated on drawings or schedules.

b. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.

c. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.

d. Sensor Density Requirements:

1) Sensor density (#/area) affects minimum installed distances required from disturbance types. Published sensor density data by the product manufacturer shall be submitted for approval. Sensor density shall be as follows:

Duct or Plenum Area (ft^2)	Total # Nodes / Location	Duct or Plenum Area (m^2)
<= 1	1 or 2	<= 0.093
>1 to <4	4	>0.093 to < 0.372
4 to < 8	6	0.372 to < 0.743
8 to < 12	8	0.743 to < 1.115
12 to <16	12	1.115 to < 1.486
>=16	16	>= 1.486

2) The number of individual sensor nodes for each rectangular location shall be maximized for performance within the placement conditions provided. In no instance shall field selected locations provide less distance between disturbances than required for maximum performance. When minimum distances allowed by the highest density of sensor distribution are exceeded, a lower density configuration that provides the same performance is acceptable.

3) Submittal documents shall include schedules indicating the number of sensors per location, the duct area and the equivalent density (#/area) for approval.

e. Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.

f. Each sensing node shall be individually calibrated in constant temperature oil baths at 3 points to NIST traceable temperature standards.

2. Measurement Performance:

a. Each sensing node shall have a temperature accuracy of ± 0.14°F (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C).

b. Each sensing node shall have an airflow accuracy of ± 2% of reading.

c. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM (25.4 m/s) between -20°F to 160°F (-28.9°C to 71°C).

d. A 3 year warranty shall be provided for the entire system.

3. Integral Transmitter and Communications:

a. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.

b. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.

c. The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection.

d. Each analog output shall be field configurable as linear 0-5/1-5 VDC, 0-10/2-10 VDC or 4-20mA signals.

e. One analog output signal shall provide the average airflow rate.

f. One analog output signal shall be field configurable to output the average temperature, the velocity weighted temperature or a binary airflow alarm.

4. Listings and Certifications:

a. The ATMD shall be UL 973 listed.

b. The ATMD shall be BTL listed.

c. The ATMD shall carry CE Mark for European shipments indicating successful satisfaction of all requirements contained in the EMC Directives, or when otherwise required in the destination country.

5. Design Equipment: Ebtron Model GTC116, HTA-104.

6. Make: Ebtron, Kurz, Sierra.

M. Liquid Flow Measurement:

1. Hi Liquid flow measurement devices shall be accurate to ± 0.75% over a turn down ratio of 10:1. Insertion probe sensing element shall be made of 316l stainless steel. The sensing element shall have an elliptical shape that eliminates the separation point at a fixed or variable location ahead of the static pressure pick up point. Device shall only require one welded insert to mount to piping system. Acceptable manufacturer shall be Preso, model BAR.

N. Safety/Status Devices:

1. Low Limit Detector: Electric type, with 20 ft. long serpentine element, with manual reset and auxiliary contacts to the DDC, set for 37°F for "freeze" protection and 55°F for fan discharge application. Provide a 20 ft. long element for every 25 sq. ft. of coil face area.

2. High Limit Detector: High limit thermostats shall be located as directed, and shall be manual reset type set at 120°F in the return and 180°F in the discharge.

Thermostats shall be double pole so as to provide input capability for alarm at the temperature control system.

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

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

O. Miscellaneous Devices:

1. Provide necessary, relays, transformers, required for a complete and operable system.

2.2 CONTROL CABINETS

A. BMS 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.

2.3 BUILDING MANAGEMENT SYSTEM

A. The BMS system shall consist of Network Controllers, standalone or application specific controllers, input/output unit modules, operator workstations, and file servers to support system configurations. The BMS system shall provide control, alarm detection, scheduling, reporting and information management for the entire facility.

B. The BMS shall be capable of being segmented, through software, into multiple local area networks per floor of building, distributed over a wide area network or sharing a single file server. This enables workstations to manage wide area network, and/or the entire system with all devices being updated and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database - with no need for a separate file server.

C. For multi-workstation systems, a file server shall be utilized capable of residing directly on the Owner's Ethernet TCP/IP preferred network with no required gateways. This network may be dedicated for temperature control systems only so it does not interfere with other networks.

D. In addition to the above local area network and wide area network, the workstation software shall be capable of managing remote systems via remote high speed network as a standard component of the software.

E. The BMS system shall be scalable and expandable at all levels of the system using the same software interface and controllers.

1. The system shall use the same application programming language for all equipment: Operator Workstation, Network Controllers, Remote Site Controllers and Standalone, or application specific, Digital Controllers.

F. The BMS system design shall include solutions for the integration of the following "open systems" protocols: BACnet, LonTalk and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFD's).

1. The system shall also provide the ability to program custom ASCII communication drivers, which shall reside in the network control unit, for communication to third party systems and devices. These drivers shall provide real time monitoring and control of the third party systems.

2.4 NETWORK CONTROLLERS

A. Network Controllers shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each Network Controller panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of Network Controllers shall be supplied to fully meet the requirements of this specification and the point list on the drawings.

B. All Network Controllers on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The Network Controllers shall have the ability to store HTML code and "serve" pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer, Netscape Navigator, etc.) to access real-time data from the entire Temperature Control System via any Network Controllers.

1. Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

2. The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller or process or network interface (BACnet, LonTalk and TCP/IP) that the Temperature Control System has knowledge of, regardless of where the point is connected on the Temperature Control System network or where it is acquired from.

3. The network controller shall act directly as the WEB server. It shall directly generate HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored in any shared network device. The Web server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the Temperature Control System WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications:

1. A minimum of 4MB of RAM shall be provided for Network Controllers with expansion up to 8MB.

2. Each Network Controller shall provide communication to both the Workstation(s) and the field buses. In addition, each Network Controller shall have at least three other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system, the Network Controller shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

3. Input/Output (I/O): Each Network Controller shall support the addition of the following types of inputs and outputs:

   a. Digital Inputs for status/alarm contacts.

   b. Counter Inputs for summing pulses from meters.

   c. Thermistor inputs for measuring temperatures in space, ducts and thermowells.

   d. Analog inputs for pressure, humidity, flow and position measurements.

   e. Digital Outputs for on/off equipment control.

   f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

4. The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

5. Each Network Controller shall include a battery-backed, real time clock, accurate to 10 seconds per day. The Real Time Clock shall provide the following: time of day, day, month, year, and day of week. In normal operation, the system clock shall be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years.

6. The power supply for the Network Controllers shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of ±20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (-48 VDC).

7. Upon restoration of power after an outage, the Network Controller shall automatically and without human intervention: Update all monitored functions;

resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

8. Each Network Controller with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of two (2) hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe of running on full UPS, the unit shall shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software:

1. The Network Controller shall contain flash ROM as the resident operating system. Application software shall be RAM resident. Application software shall only be limited by the amount of RAM memory. There shall be no restrictions placed on the type of application programs in the system. Each Network Controller shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage.

2. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The Network Controller shall have the ability to perform the following pre-tested control algorithms:

a. Proportional, Integral plus Derivative Control (PID).

b. Two Position Control.

c. Digital Filter.

d. Ratio Calculator.

e. Equipment Cycling Protection.

2. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These shall be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications: Network Controllers shall have the ability to perform any or all of the following energy management routines: **[**

    a. Time of Day Scheduling
    b. Calendar Based Scheduling
    c. Holiday Scheduling
    d. Temporary Schedule Overrides
    e. Optimal Start
    f. Optimal Stop
    g. Night Setback Control
    h. Enthalpy Switchover (Economizer)
    i. Peak Demand Limiting
    j. Temperature Compensated Duty Cycling
    k. CFM Tracking
    l. Heating/Cooling Interlock
    m. Hot/Cold Deck Reset
    n. Free Cooling
    o. Hot Water Reset
    p. Chilled Water Reset
    q. Condenser Water Reset
    r. Chiller Sequencing
    s. Static Pressure Reset/Optimizing
    t. Demand Controlled Ventilation
    u. Supply Air Temperature Reset

4. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 25,000 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Network Controller and can result in the display of one or more alarm messages or reports.

    a. Up to eight (8) alarms can be configured for each point in the controller.

b. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device.

c. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.

d. If communication with the Operator Workstation is temporarily interrupted, the alarm shall be buffered in the Network Controller. When communications return, the alarm shall be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. The Network Controller shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

2.5 STANDALONE CONTROLLERS

A. Standalone Controllers shall provide control of HVAC and lighting. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated Network Controllers.

B. Standalone Controllers programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Standalone Controllers shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the Network Controllers online. It shall be possible from a service port on any Standalone Controller to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any Network Controller or any Standalone Controller on a different field bus.

D. Support BACnet standard MS/TP bus protocol ASHRAE SS PC-15, Clause 9 on the control network.

E. Each Standalone Controller shall support the addition of the following types of inputs and outputs:

1. Digital Inputs for status/alarm contacts.

2. Counter Inputs for summing pulses from meters.

3. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.

4. Analog inputs for pressure, humidity, flow and position measurements.

5. Digital Outputs for on/off equipment control.

6. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

F. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two (2) modules shall be added to the base Standalone Controller before additional power is required.

G. Each Standalone Controller shall be able to exchange information on a peer to peer basis with other Standalone Controllers during each field bus scan. Each Standalone Controller shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each Standalone Controller shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to a Network Controller.

H. Standalone Controllers shall have as a minimum, LED indication of CPU status, and field bus status.

I. Standalone Controllers shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The Real Time Clock shall provide the following information: time of day, day, month, year, and day of week. Each Standalone Controller shall receive a signal over the network from the Network Controllers, which synchronizes all Standalone Controllers real time clocks.

J. Upon restoration of power, the Standalone Controller shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

K. Each Standalone Controller shall have at least three (3) years of battery back up to maintain all volatile memory.

L. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Standalone Controllers and can result in the display of one or more alarm messages or reports.

1. Up to eight (8) alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.

2. Alarm messages can be sent to a local terminal or modem connected to a Network Controller or to the Operator's Workstation(s).

3. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.

4. If communication with the Network Controller is temporarily interrupted, the alarm shall be saved in the Standalone Controller. When communications return, the alarm shall be transmitted to the Network Controller if the point is still in the alarm condition.

M. Air Handler Controllers shall be capable of meeting the requirements of the sequence of operation intended for each system and allow for future expansion.

1. Air Handling Unit Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.

2. Air Handling Unit Controllers shall be fully user programmable to allow for modification of the application software.

3. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.

4. A manual override switch shall be provided for all digital and analog outputs on the Air Handling Unit Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

N. Air Terminal Unit Controllers:

1. Air Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of Air Terminal Units to address current requirements as described in the Execution portion of this specification, and for future expansion:

   a. Single Duct Cooling Only
   b. Single Duct Cooling with Reheat (Electric or Hot Water)
   c. Fan Powered (Parallel or Series)
   d. Dual Duct (Constant or Variable Volume)
   e. Supply/Exhaust

2. Air Terminal Unit Controllers for single duct applications shall be provided with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an override mechanism for manual positioning of the damper during startup and service.

3. Air Terminal Unit Controllers shall contain an integral velocity sensor accurate to ±5% of the full range of the box's CFM rating.

4. Each controller shall perform the sequence of operation described in Part 3 of this specification, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending.

5. Air Terminal Unit Controllers shall be able to communicate with any other Standalone Controllers on the same field bus with or without communication to the Network Controllers managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 Air Terminal Unit Controllers per field bus.

O. Unitary Controllers:

1. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

    a. Unit Ventilators
    b. Heat Pumps (Air to Air, Water to Water)
    c. Packaged Rooftops
    d. Fan Coils (2 or 4 Pipe)

2. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

P. Lighting controllers shall provide direct control of20 amp, 120 VAC lighting circuits using mechanically held, latching relays. Controllers shall contain from 8 to 48 circuits per enclosure. Each controller shall also contain inputs for direct connection to light switches and motion detectors.

1. Each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, alarming, and trending.

2.6 OPERATOR HARDWARE

A. The BMS workstation software shall be configurable as either a single workstation system (with a local database) or multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 100MBPS or 1024MBPS.

1. All Workstations shall be Intel Core Processor based personal computers operating under the Microsoft Windows Server 2012 R2. The application software shall be capable of communication to all Network Controllers and Standalone Controllers, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

2. For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation shall automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will be acceptable.

B. File Server Requirements. The file server shall consist of the following:

1. Base Unit: 2.53GHZ/4-core/80W/8MB Xeon processor.

2. Memory: 8 GB, 1 x 8GB PC3-10600 registered dual rank x 4.

3. Hard Drives: (3) @ TB 3G SATA, 10K Hot Plug 3.5.

4. Optical Drive: Half-height SATA DVD- RW Optical Drive.

5. Network Controller: NCZ82T PC Express dual port multifunction gigabit server adapter.

6. 18.5 in. diagonal widescreen thin film transistor LCD active matrix, resolution 1366 x 768.

7. PCI Graphics Adapter w/8Mb RAM.

8. Provide server grade keyboard and mouse.

9. Software: Microsoft Windows 2012 R2.

10. HP ProLiant ML350 Series, or equal.

C. Workstation Requirements: The workstation shall consist of the following:

1. Base Unit: 3.33 GHz, 1.5 MB, L2 + 12 MD Shared L3 cache.

2. Memory: 12 GB DDR3-1066 MHz SDRAM.

3. Primary Hard Drive: 1.5 TB RAID 1 (2 x 1.5 TB SATA HDDS).

4. Secondary Hard Drive: 1.5 TB 7200 RPM SATA 2Gb/s.

5. CD Drive: Blu-Ray player and light scribe super multi DVD burner.

6. Graphics Card: 1 GB NVIDIA Geforce 460 [2 DVI, mini-HDMI, VGA adapter].

7. 18.5 in. diagonal widescreen thin film transistor LCD active matrix, resolution 1366 x 768.

8. Keyboard and Mouse: USB keyboard and optical mouse.

9. Software: Microsoft Office Professional 2010.

10. HP Pavilion Elite HPE-800 Series, or equal.

D. Printer: Provide a workstation printer to display alarms and graphics. The printer is to be a HP Officejet Pro 8100, or equal.

2.7 WORKSTATION SOFTWARE

A. General Description:

1. The software architecture shall be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC technologies. These technologies shall make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the data available from the Temperature Control System.

    a. The workstation functions shall include monitoring and programming of all BMS controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.

    b. Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays. Graphic displays shall feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the BMS system. All operator functions shall be selectable through a mouse.

2. The file server database engine shall be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity) compliant database engine shall allow for an Owner to utilize "their" choice of database and due to its "open" architecture, shall allow an Owner to write custom applications and/or reports that communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database shall contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. The BMS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface shall be able to be configured to become a user's "PC Desktop" - with all the links that a user needs to run other applications. This, along with the Microsoft Office Professional 2010 user security capabilities, shall enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BMS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied

independently to each and every class of object in the system. The system shall allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. The workstation software shall use a familiar Windows Explorer style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system allowing for point naming convention consistency. For example, each Air Temperature Unit Controller can have an input called Space Temperature and a setpoint called CFM Setpoint.

    a. The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BMS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BMS.

6. Color Graphic Displays: The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic using the mouse. Requirements of the color graphic subsystem include:

    a. LCD active matrix, resolution 1366 x 768 displays. The user shall have the ability to import AutoCAD generated picture files as background displays.

    b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be "dropped" on a graphic using a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.

c. Status changes or alarm conditions shall be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.

d. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.

e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators shall be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

7. The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user-configurable.

8. The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) shall be integrated into the overall alarm management system and shall appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports. Alarm management features shall include:

a. A minimum of 255 alarm notification levels, or classes of alarms. Each notification level shall establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.

b. Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement).

c. Automatic printing of the alarm information or alarm report to an alarm printer or report printer.

d. Playing an audible beep or audio (wav) file on alarm initiation or return to normal.

e. Sending an email or text message to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and texting of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.

f. Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temperature alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.

g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.

h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.

i. The active alarm viewer can be configured such that an operator shall type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

9. The software shall contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it shall automatically spawn the associated report editor, which shall be the most recent version of Microsoft Office.

a. Reports can be of any length and contain any point attributes from any controller on the network.

b. The report generator shall have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.

c. It shall be possible to run other executable programs whenever a report is initiated.

d. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

e. Standard reports shall include:

1) Points in each controller.
2) Points in alarm.
3) Disabled points.
4) Overridden points.
5) Operator activity report.
6) Alarm history log.
7) Program listing by controller with status.

8) Network status of each controller.

10. Spreadsheet-Style Reports: The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data, and highlight data that meets user-defined criteria.

11. HTML Reporting: The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature shall create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which shall allow those users with access to the directory to "point" their web browser at the file and view the report.

12. Scheduling: It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

    a. Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.

    b. Each schedule shall appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

    c. Schedules shall be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation shall be automatically updated to the corresponding schedule in the controller.

13. The programmer's environment shall include access to a superset of the same programming language supported in the controllers. In this environment, the programmer shall be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

14. The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller - it shall also be able to save/reload individual

objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

15. The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simply menu selection. This data shall be able to be saved to file and/or printed.

16. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

17. Fault Tolerant File Server Operation: The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions. Fault tolerant technology is not provided unless specifically stated.

    a. The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

    b. Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

    c. When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

    d. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

    e. The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

2.8 WEB BROWSER INTERFACE

A. Provide a web browser interface that will be accessible to any computer on the Owner's Intranet with Microsoft Internet Explorer 8.0 or higher. The system shall support a

minimum of 5 simultaneous users to access the system. The Web Browser Interface shall include the following features.

1. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any site in the system from anywhere on the network.

2. The browser-based interface must share the same graphical displays as the Operator Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall also support commands to change setpoints, enable/disable equipment and start/stop equipment.

3. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a copy stored in the system database.

4. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.

5. Through the browser interface, operators must be able to change schedules - change start and stop times, and add new times to a schedule.

6. Through the browser interface, operators must be able to create and edit card access personnel records, and assign the card to any and all sites for access, in any combination.

7. Through the browser interface, operators must be able to view reports of access events and access privileges. Reports must be available based on start and end time, door, area, and person. Invalid attempts must be color-coded red in the report.

8. Through the browser interface, operators must be able to view live and recorded video from any digital video recorder on the network. The interface must offer an easy method of selecting the camera to view, and for recorded video, must offer selections for start and stop time when searching video clips.

9. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.

10. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.

11. The system shall be expandable to up to 25 concurrent browser-based users per server.

2.9 SURGE SUPPRESSION (SP) RECEPTACLE

A. Provide at each DDC panel and operator workstation locations, a surge suppression receptacle with metal oxide varister to dissipate the electrical energy of voltage spikes. 20 ampere, duplex, NEMA 5-20R configuration. Back and side wiring, high impact nylon body.

B. Acceptable Make: Hubbell 5352-S.

2.10 GRAPHICS

A. System Graphic:

1. The equipment drawing will be three-dimensional. The values on the screen shall be reported in real time as well as dynamic to be updated as the value changes.

2. All components of the drawing will show their actual field location and position. Sensors will be in the exact location in reference to piping and air stream. Icons or "library" images imported during the construction of the drawing will be accurate in depiction of the device and any interaction with other components of the drawing, i.e. don't draw piping into the motor of a pump icon.

3. If there are size limitations or clutter from the number of components a link to a sub graphic having the same layout will be used to clarify.

B. Space Graphic:

1. Floor plan drawings will be linked to the supplying air handling unit or in some cases to the exhaust fan. Electronic floor plans to be provided by Architect/Engineer.

2. Floor plans showing areas served by more than one air handling unit will have the areas color-coded by air handling unit. If the air-handling unit serves different floors the color will be consistent for an air-handling unit for all floors.

3. If an area has control other than DDC it will be noted with text and left white in the background.

4. A temperature zone serving more than one space shall have a unique pattern, to distinguish that zone from other temperature zones. The patterns should slight enough as to not obscure the space temperature, room number and borders detail but visible enough to be able to distinguish between different zones. A different "peppering" of symbols (of + ^ * ≈) or patterns (hex, herringbone, verticals, etc.) will be used to define the zones.

5. Temperature zones dedicated to only one space will not have to be detailed.

6. Remote physical points such as differential monitors and the like shall be shown in their installed location.

C. The second level of graphics shall be all the DDC points to be installed under the contract overlaid on building floor plan and the Air Handling Unit and its associated systems. Electronic floor plans to be provided by Architect/Engineer.

D. Description of Operation:

1. The approved description of operation will appear on a text graphic in 12-point text written in paragraph form.

2. Additional notes may appear on the equipment graphic in an appropriate location.

E. Layout:

1. The subject device of equipment graphic will be centrally located on the drawing.

2. At the top center, the name of the equipment device will be displayed with its room number. Immediately below the PM# will be displayed. On a third line will be the capacity of the device in units common to that device i.e. air handling units in CFM, pumps in GPM.

3. The top right hand corner will contain links to associated graphics. The Description of Operation, submittal graphic, space graphic and graphic index page will be typical. Other links may be required. All graphic pages will have backward link to return to the main System Graphic.

4. The top left-hand corner will contain global data. Outside Air would be the most common other values may be required when related to the device operation. If the global data functions within the program of this unit, the point referenced in the program will be displayed.

5. The lower left-hand corner will display the operational modes of the device. Occupied, warm up, winterized and economizer would be common. Other modes will be displayed if the unit uses them.

6. In the upper right-hand area, just below the links, the setpoints of the device will be displayed. All setpoints in the various control loops of the device, DA temp, static pressure, MA will be placed in columns as the drawing permits.

7. The date of the last revision of the graphic will be displayed in the lower right corner.

F. Text:

1. Text will contrast with the background for easy reading.

2. The text will be free floating without borders or boxes unless specifically required.

G. The graphics shall include approved schematic of the equipment, sequence of operation and all wiring interface diagrams.

H. The graphic shall include all new systems, equipment and spaces.

PART 3 - EXECUTION

3.1 GENERAL SYSTEM REQUIREMENTS

A. The control of each system shall be guaranteed to perform as described in the Sequence of Operation on the drawings. Equipment, remote switches, in finished rooms shall be flush-mounted, if possible. Interlock supply and return fans, humidifiers with fans, condensers or cooling towers with air conditioning equipment and similar situations demanding coordinated operation.

3.2 SYSTEM COMPONENTS

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

B. Mounting height for all room thermostats or sensors shall be 48 in. 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.

3.3 SMOKE DAMPERS AND FIRE/FAN SHUT DOWN

A. Provide control for smoke dampers as required. Division 26 "Electric" to provide 120 volt power wiring and associated signal wiring to close all smoke partition smoke dampers associated with a particular air handling unit upon alarm at any duct smoke detector in that particular system. Coordinate the voltage of the EP switch with Division 26 "Electric".

B. Division 26 "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.

C. The DDC Contractor/Subcontractor shall provide control wiring for a digital input point for an end switch that shall prevent the operation of the air handling unit fans until its corresponding smoke dampers are proven fully open.

D. Division 26 "Electric" shall also provide a signal to the DDC control system that the fire alarm system is activated.

3.4 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 180°F and prevent the fan from operating until reset. High limit shall alarm DDC system. Low limit shall be strung on the **discharge face of preheat coils** set at 37°F. Low limit shall: prevent fan from operating, set heating coils to full heat, fully close the outside air damper, fully close the relief air dampers, open return air damper, and alarm DDC system until reset.

3.5 SYSTEM TESTING AND COMMISSIONING

A. At the time of installation, systems shall be tested for control device operation prior to the systems acceptance. A report of each systems performance shall be submitted to the Owner's Representative. The report shall include:

1. Field verification and demonstration checklist of analog input calibration, analog output operation, digital input function, and digital output operation.

2. Trend log of inputs and output, printed every two (2) hours, for one (1) week.

3. Refer to "Instructions and Adjustments".

3.6 SYSTEM DESCRIPTION - GENERAL

A. All systems shall maintain the scheduled or otherwise noted minimum outside air ventilation rate during building occupied hours.

B. Provide normally open hot water and normally closed cooling coil valves.

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

D. 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 BMS system.

E. Shutdown of air handling units and fans due to a fire alarm shall be by the Electrical Contractor. The fire alarm system will send a signal to the BMS system for monitoring purposes only of each air handling unit and exhaust system. The BMS system will provide a staggered restart of the units once the alarm is cleared.

F. All setpoints shall be adjustable.

G. Two (2) outside air temperature sensors and two (2) outside air humidity sensors are to be provided as general inputs to the BMS system. The pair of readings shall be averaged for use by the system. If an individual reading is found to be out of range by comparison, then the other reading shall be used, and an alarm shall be generated.

H. Where the normal sequence position or status of a device is allowed to be manually over-ridden by the building Owner/operator, the device shall be returned to its normal "system off" position, if the system is shut down by the BMS system or building fire alarm system. This includes overriding manually set and locked setpoints. Upon system

restart, the device shall return to its manually over-ridden status. Returning devices to their normal "systems off" position shall be done to reduce the potential of damage to the systems.

3.7 CONTROL SEQUENCE

A. **Refer to plans for control diagrams, sequences and points lists.**

END OF SECTION

[DESIGNER NOTE: REVIEW WITH PROJECT MANAGER, THE USE OF MECHANICAL FITTINGS AND COUPLINGS, BEFORE SPECIFYING "VICTAULIC", PRO-PRESS (VIEGA). ALSO REVIEW APPLICATION WITH CLIENT AND AUTHORITY HAVING JURISDICTION, E.G., DASNY, SUCF, WHO MAY ONLY ALLOW THREADED, WELDED OR SOLDERED JOINTS, OR ALLOW LIMITED USE OF GROOVED JOINT (VICTAULIC OR EQUAL) FITTINGS AND COUPLINGS. SUCF NOW ALLOWS GROOVED SYSTEMS ON HOT, CHILLED AND CONDENSER WATER PIPING WHEN LOCATED IN MECHANICAL SPACES WITH FLOOR DRAINS OR WHEN LOCATED OUTDOORS. IF MECHANICAL FITTINGS ARE TO BE ALLOWED IN HOT WATER SYSTEMS, CONSIDER HIGH TEMPERATURE LIMIT CONTROLS TO PROTECT THE GASKETS IN THE EVENT OF AN UNINTENDED TEMPERATURE EXCURSION.]

SECTION 232010 - PIPING SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

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

[DESIGNER NOTE: DELETE ARTICLE 1.2 IF FIRE STOPPING IS NOT SPECIFIED IN DIVISION 07.]

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 078413 - Penetration Firestop Systems.

1.3 SUBMITTALS

A. **[Anchors and guides. Provide detailed fabrication drawings for all field-fabricated anchors and intermediate structural elements.]**

B. **[Schedule of pipe materials, fittings and connections.]**

C. **[Grooved mechanical connection system.]**

D. **[Pressed mechanical connection system.]**

E. **[Shop fabricated tees.]**

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe and fittings shall be new, marked with manufacturer's name and comply with applicable ASTM and ANSI Standards.

B. All adhesives, sealants, primers and paint used for piping in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

[DESIGNER NOTE: FOR PIPING 12 IN. AND LARGER, THE AVAILABILITY OF SCHEDULE 40 AND SCHEDULE 80 PIPE MAY BE LIMITED, AND THE CONTRACTOR MAY TRY TO PROVIDE "STANDARD" WALL THICKNESS WHICH IS 0.375 IN. REFER TO APPENDIX "A" FOR PIPING MATRIX. NOTE THAT SCHEDULE 40 AND SCHEDULE 80 PIPE IS SUBSTANTIALLY MORE COSTLY THAN STD, DUE TO THE FACT THAT THIS PIPE IS SEAMLESS. FOR A MAJORITY OF COMMERCIAL AND INSTITUTIONAL PROJECTS THAT DO NOT REQUIRE HIGH TEMPERATURE DISTRIBUTION SYSTEMS, STD WALL THICKNESS SHOULD SUFFICE.]

2.2 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53, Schedule 40 weight **[or extra strong (Schedule 80)] [standard wall thickness (0.375 in.), 12 in. and larger]**; black or galvanized finish as called for; 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", "Thredolets", or "Sockolets" are acceptable. **[Mitered elbows, "shaped" nipples, and fabricated reductions and fabricated branch connections are not acceptable unless specifically required and reviewed by the Engineer.]** Socket weld type, 2000 psi wp, where required.

2. Threaded Fittings: Cast or malleable iron, black or galvanized, as required; drainage type where called for.

[DESIGNER NOTE: SHOP FABRICATED BRANCH CONNECTIONS (FISHMOUTHS) SHOULD BE USED WITH DISCRETION. TYPICALLY THIS METHOD OF PROVIDING BRANCH CONNECTIONS IS USEFUL AND COST EFFECTIVE AT HEADERS WHERE THERE ARE MULTIPLE TEES IN SUCCESSION, PARTICULARLY ON LARGE PIPE MAINS, E.G. PIPING SUPPLY AND RETURN HEADERS AT PUMPS AND, LOW PRESSURE STEAM HEADERS. NOTE THAT THE PIPING FRICTION LOSS AT A FABRICATED TEE IS SUBSTANTIALLY MORE THAN A FORGED TEE DUE TO THE ENTRANCE LOSSES AT THE TEE BRANCH. AN UNREINFORCED BRANCH CONNECTION IS SUBSTANTIALLY WEAKER THAN A FORGED TEE WHICH HAS THE SAME PRESSURE/TEMPERATURE/ STRUCTURAL CHARACTERISTICS OF THE PIPE SCHEDULED. THEREFORE, FABRICATED BRANCH CONNECTION SHOULD ONLY BE USED ON LOW PRESSURE/LOW TEMPERATURE SYSTEMS AND WHERE THERMAL EXPANSION OR OTHER FORCES ARE NOT EXPECTED TO IMPACT THE SYSTEM.]

3. Shop Fabricated Connections and Fittings:

a. Shop Fabricated Branch Connections: Fabricated branch connections constructed in strict conformance to the appropriate ASME B 31 Code of Construction may be acceptable as reviewed by the Engineer. All fabricated connections shall be constructed under controlled shop conditions using automated equipment. Calculations for all fabricated connections demonstrating conformance to ASME code and project

design criteria shall be prepared and submitted for acceptance prior to fabrication. Certified welding procedures, shop quality control procedures and certifications of welders and inspectors shall be submitted to the Engineer prior to fabrication.

C. Flanges, Unions and Couplings:

1. Threaded Connections:

a. Flanges: Cast iron companion type; for sizes 2-1/2 in. and larger.

b. Unions: Malleable iron, bronze to iron seat, 300 lb. wwp; for sizes 2 in. and smaller.

c. Couplings: Malleable iron, 150 or 300 lb. wwp, based on system pressure. Steel thread protectors are not acceptable as couplings.

2. Welded Connections:

a. Flanges: Welding neck type.

[DESIGNER NOTE: USE OF SLIP-ON TYPE FLANGES SHOULD BE CAREFULLY REVIEWED BY THE PROJECT MANAGER OR SENIOR ENGINEER BEFORE INCLUDING IN THIS SPEC. IF NOT CAREFULLY INSTALLED PER ASME PIPING STANDARDS THE PIPING SET-BACK AND WELD MAY INTERFERE WITH A BUTTERFLY VALVE NOT ALLOWING THE VALVE TO FULLY OPEN. THE INTERNAL WELD IS SLIGHTLY MORE SUBJECT TO CORROSION THAN A BUTT WELD. THE FLANGE HAS POOR RESISTANCE TO SHOCK AND VIBRATION AND INTRODUCES IRREGULARITY IN THE BORE. STRENGTH UNDER INTERNAL PRESSURE IS ABOUT ONE THIRD OF THE CORRESPONDING WELDING NECK FLANGE.]

b. **[Flanges (Slip-on Type): Slip-on flanges may be used in highly congested installations to save space. Locations shall be reviewed and accepted by the Engineer prior to fabrication of piping.]**

c. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents and working temperatures and pressures. **[ASME B16.21, nonmetallic, flat, asbestos free, 1/8 in. maximum thickness unless thickness or specific material is indicated.] [Flexitaulic CG or GCI spiral wound semi-metallic gaskets, where applicable.]**

[DESIGNER NOTE: FLEXITAULIC GASKETS SHOULD BE CONSIDERED FOR HIGH TEMPERATURE AND/OR HIGH PRESSURE APPLICATIONS. ADDITIONALLY, SOME OWNER'S <u>MAY</u> REQUIRE THEM.]

d. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

3. Grooved Mechanical Connections:

a. Couplings: Ductile iron, ASTM A536, with painted coating, designed for rolled grooved piping, hot dipped galvanized finish were required.

1) Grade "EHP" EPDM synthetic rubber, -30°F to 250°F temperature range, suitable for water service.

2) Gasket lubricant furnished by coupling manufacturer.

b. Bolts and Nuts: Head treated, hex head carbon steel (ASTM A183 and A449) cadmium plated or zinc electroplated.

c. 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, strapless mechanical tees and segment-welded elbows are not acceptable.

d. Design Equipment: Victaulic rigid system, Style 107N Quick Vic couplings for 12 in. and smaller.

[DESIGNER NOTE: GENERALLY USE RIGID SYSTEM AS IT IS SUPPORTED SIMILAR TO WELDED OR SCREWED SYSTEM. NOTE WHERE FLEXIBLE TYPE IS ALLOWED, THE USE OF FLEXIBLE STYLE COUPLINGS AT THE FIRST THREE JOINTS AROUND ROTATING EQUIPMENT (PUMPS, CHILLERS AND COOLING TOWERS) IS AN EFFECTIVE WAY TO REDUCE VIBRATION, SOUND AND ALIGNMENT ISSUES.]

e. **[Design Equipment: Victaulic flexible system, Style 177 and 77 couplings. If used for locations with vibration attenuation and/or stress relief requirements, three (3) couplings shall be placed in close proximity to the vibration source.]**

f. Victaulic AGS Piping System 14 in. through 24 **[60]** in.: Rigid Style W07 with Grade "E" FlushSeal gasket.

g. Victaulic AGS Piping System 14 in. through 24 **[60]** in.: Flexible Style W77 with Grade "E" FlushSeal gasket.

h. Make: Victaulic, Anvil, Tyco/Grinnell, Shurjoint.

D. 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
2 in. to 3 in.	1-1/4 in.	6 in. x 6 in. x 1/4 in.

ELBOW SIZE	SUPPORT SIZE	BASE PLATE
4 in. to 6 in.	2-1/2 in.	8 in. x 8 in. x 1/4 in.
8 in. and larger	6 in.	14 in. x 14 in. x 5/16 in.

2. Anchor bolt holes in each corner of base for securely bolting to floor or concrete base; minimum 3/4 in. bolts.

2.3 COPPER TUBE AND FITTINGS - SOLDER JOINT

A. Pipe: ASTM B88; Type K, L or M, hard temper. Soft temper only where specified. Plans show copper tube sizes.

B. Tees, Elbows, Reducers: Wrought copper, ANSI B16.22 or cast bronze; ANSI B16.8 solder end connections.

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", Engelhard "Silverbright 100", Willard Industries "Solder Safe (silver bearing), Canfield "Watersafe" or approved equal.

2.4 STAINLESS STEEL PIPE AND FITTINGS - PRESSURE-SEALED JOINTS

A. Pipe: Type 304/304L, Schedule 10S, stainless steel conforming to ASTM A312 with plain ends.

B. Couplings and fittings shall be formed of precision cold drawn stainless steel pipe with synthetic rubber O-ring seals.

C. O-ring seals shall be molded of synthetic rubber, Grade HNBR suitable for potable water up to 210°F or Grade EPDM suitable for water up to 250°F.

D. Fitting ends shall be pressed onto pipe using only a tool specifically designed for this purpose. Pipe ends must be fully inserted into the coupling and fitting housing up to the pipe stop. 500 psig maximum CWP rating.

E. Fittings: Elbows, tees, laterals, reducers, adapters as required. Same construction as couplings.

F. Design Basis: Victaulic Vic Press 316, Shurjoint, Viega Pro Press Stainless.

2.5 COPPER TUBE AND FITTINGS - PRESS FITTINGS

A. Tubing Standard: Copper tubing shall conform to ASTM B75 or ASTM B88.

B. Fitting Standard: Copper fittings shall conform to ASME B16.18, ASME B16.22, or ASME B16.26.

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

D. Make: Viega Pro-Press, Nibco, Tyco Grinnell, Elkhart Apolloxpress, Mueller.

2.6 COPPER DRAINAGE TUBE AND FITTINGS - SOLDER JOINT

A. Pipe: ASTM B306, Type DWV, hard temper.

B. Fittings: Wrought copper, ANSI B16.29 or cast bronze, ANSI B16.23; solder end connections.

C. Solder Materials: No lead solder, using alloys made from tin, copper, silver and nickel.

D. Make: Harris "Stay-Safe 50" and "Bright", Engelhard "Silverbright 100", Canfield "Watersafe" or approved equal.

2.7 COPPER TUBE AND FITTINGS - GROOVED MECHANICAL CONNECTIONS

A. Pipe: ASTM B88, Type K or L, hard temper.

B. Fittings: Wrought copper, roll grooved mechanical connections, ASTM B-75, ANSI B16.22 for sizes 2 in. - 4 in. Cast bronze, rolled grooved mechanical connections, ASTM B-584, ANSI B16.18 for sizes 5 in. - 8 in., with copper tube dimensioned grooved ends designed to accept rolled grooved couplings (flaring of tube and fitting ends to IPS dimensions is not permitted).

C. Couplings: Ductile iron, ASTM A-536, with copper colored alkyd enamel finish, designed for rolled grooved piping. Housings cast with offsetting, angle pattern, bolt pads to provide rigidity.

D. Gaskets: Grade "EHP" EPDM synthetic rubber, color-coded, -30°F to 250°F temperature range, suitable for water service.

E. Bolts and Nuts: Heat treated, hex head carbon steel, ASTM A183 and A449, cadmium plated or zinc electroplated finish.

F. Design Equipment: Victaulic Style 607 couplings.

G. Make: Victaulic, Anvil, Tyco/Grinnell, Shurjoint.

2.8 COPPER TUBE AND FITTINGS - BRAZED JOINT

A. Pipe: ASTM B88, Type K or L, hard temper.

B. Tees, Elbows and Reducers: Wrought copper, ANSI B16.22 or cast bronze, ANSI B16.18.

C. Unions and Flanges: Unions for 2 in. and smaller. Brazed type cast bronze ground joint, 150 lb. swp; flanged for 2-1/2 in. and larger, brazed type, cast bronze, companion type, gasketed and bolted, ASME drilled 150 lb. swp.

D. Brazing Materials: Class BcuP-2 for brazing copper to brass, bronze or copper. Harris, Inc. Stay-Silv 0 or approved equal.

2.9 **[SHOP FABRICATED MECHANICALLY FORMED TEE CONNECTION WITH BRAZED JOINTS**

[DESIGNER NOTE: THERE APPEARS TO BE SIGNIFICANT POTENTIAL FOR ADDITIONAL PRESSURE DROP WITH EXTRUDED TEES, AND THE INSIDE OF THE FITTING INCLUDES DISCONTINUITIES IN PIPE JOINING WHICH OFFERS PLACES FOR SCALE, DIRT AND BACTERIA TO COLLECT AS THERE IS NOT A SMOOTH TRANSITION FROM RUN TO BRANCH. EXTRUDED CONNECTIONS SHOULD ONLY BE ALLOWED WHERE THE DESIGNER EXPECTS MULTIPLE TEES TO BE REQUIRED WITH CLOSE SPACING AS IN A HEADER. THERE IS A STRONG POTENTIAL FOR HUMAN ERROR IN FIELD FABRICATED TEES WITH HAND HELD EQUIPMENT AND THEREFORE ANY EXTRUDED TEES SHOULD BE SHOP FABRICATED USING SPECIAL JIGS AND SHOP BRAZED.]

A. **Mechanically formed tee fittings shall be shop fabricated using jigs specifically designed for this purpose and shop brazed with BCuP-5 brazing material. Field formed and brazed tees are NOT acceptable.**

B. **Extruded tees shall conform to the Mechanical Code of New York State and ASME B31.9 Building Services Piping.**

C. **Mechanically formed extruded outlets shall be perpendicular to the axis of the run tube (header). They shall be formed by drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the branch wall.**

D. **The inner branch tube end shall conform to the shape of the inner curve of the run tube. Insertion of the branch tube shall be controlled to assure alignment with specified depth into the collar without extending into the flow stream so as to provide internal reinforcement to the collar.**

E. **Branches can be formed up to the run tube size as shown in ASTM F 2014. Forming procedures shall be in accordance with the tool manufacturer's recommendations.]**

2.10 HDPE PIPING FOR CONDENSER WATER

A. Pipe: Shall be High Density Polyethylene conforming to properties established by ASTM D-3350-02 with a cell classification of PE 345464C. Piping system and fittings shall be SDR 11 rated for 160 psi at 73 deg F.

B. Fittings: Shall match the rating properties as the piping. Fittings shall be factory molded and be SDR 11 rated for 160 psi at 73 deg. Fabricated and segmented fittings with a derated pressure are not acceptable.

C. Connections: Shall be joined by heat fusion. All procedures shall meet the requirements of Title 49 of the Code of Federal Regulations 192.285 as it applies to heat fusion.

D. Design Make: ISCO Industries.

E. Acceptable Make: ISCO Industries, Performance Pipe, or approved equal.

[DESIGNER NOTE: CONSIDER USING HDPE PIPING FOR CONDENSER WATER SYSTEMS THAT ARE DRAINED DOWN IN THE WINTER, IN ORDER TO AVOID THE RUST/SCALING ASSOCIATED WITH STEEL PIPE. NOTE THAT YOU MUST USE CARE IN PIPE SIZING DUE TO THE "NON-STANDARD" INSIDE DIAMETERS OF HDPE PIPING. FIND AN SDR11 HDPE PIPE DIMENSIONS TABLE TO DETERMINE PIPE SIZE. DO NOT USE YOUR "SYSTEM SYZER". IN MOST CASES THE PIPE SIZE WILL BE ONE SIZE LARGER THAN CONVENTIONAL STEEL PIPE, DUE TO WALL THICKNESS, AND THE RESULTING INSIDE DIAMETER.]

2.11 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

A. Interior CPVC:

1. Pipe: ASTM D1784 material manufactured to ASTM F441 standards. Seamless **[Schedule 40] [Schedule 80]** Chlorinated Polyvinyl Chloride (CPVC) Type 4, Grade 1 (Cell Classification 23477-BK). Socket type weld couplings ASTM **[F438] [F439]**, DR with integral bell end for solvent cementing. Solvent cement - ASTM F-493.

2. Fittings: Socket type cement weld fittings of same material and pressure class as adjoining pipe. ASTM F-438.

3. Transition fittings shall have brass male of female connections and integral CPVC socket connections.

2.12 DIELECTRIC PIPE FITTINGS

A. Description: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

B. Unions: Factory fabricated, for 250 psi minimum working pressure at 180°F, threaded or solder ends, insulating material suitable for system fluid, pressure and temperature.

C. Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig minimum pressure to suit system fluid pressures and temperatures with flange insulation kits and bolt sleeves.

D. Waterway Fittings: 300 psi maximum working pressure at 230°F, male threaded or grooved ends, electroplated ductile iron or steel body with LTHS high temperature polyolefin polymer liner.

E. Make: EPCO, Capitol Manufacturing, Watts, Victaulic, or approved equal.

F. The use of brass valves, brass nipples (3 in. and larger) and Shurjoint epoxy coated transition coupling IPS-CTS may be used for dielectric isolation. Dielectric transition fittings shall be Shurjoint Model DE30-GG for sizes 2 in. through 8 in., which shall provide effective insulation between the steel and copper systems to avoid galvanic local

cell and stray current problems. The dielectric transition fitting shall be made of ductile iron per ASTM A536 Gr. 65-45-12, electric deposition coated, with a virgin PP (propylene) lining.

2.13 REFRIGERATION PIPING

A. Type L hard temper deoxidized, dehydrated, and sealed copper tubing, refrigerant grade.

B. Refrigerant grade wrought copper fittings. Long radius elbows.

C. Factory made suction traps, Melco Type PT.

D. Piping and system shall meet the requirements of Safety Code for Mechanical Refrigeration, ANSI/ASHRAE 15-1994 and ASME/ANSI B31.5.

E. Make: Mueller, Howell Metal, Cerro, Cambridge-Lee, Universal Tube.

2.14 HANGERS, INSERTS, AND SUPPORTS

A. Hangers, Inserts, Clamps: B-Line, Grinnell, Michigan Hanger, PHD Manufacturing, Anvil, Hilti.

B. Hangers:

1. Adjustable, wrought malleable iron or steel with electroplated zinc or cadmium finish. Copper plated or PVC coated where in contact with copper piping. Hot-dipped galvanized finish for exterior locations.

2. Adjustable ring type where piping is installed directly on hanger for piping 3 in. and smaller.

3. Adjustable steel clevis type for 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 **[all] [chilled water,] [and refrigerant] [and steam (over 50 psi)]** piping.

6. Nuts, washers and rods with electroplated zinc or cadmium finish. Hot-dipped galvanized finish for exterior locations.

C. Hanger Shields:

1. Pre-Insulated Type:

a. Insulated pipes shall be protected at point of support by a 360° insert of high density, 100 psi waterproof calcium silicate, encased in a 180° sheet metal shield. Insulation insert to be same thickness as adjoining pipe

insulation and extend 1 in. beyond sheet metal shield. Insulation shall be provided with a factory installed ASJ.

2. Field-Insulated Type:

   a. #18 USSG, galvanized steel shields, minimum 120° arc. Provide ICA-HAMFAB-BLOCK, 18# density molded fiberglass inserts, between pipe and hanger shield to maintain proper spacing for insulation. Insulation inserts shall extend 1 in. beyond the sheet metal shields. Material shall comply with ASTM E84 25/50, have a thermal conductivity of K=.30 (stable) and have a service temperature of -120°F to +650°F. Install in accordance with manufacturer's printed instructions.

3. Shield Sizing:

PIPE SIZE	SHIELD LENGTH	MINIMUM GAUGE
1/2 in. to 3-1/2 in.	9 in.	20
4 in.	9 in.	20
5 in. and 6 in.	9 in.	20
8 in. to 12 in.	12 in.	18
14 in. to 24 in.	18 in.	16

4. 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. Hanger Spacing Schedules: (Based upon most stringent requirement of MCNYS and ASME B31.9)

COPPER OR PLASTIC PIPE SIZE	COPPER PIPE HANGER SPACING	PLASTIC PIPE HANGER SPACING	HANGER ROD SIZE
3/4 to 1 in.	6 ft.	3 ft.	3/8 in.
1-1/4 in.	6 ft.	4 ft.	3/8 in.
1-1/2 to 2 in.	8 ft.	4 ft.	3/8 in.
2-1/2 to 4 in.	10 ft.	4 ft.	1/2 in.
5 in. and larger	10 ft.	4 ft.	3/4 in.

STEEL PIPE SIZE	STEEL PIPE HANGER SPACING	HANGER ROD SIZE
3/4 to 1 in.	8 ft.	3/8 in.
1-1/4 in.	10 ft.	3/8 in.
1-1/2 to 2-1/2 in.	12 ft.	3/8 in.
3 to 4 in.	12 ft.	1/2 in.
5 in. and larger	12 ft.	3/4 in.

E. Inserts: Carbon steel body and square insert nut, galvanized finish, maximum loading 1,300 lbs., for 3/8 in. to 3/4 in. rod sizes. Drill through decking for hanger rods and

secure devices with integral support plate strap with sheet metal screws. Devices shall have a safety factor of four.

F. Beam Attachments:

1. C-Clamp, locknut, electroplated finish, UL listed, FM approved, for pipe sizes 2 in. and smaller.

2. Center load style with clamp attachments that engage both edges of beam, electroplated finish, UL listed, FM approved, for pipe sizes larger than 2 in., refer to "Supports" for additional requirements.

[DESIGNER NOTE: DELETE THE FOLLOWING PARAGRAPH WHERE STRUCTURE IS STEEL JOISTS OR SPANCRETE AND THERE ARE NO "I-BEAMS". INCLUDE THIS PARAGRAPH ONLY IF THE CONTRACTOR HAS ACCESS TO THE STRUCTURAL ENGINEER OF RECORD.]

3. Welded beam attachments may be considered only upon the review and acceptance of the structural engineer of record with written confirmation of weld meet configuration, location and service/pipe size submitted to the Mechanical Engineer for review.

G. Supports:

1. Provide intermediate structural steel members where required for hanger attachment. Secure member to structure. Select size of members based on a minimum factor of safety of four.

2. For Weights Under 1000 lbs.: Insert, "U" shaped channel, beam clamps or other structurally reviewed support. The factor of safety shall be at least four. Follow manufacturer's recommendations.

3. For Weights Above 1000 lbs.: Drill through floor slabs and provide flush plate welded to top of rod or provide additional inserts and hangers to reduce load per hanger below 1000 lbs.

4. Make: Hilti, ITW Ramset, Phillips "Red Head", or approved equal.

[DESIGNER NOTE: TRAPEZE HANGERS ARE ALLOWABLE ON PIPES 1-1/2 IN. AND SMALLER ONLY AS THE USE ON LARGER PIPES MAY RESULT IN POINT LOADS THAT MAY NOT BE SUPPORTABLE FROM THE STRUCTURE, PARTICULARLY BAR JOISTS. DESIGNER MAY CONSIDER ALLOWING LARGER TRAPEZE SUPPORTED PIPE, BUT POINT LOADS AND LOCATIONS SHOULD BE REVIEWED WITH THE STRUCTURAL ENGINEER. LARGER PIPE TRAPEZE HANGER LOCATIONS SHOULD BE SHOWN ON THE DRAWINGS AND DETAILED. BE CAUTIOUS OF ALLOWING TRAPEZE HANGERS ON PARALLEL PIPING RUNS WHERE PIPING IS DIFFERENTIALLY OR OPPOSITE PITCHED.]

H. Trapeze Hangers:

1. For use on 1-1/2 in. and smaller piping only. **[DESIGNER NOTE: CHANGE 1-1/2 IN. TO LARGER SIZE PIPING, BUT ONLY AS OUTLINED IN DESIGNER NOTE ABOVE.]**

2. Hangers shall be supported with rod sized with a safety factor of four.

3. May be manufactured type "U" shaped channel, or suitable angle iron or channel. Round off all sharp edges.

4. Securely fasten piping to trapeze with "U" bolt or straps, dissimilar metals shall not touch, use isolation gaskets.

5. Make: B-Line, Kindorf, Unistrut, or approved equal.

2.15 PIPING ACCESSORIES

A. Escutcheon Plates: Provide escutcheon plates on uninsulated piping in exposed and finished areas. Steel or cast brass 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. Insulated style where pipe is required to be insulated. Make: Tri-State Industries, or equal.

C. Anchors:

1. Pipe support; same material as pipe; as manufactured by Pipe Shields Model C1000 or C2000, Keflex, Metraflex, Flexonics or Advanced Thermal Systems.

2. Pipe Anchors:

a. Anchors shall be designed and located as to prevent stress to piping or building structural components from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stressing to connected equipment.

[DESIGNER NOTE: WHERE POSSIBLE, M/E ENGINEERING, P.C. SHOULD TAKE ADVANTAGE OF THE STRUCTURAL ENGINEER OF RECORD TO DESIGN ANCHOR POINTS FOR EXPANSION COMPENSATORS THAT DEVELOP SIGNIFICANT FORCES TO BE APPLIED TO THE STRUCTURE, AS IS THE CASE WITH PIPE LOOPS AND PACKED SLIP-TYPE EXPANSION DEVICES. THIS IS OF PARTICULAR CONCERN WHEN THE BUILDING STRUCTURE INCORPORATES PRECAST CONCRETE PLANKS OR BAR JOISTS. THE CONTRACT DOCUMENTS SHOULD THEN REFLECT DETAILS OF HOW ANCHORS MAY BE FABRICATED.]

3. **[All field or shop fabricated anchor and equipment and piping supports shall include detail fabrication drawings submittals accompanied by comprehensive structural engineering design and analysis by a qualified, profession engineer licensed to practice in the State of New York, using the**

performance and design criteria specific to the project and system in question.]

D. Pipe Roll Stand: Cast iron roll stand. Make: Advanced Thermal Systems, Carpenter and Patterson, ITT Grinnell, Pipe Shields.

2.16 SLEEVES

A. Standard Type:

1. Schedule 40 black steel pipe sleeves shall be used for sleeves in horizontal and vertical applications through structural surfaces. Sleeves shall extend a minimum of 1 in. beyond both sides of the structure surface being penetrated. The sleeve shall be sized to account for the total diameter of the service, inclusive of insulation and the appropriate annular space for firestopping installation or requirements of the sealing element manufacturer.

2. Full circle water stop collar for sleeves located in below grade walls, wet wells and waterproofed surfaces. The collar shall be fabricated from steel plate and welded to the sleeve around its entire circumference.

3. 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. Sleeves shall extend a minimum of 1/2 in. beyond both sides of the non-structural vertical surface being penetrated. The sleeve shall be sized to account for the total diameter of the service, inclusive of insulation and the appropriate annular space for firestopping.

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° waterproofed calcium silicate insert sized to extend 1 in. beyond wall or floor penetration. Calcium silicate insert shall be the same thickness as adjoining pipe insulation. Spacing between shield and can packed at each end with double neoprene rope positively fastened.

2.17 SEALING ELEMENTS

A. Expanding neoprene link type, watertight seal consisting of interlocking links with zinc plated bolts.

1. Make: Thunderline "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

B. 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.

[DESIGNER NOTE: DELETE ARTICLE 2.18 IF FIRESTOPPING IS SPECIFIED IN DIVISION 07, SECTION 078413 - PENETRATION FIRESTOP SYSTEMS.]

2.18 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 "Penetration Firestop Systems". The system shall meet the standard fire test for Penetration Firestop Systems designated ASTM E814. Firestop system 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 with the manufacturer's recommendations and other requirements necessary to meet the testing laboratory's listing for the specific installation.

2.19 PIPING MATERIALS AND SCHEDULE

A. See Exhibit "A", "Schedule of Piping Materials" at end of this Section for (HVAC) piping.

PART 3 - EXECUTION

3.1 EQUIPMENT AND SYSTEMS

A. Provide 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, union, flanges, and valves, to allow for easy part removal and maintenance. Offset piping and change elevation as required to coordinate with other work. Avoid contact with other mechanical or electrical systems. Provide adequate means of draining and venting units, risers, circuits and systems. Install drains consisting of a tee fitting with a 3/4 in. ball valve with hose end cap and chain, at low points in hydronic piping system mains, and elsewhere as required for system drainage.

B. Conceal piping unless otherwise called for. Copper tubing shall be cut with a wheeled tubing cutter or other approved copper tubing cutter tool. The tubing must be cut square to permit proper joining with the fittings. 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 unless submitted and accepted per Part 2. Do not install valves, union and flanges in inaccessible locations. Provide trap seal of adequate depth on drain pans.

C. Provide reducers at all control valves, where control valve is smaller than pipeline size. Reducers for steam control valves shall be eccentric type. Provide unions at each side of every control valve and reducers directly adjacent to the unions.

D. Provide reducers at all balance valves, where balance valve is smaller than pipeline size.

3.2 PIPING OVER ELECTRICAL EQUIPMENT

A. Contractor shall route piping to avoid installation directly over electric equipment, including, but not limited to panels, transformers, disconnects, starters, motor control center, adjustable speed drives and fused switches.

B. Piping shall not be installed in the dedicated electric and working space as defined by NEC 110. Dedicated electrical space is generally equal to the depth and width of electrical equipment, and extends 6 ft. above the electrical equipment, or to a structural ceiling. Dedicated working space is a minimum of 30 in. wide or the width of equipment (whichever is larger) a minimum of 6 ft.-6 in. tall, with a depth of 3 ft. to 9 ft. depending on the voltage.

3.3 WATER **[AND GLYCOL]** SYSTEMS

A. Top connection for upfeed, bottom or side connection for downfeed. Grade off level; up in direction of flow and down toward drain.

3.4 STEAM AND CONDENSATE PIPING

A. Install with bottom of pipes in line. Connections to mains or headers are to be made within 45° of top dead center of the pipe, unless otherwise called for. Drip ends of mains and at low points where condensation may collect. Make counter-flow piping one pipe size larger than vertical pipe. Provide 2 in. x 6 in. (minimum) deep-capped scale pocket, 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.

3.5 REFRIGERATION PIPING

A. Fittings brazed with silver brazing alloy. Guarantee refrigerant charge for one year from date of final acceptance. Provide for flexibility at compressor connections. Piping and system shall meet the requirements of Mechanical Refrigeration Safety Code, ANSI B9.1. Clean piping, then pump-down and evacuate system to 0.1 in. VAC break vacuum with dry nitrogen and re-evacuate to 0.1 in. VAC and hold for four (4) hours; then charge system. Charge with refrigerant as recommended by manufacturer.

3.6 HANGERS, INSERTS AND SUPPORTS

A. Piping shall not be supported by wires, band iron, chains, or from other piping. Support each pipe with individual hangers from concrete inserts, welded supports, or beam clamps of proper configuration and point loading design requirements for each location

including the designated safety factor. Trapeze hangers are acceptable for racking of multiple pipes of 1-1/2 in. 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 rustproofed structural steel members, where required for proper support. Provide oversized hangers where insulation/supports must pass between pipe and hanger. Only concentric type hangers are permissible on piping larger than 2-1/2 in., "C" types are permitted for piping 2-1/2 in. and smaller. Provide riser clamps for each riser at each floor.

B. Provide a pipe hanger within 12 in. of pipe unions and piping connections to equipment, in order to facilitate disconnections of piping without pipe sagging.

3.7 HANGERS ATTACHED TO JOISTS

A. Individual hangers may be suspended directly from the bottom chord panel point provided that the sum of the concentrated loads within the chord panel does not exceed 100 pounds and the attachments are concentric to the chord. (Eccentrically loaded joists using beam clamps or other attachment methods are not acceptable.)

B. For nominal concentrated loads between panel chords, which have been accounted for in the specified uniform design load for the joists, this Contractor is to provide struts to transfer the load to a panel point on the opposite chord as reviewed and acceptable by the Structural Engineer of Record.

3.8 PIPE CONNECTIONS

A. Solder Connections: Nonacid flux and clean off excess flux and solder.

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

C. Brazed Connections: Make joints with silver brazing alloy in accordance with manufacturer's instructions. Remove working parts of valves before applying heat. "Walseal" fittings may be used; if sufficient alloy is showing, face braze such joints.

D. Threaded Connections: Clean out tapering threads, made up with pipe dope; screwed until tight connection. Pipe dope must be specific for each application.

E. Flanged Joints: Select appropriate gasket material, size, type and thickness for service applications. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

F. Dielectric Pipe Fittings: Provide dielectric protection devices at ALL equipment connections where dissimilar metals meet. In addition, provide dielectric unions in all open type piping systems (condensing water, domestic water, etc.) where dissimilar metals are to be joined. Dielectric protection devices are not required in typical closed systems such as heating water, chilled water, heat pump loop, etc. except for the

equipment connections. Dielectric protection systems are not required for air or gas systems.

G. Grooved Mechanical Joints: Pipe to be prepared in accordance with the latest Grooving Specification of the manufacturer utilized. 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. Lubricant shall be applied to gasket and/or pipe ends and housing interiors to eliminate pinching the gasket. All grooved couplings, fittings, and specialties shall be the products of a single manufacturer. A factory-trained field representative of the mechanical joint manufacturer shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Provide a field report verifying that factory trained representative has provided on-site training and that Contractor has coupled recommended installation procedures. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

H. HDPE Pipe Connections: Shall be joined by heat fusion. All procedures shall meet the requirements of Title 49 of the Code of Federal Regulations 192.285 as it applies to heat fusion.

3.9 WELDING **[USE THIS ARTICLE FOR MOST PROJECTS]**

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded pipe 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, 18 in. on straight runs. Welds must be at least full thickness of pipe 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. 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 following areas: [Boiler Rooms], [Mechanical Rooms], [Crawl Spaces].]** When welding galvanized pipe, apply cold galvanizing on joint after welding.

3.10 WELDING **[USE FOR CRITICAL SYSTEMS]**

A. Piping shall comply with the provisions of the latest revision of the ANSI Code for Pressure Piping, B31.1 - Power Piping. Boiler external piping shall comply with the provisions of the latest revision of Section I of the ASME Boiler and Pressure Code. Before welding is performed, the Contractor shall submit to the Owner's Representative, a copy of his Standard Welding Procedure Specifications together with the Procedure Qualification Record as required by Section IX of the ASMEE Boiler and Pressure Vessel Code. Before welder shall perform welding, the Contractor shall submit to the Owner's Representative, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests as required by Section IX of the ASME Boiler and Pressure Vessel Code. The types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of ANSI Code for Pressure Piping, B31.1 - Power Piping. If requirements for non-destructive examinations are to be other than that stated above, the degree of examination and basis of rejection shall be a matter of prior written

agreement between Contractor and the Owner. Contractor shall be responsible for the quality of welding shall repair or replace any work not in accordance with these specifications.

3.11 HANGER SHIELDS

A. Provide at hangers for **[all] [chilled water,] [and refrigerant]**, **[and steam (over 50 psi)]** piping. Pre-insulated type or field-insulated type at Contractor's option.

3.12 SLEEVES

A. Provide for pipes passing through floors, 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 refrigerant] [and steam (over 50 psi)]** piping.

C. Standard Type: Provide for piping, except as called for.

D. Extend 1/8 in. above finished areas. In above grade mechanical and other areas with floor drains; use steel pipe sleeves 2 in. above floor. Use pipe sleeves in bearing walls, structural slabs, beams and other structural surfaces, and where called for. Sleeves shall be as small as practical, consistent with insulation, so as to preserve fire rating. Fill abandoned sleeves with concrete. Provide rubber grommet seals for pipes passing through ducts or air chambers or built-up housings.

3.13 ANCHORS

A. Provide piping system anchors where 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 both directions. In lieu of a single anchor fabricated for two directional control, two (2) individual anchors may be provided. Provide detailed fabrication drawings for all field-fabricated anchors.

B. Design anchors and equipment and piping supports including comprehensive structural engineering analysis by a qualified professional engineer, licensed to practice in the State of New York using the performance and design criteria specific to this project.

3.14 ALIGNMENT GUIDES

A. Provide alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install **[two (2)]** or more guide(s) on each side of flexible expansion loop. Install guides nearest to expansion joint not more than **[four (4)]** pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

3.15 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 Walls and Floors: Use waterproof sealing element, device, or compound.

3.16 ESCUTCHEON PLATES

A. Provide polished chrome escutcheon plates for uninsulated exposed piping passing through floors, walls or ceilings in finished areas.

3.17 CLEANING **[HOT WATER]** AND **[CHILLED WATER]** AND **[GLYCOL]** SYSTEMS

A. Provide the services of an experienced Water Treatment Subcontractor.

B. After each closed system has been tested and thoroughly flushed, the entire piping system shall be cleaned by, or as per, the Water Treatment Subcontractor.

C. Operate pumps and arrange control system so that all control valves are open. Fill, vent and circulate system with this solution, while rising to design temperature.

D. Remove, clean and/or replace air vents, strainers, and check valves, which do not function properly. After cleaning strainers, circulate for additional time, then clean strainers again; repeat until strainers are found clean. Drain and refill system.

E. Provide a batch chemical feed tank, valving and accessories as shown in the Contract Documents. Add water treatment as necessary to prevent deterioration of piping systems and equipment due to oxygen, acid, scaling, etc. Submit typewritten letter to inform Owner's Representative upon completion of the work.

F. Pumps shall not be operated continuously until system is flushed, strainers cleaned and water treatment is complete.

[DESIGNER NOTES:

<u>CLOSED SYSTEM</u>: SYSTEMS CLEANED AS ABOVE AND USING ONTARIO WATER OR WATER FROM OTHER LARGE LAKES NEED NO FURTHER TREATMENT. PARAGRAPH "G" CAN BE OMITTED IN THESE CASES. PARAGRAPH "G" MUST BE USED IF WELL WATER, CERTAIN OPEN RESERVOIRS OR OTHER WATERS OF POOR QUALITY ARE USED.

<u>OPEN SYSTEM</u>: COMBINE BUT DO NOT DUPLICATE PARAGRAPH "G" WITH SECTION "WATER TREATMENT".]

G. 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 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, etc.

5. Water treatments 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.

3.18 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°F.

[Water Treatment:]

[WRITE SPECIAL, GENERALLY NOT REQUIRED IF WATER QUALITY IS GOOD, EXCEPT FOR PROCESS STEAM AND STEAM SYSTEMS ABOVE 50 psi.]

3.19 TESTS

A. Test piping and accessories before insulation, **[connection to existing piping]** or 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 tests have been successfully completed.

B. Schedule of Test Requirements:

1. **[Hot,] [Chilled,] [Glycol,] [Condenser,] [Domestic]** Water: Hydrostatic, 100 psig at high point of system; two (2) hours duration.

2. Steam (50 psi and Lower), Drip and Condensate Piping: 125 psig hydrostatic pressure; two (2) hours duration.

3. Steam (over 50 psi), Drip, and Condensate Piping: Hydrostatic test, 1-1/2 times working pressure; two (2) hours duration.

4. Oil Piping:

   a. Isolate from tank and pumps and test with nitrogen to maximum pressure of 50 psi for 2 in. and smaller piping and 30 psi for 2-1/2 in. and larger for not less than two (2) hours. Provide a pressure relief valve in the system being tested set for 10% more than the test pressure.

   b. In addition, test suction piping under 20 in. of mercury vacuum for three hours. Test storage tank with nitrogen at 5 psi pressure for three (3) hours.

[DESIGNER NOTE: MOST SMALL REFRIGERANT SYSTEMS MAY BE SAFELY TESTED AT 150 PSI WITHOUT THE ADDITION OF ISOLATION VALVES AND PRESSURE RELIEF VALVES (APPLIES TO MOST DUCTLESS SPLITS AND COMPUTER ROOM UNITS WITH REMOTE CONDENSING UNITS). LARGER BUILT-UP UNITS WITH AIR COOLED OR WATER COOLED CONDENSERS MAY BE TESTED TO 300 PSI ON THE "HIGH-SIDE" IF THE REQUISITE SHUT-OFF VALVES ARE AVAILABLE TO PROTECT COMPONENTS THAT CANNOT BE TESTED TO THAT PRESSURE.]

5. Refrigeration:

   a. After installation, charge system with dry nitrogen to manufacturer's recommended pressure.

   b. System shall hold this charge with no pressure drop for 24 hours.

6. Gas Piping: Test with air to a maximum test pressure of 50 psi for 2 in. and smaller piping, 30 psi for 2-1/2 in. and larger piping for two (2) hour duration and as required by local utility purveyor. Provide a pressure relief valve in the system set for 10 psi more than the test pressure.

7. Bottled Gas Piping: As required by supplier; but not for less than six (6) hours at 15 psi.

8. Compressed Air Piping (Other than Temperature Controls): Test with air to a maximum test pressure of 1.5x working pressure or 100 psi, whichever is fewer, two (2) hour duration. Provide a pressure relief valve in the system being tested set for 10% more than the test pressure.

9. Test: No change in pressure under stable temperature conditions.

10. Equipment: Test at working pressures.

3.20 CONNECTIONS TO SPECIAL EQUIPMENT

A. Sterilizers:

1. Sterilizing equipment will be furnished **[ ]** and set in place by **[ ] [this Contractor]**.

2. This Contractor closely coordinates piping connections to equipment with other trades.

3. Control valves, individual pressure reducing valves and thermostatic traps for sterilizing equipment provided by **[this Contractor] [equipment manufacturer]**.

4. This Contractor shall provide necessary piping, valves, strainers and fittings.

3.21 PROTECTION AGAINST PHYSICAL DAMAGE

A. In concealed locations where piping, other than cast-iron or steel, is installed through holes or notches in studs, joists, rafters or similar members less than 1-1/2 in. from the nearest edge of the member, the pipe shall be protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575 in. (No. 16 gage) shall cover the area of the pipe where the member is notched or bored, and shall extend note less than 2 in. above sole plates and below top plates.

3.22 PIPE LINE SIZING

A. Pipe sizes called for are to be maintained. Pipe sizing changes 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 end of Exhibit "A")

[DESIGNER NOTE: PVC PIPE NOT ALLOWED IN CITY OF ROCHESTER OR ON SED PROJECTS. CHECK APPLICATION BEFORE USING.]

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Hot water heating	Schedule 40, black steel **[standard wall thickness 12 in. and larger]**	Malleable iron and butt weld	Screwed 2 in. and smaller; Welded 2-1/2 in. and larger; (SEE NOTE 1)
Hot water heating (optional)	Schedule 40, black steel **[standard wall thickness 12 in. and larger]**	Grooved, rigid couplings	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Hot water heating (optional)	Type L copper	Wrought copper or cast bronze, solder end	No-lead solder for 2 in. and smaller; 95/5 for 2-1/2 in. and larger
Hot water heating (optional)	Type L copper	Wrought copper or cast bronze	Viega Pro-Press, Nibco Press, Elkhart Apolloxpress

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Hot water heating (optional)	Type L copper	Wrought copper or cast bronze	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Chilled water	Schedule 40, black steel **[standard wall thickness 12 in. and larger]**	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)	Schedule 40, black steel **[standard wall thickness 12 in. and larger]**	Grooved rigid couplings	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Chilled water (optional)	Type L copper	Wrought copper or cast bronze solder end	No-lead solder for 2 in. and smaller 95/5 for 2-1/2 in. and larger
Chilled water (optional)	Type L copper	Wrought copper or cast bronze	Viega Pro-Press, Nibco Press, Elkhart Apolloxpress
Chilled water (optional)	Type L copper	Wrought copper or cast bronze	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Heat pump water	Schedule 40, black steel	Malleable iron and butt weld	Screwed 2 in. and smaller; Welded 2-1/2 in. and larger; (SEE NOTE 1)
Heat pump water (optional)	Schedule 40, black steel	Grooved, rigid couplings	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Heat pump water (optional)	Type L copper	Wrought copper or cast bronze, solder end	No-lead solder
Heat pump water (optional)	Type L copper	Wrought copper or cast bronze	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Heat pump water (optional)	Type L copper	Wrought copper or cast bronze	Viega Pro-Press, Nibco Press, Elkhart Apolloxpress
Refrigerant	Type L refrigerant grade hard temper, deoxidized copper	Wrought copper, solder end	Sil-Flo "5" silver brazing

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Vent, overflow, drain	Schedule 40, galvanized steel or Type M copper	Cast iron drainage type or wrought copper	Threaded or solder
Vent, overflow, drain (optional)	Schedule 40, galvanized steel or Type M copper	Grooved, rigid couplings	Victaulic mechanical coupling with gasket
Steam up to 50 psi	Schedule 40, black steel	2000# forged steel or cast iron for screwed; butt weld fittings for welded or flanged	2-1/2 in. and larger butt welded or flanged; 2 in. and smaller screwed or socket welded (SEE NOTE 1)
Steam over 50 psi	Schedule 40, black steel	Butt weld, flanged and socket weld fittings	2-1/2 in. and larger butt weld and flanged fittings; 2 in. and smaller socket weld fittings
Steam (hot) condensate and drip lines	Schedule 80, black steel	2000# forged steel or cast iron for screwed; Extra strong butt weld fittings for welded or flanged	2-1/2 in. and larger butt welded or flanged; 2 in. and smaller screwed or socket welded (SEE NOTE 1)
Boiler feed and pumped condensate (50 psi and lower)	Schedule 40, black steel	2000# forged steel or cast iron for screwed; butt weld fittings for welded or flanged	2-1/2 in. and larger butt welded or flanged; 2 in. and smaller screwed or socket welded (SEE NOTE 1)
Boiler feed (over 50 psi)	ASTM A53 Grade B Schedule 80	Butt weld, flanged and socket weld fittings	2-1/2 in. and larger butt weld and flanged fittings; 2 in. and smaller socket weld fittings
Condenser water	Schedule 40, black steel (outside piping shall be galvanized or painted per job requirements if not insulated/jacketed)	Butt weld; malleable iron; grooved, rigid couplings	Butt weld 2-1/2 in. and larger; screwed 2 in. and smaller; mechanical with gasket 1-1/2 in. and larger (SEE NOTE 3)
Condenser water, exterior	SDR11 HDPE	HDPE	Heat fusion welded
Swimming pool water	Schedule 80, CPVC	Socket type	Solvent weld (SEE NOTE 2)
Glycol	Schedule 40, black steel	2000# forged steel or cast iron for screwed;	2-1/2 in. and larger butt welded or flanged; 2 in. and smaller

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
		butt weld fittings for welded or flanged	screwed or socket welded (SEE NOTE 1)
Glycol (optional)	Schedule 40, black steel	Grooved rigid couplings	Mechanical with gasket, 1-1/2 in. and larger (SEE NOTE 3)
Glycol (optional)	Type L copper	Wrought copper	No-lead solder
Glycol (optional)	Type L copper	Wrought copper or cast bronze	Viega Pro-Press, Nibco Press, **Elkhart Apolloxpress**
Domestic water	Type L copper	Solder end	No-lead solder
Domestic water (optional)	Type L copper	Wrought copper or bronze	Viega Pro-Press, Nibco Press, Elkhart Apolloxpress
Domestic water (optional)	Schedule 40, galvanized steel	Grooved rigid couplings	Mechanical with gasket 2-1/2 in. and larger (SEE NOTE 3)
Natural gas and gas vent	Schedule 40, black steel	Butt weld, 2-1/2 in. and larger; Screwed 2 in. and smaller; 150#	Welded or screwed; provide adequate drip, scale pockets
Oil suction, vent, fill and return (interior)	Schedule 40, black steel	Butt weld, 2-1/2 in. and larger; screwed 2 in. and smaller	Welded or screwed
Oil suction return, fill and vent (exterior)	**[SEE "UNDERGROUND PIPING SYSTEMS" SECTION]**		
Steam underground	**[SEE "UNDERGROUND PIPING SYSTEMS" SECTION]**		
Chilled water underground	**[SEE "UNDERGROUND PIPING SYSTEMS" SECTION]**		
[Snow melting and radiant floor]	**[SEE "RADIANT FLOOR AND SNOW MELTING SYSTEM SECTION 238316.11]**		
Water treatment (max. 100 psi up)	Schedule 80, PVC **[CPVC]**	Socket type PVC **[CPVC]**	Solvent welding **[(SEE NOTE 2)]**

[NOTES FOR EXHIBIT "A":]

[NOTE 1: **Screwed piping permitted in Crawl Spaces, Mechanical Rooms and Boiler Rooms.]**

[NOTE 2: **CPVC piping must have flame spread rating of 25 or less and a smoke developed rating of 50 or less.]**

[NOTE 3: **Grooved piping shall not be installed in shafts.]**

END OF SECTION

[DESIGNER NOTE: APPENDIX A BELOW IS FOR INFORMATION ONLY. DO NOT INCLUDE IN SPECIFICATION.]

APPENDIX A

PIPING MATRIX

Pipe Size	Pipe Type	Wall Thickness	Cost per Ft.	Welded Fitting Thickness	Pipe Size	Pipe Type	Wall Thickness	Cost per Ft.	Welded Fitting Thickness
12"	STD	0.375	37.49	0.375	26"	STD	0.375	--	0.375
	40	0.406	84.37*	0.406		40	--	--	--
	XS	0.500	49.99	0.500		XS	0.500	--	0.500
	80	0.688	61.46*	0.688		80	--	--	--
14"	STD	0.375	44.88	0.375	28"	STD	0.375	--	0.375
	40	0.438	109.56*	0.438		40	--	--	--
	XS	0.500	57.68	0.500		XS	0.500	--	0.500
	80	0.750	151.06*	--		80	--	--	--
16"	STD	0.375	47.94	0.375	30"	STD	0.375	132.37	0.375
	40	0.500	62.82	0.500		40	--	--	--
	XS	0.500	62.82	0.500		XS	0.500	178.10	0.500
	80	0.844	192.14*	--		80	--	--	--
18"	STD	0.375	56.08	0.375	32"	STD	0.375	--	0.375
	40	0.562	148.98*	0.562		40	0.688	--	--
	XS	0.500	155.44*	0.500		XS	0.500	--	0.500
	80	0.938	292.89*	--		80	--	--	--
20"	STD	0.375	67.99	0.375	34"	STD	0.375	--	0.375
	40	0.594	191.23*	0.594		40	0.688	--	--
	XS	0.500	169.00	0.500		XS	0.500	--	0.500
	80	1.031	346.10*	--		80	--	--	--
22"	STD	0.375	66.12	0.375	36"	STD	0.375	--	0.375
	40	--	--	--		40	0.750	--	--
	XS	0.500	222.04*	0.500		XS	0.500	--	0.500
	80	1.125	--	--		80	--	--	--
24"	STD	0.375	77.68	0.375	* Denotes Seamless Pipe Pricing from Ferguson Enterprises as of 4/12/07				
	40	0.688	295.96*	--					
	XS	0.500	97.99*	0.500					
	80	1.219	--	--					

END OF APPENDIX A

SECTION 232123 - PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 SUBMITTALS

A. Shop drawings and performance curves, on pumps and pump accessories clearly indicate which equipment is being submitted.

B. Provide catalog information on motors as specified in Section 230513.

PART 2 - PRODUCTS

2.1 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 shall be statically and dynamically balanced. Provide mechanical seals for closed systems, constructed of carbon rings with ceramic mating seat up to 220°F. Provide packing type seals for open systems only. Provide materials suitable for water pressures, temperature and conditions for each application. Provide tapped discharges and suction connections for gauges, vent and drain. Provide factory trimmed impeller if required, to meet initial delivery requirements.

B. Provide the services of a factory service engineer or machinist to check each pump alignment before pump is started, using laser equipment.

2.2 SELECTION CRITERIA

A. Pumps shall be non-overloading over their entire performance ranges, with trimmed impeller as required to meet initial delivery requirements. Pump selection shall not take into account, or infringe on the service factor of the motor.

B. Select pumps at a point within the maximum efficiency for a given impeller casing construction. Deviations within 3 percent of maximum efficiency are permissible, provided that the lesser efficiency is not less than the scheduled efficiency.

C. Pumps may not be selected such that the impeller diameter is larger than 90 percent of the published maximum diameter for the casing using smaller equipment than the scheduled equipment.

2.3 CIRCULATOR PUMPS

A. The pump shall be a maintenance-free, in-line, single stage, wet rotor type with the motor mounted **directly to the pump volute. The pump valve shall be constructed of cast iron and rated at 145**psi working pressure. The impeller shall be secured directly to

the motor shaft by means of a split cone. The motor shaft shall be constructed of aluminum oxide ceramic and shall be supported by two radial bearings mounted in bearing plate and rotor can. The pump shall not have a coupling or mechanical seal. Design Equipment: Grundfos.

2.4 BASE MOUNTED END SUCTION TYPE

A. Designed for continuous operation between 40° and 225°. 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. Pump shall be direct connected to the drive motor by means of a rubber insert, flexible coupling with ANSI/OSHA guard. Pump and motor shall be mounted on a groutable structural steel main-frame with welded cross members. Pumps used in a variable speed pumping system shall contain couplings suitable for very low and intermittent torque loads.

B. Design Equipment: Bell & Gossett Series e-1510.

C. Acceptable Make: Armstrong, Bell & Gossett, Taco, Grundfos CBS, Paco LF, Patterson.

2.5 VERTICAL SPLIT CASE TYPE

A. Designed for continuous operation between 40° and 225°F. Single stage, double suction with vertical or horizontal inlet, as called for on Contract Drawings. Vertical split case of cast iron construction for 175 psi wp; provided with drain, vent and gauge plugs. Enclosed, bronze double suction impeller mounted on 18-8 stainless steel shaft with regreasible ball bearings. Pump shall be direct connected to the drive motor by means of a flexible center dropout coupling to permit servicing without removing motor or pump rotating element; provide with ANSI/OSHA coupling guard. Pump and motor shall be mounted on a structural steel mainframe with welded cross members.

B. Design Equipment: Bell & Gossett Series VSX.

C. Make: Armstrong, Bell & Gossett, Taco, Grundfos CBS, Paco KPV.

2.6 HORIZONTAL SPLIT CASE TYPE

A. Designed for continuous operation between 40° and 250°F. Single stage, double suction. Casing horizontally split, with suction and discharge nozzles cast integral with lower half and on opposite sides; constructed of cast-iron for 150 psi wp with left or right-hand rotation. Flanged connections, faced and drilled for 150 lb. Enclosed, bronze impeller, double inlet hydraulically balanced one-piece type, secured to shaft by feather key and locking collars. Shaft shall be machined from Type 420 stainless steel, induction hardened and polished to 500 Brinell hardness. Shaft sleeves shall be type 416 stainless steel with ceramic coating. Shaft shall be mounted within outboard, grease lubricated, single row, deep groove type, ball bearings designed for 150,000 hours average life. Shaft seals shall be mechanical type with carbon ring and Ni-Resist face, stainless steel trim and Buna-N elastomers, equal to John Crane Type 1. Direct connected to motor shaft by means of a flexible coupling, with ANSI/OSHA coupling guard. Pump and motor shall be mounted upon a formed steel baseplate, ribbed and reinforced for rigidity with provisions for grouting, and provided with drip channels and collection points for drainage. The entire rotating assembly shall be removable and reinstalled without

disturbing the alignment or exposing the bearings to dirt or water. Pumps used in a variable speed pumping system shall contain couplings suitable for very low and intermittent torque loads.

B. Design Equipment: Bell & Gossett Series HSC.

C. Make: Aurora Pump, Goulds Pumps, Ingersoll-Rand, Peerless Pump, Taco, Grundfos CBS, Paco KP Series, Patterson.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Provide 6 in. concrete pad for each base mounted pump. Level base so that pump and pump casing are not strained. Align pumps as directed by manufacturer. After pumps have been aligned, install dowels to prevent shifting. Fill base with non-shrink grout 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.

D. Base mounted end suction pumps shall be provided with inlet suction diffusers where shown on drawings. 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.

E. In-line pumps shall be installed using continuous-thread, hanger rods and elastomeric hangers of size required to support weight of in-line pumps.

F. **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.**

G. **Provide inertia bases as specified, determine exact height of bases required for base mounted elbows; shim to match mounting height of base elbow with inlet and outlet of pump. Refer to Specification Section 230548 for additional details.**

3.2 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment services for all pumps that use a coupler attached to the device train, whether base mounted or inline mounted. Alignment shall be accomplished with a laser shaft alignment system.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

E. Provide an alignment report indicating alignment setup data, tolerances and final results.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

6. Start motor.

7. Open discharge valve slowly.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

SECTION 233100 - SHEET METAL AND DUCTWORK ACCESSORIES CONSTRUCTION

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 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. SMACNA HVAC Air Duct Leakage Test Manual.
4. 2020 Energy Conservation Construction Code of New York State.
5. SMACNA Kitchen Ventilation and Food Service Equipment Fabrication and Installation Guidelines.
6. NFPA Standard 96.
7. Plans and Specifications which exceed the requirements in any of the referenced standards.
8. 2020 Mechanical Code of New York State.

B. All sheet metal shall be fabricated and installed by an experienced Contractor specializing in this type of work.

C. All ductwork and fittings shall have a computer generated label affixed to the exterior surface of each section, detailing all applicable information including the duct dimensions, gauge, reinforcement type/class and connection type by systems manufacturer. Galvanizing thickness shall be clearly stenciled on each duct section.

D. All ductwork on the project shall meet the SMACNA Duct Cleanliness For New Construction Guidelines, "Advanced Level" of duct cleanliness for production, delivery, storage and installation of ductwork.

1.3 SUBMITTALS

A. Ductwork Shop Drawings.

B. Duct Access Doors.

C. Flexible Duct.

D. Submit a complete shop standard manual including miscellaneous materials, and construction details for all shop fabricated materials including, but not limited to, volume dampers, turning vanes, duct sealant, equipment flexible connections, access doors, flexible duct, acoustical duct lining, etc.

1.4 GENERAL

A. All adhesives, sealants, primers and paint used for ductwork in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

1.5 DUCTWORK CLASSIFICATION

A. Duct systems are to be classified and constructed per the SMACNA Velocity-Pressure classification system as follows:

1. All ductwork shall be constructed for a minimum pressure class of 2 in. w.g. (unless stated otherwise) for the following systems, as applicable:

a. Supply duct downstream of terminal units.

b. Typical low pressure supply ductwork.

c. Typical return ductwork.

d. Typical low pressure exhaust ductwork.

2. Supply duct upstream of terminal units shall be constructed for a minimum pressure class of 3 in. w.g. unless otherwise stated or required as per below.

3. Pressure classes above 3 in. w.g. shall be provided as follows, based upon the external static pressure as scheduled for each specific fan.

Scheduled External Static Pressure	**Pressure Class**
Over 3 in. up to 4 in. w.g.	4 in. w.g.
Over 4 in. up to 6 in. w.g.	6 in. w.g.
Over 6 in. up to 10 in. w.g.	10 in. w.g.

1.6 DUCTWORK SHOP DRAWINGS

A. Prepare minimum 1/4 in. scale drawings:

1. Detailed ductwork shop drawings shall include size, layouts and pressure classifications. Any ductwork installed without benefit of review by the Engineer of Record may be subject to replacement at the expense of the Contractor.

2. Constructed from actual field inspections and measurements so as to assure a complete job.

3. Incorporate dimensions of actual equipment proposed for use on the project.

4. Showing adequate sections, elevations, and plan views and indicating the bottom of ductwork elevations from the finished floor.

5. Indicating all volume dampers, fire dampers, smoke dampers, damper access doors and other accessories required for a completed 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. Indicate roof, wall and floor opening dimensions and locations shown on shop drawings.

D. Submit prints to each Contractor of the other trades for review for interference's and coordination with their work.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. Unless otherwise called for, provide materials in accordance with Exhibit I at the end of this section.

2.2 SQUARE AND RECTANGULAR DUCTWORK

A. Materials:

1. Galvanized Sheetmetal: Comply with ASTM A653 and A924, with G90/Z275 coating.

2. Stainless-steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in Exhibit "I"; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D or No. 3 as indicated in Exhibit "I".

3. Aluminum sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

4. Gauges per SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. 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 sealant. "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. Factory or shop fabricated rolled or machine pressed longitudinal seams does not require sealant.

C. Corner closures shall be required as described and illustrated by SMACNA Duct Construction Standards.

D. Throat radius on all elbows shall not be less than the dimension of the duct plane of radius. Where this cannot be maintained, use shorter radius with internal guide vanes, or square elbow with turning vanes.

E. Bracing and hanging of ductwork shall be per SMACNA Standards for size and system class of ductwork being used.

F. Any transformations shall not reduce the ductwork cross-sectional area. Maximum angle in straight duct, 20° for diverging flow and 30° for contraction flow. Transformation from square to round or flat to oval seams welded or brazed.

2.3 ROUND DUCTWORK

A. Standard Round Ductwork:

1. Materials:

a. Galvanized Sheetmetal: Comply with ASTM A653 and A924, with G90/Z275 coating.

b. Stainless-steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in Exhibit "I"; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D or No. 3 as indicated in Exhibit "I".

c. Aluminum sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

d. Gauges per SMACNA Duct Construction Standards. Spiral lock-seam or longitudinal fusion-welded.

2. All spiral ducts 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.

3. **No stovepipe will be allowed.**

4. Round Ductwork Fittings:

a. All fittings fabricated per SMACNA Standards for round and flat-oval ductwork, material to match straight pieces of ductwork.

b. Fittings shall have continuous, welded seams.

c. 90° tees shall be conical type. 90° tees and 45° 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.

d. Round taps off the bottom of rectangular ducts down to diffusers shall be made with a 45° square to round shoe-tap.

5. Elbows:

a. Diameters 3 in. through 8 in.: Two-section stamped and continuously welded elbows, material to match straight pieces of ductwork.

b. Over 8 in.: Gored construction with standing seam construction and internally sealed or continuously welded. Less than 35° - two gores, 36° to 70° - three gores, over 71° - five gores.

c. Fabricated to a centerline radius of 1.5 times the cross-section diameter.

6. Joints:

a. For duct construction pressure 3 in. w.g. or greater:

1) Round Joints:

a) Unexposed Duct 3 in. - 30 in. Diameter: Connect round duct with a one piece interior slip coupling, at least two gauges heavier than duct wall, beaded at center and fastener to duct with screws. Seal joint with an approved sealant applied continuously around both end of coupler prior to assembling and after fastening.

b) All Exposed Duct and Unexposed Duct 30 in. - 72 in. Diameter: Install using a three piece, gasket flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure band, which compress the gasket between the internal flanges.

(1) Acceptable Manufacturer: Ductmate Industries "Spiralmate" system or approved equal.

c) Above 72 in. Diameter: Install using companion angle flanged joints as defined in Figure 3-1 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal and Flexible" Third Edition. Refer to manual for proper sizing and construction details.

d) Dust collection systems and exposed duct 3 in. - 14 in. use a one piece, polyethylene lined gasket connector with integrated bolt for the closure system.

(1) Acceptable Manufacturer: Ductmate Industries "Quicksleeve" or approved equal.

b. Pipe-to-pipe joints in diameters up to 60 in. shall be by the use of sleeve couplings, reinforced by rolled beads.

c. Pipe-to-fitting joints in diameters up to 60 in. shall be by slip-fit of projecting collar of the fitting into the pipe.

d. Insertion length of sleeve coupling and fitting collar shall be 2 in. up to 36 in. diameter and 4 in. above 36 in. diameter.

e. Pipe-to-pipe and pipe-to-fitting connections in ductwork above 60 in. in diameter shall be made by angle ring flanges. The flange on the pipe shall be a 2 in. x 2 in. x 3/16 in. angle attached to the pipe with a continuous weld. The fittings shall have a loose ring "Van Stone" flange. A 5/8 in. flange shall be provided to act as a gasketing surface for sealing with the angle ring being a rolled, welded ring 2 in. x 2 in. x 3/16 in. Bolt hole spacing for angle rings shall be 6 in. centers.

f. If longitudinal seam duct greater than 60 in. in diameter is supplied in lengths greater than 4 ft., one angle ring must be welded to the duct on 4 ft. centers for support.

g. Clothes dryer exhaust duct connections shall be made with Ductmate Quick-Sleeve Round Duct Connector, or an approved equal, for use with round duct sizes ranging from 3 in. through 14 in. in diameter. The installation of the connector shall be in accordance with the manufacturer's instructions. The connector shall consist of galvanized metal sleeve, complete with fastening system to compress gasket. Sleeve will properly retain and compress gasket while providing rigidity to duct upon assembly. A polyethylene gasket shall have sufficient elasticity to accommodate the spiral duct seam.

2.4 DUCTWORK SEALING

A. SMACNA Duct Sealing Classification shall be used for duct systems using the following criteria:

1. Ductwork and all plenums with pressure class ratings shall be constructed to Seal Class A, as required to meet the requirements of SMACNA Duct Construction Standards and with standard industry practice, including transverse joints, longitudinal seams, fitting connections, and all penetrations of the duct wall.

2. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage. Pressure sensitive tape shall not be used.

3. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels and duct connections to equipment.

4. Sealing that would void product listings is not required.

5. Spiral lock seams need not be sealed.

B. Duct sealant for indoor applications shall be non-fibrated, water based, Hardcast Iron-Grip IG-601, Ductmate PRO Seal, Foster 32-17 or Childers CP146.

C. Duct sealant for outdoor applications shall be fibrated, water based, Hardcast Versa-Grip VG-102, Ductmate Fiberseal, Foster 32-17 or Childers CP148.

D. Sealants and tapes shall be listed and labeled in accordance with UL 181A or UL181B and marked according to type.

2.5 TURNING VANES

A. Provide in mitered elbows as shown on contract drawings. Vanes 36 in. or longer shall be double wall air foil type. All turning vanes shall be installed as per the latest SMACNA Standards. Turning vane size and spacing shall be as per SMACNA. Turning vane spacing greater than SMACNA Standards is not acceptable.

B. Turning vanes shall be Harper or equivalent double wall turning vanes fabricated from the same material as the duct.

C. Turning vane front and back panels shall be securely locked together with adequate crimping to prevent twisting of vane. Vane shall be capable of withstanding 250 pounds of tensile load when secured according to the manufacturer's instructions.

D. Rails for mounting turning vanes shall have self locking, friction fit tabs designed to facilitate proper alignment of vanes. Tab spacing shall be as specified in Figure 4-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal and Flexible". Rail systems with non-compliant tab spacing shall not be accepted.

E. Acoustical Turning Vane: Shall be used in applications that require quiet operating systems. Mounting rails shall have friction insert tabs that align the vanes automatically.

F. Acceptable Manufacturer: Ductmate Industries PRO-Rail Turning Vane or approved equal.

2.6 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 Ventlock 639 elevated dial regulator for 2 in. insulated ductwork.

B. Multiple Blade Type Volume Dampers: Provide multiple blade volume dampers in ductwork above 12 in. in height.

1. Heavy duty, manual balancing dampers suitable for application in HVAC systems with velocities to 1,500 ft. per minute, open position and max. pressure of 3 in. w.g. close position. Ruskin MD 35 or equivalent.

2. Fabrication:

a. Frame: 5 in. x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gauge U-channel.

3. Blades:

a. Style: Single skin with 3 longitudinal grooves.

b. Action: Parallel

c. Orientation: Horizontal

d. Material: Minimum 16 gauge equivalent thickness, galvanized steel.

e. Width: Nominal 6 in.

4. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.

5. Linkage: Concealed in frame.

6. Axles: Minimum 1/2 in. diameter, plated steel, hex-shaped, mechanically attached to blade.

7. Control Shaft: 3/8 in. square plated steel.

8. Finish: Mill galvanized.

a. Actuator: Hand quadrant for 3/8 in. square extended shaft.

b. Hand Quadrant Standoff Bracket: 2 in. standoff for insulated ductwork.

c. Oillite bearings.

d. Factory Sleeve: Minimum 20 gauge thickness, minimum 12 in. length.

C. Fire Dampers: See "Fire Dampers" Section.

D. Automatic Air Dampers: Furnished as part of "Building Management System" Section 230923 and installed by this Contractor.

2.7 FLEXIBLE AIR DUCTS AND CONNECTORS

A. Flexible air ducts and connectors shall be constructed in compliance with NFPA Bulletin 90A, 90B and UL Standard 181 and shall be listed and labeled as Class I Air Duct.

B. Flexible air ducts and connectors shall be tri-laminate:

1. Consisting of corrosion resistant galvanized steel helix encapsulated by a double lamination of polyethylene or spun bond nylon.

2. Factory applied (R 6.0) fiberglass exterior insulation, sheathed in a seamless, tri-directionally reinforced, metalized polyester, exterior vapor barrier.

3. R-value shall be classified by Underwriters Laboratories, and certified by the Air Diffusion Council, in accordance with ADC Flexible Duct Performance and Installation Standard (1991), using ASTM C-518, at installed wall thickness, on flat insulation only. Comply with ASHRAE/IESNA 90.1.

4. Recommended operating pressure for flexible ductwork shall be three times maximum system press but not less than 6 in. w.g. positive pressure for 4 in. - 20 in. dia., 5 in. wg. negative pressure through 16 in. dia., 1 in. negative pressure for 18 in. and 20 in. dia. Maximum velocity of 5500 fpm.

5. Operating temperature range - 20°F to 250°F, intermittent @1/2 in. pos. w.g. max., -20°F to 140°F, continuous at maximum pressure.

6. Flame Spread: 25 max. smoke developed rating: 50 max.

7. Porous inner core flexible duct shall not be used.

C. Static pressure and thermal performance shall be tested and certified in accordance with Air Diffusion Council (ADC) Test Code FD-72-R1 under conditions of 140°F for 164 hours and 180°F for 4 hours.

D. Acoustical performance shall be certified in accordance with ASTM E 477 and/or Air Diffusion Council Test Code FD-72-R1.

1. Minimum Acoustic Performance:

a. The insertion loss (dB) of a 6 foot length of duct when tested in accordance with ASTM E477 at a velocity of 1000 feet per minute shall be at least:

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
8 inch dia.	26	27	27	31	32	27
12 inch dia	22	26	24	31	31	20

E. Friction loss and leakage for flexible duct only shall be certified in accordance with Air Diffusion Council Test Code FD-72-R1. Leakage for connections shall be accordance with UL 181 requirements.

F. Basis-of-Design: Flexmaster 6B (R-6.0)

G. Acceptable Manufacturers:

1. Dundas-Jafine Type SPC R6.0 **[**

2. Hart & Cooley Type F216 (R-6.0) Flexible Technologies, Inc. Thermaflex Type M-KE (R-6.0)

3. Atco Rubber Products, Inc. Type 036 (R-6.0)

2.8 FLEXIBLE DUCT ELBOW SUPPORT

A. Provide flexible duct elbow support for flexible duct connected directly to a diffuser collar.

B. Elbow support shall be a radius forming brace designed to form flexible duct into a 90° elbow not less than one duct diameter in centerline radius.

C. Elbow support shall be manufactured from 100% recycled copolymer polypropylene with a universal fit of 4 in. thru 16 in. and be UL listed.

D. Basis-of-Design: Titus Flexright.

2.9 FLEXIBLE CONNECTIONS TO FANS AND EQUIPMENT

A. Basis of Deign: Ventfabrics, Inc.

B. Acceptable Manufacturers: Ductmate Industries, Inc., Duro Dyne Inc., Elgen Manufacturing, Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Materials: Flame-retardant or noncombustible fabrics, water and mildew resistant UL Standard 214.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 in.wide attached to two (2) strips of 2-3/4-in. wide, 0.028-in. thick, galvanized sheet steel or 0.032 in. thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.

2. Tensile Strength: 480 lbf/in. in the warp and 360 lbf/in. in the filling.

3. Service Temperature: Minus 40 to plus 200°F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.

2. Tensile Strength: 530 lbf/in. in the warp and 440 lbf/in. in the filling.

3. Service Temperature: Minus 50 to plus 250°F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-in. movement at start and stop.

2.10 ACCESS DOORS

A. General:

1. Provide access doors of adequate size to allow easy access to the equipment that will require maintenance. Provide insulated or acoustically lined doors to prevent condensation where applicable.

2. Manufacturer to provide an installed neoprene gasket around perimeter of access door for airtight seal.

3. Systems 3 in. w.g. or less shall utilize a hinged, cam, or hinged and cam square framed access door.

4. Systems 4 in. w.g. and above shall utilize a sandwich type access door. Construct doors in accordance with Figure 7-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible" Third Edition.

5. Approved Manufacturer: Ductmate Industries "Sandwich" style door or approved equal.

6. All access doors shall be continuous piano hinged type, unless noted otherwise.

7. Non-hinged only allowed where clearance to ceiling does not allow a full 90° swing.

8. Double panel insulated type when used in insulated duct.

9. Single panel uninsulated type allowed in un-insulated duct.

10. Pressure rated according to system in which being installed. Door-to-frame and frame-to-duct gasketing.

11. Provide specified Seal Class A or B ductwork sealing around frame, and hand adjust the latch tension for proper seal, on all access doors other than sandwich panel (Ductmate) style.

12. MINIMUM access door size for ducts 12 in. or less in depth is 12 in. x 8 in.

13. MINIMUM access door size for ducts 12 in. to 18 in. in depth is 18 in. x 14 in.

14. MINIMUM access door size for ducts more than 18 in. in depth is 24 in. x 18 in.

15. In ducts which require multiple section fire dampers due to duct size, provide one access door for each fire damper section.

16. Access doors for fire and smoke dampers shall be permanently labeled with 1/2 in. high lettering reading "SMOKE DAMPER" or "FIRE DAMPER".

17. Grease exhaust duct doors shall be grease and air tight, UL 1978 listed, meet NFPA 96 standards and all mechanical codes. Grease duct access doors can be sandwich type or with a weld on frame, with/without hinge. Approved Manufacturer: Ductmate Industries "Ultimate" style door or approved equal.

18. All grease duct access doors used must be accompanied by independent testing in conjunction with each manufacturer's respective wrap system for high temperature applications.

B. Door Types:

1. Low Pressure Systems (2 in. w.g. pressure class): National Controlled Air ADH-1, Ruskin ADH22, Vent Products 9701, Air Balance FSA-100, Safe Air SAH, Nailor.

2. Medium and High Pressure Systems (3 in. w.g. pressure class and higher):

a. Rectangular Duct: Ductmate Industries "Ultimate" Style Door, or equal.

b. Round Duct: Ductmate Industries Round Sandwich type, or equal. 8 in. x 4 in. for ducts 14 in. and less in diameter. Ductmate Industries Round Sandwich type 16 in. x 12 in. for ducts more than 14 in. in diameter.

c. Furnish and install factory supplied protector molding on cut medal edge for all Ductmate access doors.

3. Kitchen Hood Exhaust Systems: In accordance with the latest requirements of NFPA 96, grease-tight, flanged and bolted. Approved Manufacturer: Ductmate Industries "Ultimate" style door or approved equal.

2.11 BOILER BREECHINGS AND FLUES

A. Gauges, reinforcing and other features shall not be less than required by SMACNA.

B. Flanged at boiler connections. Allow for expansion.

C. Furnish ten gauge black steel sleeves and coordinate installation at stack openings with other trades. Caulk space between breeching and stack sleeve gastight with fireproof rope.

D. Provide cleanout doors at end of breeching and adjacent to stack as shown on drawings.

E. Fireproof gaskets at joints and cleanouts.]

2.12 EXHAUST HOODS AND HOOD CONNECTIONS

A. General Requirements:

1. Provide hoods and/or duct connections to hoods/fans where furnished by others.

2. Duct material, thickness and joints as required for gases and vapors involved and per SMACNA.

3. Clearance between bottom of hood and floor shall be 78 in.

4. Provide continuous internal channel brackets for supporting lighting fixtures, coordinate with and install to suit Division 26 "Electrical".]

B. Kitchen Hood Duct Connections:

1. Exposed duct shall be 304 stainless steel, #3 polish finish, welded construction.

2. Concealed duct shall be black steel, welded, flanged and gasketed.

3. Metal gauges comparable to similar duct sizes with adequate stiffening, 16 gauge minimum thickness.

4. Support from building structural members.

C. Dishwasher Hood:

1. Hood and exposed duct shall be 304 stainless steel, #3 polished finish, welded construction.

2. Install butterfly damper near each opening with operator Ventlok #688.

3. Exposed vertical duct, with stainless steel, escutcheon at ceiling, and stainless steel angle flange at hood.

4. Exact duct configuration and location as required for machine as finally installed.

2.13 ACOUSTIC-THERMAL DUCT LINING IN DUCTWORK

A. General: Comply with NFPA Standard 90 and NAIMA Standard AHC-101.

B. Materials: ASTM C 1071, Type I. Glass mineral wool insulation coated with an anti-microbial EPA registered coating that seals the airstream surface fibers into a smooth,

low-friction surface acoustic ductliner shall be of thickness shown in the table. Density at 1.5 PCF. Maximum "K" value to be 0.24 btu/in. /sq. ft. /degrees F. /hr. when tested in accordance to ASTM C177. Acoustic duct liner to be suitable for use up to 6000 feet per minute air velocity and temperatures up to 250°F. The acoustic duct liner shall not accelerate the corrosion of steel, copper or aluminum. The liner shall not absorb greater than 3% by weight when tested per ASTM C1104. Acoustic duct liner shall provide the minimum sound absorption coefficients shown below when tested per ASTM C423 and ASTM E795, Mounting Type A.

OCTAVE BAND FREQUENCIES HZ							
Thickness	**125**	**250**	**500**	**1000**	**2000**	**4000**	**NRC**
1-1/2 in.	.23	.50	.87	.92	.93	.93	.80
2 in.	.37	.76	1.02	1.00	.98	.92	.95

C. Thickness: Unless otherwise noted, all supply air ductwork indicated to be acoustically lined, shall have 1-1/2 in. thick liner with a minimum R value of 6. Return or exhaust ductwork, if acoustically lined, shall be of a thickness specifically noted. Note that per the symbol list (L) equals 1-1/2 in. thick. If called for on the plans, (2L) equals 2 in. thick.

D. Fire Hazard Classification: Flame spread rating of not more than 25 and a smoke developed rating of no higher than 50, when tested in accordance with ASTM E84, UL 723, UL/ULC S102-M88 and NFPA 255.

E. Liner Adhesive: Comply with NFPA Standard 90A, ASTM C919, and maximum VOC requirements of LEED EQ 4.1 and EQ 4.2.

F. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct. Provide fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50 pound tensile dead load test perpendicular to the duct wall.

1. Fastener Pin Length: As required for thickness of insulation, and without projecting more than 1/8 inch into the airstream.

2. Adhesive for Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

G. Design Equipment: Knauf Atmosphere.

H. Acceptable Makes: Knauf Atmosphere, Certainteed ToughGard R.

OCTAVE BAND FREQUENCIES HZ							
Thickness	**125**	**250**	**500**	**1000**	**2000**	**4000**	**NRC**
1-1/2 in.	.10	.47	.85	1.01	1.02	.99	.85
2 in.	.25	.66	1.00	1.05	1.02	1.01	.95

I. For duct velocities above 4000 fpm, provide metal "build-outs" of proper height, welded to the ductwork for turning vanes and dampers.

2.14 CABLE SUSPENSION SYSTEM

A. Ductwork not required to be exterior insulated in exposed installations may be installed using a cable suspension system.

B. Ductwork shall be installed using load rated, stainless steel cable suspension systems. Cables shall be pre-cut lengths, type 316 stainless steel with fused ends, and pre-made end attachments.

C. Cable grips shall be of 316 stainless steel and have an internal tamperproof cable release mechanism.

D. Stress distribution saddles shall be prescribed in addition for the support of rectangular duct on corners as necessary.

E. Hangers shall have a manufacturer's published safe working load and have a 5 to 1 safety factor.

F. Hang and support ductwork as defined in the latest edition of SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible".

G. Adjustable steel cable hanging system consisting of spring loaded, serrated clamping mechanism shall be tested and certified in compliance with all applicable SMACNA standards for upper and lower attachment methods.

1. All approved systems must be installed using matching components including steel cable, clamping mechanism and hardware approved by the manufacturer for its corresponding load rating. No Substitution of manufacturer's components is permitted.

2. Approved systems must be installed per the manufacturer's specific instructions and must not exceed the stated working load rating at any point throughout the system.

H. Supports, bar/angle reinforcements, and other products that are not part of the duct that are manufactured of uncoated mild steel shall either be painted with two (2) coats of primer or shall be manufactured of a galvanized equivalent material.

I. Approved Manufacturer: Ductmate Industries "Clutcher" Cable Hanging System or Gripple Inc.

2.15 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Ventlock 699 or 699-2 based upon insulation thickness.

C. Install duct test holes where required for duct traverse testing and balancing purposes.

PART 3 - EXECUTION

3.1 REQUIREMENTS

A. Equipment and systems shall be installed in accordance with local and state codes and regulations having jurisdiction. Bracing and hanging of ductwork shall be per SMACNA - HVAC Duct Construction Standard

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 interferences. 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.

D. Keep openings continuously closed and sealed with protective plastic wrapping during construction to prevent entrance of dirt and debris.

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.

G. Provide necessary openings, 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° shoe-tap extension collars.

I. Provide 14 gauge sleeves for ducts passing through Mechanical Room floors. Set sleeves 4 in. above finished floor in Mechanical Rooms, seal watertight to floor.

J. Where a return or exhaust duct is shown to be left open ended, provide hardware mesh screen at opening.

K. Do not utilize flexible ductwork or connection in any way to connect variable or constant volume boxes to ductwork.

L. For duct penetrations of non-rated walls, provide sheet metal angle framing or sheet metal closure panels around the entire perimeter of each duct wall penetration on both sides of the wall, where the gap exceeds 1/4 inch. Where the gap is less than 1/4 inch, the gap may be caulked on both sides of the wall. Non-rated wall penetrations SHALL NOT be fire caulked under any circumstances.

M. For duct penetrations of rated walls, see Specification Section 230500 - Basic Mechanical and Electrical Requirements.

N. Ductwork that is called for to be welded shall be fully welded, continuous around the entire perimeter at all joints/seams, and shall be fully airtight and watertight.

3.2 FLEXIBLE CONNECTIONS

A. Provide flexible connections for the intake and discharge connections of duct connected to fans and air handling equipment.

B. Round connections are to be made with adhesive and metal drawbands with ends tightly bolted.

C. Rectangular connections shall be made with material securely held in grooved seam between flanges. Attach with adhesive and mechanical fasteners on 6 in. centers.

D. Connections shall be made with a minimum of 2 in. space between duct and equipment collars, installed in line, and with 1 in. excess material folded so as not to interfere with airflow through connection.

E. Mechanically fastened and sealed, with specified duct sealant, at duct and equipment connections.

3.3 FLEXIBLE AIR DUCTS AND CONNECTORS

A. "Air duct" applies to conduit or passageway for conveying air to or from heating, cooling, air conditioning or ventilating equipment but not including the plenum as defined in NFPA 90A. "Air connector" applies to conduit for transferring air between an air duct or plenum and an air terminal device or an air inlet or an air outlet as defined by the NFPA 90A.

B. For round to oval connections, provide round-oval flexible adapter.

C. Flexible air ducts and connectors shall be provided in fully extended condition, free from kinks.

D. Flexible air ducts and connectors shall not be used in systems with entering air temperatures in excess of 250°F.

E. Flexible air ducts and connectors shall use only the minimum length required to make the connection and shall be installed in the horizontal or vertical position. Flexible elbows are not acceptable. Do not exceed a maximum length of 48 **[36]** in., fully extended.

F. Flexible air ducts and connectors shall use minimum 1/2 in. wide positive locking, steel worm drive clamp, or nylon plenum rated straps for joints and connections. One clamp or strap for the inside core liner and one clamp or strap for the outer jacketing. When non-metallic (nylon) straps are used, they should be listed and labeled to standard UL 181B. Fastener package should be marked UL 181 B-C.

G. Collars to which flexible duct is attached shall be beaded and a minimum of 2 in. in length. Wrap twice with UL 181 tape and secure with clamp or strap. Sleeves used for joining two sections of flexible duct shall be beaded and a minimum of 4 in. in length. The draw band shall be positioned behind the bead on the metal collar.

H. Outer vapor barrier and insulation shall be slid over inner core and collar, wrapped twice with UL 151 tape and secured with a clamp or strap.

I. Connections shall be per SMACNA "HVAC Duct Construction Standards - Metal and Flexible", Air Diffusion Council "Flexible Duct Performance and Installation Standards" and NAIMA Installation Standards.

J. Flexible duct shall be supported at manufacturer's recommended intervals, but no greater distance than 2'-6" on center and prior to all 90 degree bends. Maximum permissible sag shall be 1/2 in. per foot of support spacing. Provide a minimum of one hanger on each run of flexible duct.

K. A connection to rigid duct or equipment shall be considered a support joint. Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the centerline of the bend.

L. Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case shall the material contacting the flexible duct be less than 1-1/2 in. wide. Factory installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when the manufacturer's recommended procedures are followed.

M. The hanger shall be strapped around the flexible duct and secured to the structure above. Hangers shall not be attached to other mechanical or electrical objects. Hangers may be attached to an approved trapeze. Ceiling grid shall not be used to fabricate a trapeze. Support hangers shall be installed horizontal. Screws shall not be used to penetrate the flexible duct to attach to the hanger.

N. Provide flexible duct connections and splices in accordance with manufacturer's recommended installation instructions.

O. Seal flexible duct connections with sealing materials listed and labeled in accordance with UL 181B. Mechanically secure connections with approved clamping materials.

3.4 TURNING VANES

A. Install only in square elbows of equal dimensions.

B. Install as per latest SMACNA Standards.

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 in. w.g.

3.5 DUCT CLEANLINESS AND CLEANING AFTER INSTALLATION

A. Duct Cleanliness:

1. All ductwork on the project shall meet the SMACNA Duct Cleanliness For New Construction Guidelines, "Advanced Level" of duct cleanliness for production, delivery, storage and installation of ductwork.

2. Prior to shipment to the jobsite, all duct ends and openings must be covered with a heavy duty, dual-ply, clear polyethylene protective film. Open ends are to be kept covered during transport, storage, and installation. As ductwork is installed at the job site, open ends are to be covered to maintain cleanliness.

3. The film must be securely affixed to protect against dirt and debris, and must be translucent to facilitate inspection of interior surfaces without removing the film. The film is have a elongation rating of 600% and a break strength of 13.1 lbs./in. The film shall contain no VOC's, and shall leave no residue on duct after removal.

4. Manufacturer: Ductmate Industries ProGuard (heavy duty grade clear).

B. Cleaning After Installation:

1. Interior surfaces shall be free of dust and debris prior to initial start up. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes. Any cleaning of duct systems shall comply with recommendations of NAIMA and NADCA.

2. Clean external surfaces of foreign substances that might cause corrosion, deterioration of the metal, or where ductwork is to be painted.

3. Clean debris from system before fans are turned on.

4. Keep openings continuously closed during the construction period.

5. Pay damages resulting from dirt blown on painted or other finished surfaces.

6. Repair or replace damaged fan wheels, dampers, or other system parts damaged as a result of debris.

7. Clean system as many times as required until the entire system is dirt free.

3.6 INSTALLATION OF ROUND DUCTWORK

A. Use factory-fabricated couplings for joints.

B. After the joint is slipped together, sheet metal screws are placed 1/2 in. 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.

3.7 TEST OF DUCTWORK

A. Conduct duct leakage tests per SMACNA "HVAC Air Duct Leakage Test Manual" and per the requirements of the 2020 Energy Conservation Construction Code of New York State, for all ductwork systems designed to operate at static pressures of 3.0 in. w.g. or greater. Representative sections totaling no less than 25% of the total duct area, per system, for the designated pressure class shall be tested as well as all associated ductwork located out-of-doors. All areas shall be as selected by the Engineer. Positive pressure leakage testing is acceptable for negative pressure ductwork. The rate of air leakage (CL) must be less than or equal to 4.0, as determined by equation 4 - 8 in 2020 ECCCNYS, which reads: $CL=F/P^{0.65}$ where F = measured leakage rate in CFM per 100 sq. ft. of duct surface, and P = static pressure of the test. 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.

B. Provide test reports indicating pressure tests performed. Include date, section tested, test pressure and leakage rate.

C. Ductwork not required to be tested for leakage, shall be checked and guaranteed to meet the standards of the specified SMACNA Duct Seal Class A. 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.

3.8 DAMPERS AND AIR CONTROL DEVICES

A. Provide volume dampers at all air outlets, diffusers, grilles and as noted on plans. Provide volume dampers at all low pressure supply, return and exhaust, branch ducts and as noted on the plans.

B. 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.

C. When dampers are installed in acoustically lined ductwork, install with insulated "build-outs" per SMACNA.

D. Install fire dampers in accordance with "Fire Dampers" Section and applicable codes.

E. Install all dampers furnished as part of "Building Management System" Section.

3.9 ACCESS DOORS

A. Provide for access to upstream side of duct mounted reheat coils, dampers, damper motors, fire dampers, smoke dampers, smoke detectors, control devices, fan bearings, and equipment requiring periodic inspection or service. Provide labels for fire and smoke dampers as called for in Part 2 - Products.

B. For ducts that are too small to install an access door of the minimum specified size, provide a 12 in. long section of removable ductwork for maintenance and inspection access. Removable ductwork shall be fastened between device requiring access and next duct section with duct flanges or Donaldson Torit clamp with PVC foam seal. For ducts that are required to be insulated, provisions shall be made to allow insulation to be easily removed and re-installed.

C. Provide access service openings as required by NFPA 96 at 20 ft. intervals along horizontal ducts and at each vertical riser for kitchen hood exhaust.

3.10 DUCT SUPPORTS

A. Provide per SMACNA, same material as duct. Hanger bands to extend down sides and turn under bottom 2 in. Minimum two metal screws per hanger. Angle iron on larger duct spaced per building structural system but not greater that 8 ft. Provide extra support angles as required.

B. Provide additional supports as required to support reheat coils, air terminal units, filter enclosures, and any other duct mounted equipment independent from the associated ductwork system.

3.11 AIR AND WATERTIGHT DUCTWORK

A. Where water and snow may accumulate on 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.

1. Kitchen hood exhaust ductwork.

2. Dishwasher hood and exhaust ductwork.

3. Shower room exhaust ductwork.

4. Intake and exhaust plenums.

5. Dryer exhaust ductwork.

B. Test for Watertightness: Before concealment, apply water by hose to check for leaks, witnessed by Owner's Representative.

3.12 BOILER BREECHINGS AND FLUES

A. Pitch upward and install in accordance with fuel burning equipment manufacturer's written instructions.

B. Provide barometric damper and other accessories in accordance with fuel burning equipment manufacturer's written instructions.

3.13 ACOUSTIC-THERMAL DUCT LINING

A. Increase metal duct dimensions to accommodate lining. Adhere lining to interior side of duct; minimum 90% coverage of Benjamin Foster 85-20 fire retardant adhesive, UL approved. Stapling method of attaching will not be permitted. Mechanical fasteners shall not pierce the sheet metal. Installing fasteners with spacing as per SMACNA Standards. Multiple layers of liner to achieve indicated thickness is prohibited.

B. Abutting edges of acoustic linings shall be sealed with a fire resistant neoprene coating, and exposed edges of acoustic linings shall be installed with sheet metal nosing to prevent erosion.

C. Lining shall not impart odor to the air, delaminate or be loosened by the airstream under normal operating conditions. Lining which is damaged during fabrication or shipment shall not be installed.

D. Supply ductwork downstream of terminal unitsshall have 1-1/2 in. thick acoustical lining for a minimum of 8feet. All air outlets shall be installed downstream of this minimum distance.

E. Provide 1-1/2 in. thick acoustical lining for a minimum of 10feet upstream anddownstream of all supply and return fans.

3.14 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" **[28 "Electronic Safety and Security"]**.

3.15 RESIDENTIAL TYPE CLOTHES DRYER EXHAUST DUCTWORK AND LAUNDRY ROOMS IN RESIDENTIAL BUILDINGS

A. There shall be no fasteners of any kind protruding into the duct airstream.

B. Flexible ducts (code defined as transition ducts) used to connect the dryer to the exhaust duct system shall be metal, and shall be a single length that is listed and labeled for such use, in accordance with UL 2158A. The length of the transition duct shall not exceed 48 in.

C. Provide a UL classified dryer transition connection receptacle for recessed mounting in the wall behind each dryer. For a 4 in. stud wall, provide a Dryerbox Model DB-350 with an oval top duct connection opening. For a 6 in. stud wall or an 8 in. concrete block wall, provide a Dryerbox Model DB-425 with a 4 in. round top duct connection opening. Install per the manufacturers recommendations.

D. The maximum length of the clothes dryer exhaust duct shall not exceed 35 equivalent ft. from the connection to the transition duct from the dryer, to the outlet terminal. The

maximum length shall be reduced for the fittings used per the applicable code. The maximum length does not include the transition duct.

E. Where the dryer exhaust duct system is concealed within the building construction, the total equivalent length of the exhaust duct shall be identified on a permanently mounted placard similar to below, as illustrated in International Mechanical Code Commentary.

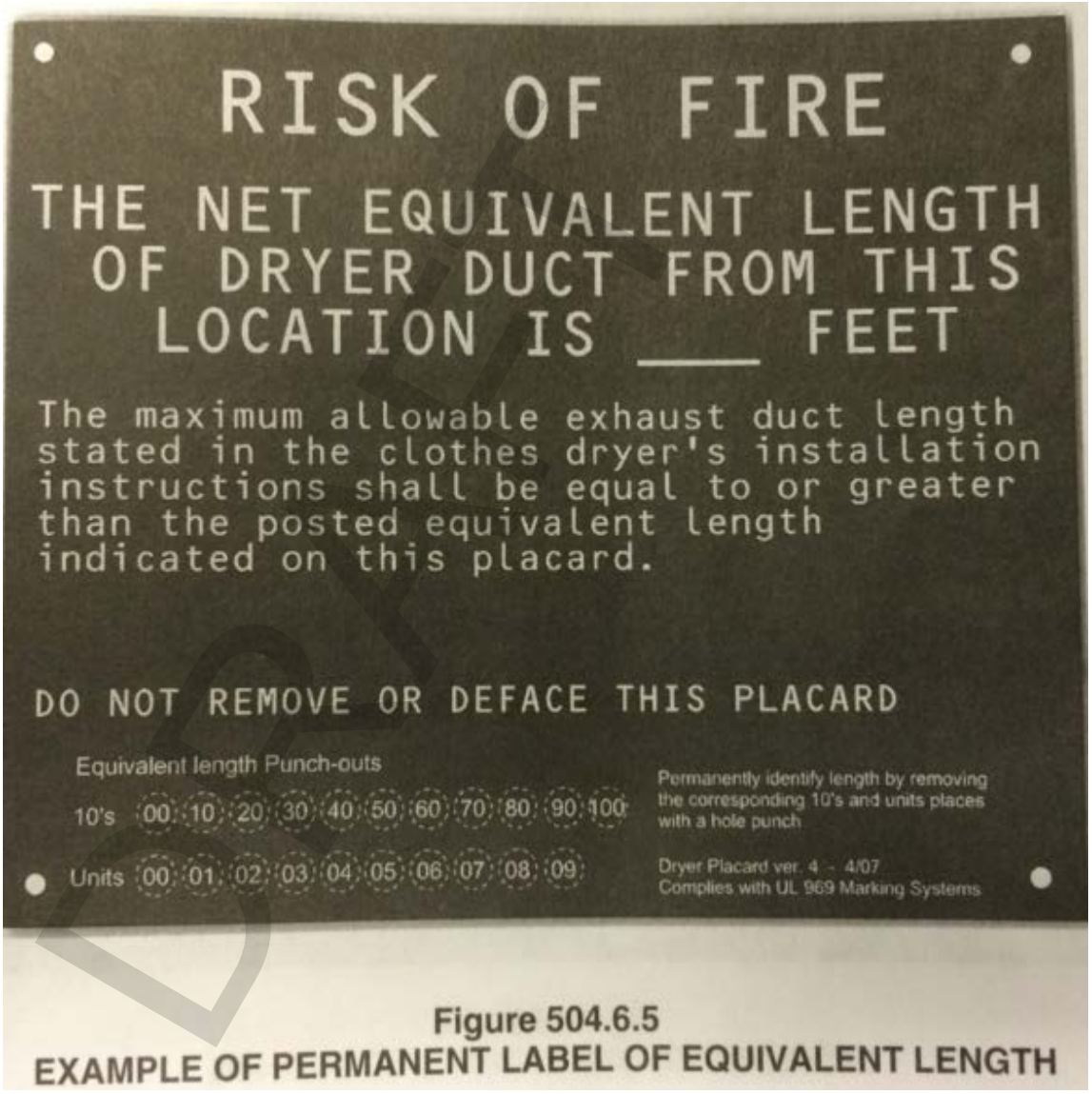

Figure 504.6.5
EXAMPLE OF PERMANENT LABEL OF EQUIVALENT LENGTH

F. Protective plates shall be placed where nails or screws from finish work are likely to penetrate the clothes dryer exhaust ductwork. Shield plates shall be placed on the finished face of all framing members where there is less than 1-1/4 in. between the duct and the finished face of the framing member. Protective shield plates shall be constructed of 0.062 in. (16 gauge) and extend a minimum of 2 in. above the framing sole plates and below the framing top plates.

G. Provide metal wall cap exhaust outlets and roof jack exhaust outlets for dryer venting as called for in the Contract Documents.

1. Wall cap clothes dryer outlets shall be 4 in. Lambro Model 281, aluminum vent with tailpiece, trim plate, UL listed flexible transition duct, and galvanized tension clamps, or approved equal.

2. Roof jack clothes dryer outlets for sloped roofs shall be Dryer Jack Model 486 (Extra Clearance Unit), constructed of 26 gauge galvalume with nailing flange, backdraft damper and factory powder coat finish (available in brown, white and black), or equal. Color selection by the architect.]

3. Flat roof clothes dryer outlets shall be Dryer Jack Model DKU486U (flat roof model), constructed of 26 gauge galvalume, with 4 inch dryer vent connection, integral backdraft damper, 2.75 inch turned down perimeter flashing color with spot welded corners for use with a roof curb. Provide an 18 inch high roof curb conforming to the requirements of specification Section 230530.

3.16 DUCT SEALING

A. Preparation:

1. Clean surfaces of dirt, oil, grease and loose of foreign matter that could impair adhesion, using soap and water or solvent.

2. Allow surfaces to dry completely before proceeding.

B. Installation of Sealant System:

1. Apply sealant system to duct joints, fasteners, and seams in accordance with manufacturer's instructions.

2. Apply sealant by brush, putty knife or caulk gun, to full coverage. Remove excess adhesive immediately.

3. Completely seal duct joint, fasteners and seams without voids, to a minimum 20 mil thick wet film.

4. Apply and store at ambient temperature of 40°F to 100°F; and protect from freezing until dry.

C. Field Quality Control:

1. Allow duct sealant system to cure a minimum of 72 hours before operating the system.

2. Do not apply external duct insulation or coatings until the joints have been inspected by the Owner's Representative.

EXHIBIT I - DUCTWORK MATERIALS

SERVICE	MATERIAL	SPECIAL REQUIREMENTS
Supply, return, vent, relief, outside and exhaust	Lock forming quality, galvanized steel ASTM A653 and A924, galvaneal/paint grip if not insulated and exposed	Joints and features as called for
Exterior double wall ductwork	Pre-manufactured galvanized steel, double wall, 3 in. insulation between walls, solid inner liner with thickness per SMACNA, outer duct one gauge heavier. McGill Airflow LLC, or similar.	Horizontal top surfaces cross-broken for positive water drainage where shown as rectangular, Ductmate joints, seal Class A, and outdoor duct sealant applied per spec, watertight construction.
Exterior ductwork	Galvaneal/paint grip (ready for paint) if not insulated, otherwise same as above	Horizontal top surfaces crossbrocken for positive water drainage, Ductmate joints, seal Class A, and outdoor duct sealant per spec
Dishwasher, exposed Kitchen hood and exposed laundry room exhaust	Type 304 stainless steel, with #3 polished finish where exposed	Braze or weld airtight/watertight
Residential type clothes dryer exhaust	Snap lock galvanized steel minimum thickness 30 gauge per code	Mechanical band clamp connector (Ductmate Quick-Sleeve, or equal) No mechanical fasteners of any kind shall protrude into the airstream
Concealed kitchen hood exhaust	16 gauge black steel	Joints welded airtight/watertight, flanged and gasketed at connections to hood
Grease Ducts]	Manufactured double wall	Installation to meet NFPA 96
Commercial laundry equipment exhaust	Type 304 stainless steel with #3 polished finish where exposed	Joints welded airtight/watertight, flanged and gasketed at connections. Inside surfaces smooth.

SERVICE	MATERIAL	SPECIAL REQUIREMENTS
Breachings and flues	10 gauge black steel	Joints welded airtight/watertight, flange at connections
Accessories, dampers and air turns	Same material and gauge as parent duct	----------

END OF SECTION

SECTION 233110 - GREASE DUCT SYSTEM

1.1 GREASE DUCT SYSTEMS

A. Provide factory built grease duct system laboratory tested and listed by the Underwriters Laboratories, Inc., for use with commercial cooking equipment as described in NFPA 96.

B. Double wall ducting shall have an outer jacket of aluminized steel .025 in. thick in 6 in. through 24 in. diameter and 0.34 in. thick for larger diameters. Exception! Where exposed to weather, the outer jacket shall be 0.25 in. stainless steel, type 304. There shall be a minimum 1 in. air space between the walls. The inner liner shall be Type 304 stainless steel with a nominal thickness of 0.35 in. for all sizes.

C. System shall be designed to provide access for inspection and cleaning at each change of duct direction; permit drainage of grease residue through a duct section; enable the system to allow for thermal expansion; and to allow for the specified fire suppression equipment to be integrated into the grease ductwork. Horizontal runs greater than 20 ft. per NFPA 96. Joints of the inner liner shall be sealed using V Bands and high temperature ceramic joint cement, as supplied by the manufacturer. Ducts extending above roof surfaces shall terminate as required by NFPA 96, and as called for.

D. Ductwork, accessories, equipment, and arrangement shall be provided with features and connectors to suit a Dry Chemical Extinguishing System per NFPA 17.

E. Provide ventilated roof thimbles, wall supports, wall guides, drain tees, access sections, adjustable lengths, plate support assemblies, duct drains, hood transitions, nozzle sections, and other factory make parts to suit the installations called for.

F. Provide a drawing showing application details for approval.

G. System shall be Selkirk Metalbestos Model PS Grease Duct.

1.2 INSTALLATION OF GREASE DUCT SYSTEMS

A. Install per NFPA 96 and according to special instruction for Model PS systems as follows:

1. Section A - General Information.

2. Section B - Tees, Elbows, Increasers.

3. Section C - Adjustable lengths, guiding and support.

4. Section D - Plate supports.

5. Section E - Wall supports and guides.

6. Section F - Roof and wall penetrations.

B. Provide Work above roof as follows:

1. Provide ventilated roof thimble storm collar and flashing. Flashing shall be of material and arrangement approved by Owner's Representative. Storm collar shall be stainless steel to match duct material.

2. Extend duct system beyond storm collar with 90° WYE with tee cap cleanout and then connect to utility blower.

3. Extend storm collar and duct to upblast type exhaust fan.

4. Provide packing and seal the entire system.

5. Duct Enclosure And Surroundings:

   a. All ductwork shall be housed in fire rated enclosures provided by General Contractor. Cooperate with the installing Contractor when locating ducts and supports so as to permit the installation of a proper fire resistant barrier.

6. Combustibles of any kind will not be permitted within 6 in. of any part of duct system.

END OF SECTION

SECTION 233313 - FIRE DAMPERS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 SUBMITTALS

A. Submit product data, types, schedule of sizes, locations, and installation arrangements of all dampers.

B. Submit manufacturer's UL listed installation details for each mounting arrangement.

1.3 QUALIFICATIONS

A. Provide work in accordance with the latest requirements of the Mechanical Code of New York State, UL 555, UL 555S and UL555C. Fire dampers shall be Underwriter's Laboratories classified and labeled.

PART 2 - PRODUCTS

2.1 FIRE DAMPERS

A. Curtain type damper of galvanized steel (304 stainless steel for ductwork containing shower room exhaust, wet location exhaust, and corrosive fume exhaust) construction with fusible link, 20 gauge frame and 24 gauge blades. UL listed and labeled.

1. 100% free area with welded head

2. Square, rectangular, round or oval duct connection as required by duct connections.

3. 1-1/2 hour rated dampers for walls or floors rated less than three hours. Three-hour rated dampers for three and four hour walls or floors.

4. With factory fabricated sleeve with fixed and slip flanges.

5. Fusible link temperature rating of 165°F**. 212°F**.

B. Design Equipment: Ruskin Model IBD2 Style **B.**

C. Make: Ruskin, Air Balance, National Controlled Air, Prefco, Venco, Greenheck, Nailor.

PART 3 - EXECUTION

3.1 LOCATIONS

A. Provide fire dampers in all one, two and three hour rated wall and floor penetrations.

3.2 INSTALLATION

A. Provide sleeve, angles, and access doors for installation in accordance with the latest requirements of SMACNA, NFPA, UL and damper manufacturer.

B. Provide sheet metal access doors with labels, as called for in Specification Section 233100 in ductwork for dampers and accessories.

C. Provide ceiling or wall access doors for dampers and accessories.

D. Install dampers square and free from racking.

E. Do not compress or stretch the damper frame into the duct or opening.

F. Provide bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

G. Provide insulation end seal fittings for double wall ductwork where same connects to damper assembly.

H. Provide thermal blanket in accordance to NFPA requirements at diffusers, register and grille penetrations of fire rated ceilings where fire dampers are required.

3.3 CERTIFICATION

A. Contractor shall certify that dampers are accessible for servicing, are installed properly, and are operational. Submit three (3) copies of signed certification to the Owner's Representative for review.

3.4 IDENTIFICATION

A. Provide damper tags and charts.

1. Fasten tag to ductwork adjacent to the dampers.

2. Number each damper and make chart listing.

a. Number.

b. Location.

c. Air system in which they are installed.

B. Submit three (3) copies of chart to the Owner's Representative for review.

END OF SECTION

SECTION 233400 - FANS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 SUBMITTALS

A. Submit product data for all fans, motors, drives, and accessories. Include all fan curves fan operating point, and sound data.

1.3 QUALITY ASSURANCE

A. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories shall be provided as called for or scheduled. 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 Sp	Class
Up to 3-3/4 in. WG-STD	I
Up to 6-3/4 in. WG-STD	II
Up to 12-3/4 in. WG-STD	III

C. Conventional Motors:

1. Motor sizes shall be as scheduled. Refer to Specification Section 230513 for motor types, efficiency requirements, and acceptable motor manufacturers. All belt-driven fan motors shall be mounted on either an adjustable slide base or a pivoting base.

D. EC Motors:

1. Motors shall be Electronically Commutated Type (EC), variable speed, DC, brushless motors specifically designed for use with single phase, 277 volt (or 120 volt), 60 hertz electrical input.

2. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator.

3. Motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in-soft start and soft speed change ramps.

4. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motors shall be direct coupled to the blower.

5. Motor shall maintain a minimum of 85% efficiency over its entire operating range and have a turndown to 20% of full speed, (80% turndown).

6. Provide manual fan speed output control for field adjustment of the fan airflow setpoint.

7. Inductors shall be provided to minimize harmonic distortion and line noise.

8. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from the fan to the terminal unit casing.

9. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy.

10. The fan **[terminal unit]** manufacturer shall provide a factory installed PWM controller for either manual or DDC controlled fan CFM adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 VDC signal from the DDC controller (provided by the controls contractor) to control the fan CFM. When the manual PWM controller is used, the factory shall present the fan CFMs as shown on the schedule.

11. Acceptable Manufacturers: Emerson Ultratech, U.S. Motors-Nidec, GE-ECM, A.O. Smith or equivalent.

E. 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. Size drive for 200% of motor rating when motor is 10 HP and larger. Size for 150% of motor rating when motor is less than 10 HP.

   b. Motors 5 HP and larger shall be provided with a minimum of two (2) belts. All belt sets shall be matched.

   c. Cast iron or cast steel pulleys.

   d. Provide 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.

   e. Belts shall be oil and heat resistant, non-static type.

f. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts.

g. All belt drive fan motor selections must include an allowance for medium drive losses as established by AMCA Publication 203.

F. Motor Pulleys:

1. 5 HP and Smaller: Adjustable type to produce 15% speed change above and below scheduled fan speed. 7-1/2 HP and Larger: Fixed type.

2. 5 HP and Smaller: "A" section, 2.6 in. minimum pitch diameter.

3. 7-1/2 HP to 20 HP: "B" section, 4.6 in. minimum pitch diameter.

4. 25 HP and Larger: "C" section 7.0 in. minimum pitch diameter.

5. Drive ratio not over 4:1.

G. Bearings:

1. Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy-duty regreasable ball type in a pillow block cast iron housing selected for a minimum L50 life in excess of 200,000 hours as maximum cataloged operating speed.

H. Wheels and Propellers:

1. All wheels and propellers shall be balanced in accordance with AMCA Standard 204-96, balance quality and vibration levels for fans. Wheel shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency.

2. Blades on all sizes shall be continuously welded to the backplate and deep spun inlet shroud.

3. All hubs shall be keyed and securely attached to the fan shaft.

I. Blower Shafts:

1. All blower shafts shall be AISI-C-1045 hot rolled and accurately turned, ground and polished. Shafting shall be sized for a critical speed of at least 125% of maximum cataloged operating speed.

J. Coating:

1. All steel fan components shall contain an electrostatically applied, baked polyester powder coating. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.

K. Vibration isolation for units shall be furnished by the fan manufacturer unless otherwise noted. Provide guided springtype vibration isolators.

L. Certifications:

1. Fan shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (CUL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

2. All units shall bear an engraved aluminum nameplate and shall be shipped in ISTA certified transit-tested packaging.

PART 2 - PRODUCTS

A. Square Centrifugal:

1. Construction:

a. The fan shall be bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge galvanized steel with integral inlet and outlet flanges.

b. Pivoting motor plate shall utilize threaded L-studs for positive belt tensioning.

c. Bolted access doors shall be provided on three (3) sides, sealed with close cell neoprene gasketing.

d. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation.

2. Wheel:

a. Wheel shall be aluminum, non-overloading, centrifugal backward inclined, flat blade type. Hub shall be cast and precision machined, also constructed of 100% aluminum.

3. Accessories:

a. Motor Cover.

b. Inlet/Outlet Flex Duct connector.

c. Disconnect Switch - Factory wired and mounted.

d. Backdraft Damper

e. Speed Controller (For Direct Drive Models Only) - Factory wired and mounted

4. Basis-of-DesignProduct indicated in schedule.

B. Ceiling, Wall or Inline Mounted, Direct Driven, Centrifugal Exhaust Fan:

1. Construction:

a. The fan housing shall be minimum 20 gauge galvanized steel and acoustically insulated.

b. Blower and motor assembly shall be mounted to a minimum 14 gauge reinforcing channel. Motor shall be resiliently mounted.

c. Unit shall be supplied with integral wiring box.

d. Discharge position shall be convertible from right angle to straight through by moving interchangeable panels. The outlet duct collar shall include reinforced aluminum dampers with continuous aluminum hinge rods and brass bushings. To accommodate different ceiling thickness, an adjustable prepunched mounting bracket shall be provided.

e. A powder painted white steel grille shall be provided as standard.

2. Wheel:

a. Wheels shall be twin DWDI centrifugal forward curved type, constructed of galvanized steel.

3. **Accessories:**

a. Disconnect switch - Factory mounted and wired].

b. Fan Speed Controller (For Direct Drive Models Only) - Factory mounted and wired.

4. Basis-of-Design: Product indicated in schedule.

2.2 ROOF FANS

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:

1. Acme, Cook, Greenheck, Twin City, PennBarry.

B. Spun Aluminum Downblast Centrifugal Exhaust Ventilator:

1. Construction:

a. The fan shall be bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure.

b. The aluminum base shall have continuously welded curb cap corners for maximum leak protection, and shall be tall enough to cover the wood nailer on roof curb.

c. The discharge baffle shall have a rolled bead for added strength.

d. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections.

e. Bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.

f. Hinged at curb so that entire fan can be tilted upward for maintenance, access to dampers, and access to damper motor.

g. 1/2 in. x 1/2 in. aluminum wire mesh bird screen.

2. Wheel:

a. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub.

3. **Accessories:**

a. Backdraft Damper - Gravity.

b. Backdraft Damper - Motorized.

c. Roof Curb - In accordance with Section 230530.

d. Disconnect Switch - Factory wired and mounted.

e. Fan Speed Controller (For Direct Drive Models Only) - Factory wired and mounted.

4. Basis-of-Design: Product indicated in schedule.

C. Spun Aluminum Upblast Centrifugal Kitchen Exhaust Ventilator:

1. Construction:

a. The fan shall be bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure.

b. The aluminum base shall have continuously welded curb cap corners for maximum leak protection.

c. The discharge baffle shall have a rolled bead for added strength.

d. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections.

e. Bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. A 1 in. thick, three pound density foil back heat shield shall be utilized to protect the motor.

f. Hinged at curb so that entire fan can be tilted upward to permit inspection and cleaning, as required for commercial cooking equipment by NFPA 96. Provide service hold-open cables.

2. Wheel:

a. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub.

3. Certifications:

a. For grease laden vapor applications, fan shall be listed by Underwriters Laboratories (UL 762) and UL listed for Canada (Power ventilator for restaurant exhaust applications).

4. Accessories:

a. Hinged Base.

b. Disconnect Switch.

c. Vented Curb Extension.

d. Roof Curb Specifically Designed for Grease Applications.

e. Grease Collection System.

f. Grease Trough.

5. Basis-of-Design: Product indicated in schedule.

2.3 CONTROL (MOTORIZED) DAMPERS

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:

1. Ruskin, Tamco, Greenheck.

B. Provide control dampers as shown on the drawings and diagrams, to meet the following minimum construction standards:

1. Leakage: Class 1, 4 CFM/sq. ft. at 1 in. w.c., tested per AMCA Standard 500-D-98, and AMCA Standard 500-D-98, and AMCA Standard 511 and bearing AMCA's Certified Ratings for both air performance and air leakage.

2. Frame: 16 gauge galvanized steel structural hat channel with tabbed corners for reinforcement to meet 13 gauge criteria.

3. Blades: 14 gauge (equivalent thickness galvanized steel) roll forward air foil type for low pressure drop and low noise generation. Blades shall be parallel for two-position dampers and opposed, for modulating dampers.

4. Blade Seals: Ruskiprene, suitable for -72°F to 275°F mechanically locked into the blade edge.

5. Jamb Seals: Flexible metal compression type.

6. Blade Axles: 1/2 in. plated steel hexagonal positively locked into the damper blade. Linkage concealed out of the airstream.

7. Bearings: Corrosion resistant, permanently lubricated stainless steel sleeve.

8. Dampers subject to corrosive fumes or humidity shall be constructed of stainless steel.

9. Dampers over 48 in. in length and height shall be made in multiple sections.

10. Where damper sizes are not specifically indicated, they shall be sized by the Building Management System ContractorMaximum velocity shall be 1500 FPM and maximum pressure drop 0.1 in. w.g.

11. Where shown or required for proof of closure or open position, provide factory installed damper positioning switch package Ruskin Model SP-100.

12. Dampers shall be as manufactured by Ruskin CD 60 control damper, or equivalent Tamco, Greenheck or Nailor.

13. Basis of Design: Ruskin CD60

2.4 BACKDRAFT DAMPERS (HORIZONTAL MOUNT - AIR FLOW UP) (1000 FPM AND 1500 FPM)

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:

1. Ruskin, Greenheck, Air Balance Inc., American Warming and Ventilating, Nailor.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 FPM (Ruskin BD2/A1Maximum System Pressure: 1.5 in. w.g..

D. Operating Pressure: BD2A1 .03 in. w.g. start to open - .10 blades fully open]

E. Frame: Hat-shaped 6063TS .090 in. thick extruded aluminum with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, ,] maximum 6 in. width, 0.025 in. thick, roll-formed aluminum (BD2A1 with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.

2. Diameter: 0.20 in.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Counterweights and spring-assist kits for vertical airflow installations.

N. Basis of Design: Ruskin BD2A1

2.5 BACKDRAFT AND PRESSURE RELIEF DAMPERS (HORIZONTAL MOUNT - AIR FLOW UP) (1500 - 2500 FPM)

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:

1. Ruskin, Greenheck, Air Balance Inc., American Warming and Ventilating, Nailor.

B. Description: Gravity balanced

C. Maximum Air Velocity: 1500 to 2500 FPM.

D. Maximum System Pressure: 4 in. w.g.

E. Operating Pressure: .12 in. w.g. blades start to open, .20 in. w.g. blades fully open.

F. Frame: Hat-shaped, 6063TS - .070 in. thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

G. Blades: Multiple single-piece blades, end pivoted, maximum 6 in. width, .070 in. thick, roll-formed aluminum with sealed edges.

H. Blade Action: Parallel.

I. Blade Seals: Extruded vinyl, mechanically locked.

J. Blade Axles:

1. Material: Galvanized steel.

2. Diameter: 0.20 in.

K. Tie Bars and Brackets: Aluminum.

L. Return Spring: Adjustable tension.

M. Bearings: Synthetic pivot bushings.

N. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Counterweights and spring-assist kits for vertical airflow installations.

3. **SPC static pressure control.**

O. **Basis of Design: Ruskin BDG (gravity balanced)**

PART 3 - EXECUTION

3.1 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. Provide necessary support steel for equipment. 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.

END OF SECTION

SECTION 233713 - REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 SUBMITTALS

A. Registers/Grilles/Diffusers: Submit product data including room schedule listing size, CFM, throw, direction of throw, accessories, finish, material type, color chart, pressure drop and noise criteria.

1.3 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 N.C. - 24, measured at occupant level; notify Owner's Representative of problems prior to submittal.

B. Pressure drop, airflow and noise criteria selection is based on design equipment. Manufacturers not submitting design makes must provide written certification in front of submittal that equipment submitted has been checked against and performs equal to the design make.

C. Borders and frames shall be coordinated with materials and ceiling systems to integrate with architectural ceiling details and finishes scheduled.

D. Locations of ceiling mounted air terminal devices shall be coordinated with locations shown on architectural reflected ceiling plans.

E. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw and pressure drop. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

1.4 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 the 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) as scheduled.

D. Design Equipment: Titus unless otherwise noted.

E. Manufacturers: Anemostat, Carnes, Krueger, Titus, Price, Tuttle and Bailey, Nailor.

1.5 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. Suitable for recessed mounting unless otherwise indicated.

4. Provide square to round neck transitions as required.

5. 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) as scheduled.

C. Frame style shall be suitable for ceiling type in which diffuser is to be installed.

D. Design Equipment: Titus unless otherwise noted.

E. Manufacturers: Anemostat, Carnes, Krueger, Titus, Price, Tuttle and Bailey, Nailor.

PART 2 - PRODUCTS

2.1 SUPPLY TYPES

A. Type 1 - (Smooth Face Type):

1. Steel construction with 22 gauge back pan and 22 gauge face panel with rolled edges that finishes flush with ceiling system.

2. Round neck - minimum 1-1/4 in. collar for duct connection.

3. Frame suitable for ceiling type.

4. With optional directional air flow pattern controllers that are concealed behind the face or in the neck.

5. Face panel shall be removed and securely held in place to the back pan without noise or vibration.

6. Horizontal airflow pattern.

7. Panel Size: 24 in. x 24 in.

8. Model: Titus OMNI.

B. Type 2 - (Supply Air Grille):

1. Steel 20 gauge frame construction with double deflection capability and the front blades shall be parallel to the long dimension. Solid extruded aluminum air foil blades mounted in friction pivots for individual blade adjustment, spaced on 3/4 in. centers.

2. 1-1/4 in. wide flange with sponge rubber gasket.

3. Model: Titus 272-RL.

C. Type 3 - (Square Face Type):

1. Steel 22 gauge construction with round neck.

2. Directional flow pattern as indicated.

3. Frame suitable for ceiling type.

4. 1-3/4 in. deep inlet collar for duct connection.

5. Panel Size: 24 in. x 24 in.

6. Model: Titus TMS.

D. Type 8 - (Linear Diffuser):

1. Adjustable 180° pattern controllers to change both direction and volume at discharge air.

2. Multiple 1 in. slots and lengths as specified.

3. Border type shall be suitable for ceiling.

4. Extruded aluminum frames with black 16 gauge steel pattern controllers.

5. **[Provide optional accessories to achieve continuous slots as required.]**

6. **[Provide [insulated] [uninsulated] plenum.]**

7. Model: Titus Model ML-39.

2.2 RETURN/EXHAUST TYPES

A. Type A - (Exhaust and ReturnGrilles):

1. Steel construction with 22 gauge frame and blades, with horizontal bars on a **3/4 in.**spacing set at 35° fixed deflection.

2. 1-1/4 in. wide flange.

3. The blades shall be parallel to longdimension.

4. Model: Titus 350-RL

B. Type B - (Exhaust and **Return Grille**):

1. Steel construction with minimum 20 gauge 1-1/4 in. border and 20 gauge curved hemmed edge blades on a **1/2 in. spacing set at 30° fixed deflection. The blades shall be parallel to long**dimension.

2. Border type shall be compatible with ceiling system.

3. Model: Titus [5-RL

C. Type C - (Aluminum Exhaust and Return Grille):

1. Aluminum construction with horizontal blades on a 3/4 in. spacing and set at 35° fixed deflection.

2. 1-1/4 in. wide border with minimum thickness of .040 - .050 in. interlocked at all four corners and mechanically fastened.

3. The blades shall be parallel to longdimension.

4. Model: Titus 350-FL

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions. Rough in or install per reflected ceiling plan or in location instructed by Owner's Representative.

B. Provide approved air extractors behind all duct mounted supply registers in exposed ductwork.

C. When the final connection to an exhaust or return grille is made, a 12 in. minimum height plenum box must be supplied to all grilles. Plenum dimensions shall match grille size. Paint inside of plenum box flat black. Provide 1 in. acoustical lining in plenum box. Oversize the plenum to account for the thickness of the lining.

D. Seal all supply and return registers, grilles and diffusers during construction operations to limit dust entering HVAC systems and ductwork. Seals may be removed just prior to testing and balancing, but not without the approval of the Owner's Representative.

END OF SECTION

SECTION 233723.16 - LOUVERS AND PENTHOUSES

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 SUBMITTALS TO THE ARCHITECT/ENGINEER

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

2.1 LOUVERS

A. Factory constructed high performance drainable, fixed, extruded aluminum 6 in. deep louvers.

B. Provide mullions where blade lengths exceed 60 in.

C. Sill extension and sill style as required by job conditions.

D. Heads, sills and jambs to be one piece structural members of 6063-T6 alloy with integral caulking slot and retaining beads.

E. Mullions shall be sliding interlock with internal drain(s).

F. Blades to be one piece extrusions with gutter(s) designed to catch and direct water to jamb and mullion drains.

G. Extrusion thicknesses shall be as follows: Heads, Sills, jambs and mullions: 0.115". Fixed Blades: 0.125"

H. Closed cell PVC compression gaskets shall be provided between bottom of the mullion or jamb and the top of the sill to insure leak tight connections.

I. All fasteners to be aluminum or stainless steel.

J. All louvers to be furnished with 5/8 in. flattened expanded mesh, aluminum bird screen with a .055 in. thick extruded aluminum frame. Screens and screen frames to be standard mill finish.

K. All louvers shall be finished with powder coating of a color to be selected at the time of submittal review. Coating to be 1.5 to 3 mil. thick full strength 100% resin Fluoropolymer coating. Finish to adhere to a 4H Hardness rating. The louver

manufacturer shall supply an industry standard 20-year limited warranty against failure or excessive fading of the Fluoropolymer powder coat finish.

L. Design Equipment: Construction Specialties **[A4097] [A6097]**.

M. Makes: Construction Specialties, Inc., American Warming & Ventilating Inc., Arrow United Industries, Louvers & Dampers, Inc., Ruskin, Nailor.

PART 3 - EXECUTION

3.1 GENERAL

A. Install louvers and penthouses as per manufacturer's recommendations.

3.2 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.) Slope ductwork, and plenum to louver weephole or provide drain.

B. Structural supports shall be designed and furnished by the louver manufacturer to carry a wind load in accordance with the Building Code of New York State.

END OF SECTION

SECTION 235216 – CONDENSING FIRETUBE BOILERS

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim and accessories for generating hot water. Boiler configuration and sizing represents range of operation through entire year connected load profile.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.

1. Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length and footprint for each submitted boiler.

B. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 50% , and minimum firing level input rates at incoming water temperatures ranging from 80°F to 160°F.

C. Pressure Drop Curve. Submit pressure drop curve for flows ranging from minimum to maximum flow (gpm). Indicate unit pressure drop at full fire and 40 deg. F delta T operation. Deviations from design parameters shall be considered and coordinated with requirements of associated pumps and piping arrangements.

D. Shop Drawings: For boilers, boiler trim and accessories include:

1. Plans, elevations, sections, details, service clearances and attachments related to other work.

2. Wiring Diagrams for power, signal wiring, control wiring and building controls interface details. Indicate available BMS communication protocols compatible with intended control system type/brand.

3. Integrated boiler controls package components and detailed capabilities including interfaces for sequencing and associated pump control.

4. Inclusion of gas regulator or coordination with contractor provided regulator for incoming service and requirements of boiler. Indicate required inlet and outlet required piping distances.

E. Source Quality Control Test Reports: Reports shall be included in submittals.

F. Field Quality Control Test Reports: Reports shall be included in submittals.

G. Operation and Maintenance Data: Data to be included in boiler emergency, operation and maintenance manuals.

H. Warranty: Standard warranty specified in this Section

I. Other Informational Submittals

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

2. Hydrostatic testing of piping external to boiler: Submit piping test reports per specification 232010 - Piping Systems and Accessories.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Boilers must be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

C. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers".

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

F. UL Compliance: Boilers must be tested for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

G. NOx Emission Standards: When installed and operated in accordance with manufacturer's instructions, condensing boilers shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.1; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, and Rule 117.465.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with the GC. Cast anchor-bolt inserts into bases.

B. Coordinate gas pressures and associated regulator sizing requirements with Division 22.

C. Coordinate physical size of unit vs. the required clearances relative to rigging path, and the required service clearances for the installation location.

D. Coordinate the emergency shut down button per ASME CSD-1 requirements with Division 26.

1.6 WARRANTY

A. Standard Warranty: Boilers shall include manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers

a. The pressure vessel/heat exchanger shall carry a 10 year from startup, non-prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.

b. Manufacturer labeled control panels are conditionally warranted against failure for (2) two years from startup.

c. All other components are conditionally guaranteed against any failure for 18 months from startup.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Performance capabilities, unit sizing for project scheduled load capability, physical product size and required clearances relative to the intended installation location, rigging limitations (both size and weight). Maximum boiler output, efficiency and minimum fire output (turndown) shall be evaluated for compliance with system design.

B. Multiple boiler sizes when utilized for seasonal turndown must be from the same manufacturer and compatible for parallel sequenced operation within the scheduled range of operation. Transition from minimum to maximum system capacity shall be seamless with output overlap between various boiler sizes.

C. Basis-of-Design Product: Subject to compliance with requirements, **Lochinvar** or a comparable product by one of the following:

1. AERCO International

2. Lochinvar

3. Raypack

4. Camus

5. Laars

6. Cleaver Brooks

2.2 CONSTRUCTION

A. Description: Boiler shall be natural gas fired, fully condensing, fire-tube design. Power burner shall have full modulation. The minimum firing rate shall not exceed scheduled capacity. Boilers that have an input greater than listed above at minimum fire will not be considered. Boilers to discharge into a positive pressure AL29-4C vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled and factory-tested, fire-tube condensing boiler with stainless steel heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls. Boiler sizing to match scheduled inputs. Boiler operational output temperature to be a minimum of **180 °F**

B. Heat Exchanger: The heat exchanger shall be constructed of 439 (or 316L) stainless steel fire tubes and tubesheets, with a one-pass combustion gas flow design. The fire tubes shall be 5/8" OD, with no less than 0.049" wall thickness. The upper and lower stainless steel tubesheet shall be no less than 0.25" thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tubesheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 10-inch diameter.

C. Pressure Vessel: The pressure vessel shall have a minimum water volume of 18 gallons per MMBTU input. The boiler water pressure drop shall not exceed 5 psig at 20 deg.F rise associated flow for boiler of 4 MMBTU or less and 7 psig max for 5-6 MMBTU boilers. The boiler water connections shall be flanged 150-pound, ANSI rated. The pressure vessel shall be constructed of SA53 carbon steel, with a 0.25-inch thick wall and 0.50-inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code.

D. Modulating Air/Fuel Valve and Burner: The boiler burners shall be capable of scheduled turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. Design turndown ratio is **10:1.** The burner shall produce less than 9 ppm of NOx corrected to 3% excess oxygen. The burner shall be metal-fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable speed cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

E. Minimum boiler efficiencies shall be as follows at a 20 degree delta-T:

EWT	100% Fire	50% Fire	7% Fire
160 °F	87%	87%	87%
140 °F	88%	88%	88%
120 °F	89%	90%	90.5%
100 °F	93.7%	95%	95%
80 °F	96%	98%	98.6%

F. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with a **[6] [8] [10] [12] [14]** inch diameter flue connection. The exhaust stack shall have a collecting reservoir and a gravity drain for the elimination of condensation. Exhaust venting shall be watertight.

G. Blower: The boiler shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.

1. Motors: Blower motors shall comply with requirements specified in Division 23 Section "Motors".

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require a motor to operate in the service factor range above 1.0.

H. Ignition: Ignition shall be via spark ignition with 100 percent main-valve shutoff and electronic flame supervision.

I. The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency.

J. Enclosure: The sheet metal enclosure shall be fully removable, allowing for easy access during servicing.

K. Boiler to be suitable for use with propylene glycol up to 50% concentration. Derating dependent on fluid manufacturer variations.

2.3 CONTROLS

A. Boiler control shall be a stand-alone factory packaged system provided as part of boiler.

B. The entire system shall be Underwriters Laboratories recognized.

C. The control panel shall consist of individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:

1. A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module for all message enunciation

2. A CPU board housing all control functions

3. An electric low-water cutoff board with test and manual reset functions

4. A power supply board

5. An ignition /stepper board incorporating flame safeguard control

6. A connector board

7. Each board shall be individually field replaceable.

D. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

E. The control panel hardware shall support both RS-232 and RS-485 remote communications.

F. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 34 separate fault messages.

G. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:

1. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.

2. Setpoint Low Limit: Allow for a selectable minimum operating temperature.

3. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

H. The boiler control system shall incorporate the following additional features for enhanced Building Management System (BMS) interface thru a BacNET or Modbus connection:

1. System start temperature feature

2. Pump delay timer

3. Auxiliary start delay timer

4. Auxiliary temperature sensor

5. Analog output feature to enable simple monitoring of temperature setpoint, outlet temperature or fire rate

6. Remote interlock circuit

7. Delayed interlock circuit

8. Fault relay for remote fault alarm

I. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

J. Each boiler shall have an oxygen monitoring system that will measure the oxygen content of the exhaust gasses in real-time. Output of O2 information shall be displayed on the control panel.

K. Each boiler shall have integrated boiler sequencing and modulation control capable of multi-unit sequencing with lead-lag functionality and parallel operation of between 2 and 8 boilers of various sizing. The system will incorporate the following capabilities:

1. Efficiently sequence multiple units on the same system to meet load requirement.

2. Integrated control and wiring for seamless installation of optional isolation valve or primary variable speed pump control. When valves are utilized, the system shall operate one motorized valve per unit as an element of load sequencing. Valves shall close with decreased load as units turn off, minimum of one must always stay open for recirculation.

3. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.

4. Designated master control, used to display and adjust key system parameters.

5. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status should be shown on the individual unit displays.

6. Designated master control, used to display and adjust key system parameters.

7. Boiler control shall be capable of starting and stopping associated boiler pump and modulating speed for peak efficiency or constant delta T setting.

L. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The system shall control the boiler outlet header temperature within +2ºF. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate

temperature control with excellent variable load response. The controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature. The control system shall have the following anti-cycling features:

1. Manual designation of lead boiler and last boiler.

2. Lead boiler rotation at user-specified time interval.

3. Delay the firing/shutting down of boilers when header temperature within a predefined deadband.

M. When set on Internal Setpoint Mode, temperature control setpoint on the contoller shall be fully field adjustable from 50ºF to **[185][190][200]**ºF in operation. When set on Indoor/Outdoor Reset Mode, the controller will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the controller will operate the plant to vary header temperature setpoint linearly when an externally applied variable signal is supplied from master header sensor through Siemens building automation control system. When set on "external building controls" Temperature Control Mode, the boiler controller will operate the plant to vary header temperature setpoint as an external communication utilizing the coordinated protocol(s) through appropriate available communication port. The boiler controller shall have a vacuum fluorescent display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each boiler by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central control system and individual boilers shall be twisted pair low voltage wiring, with the boilers 'daisy-chained' for ease of installation. All field wiring and communication devices must be coordinated between equipment and building control systems for complete operable system.

2.4 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the boiler.

2.5 VENTING

A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, condensing flue gas service. Sizing to be as shown on drawings and in accordance with the manufacturer's recommendations.

B. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors. Make up air shall be individually ducted to each unit with an associated interlocked isolation damper. Sizing to be as shown on drawings and in accordance with the manufacturer's recommendations. The minimum sealed combustion air duct size for each boiler shall be according to installed unit manufacturer installation guide requirements. Combustion air intake ducts shall be insulated.

C. Common venting and common combustion air is not allowed unless approved by manufacturer. Consult manufacturer for common vent and common combustion air sizing.

D. Venting must be approved by the manufacturer and installed per the guidelines specified in the manufacturer's venting guide.

2.6 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.

C. Allow Owner access to source quality-control testing of boilers. Notify the Engineer 14 days in advance of testing.

2.7 CONDENSATE NEUTRALIZATION

A. Provide a condensate neutralization kit for field installation on each boiler to adjust condensate pH level prior to discharging to drain.

1. Kit shall be PVC construction with removable end cap to replace neutralization material.

2. Provide limestone neutralization material.

3. Coordinate drain elevation and location with available floor drain(s).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation examine roughing-in requirements for concrete equipment bases, anchor-bolt sizes and locations and piping and electrical connections to verify actual locations, sizes and other conditions affecting boiler performance, maintenance and operations.

B. Boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections. Coordinate with existing or new floor drains.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete bases.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings and specialties.

B. Install piping adjacent to boiler to permit service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide a drain valve.

D. Connect gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required. Provide all gas train vents to outdoors and terminate with screened discharge fittings. Paint all exterior vent piping.

E. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.

F. Install piping from safety relief valves to within 6" of a floor drain, or a glycol fill tank if applicable.

G. Boiler Venting

1. Install flue venting kit.

2. Connect venting full size to boiler connections.

H. Install combustion air intake ductwork from building exterior to boiler intake. Insulate ductwork per specification 230710 - Insulation.

I. Provide combustion air openings in accordance with the NYS Fuel Gas Code.

J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections

1. Perform installation and startup checks according to manufacturer's written instructions.

2. Perform hydrostatic test. Repair leaks and retest until no leaks exist.

3. Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.

b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests: The boiler manufacturer is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the boiler manufacturer to complete the following performance tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine capacity and efficiency of boilers.

   a. Test for full capacity.

   b. **Test for boiler efficiency at low fire, 20, 40, 60, 80, 100, 80, 60, 40 and 20 percent** of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.

5. Provide analysis equipment required to determine performance.

6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

7. Notify **[Campus] [Owner's]** site representative or engineer in advance of test dates.

8. Document test results in a report and submit to Engineer or Owner.

END OF SECTION

SECTION 236426.20 - AIR-COOLED ROTARY SCREW WATER CHILLER

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all materials, equipment and services as described in the Contract Documents.

1.2 SUBMITTALS

A. ARI certified part load performance data for 100%, 75%, 50% and 25% load.

B. Dimensional data and weights of all sections.

C. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, sound data, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.

D. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

E. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed and wiring by others.

F. Clearly identify all equipment and accessories included in quotation, as well as any Scope of Work excluded. List and identify any Scope of Work required of other companies.

1.3 START-UP AND INSTALLATION DATA

A. Manufacturer of refrigeration machine responsible for:

1. Furnishing complete installation drawings, templates, wiring diagrams, refrigerant piping diagrams, and instruction manuals for the equipment.

2. Submitting drawings either made especially for this job or distinctly modified for same; errors resulting from use of standard factory drawings, responsibility of this Manufacturer.

3. Supervising and checking installation for compliance with manufacturer's recommendations.

4. Checking out machines and actual start-up of same.

5. Advising and assisting Contractor in making final adjustments, i.e.:

a. Regulating flow of chilled water, sizing of refrigerant piping, etc.

b. To provide for proper balance and most economical operation, such as setting operating controls and setting and checking safety.

6. Providing five (5) year parts and labor warranty. This coverage will not exceed five (5) years from start up or five (5) years and six (6) months from shipment, whichever occurs first.

7. Furnishing Engineers log of results, all balancing and adjusting for various load conditions, including pressures, temperatures, flow quantities, etc.

8. Furnishing Contractor and Engineer with exact location and arrangement of all piping thermostats, flow switches, gauges, thermometers, insertion wells, etc., required.

9. Thoroughly instructing Owner's operating, personnel in proper operation of equipment.

1.4 GENERAL REQUIREMENTS

A. Completely factory assembled, wired and tested prior to shipment. Include initial charge of lubricating oil.

B. Chillers shall shut down for low oil pressure, condenser high pressure, chilled water low temperature, motor overload.

C. Chiller performance shall be in ARI certified in accordance with Standard 550-88 for the conditions scheduled.

D. Chiller shall comply with the requirements of ASHRAE Standard 15 - Safety Code for Mechanical Refrigeration.

PART 2 - PRODUCTS

2.1 CHILLERS

A. Compressors and Motors:

1. Shall be a 3600 RPM, serviceable semi-hermetic type rotary compressor with: capacity control slide or capacity control variable speed compressor, integral single stage economizer, oil sump heater and differential refrigerant pressure oil pump.

2. Compressor motor shall be a hermetically sealed, two pole, squirrel cage motor cooled by liquid refrigerant.

3. Unit shall utilize R-134A as refrigerant.

B. Evaporator Section:

1. Shall be shell and tube type, with removable heads.

2. Seamless copper tubes .028 in. tube wall thickness shall be mechanically expanded into the tube sheets. Tubes shall be individually replaceable.

3. Designed, tested and stamped in accordance with ASME Code for refrigerant side working pressure of 300 psig and waterside working pressure of 215 psig.

4. The water boxes shall have piping water connections for chilled water connections that matches piping connection system to be utilized by the Contractor.

5. Factory insulated with a 1-1/4 in. minimum layer of foam type insulation; k = 0.26. Insulate and cover all low temperature surfaces including evaporator, water boxes, suction elbow, economizer and water cooling lines.

6. Shall be equipped with vent; drain and temperature sensor fittings.

7. **Evaporator shall be remote mounted indoors.**

C. Refrigerant Circuit: A minimum of two (2) independent refrigerant circuits are required with no more than two compressors per circuit.

1. Refrigeration controls, chillers and condensers shall be isolated with shut off valves.

2. Refrigerant circuits shall include hot gas muffler, combination moisture indicator and sight glass, refrigerant filter-dryer, liquid line solenoid valve, maximum operating pressure thermal expansion valve, compressor and suction service charging valve. Discharge and oil line check valve, high side pressure relief valves.

3. Full operating charge of oil.

4. Capacity modulation down to a minimum 15% of rated full output via slide valve slide valve shall adjust and modulate infinitely. Stepped slide valve movement is not acceptable. Variable speed compressor operation for capacity control is also acceptable.

D. Controls:

1. The chiller shall be controlled by a stand-alone direct digital control (DDC) system. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

2. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensor, actuators, relays and switches.

3. Safeties - The chiller control panel shall monitor such safeties as motor starting and running, loss of phase, time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure on each circuit with indicating light, low evaporator refrigerant pressure, evaporator water flow, low oil flow, and proper operation of unit controls and sensors.

4. The chiller control panel is to be provided with the following dial type pressure gauges.

a. Evaporator refrigerant pressure.

b. Condenser refrigerant pressure.

5. The chiller control panel is to be provided with a starts counter and running time meter.

6. The front of the chiller control panel shall be capable of displaying the following:

a. Entering and leaving evaporator water temperature.

b. Chilled water setpoint.

c. Electrical current limit setpoint.

d. Chiller operating mode.

e. Chiller diagnostic codes.

7. The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature tripouts during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A diagnostic code, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

8. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

9. The unit control panel shall provide leaving chilled water temperature reset based upon a 4-20ma or 0-10 VDC signal from building automation system.

10. The micro computer controls shall provide all control functions including compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, auto/lead/lag compressor starting.

E. Starter:

1. Provide unit mounted and wired combination wye-delta magnetic starters. The starters shall be in accordance with the standard specifications of the chiller manufacturer, Specification Section 230513, and shall include the following minimum accessories:

a. Control transformer, fused on both primary and secondary.

b. Three-phase overload protection.

c. Pilot relay.

d. Across-the-line oil pump starter.

e. Low voltage relay.

f. Non-fused disconnects on main circuits.

F. Air Cooled Condenser:

1. Casing:

a. One piece welded assembly. Mount on guided spring type vibration isolators.

b. Exterior surface phosphatized, epoxy primered and finished with baked-on enamel.

2. Fans and Motors:

a. Vertical discharge, direct-drive fans with TEAO motors.

b. Statically and dynamically balanced.

c. Aluminum blades and zinc-plated steel hubs, low noise type or one-piece molded design.

d. Permanently lubricated ball bearings, built-in current and thermal overload protection, and weathertight slinger over shaft.

e. Isolated from unit structure with rubber-in-shear isolation.

3. Coil:

a. Air-cooled.

b. Aluminum fin; seamless copper tubing.

c. Subcooler circuit with liquid accumulator.

d. Factory tested at 450 psig air pressure under water; vacuum dehydrated.

4. Controls:

a. Factory wired and mounted control panel containing:

1) Fan motor contactors.

2) Fan cycling thermostats.

3) Compressor interlock.

4) 115 volt control power transformer.

b. Wiring harness for control to activate the condenser unit and to interlock the condenser controls with the chiller.

G. Accessories:

1. Flow switch for safety interlock to prevent operation of machine without proper evaporator flow.

2. Factory installed anti-recycle timer and timed periodic pumpout. Set at 15 minutes; field adjust as necessary to meet actual job requirements.

3. Isolation valves to manually isolate full refrigerant charge in condenser during servicing.

4. Motor surge protector.

5. **Provide full height of chiller, factory installed and architectural louver panels for all sides of unit.**

6. Provide field installed sound attenuation option consisting of acoustical material to be wrapped around the compressors, oil separators, suction lines, and discharge lines off the compressors. Sound levels at operation at 100 percent capacity with the acoustical package installed shall not exceed 77 dB (60 Hz) at 30 ft.

H. Design Equipment: Trane "Series R" RTAC.

I. Make: Trane, Daikin Applied, York, Carrier.

PART 3 - EXECUTION

3.1 CHILLER INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. General:

1. Obtain installation and wiring diagrams, piping diagrams, etc., from manufacturer.

2. Providing piping, valves and accessories to connect flow switches, oil piping, and other miscellaneous special devices or piping required for actual machine selected; obtain exact requirements from manufacturer of equipment before submitting bid.

3. Install thermometers, drain valves and pressure gauges at all inlets and outlets.

4. Coordinate work in area adjacent to machine to insure adequate clearances for operating and service, as well as tube pulling space.

5. Prevent freeze-up from any cause.

6. Insulate completely as recommended by manufacturer those areas of unit not factory insulated.

C. Piping Connections:

1. Use flexible connectors at chilled water connections.

2. Verify chilled water IN and OUT, before piping.

3. Install thermometer wells, flow switches, pressure gauges, etc. as directed by manufacturer.

4. Provide refrigerant piping, sized and routed as per the chiller manufacturer's recommendations, if evaporator is remote mounted.

5. Install thermometers in all entering and leaving water piping.

6. Install all necessary air vents, drains, controls, and auxiliary piping or accessories.

3.2 ELECTRIC WIRING

A. Electrical Contractor shall provide all power wiring to chiller.

B. HVAC Contractor shall provide all control wiring at chiller, including flow switches, pressure switches, control circuit transformer, etc.

3.3 ACCESSORIES

A. Install accessories which are not factory mounted.

END OF SECTION

SECTION 237413.10 - PACKAGED ROOFTOP UNIT

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

1.3 QUALIFICATIONS

A. Complete unit and accessories shall comply with the New York State Energy Conservation Construction Code. Unit shall have UL and AGA label.

1.4 MANUFACTURER'S WARRANTY

A. Provide parts warranty (excluding refrigerant) for one year from start-up or 18 months from shipment, whichever occurs first.

B. Provide five (5) year extended warranty for compressors.

C. Provide five (5) year heat exchanger limited warranty.

PART 2 - PRODUCTS

2.1 PACKAGED ROOFTOP UNITS

A. General:

1. Units shall conform to ANSI Z21.47/UL1995 for construction of packaged air conditioner.

2. The contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

3. Units furnished and installed shall be packaged rooftops as scheduled on contract documents and these specifications. Cooling capacity ratings shall be based on

ARI Standard 210. Units shall consist of insulated weather-tight casing with compressors, air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and unit controls and drives.

4. Units shall be 100% factory run tested and fully charged with R-410A.

5. Units shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

6. Units shall be dedicated down flow or dedicated horizontal airflow as manufactured.

7. Wiring internal to the unit shall be colored and numbered for identification.

B. Unit Casing:

1. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating with removable access panels. Structural members shall be 18-gauge with access doors and removable panels of minimum 20 gauge.

2. Units cabinet surface shall be tested 1000 hours in salt spray test in compliance with ASTM B117.

3. Cabinet construction shall allow for all service/maintenance from one side of the unit.

4. Cabinet top cover shall be one-piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

5. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section. Access panels shall be hinged.

6. Units base pan shall have a raised 1-1/8 in. high lip around the supply and return openings for water integrity.

7. Insulation: Provide 1/2 in. thick fiberglass insulation with foil face on all exterior panels in contact with the return and conditioned air stream. All edges must be captured so that there is no insulation exposed in the air stream.

8. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

9. Provide through-the base electrical power and control service; eliminating the need for separate roof penetrations.

10. Provide through-the-base gas piping including a pre-assembled black steel piping, manual gas shutoff valve (with 1/8 in. NPT pressure tap), elbows and union.

11. The base of the unit shall have three (3) sides for forklift provisions. The base of the units shall have rigging/lifting holes for crane maneuvering.

C. Air Filters:

1. Factory installed filters shall mount integral within the unit and shall be accessible through access panels. 2 in. thick pleated MERV 8 filters shall be furnished and installed.

D. Fans and Motors:

1. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.

2. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.

3. Provide units 5 tons and below with direct drive, multiple-speed, dynamically balanced supply fans.

4. Provide units 3-5 tons with belt driven supply fans with adjustable motor sheaves.

5. Provide units 6 tons and above with belt driven, supply fans with adjustable motor sheaves.

6. Outdoor and indoor fan motors shall be permanently lubricated and have internal thermal overload protection.

7. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.

8. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

E. Gas Fired Heating Section:

1. Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided. Provide capability for gas piping through the side of the unit.

2. Heating section shall be factory run tested prior to shipment.

3. Induced draft combustion type with direct spark ignition system, redundant main gas valve, and 2-staged heat.

4. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Provide flame rollout switches.

5. Induced draft blower shall have combustion air proving switches and built-in thermal overload protection on fan motor.

6. Heat Exchanger: Provide tubular section type constructed from 18-gauge aluminized steel.

7. Burners: Burners shall be of the in-shot type constructed of stainless steel.

8. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

F. Evaporator Coil:

1. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

2. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

3. Provide factory installed thermal expansion valve (TXV) for each refrigerant circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

4. Provide a removable, reversible, cleanable double sloped drain pan for base of evaporator coil constructed of PVC

G. Condenser Section:

1. Provide internally finned seamless copper tube mechanically bonded to configured aluminum fins. Factory pressure test to 450 psig.

2. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

3. [Condenser coil shall be epoxy coated.]

H. Refrigeration System:

1. Compressors: Provide direct drive, hermetic type, scroll compressor with centrifugal type oil pump. Motor shall be suction gas cooled and have internal spring isolation. Compressors shall include crankcase heaters, internal pressure relief, temperature and current sensitive overloads.

2. Units shall have cooling capabilities down to 0 degree F as standard. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.

3. Provide each unit with refrigerant circuits factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports.

4. Refrigeration System Options:

   a. Thermal expansion valve.

   b. Dehumidification (hot-gas reheat) option.

   c. High-pressure refrigeration control.

   d. Frostat

   e. Crankcase Heater.

I. Exhaust/Return Section

1. Provide a factory supplied field installed power exhaust assembly that shall assist the barometric relief damper in the economizer in relieving building pressurization.

J. Outdoor Air Section:

1. Provide a fully integrated field-installed 100% modulating outside air economizer with unit return and barometric relief air dampers, minimum position setting, preset linkage, wiring harness with plug. Unit operation is through primary temperature controls that automatically modulate dampers to maintain space temperature conditions.]

K. Operating Controls:

1. Provide factory-wired roof top units with 24 volt control circuit with control transformers, contactor pressure lugs or terminal block for power wiring. Contractor to provide field-installed unit-mounted disconnect switch. Units shall have single point power connections. Field wiring of zone controls to be NEC Class II.

2. Provide microprocessor unit-mounted DDC control which when used with an electronic zone sensor provides proportional integral room control. This UCM shall perform all unit functions by making all heating, cooling, and ventilating decisions through resident software logic.

3. Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.

4. Provide an anti-cycle timing and minimum on/off between stages timing in the microprocessor.

5. Economizer Preferred Cooling: Compressor operation shall be integrated with economizer cycle to allow mechanical cooling when economizer is not adequate to satisfy zone requirements. Compressors are enabled if space temperature is recovering to cooling setpoint at a rate of less than 0.2 degrees per minute. Compressor low ambient lockout overrides this function.

6. Control Options:

a. LonTalk communication interface.

b. Fan failure switch.

c. Dirty filter switch.

d. Supply air smoke detector.

e. Return air smoke detector.

f. Ventilation override accessory: set to 3 different pre-programmed sequences for smoke purge, pressurization, and exhaust.

L. Staging Controls:

1. Provide NEC Class II, electronic, adjustable zone control to maintain zone temperature setting.

2. Provide manual/automatic changeover control with (off-heat-auto-cool), and fan control switch (auto-on).

3. Provide controller for by-pass VAV operation on constant volume rooftop that has been tested and supplied by HVAC equipment manufacturer. If by-pass VAV dampers are substituted and are not provided by the manufacturer, then it is the responsibility of the mechanical contractor to prove to the engineer that the complete system is compatible and operates properly.

4. Provide programmable electronic microcomputer based zone control.

M. Roof Curb:

1. Contractor shall provide factory supplied roof curb, 16-gauge perimeter made of zinc-coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly

2. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

N. Design Equipment: Trane.

O. Make: Carrier, Daikin Applied, Trane, York.

PART 3 - EXECUTION

3.1 PACKAGED ROOFTOP UNIT

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory-shipping covers in place until installation.

C. Contractor shall verify that proper power supply is available.

D. Provide for roof openings and framing as called for. Set and secure curb to roof, and unit to curb. Shim roof curb level.

E. Pipe coil drains to spill to roof, provide "P" trap of proper depth.

F. Install unit in strict accordance with manufacturer's instructions.

G. Arrange to have equipment manufacturer's technician to verify installation for compliance with manufacturer's recommendations.

H. Arrange to have equipment manufacturer's technician perform start-up of equipment, instruct Owner's Representative in the proper operation of the equipment.

END OF SECTION

SECTION 238126.11 - DUCTLESS SPLIT SYSTEM AIR CONDITIONER

PART 1 - GENERAL

1.1 WORK INCLUDED

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

1.2 SUBMITTALS

A. Submit product data for split system ductless air conditioner, including condensing unit, refrigerant piping diagrams, and control and wiring schematics.

1.3 GENERAL REQUIREMENTS

A. Provide units to fit intended use and location as indicated:

1. Capacity, size and arrangement, 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 210 rated.

3. Unit to meet or exceed minimum SEER Requirements of New York State Energy Code and Department of Energy (DOE).

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT WALL MOUNTED TYPE)

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 in. OD copper tubing. Coils shall be factory pressure and leak tested.

2.2 CONDENSING UNIT

A. The condensing unit shall be fully charged from the factory for up to 100 ft. of piping. The unit must be designed to operate at outdoor ambient temperatures as high as 115°F and as low as -20°F, with low-ambient kit. 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 glued with minimized brazed joints. The coil shall be 3/8 in. O.D. seamless aluminum glued to a continuous aluminum fin. The coil shall be protected on all four sides by louvered panels.

2.3 ACCESSORIES

A. Wall Mounted Microprocessor Controller:

1. Liquid crystal digital display indicating: Operating mode, setpoint temperature, room temperature, timer setting, fan speed and airflow direction.

2. Self diagnostic fault indication.

3. 24 hour on-off timer.

4. Previous setpoint memory feature.

B. Low ambient protection kit with wind baffle. Allow unit operation down to 0°F -20°F

C. Auto restart following power failure.

D. Condensate drain hose.

E. Pre-charged uninsulated refrigerant piping lines.

2.4 DESIGN EQUIPMENT

A. Mitsubishi.

2.5 ACCEPTABLE MAKE

A. Sanyo, Mitsubishi, EMI, Carrier.

PART 3 - EXECUTION

3.1 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. Connect condensate to piping left by Plumbing Contractor.

C. Provide refrigerant piping and control wiring.

D. Provide any and all necessary control wiring

END OF SECTION

SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation shown on Contract Drawings.

1.2 SUBMITTALS

A. Submit product data for room fan coil units and accessories.

PART 2 - PRODUCTS

2.1 GENERAL

A. Baked enamel finish of color selected from manufacturers standard colors. Each piece of equipment boxed separately and tagged by room number.

B. Coordinate voltages of valve and damper operators to be provided, with the DDC system controls subcontractor.

2.2 CONSOLE FAN COIL UNITS

A. Cabinets:

1. 18 gauge steel removable front enclosure so that internal operating parts are accessible for service or replacement.
2. Bar supply grilles.
3. Isolated valve compartment.
4. Access to motor, fan assembly, and filters.
5. Type as required for job conditions.
6. Return air grilles.
7. Insulated drip pan for coil and valve sections.
8. Insulated cabinet with material in compliance with NFPA 90A requirements.

B. Heating Coils:

1. Copper tubes and headers, nonferrous fins.

C. Cooling Coils:

1. Copper tubes and headers, nonferrous fins.

D. Motors:

1. Multispeed, tapwound permanent split capacitor high efficiency type.

2. Built-in overload protection.

3. Resilient mountings to dissipate noise and magnetic vibration.

4. Quick detachable motor cords.

5. Permanently lubricated bearings.

E. Shall not exceed sound data as scheduled. Acoustical data is published manufacturer's data obtained by tests in accordance with ARI Standard 350-086.

F. Options:

1. Fresh air intake damper (where shown on plans) with two-position spring-return electric operator.

2. Keylock panel and access doors.

3. Manual air vent.

4. Disconnect switch.

5. 1 in. pleated throwaway filter.

6. Deluxe 2-way factory installed piping package with manual circuit setter, unions, strainer and supply side ball valve.

7. Unit-mounted fan speed switch.

G. Design Equipment: Trane.

H. Make: Carrier, Daikin Applied, Trane.

2.3 RECESSED FAN COIL UNITS

A. Arrangement:

1. Base unit designed for fully recessed wall installation.

2. Features and accessories shall be the same as console type, except for the following:

a. Base casing shall be provided in lieu of finished cabinet. Return grille.

b. Remote flush mounted speed switch shall be provided.

B. Design Equipment: Trane.

C. Make: Carrier, Daikin Applied, Trane.

2.4 LOW PROFILE - RECESSED FAN COIL UNITS

A. Arrangement:

1. Base unit designed for fully recessed wall installation.

2. Features and accessories shall be the same as console type, except for the following:

a. Base casing shall be provided in lieu of finished cabinet. Return Grille.

b. Remote flush mounted speed switch shall be provided.

c. Maximum unit height 14 in.

B. Design Equipment: Trane.

C. Make: Carrier, Daikin Applied, Trane.

PART 3 - EXECUTION

3.1 GENERAL

A. Left hand or right hand piping connections for supply and return. Obtain complete instructions from unit manufacturer regarding each item and proper installation of same. Adjust motor speed.

3.2 INSTALLATION

A. In accordance with manufacturer's recommendations. Install piping within valve compartment to allow for pipe insulation. Provide drain piping. Vacuum clean inside of unit prior to operating units. Provide flexible duct connections at supply and return connections to ceiling units. For recessed and ceiling units, coordinate location of valves, fittings, filters, with access panels, to allow for convenient service of components. END OF SECTION