SECTION 230009
MECHANICAL SELECTIVE DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Extent of Work

Removal and demolition of selected items from selected areas of the building as indicated on the Drawings and as required to complete the Work.

1.02 SUBMITTALS

A. Submit a schedule indicating proposed methods and sequence of operations for selective removals and demolition Work, prior to commencement of operations. The sequence of operations shall be planned, in detail, to ensure uninterrupted progress of school sessions.

B. Submit details and procedures for dust and noise control.

C. Signed receipt for salvaged items delivered to the Owner.

D. Quality Control Submittals

1. Contractor Qualifications

a. Provide proof of Contractor and Professional Engineer qualifications specified under "Quality Assurance".

b. Provide proof of Refrigerant Recovery Technician qualifications

E. Sustainability Submittals

1. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

2. Statement of the measures taken to reduce air with dust and particulate matter.

1.04 RESPONSIBILITY, PROTECTION, DAMAGES, RESTRICTIONS

A. Condition of Space

The Owner assumes no responsibility for actual condition of the space in which removals and demolition Work is performed.

B. Protections

Provide temporary barricades and other forms of protection required to protect property, personnel, students and general public from injury due to selective removals and demolition work.

1. Provide protective measures as required to provide free and safe passage of students, school personnel, and the general public.

2. Protect from damage existing finish work that is to remain in place and which becomes exposed during operations.

3. Protect floors with building paper or other suitable covering.

C. Damages

Promptly repair any and all damages to all property and finishes caused by the removals and demolition work; to the Owner's satisfaction and at no extra cost to the Owner.

D. Explosives

The use of explosives is prohibited.

E. Power-driven Tools (for interior removals and demolition).

Only hand-held electric power-driven tools conforming to the following criteria shall be used to cut or drill concrete and masonry:

1. Electric Chiselling Hammer

   a. Power Data 115 Volts AC
   7-8 Amps
   Three-wire grounded connection

   b. Percussion 2400-2600 Impacts/Minute

   c. Type/Size Hand-held (+ 18-inch length)

   d. Unit Weight 12-15 pounds (minus chisel bit)

2. Electric Hammer Drill

   a. Power Data 115 Volts AC
   5-8 Amps
   Three-wire grounded connection

   b. Percussion 2400-3200 Impacts/Minute

   c. Type/Size Hand-held (+ 18-inch length)

   d. Unit Weight 12-15 pounds (minus chisel bit)

e. Speed Data 0-0500 RPM (Under load)

1.05 QUALITY ASSURANCE

A. Qualifications

1. Company specializing in performing the Work of this Section shall have a minimum of 3 years experience and shall have worked on 3 projects of similar size.

2. Preparation of details of shoring and bracing and underpinning shall be under the direct supervision of and bear the seal of a Licensed Professional Engineer of the State of New York experienced in the design of such work, who shall also be responsible for construction supervision of such.

3. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.

B. Regulatory Requirements

1. Work of this Section shall conform to all requirements of the NYS Building Code and all applicable regulations and guidelines of all governmental authorities having jurisdiction, including, but not limited to, safety, health, and anti-pollution regulations. Where more stringent requirements than those contained in the Building Code or other applicable regulations are given in this Section, the requirements of this Section shall govern.

2. Conform to the requirements of "Safety and Health Standards, Subpart P - Excavations, Trenching and Shoring" - OSHA.

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION

3.01 INSPECTION

A. Prior to commencement of the selective removals and demolition Work, inspect the areas in which the Work will be performed. Determine and list the existing conditions of rooms or area surfaces and equipment. After the Work in each respective area is completed, determine if adjacent surfaces or equipment have been damaged as a result of the Work; if so, the damage shall be corrected at the Contractor's expense.

3.02 REMOVALS AND DEMOLITION WORK

A. Perform selective demolition Work in a systematic manner and use such methods as are required to complete the Work indicated, and in accordance with the Specifications and governing City, State, and Federal regulations.

B. When walls, partitions, floors, and ceilings (or portions thereof) are indicated to be removed; unless indicated otherwise:

1. Remove all items attached to the surfaces of the construction to be removed.

2. Remove all plumbing piping, fixtures, accessories and rough-in occurring on or in the construction to be removed; cap piping and/or re-route lines as indicated or required.

3. Remove all connectors, piping, ductwork and other HVAC items and accessories occurring on or in the construction to be removed; cap and/or re-route piping and ductwork as indicated or required.

4. Remove all electrical wiring, to include, but not limited to, lighting, communications, alarms and all related appurtenances, conduits, devices, fixtures, and other electrical items and accessories occurring on or in the construction to be removed; disconnect power and remove wiring and conduit back to source.

C. Carefully remove items, equipment and materials to be retained by the Owner and deliver them to locations indicated in the Article titled "Ownership of Materials".

3.03 DISPOSAL OF DEMOLISHED MATERIALS

A. Remove debris, rubbish and other materials resulting from the removals and demolitions from the building immediately; transport and legally dispose of materials off-site. Disposal method shall be in accordance with City, State, and Federal regulations. Items to be retained by the Owner shall be delivered to locations indicated in the Article titled "Ownership of Materials".

B. Burning of removed materials is not permitted on the job site.

3.04 CLEAN-UP AND REPAIR

A. Upon completion of removals and demolition Work, remove tools, equipment and all remaining demolished materials from the site.

B. Repair all damaged areas caused by the removals and demolition Work. Repair adjacent construction or surfaces soiled or damaged by selective demolition work.

C. All areas in which Work was performed under this Section shall be left "broom-clean."

3.05 OWNERSHIP OF MATERIALS

A. All equipment, materials, and items removed shall remain the property of the Owner, if desired; equipment, material and items not desired to be re-used or retained by the Owner shall be removed from the site by the Contractor. The Owner will designate which equipment, materials and items will be retained.

END OF SECTION

SECTION 230523

VALVES

PART 1 GENERAL

1.01 ABBREVIATIONS

A. IBBM: Iron body, bronze mounted.

B. OS&Y: Outside screw and yoke.

C. WOG: Water, oil, gas.

D. WSP: Working steam pressure.

1.02 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets and specifications for each valve type.

B. Valve Schedule: List type of valve, manufacturer's model number, and size for each service application.

1.03 MAINTENANCE

A. Special Tools:
1. One wrench for each type and size wrench operated plug valve.
2. Two insert changing tools, and one spare insert for each self contained thermostatic radiator control valve.

PART 2 PRODUCTS

2.01 VALVES - GENERAL

A. Valve Standardization: Valves from one or more manufacturers may be used, however valves supplied for each specific valve type shall be the product of one manufacturer.

B. Valves shall be first quality, free from all imperfections and defects, with body markings indicating manufacturer and rating.

C. Valve parts of same manufacturer, size and type shall be interchangeable.

D. Manually operated gate, globe and angle valves shall be of rising stem type, unless otherwise specified.

E. Valves which use packing, shall be capable of being packed when wide open and under full working pressure.

F. Size valves the same size as the piping in which they are installed, unless specified otherwise.

2.02 GATE VALVES

A. Type A: 125 psig WSP, 200 psig WOG, bronze body, union bonnet, solid wedge disc, and threaded ends. Acceptable Valves: Crane428UB, Hammond IB617, Jenkins 47CU, Milwaukee 1152, Nibco T134, and Stockham B105.

B. Type C: 125 psig WSP, 200 psig WOG up to 12 inch size, and 150 psig WOG for 14 inch and 16 inch sizes; IBBM OS&Y, bolted bonnet, solid wedge disc, and threaded or flanged ends depending on size. Acceptable Valves: Crane 464-1/2 & 465-1/2, Hammond IR1140, Milwaukee F2885, Nibco T6170 & F6170, and Stockham G620 & G623

C. Type D: 125 psig WSP, 200 psig WOG, bronze body, threaded bonnet, solid wedge disc, and solder ends. Acceptable Valves: Crane 1330, Hammond IB635, Jenkins 991AJ, Milwaukee 149, Nibco S111, and Stockham B108.

D. Type F: 250 psig WSP, 500 psig WOG up to 12 inch size, and 200 psig WSP, 300 psig WOG for 14 inch thru 20 inch sizes, IBBM 0S&Y, bolted bonnet, solid wedge disc, and threaded or flanged ends depending on size. Acceptable Valves: Crane 7-1/2, Hammond IR330, Jenkins 204C, Milwaukee F2894, Nibco F6670, and Stockham F667.

E. Type G: 300 psig WSP, 600 psig WOG, bronze body, union or bolted bonnet, solid wedge disc, cupro-nickel alloy or stainless steel seat rings, and threaded ends. Acceptable Valves: Crane 634E, Hammond IB658, Jenkins 2280UJ, Milwaukee 1184, Nibco T174SS. and Stockham B145.

F. Type H: 150 psig WSP. 300 psig WOG, bronze body. union bonnet. solid wedge disc, and threaded ends. Acceptable Valves: Crane 431UB, Hammond IB629, Jenkins 47CU, Milwaukee 1151. Nibco T134. and Stockham B120.

G. Type I: 150 psig WSP. 300 psig WOG, bronze body. union bonnet. solid wedge disc, and solder ends. Acceptable Valves: Hammond IB648, Milwaukee 1169, and Nibco S134.

2.03 GLOBE AND ANGLE VALVES

A. Type J: 125 WSP, 200 psig WOG, bronze body, threaded bonnet, and threaded ends. Acceptable Valves: Crane 1, Hammond IB440 & IB463, Jenkins 101J, Milwaukee 502, Nibco T211 & T311, and Stockham B16.

B. Type K: 125 psig WSP, 200 psig WOG, IBBM OS&Y, bolted bonnet, and threaded or flanged ends depending on size. Acceptable Valves: Crane 351 & 353. Hammond IR116. Jenkins 613C & 615C, Milwaukee F2981. Nibco F718B & F818B, and Stockham G512, & G515.

C. Type M: 250 psig WSP, 500 psig WOG, IBBM OS&Y, bolted bonnet, renewable seat and disc, and threaded or flanged ends depending on size.

Acceptable Valves: Crane 21E, Hammond IR313, Jenkins 923C, Milwaukee F2983, Nibco F768B & F869B, and Stockham F532.

D. Type O: 125 psig, 200 psig WOG, bronze body, threaded bonnet, and solder ends. Acceptable Valves: Crane 1310, Hammond IB423, Jenkins 1200C, Milwaukee 1502, Nibco S211, and Stockham B17.

E. Type P: 150 psig WSP, 300 psig WOG, bronze body, union bonnet, threaded ends, with 500 Brinell hardness stainless steel renewable plug and replaceable seat ring. Acceptable Valves: Crane 14-1/2, Hammond 444, Jenkins 2032J, Milwaukee 591A, and Stockham B29.

2.04 CHECK VALVES

A. Type S: 125 psig WSP, 200 psig WOG, bronze body, brass or bronze trim, horizontal swing, renewable and regrindable disc, and threaded ends. Face discs for cold water service with teflon. Acceptable Valves: Crane 37, Hammond IB940, Jenkins 4092, Milwaukee 509, Nibco T413Y, and Stockham B319Y.

B. Type T: 150 psig WSP, 300 psig WOG, bronze body, brass or bronze trim, horizontal swing, renewable and regrindable disc, and threaded ends. Face discs for cold water service with Buna-N or teflon. Acceptable Valves: Crane 137, Hammond IB944, Jenkins 4092 & 4037J, Nibco T4331, and Stockham B321.

C. Type U: 125 psig WSP, 200 psig WOG, bronze body, brass or bronze trim, horizontal swing, renewable and regrindable disc, and solder ends. Face discs for cold water service with teflon. Acceptable Valves: Crane 1340, Hammond IB912, Jenkins 4093, Milwaukee 1509, Nibco S413Y, and Stockham 309Y.

D. Type V: 125 psig WSP, 200 psig WOG, IBBM, horizontal swing, bolted bonnet, regrindable and renewable seat ring and disc, and threaded or flanged ends depending on size. Discs on valves 4 inch size and larger may be cast iron with bronze face. Acceptable Valves: Crane 372, & 373, Hammond IR1124, Jenkins 623CJ & 624CJ, Milwaukee F2974, Nibco F918, and Stockham G927 & G931.

E. Type W:
   1. Globe Style Silent Check Valve: IBBM or semi-steel with bronze mounting, renewable seat and disc, 18-8 stainless steel spring, and flanged ends.
      a. Acceptable Valves (125 psig flange pressure rating): Apco Series 600, Combination Pump & Valve 20D, Hammond IR9354, Milwaukee 1800, Nibco F910, and Williams Hager 636.
   2. Wafer Style Silent Check Valve: IBBM or semi-steel with bronze mounting, renewable seat and disc, 18-8 stainless steel spring, and flanged ends.
      a. Acceptable Valves (125 psig flange pressure rating): Apco Series 300, Combination Pump and Valve 10D, Hammond IR9253, Milwaukee 1400, Nibco W910, and Williams Hager 329 & 375.

F. Type X: 300 WSP, 600 psig WOG, bronze body, brass or bronze trim, horizontal swing, renewable and regrindable disc, and threaded ends. Face disc for cold water service with Buna-N or teflon. Acceptable Valves: Crane 76E, Hammond IB949, Jenkins 4962J, Milwaukee 507, Nibco T4731, and Stockham B375.

G. Type Y: 250 psig WSP, 500 psig WOG, IBBM, horizontal swing, bolted bonnet, regrindable and renewable seat ring and disc, and threaded or flanged ends depending on size. Discs on valves 4 inch size and larger may be cast iron with bronze face. Acceptable Valves: Crane 39E, Hammond IR322, Jenkins 339C, Milwaukee F2970, Nibco F968B, and Stockham F947.

H. Type Z: 125 psig flange pressure rating, cast iron body, wafer style, split clapper plate type with integral body seat ring, plain or flat face end connections, resilient Buna-N seal vulcanized to body seat ring; aluminum, bronze or stainless steel clapper plates; Type 316 stainless steel clapper springs and hinge pins; and nickel plated steel or stainless steel stop pieces. Acceptable Valves: Apco Series 9000, Nibco W920W, Stockham WG970, and Marlin Duo-Check II.

2.05 PLUG VALVES

A. Type AA: 200 psig WOG, lubricated type with standard port opening, cast iron or semi-steel body, sealed lubrication system with lubricant fitting and dial indicator, cylindrical plug or teflon tapered plug, lubricant grooves in body or plug, threaded or flanged ends depending on size, and capable of lubrication with valve under pressure and plug in any position.

1. Acceptable Valves:
   a. 1/2 inch to 3 inch size: Homestead 611 & 612, Resun R1430 & R1431, and Rockwell 142 & 143.
   b. 4 inch size: Homestead 611 & 612, , Resun R1430 & R1431, and Rockwell 142 & 143.
   c. 5 inch size: Homestead 611 & 612, Resun R1431, and Rockwell 143.
   d. 6 inch size: Homestead 611 & 612, , Resun R1431, and Rockwell 143.
   e. 8, 10 & 12 inch sizes: Homestead 612G. Resun R1431WGA. and Rockwell 149.
2. Operators:
   a. 6 inch size and Less: Wrench operator.
   b. 8 inch size and Up: Worm gear operator.

B. Type AB: 100 psig WOG, gas cock type with cast iron or bronze body, bronze plug, square head, wrench operator, and threaded ends. Acceptable Manufacturers: Crane, Eclipse Combustion, and McDonald.

2.07 BUTTERFLY VALVES

A. Type BF: Iron body, flangeless wafer or lugged type, (lug for each bolt hole, drilled and tapped for cap screws), with replaceable reinforced resilient EPT (EPDM) seats, bronze or nickel plated ductile iron discs, phosphate coated steel or stainless steel stems, and raised necks able to accommodate 2 inches of

insulation. Acceptable Manufacturers: Crane, Demco, De Zurik, Hammond, Keystone, Milwaukee, Nibco, Stockham, and Watts.

1. Pressure Ratings:
   a. 12 inch size and Less: 200 psig WOG at 275 degrees F.

B. Type BF-HP: ANSI Class 150 lug style carbon steel body, stainless steel disc and stem, RTFE seats and bushings. Acceptable Manufacturers: Crane, Hammond, Keystone, Milwaukee, and Stockham.

C. Operators:
   1. 6 inch size and Less: Manual actuator handles with external indication of disc position, and suitable means of locking actuator in any fixed position.
   2. 8 inch size and Up: Worm gear operator.

2.07 COMBINATION BALANCING AND SHUT-OFF VALVES

A. Heavy duty brass construction of angle or straightway pattern with 200 psig working water pressure at 250 degrees F, one union connection and one threaded or solder end, visible graduated dial indicator, memory stop, and wheel handle with full turn opening. Acceptable Manufacturers: Dunham-Bush, and Spirax Sarco.

2.08 WATER PRESSURE REDUCING VALVES

A. Cold Water Make-Up Service:
   1. Adjustable direct acting, spring loaded, diaphragm operated, single seat type conforming to ASSE 1003 - Performance Requirements for Water Pressure Reducing Valves for Domestic Water Supply Systems. Acceptable Manufacturers: Bell & Gossett, Watts, and Wilkins.
      a. Body: Brass or bronze construction.
      b. Wetted Parts: Brass, bronze, stainless steel, or nickel alloy construction.
      c. Renewable seat and removable composition disc.
      d. Integral low inlet pressure check valve.
      e. Operating Temperature Range: 33-160 degrees F.
      f. Maximum Working Pressure: 125 psi.
   2. Pressure reducing valves with integral strainers may be substituted for approval, in lieu of separate valve and strainer, if integral strainer and valve meet individual valve and strainer specifications.

2.09 SAFETY AND RELIEF VALVES

A. General Requirements: Valves shall be as specified by ASME Code governing manufacture of such valves within scope of their particular usage, i.e., Heating Boilers, Unfired Pressure Valves, etc., shall be tested, rated and listed, unless otherwise specified. Valves for applications specified shall conform to the ASME Code, Section IV, Heating Boilers and the following:
   1. Valves for steam heating boilers operating at a maximum pressure of 15 psi shall have a maximum pressure setting of 15 psig. Sizing of valves

shall be accordance with ASME Table HG 400.1. Valve bodies shall be bronze or cast iron, with discs and seats of bronze.

2. Valves for hot water heating boilers shall conform to the requirements of the ASME Code and have a maximum pressure setting of 30 psig. Valves shall be of safety relief type, i.e., shall lift slowly to relieve normal thermal pressure build-up and "pop" to relieve excessive pressure due to "runaway" conditions, caused by the failure of any pressure control device and shut-down firing mechanism on excessive pressure indication. Valve bodies shall be bronze or cast iron, with non-vulcanizing synthetic discs and with seats of bronze.
3. Valves for direct fired domestic hot water boilers shall conform to requirements of ASME Code, Section IV, Paragraph HG 400.2(a). Valves shall be of temperature-pressure type, rated at 125 psig test pressure. Thermostatic element shall, on rising temperature, cause the valve to open at 188 degrees F. and valve shall deliver its rated capacity at 208 degrees F. and close drip tight at 183 degrees F. Valves for use on gas fired heaters shall be AGA approved and shall be so stamped or marked.
4. Valves for combination domestic hot water heater and storage tanks shall conform to the requirements of ASME Code, Section IV and USA Standard Z21.22 and shall be NBB listed. Valves shall be of the temperature - pressure type. Thermostatic element shall, on rising temperature, cause the valve to open at 200 degrees F. and valve shall deliver its rated capacity at 210 degrees F. and close drip tight at 195 degrees F. Valves shall be sized in accordance with Unfired Vessel Code.
5. Valves for Unfired Pressure Vessels: Safety and safety relief valves on secondary side of unfired pressure tanks, water heaters and heat exchangers shall comply with Code, requirements governing applicable equipment as outlined, in ASME Code, Section IV, Article 4, Paragraph HG 400.3 and as follows: Secondary side of heat exchanger shall be protected by officially rated valves, set for same pressure or temperature as heretofore specified, when secondary side furnishes steam or hot water for purpose equivalent to purposes for which a boiler would be installed; valves for this purpose shall be sized in accordance with Unfired Vessel Code.
6. End Connections: Unless otherwise specified, safety valves, relief valves and safety relief valves, in sizes 3/4 inch to 3 inches IPS inclusive, may be furnished with male or female pipe thread inlet and female pipe thread outlet; valves over 3 inches IPS must be furnished with 125 lb. or 250 lb. flanged inlet and may be equipped with female threaded or 125 lb. flanged outlet.

2.10 NEEDLE STOP VALVES

A. For Temperatures to 300 degrees F.: All brass or forged carbon steel construction, union bonnet, threaded ends, built for 1000 psi at 300 degrees F. Acceptable Manufacturers: Marsh Instrument Co., H.O. Trerice Co., Weksler Instruments Co.

2.11 GAGE COCKS

A. Gage Cocks: All brass construction, "T" or lever handles, threaded ends, built for 300 psig hydraulic pressure. Acceptable Manufacturers: Marsh Instrument Company, Mueller Instruments Co., H.O. Trerice Co. and Weksler Instruments Corp.

2.12 GROOVED END VALVES

A. Valves shall be of type, material and pressure rating, as required by the particular application, as approved.

2.13 VACUUM RELIEF VALVES

A. For Use With Water: Watts Regulator Co. No. N36.

2.14 BALL VALVES

A. Type BV: 150 psig WSP, 600 psig WOG, 2 piece bronze body, solid blow-out proof stem, teflon seats, chrome plated brass ball, teflon seals, corrosion resistant steel lever handles with vinyl grips, balancing stop, and threaded or solder ends. Acceptable Manufacturers: Conbraco, Hammond, Milwaukee, Nibco, and Watts.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install valves at locations noted on the drawings or specified.

3.02 VALVE APPLICATION SCHEDULE

A. Schedule of valve applications for the different services is as follows:
   1. Boiler Feed Pump, Suction and Discharge (BFS & BFD). 125 psig and Less:
      a. 4 inch and Less: A gates, J globes or angles, and S checks.
      b. 5 inch and Up: C gates, K globes or angles, and W or Z checks.
   2. Chemical Feed (CMF) 125 psig and Less: A or D gates, J or O globes or angles, and S or U checks.
   3. Domestic Hot Water and Circulating (DHW & DHWC) 125 psig and Less:
      a. 3 inch and Less: A or D gates or BV balls, J or O globes or angles, and S or U checks.
      b. 4 inch and Up: C gates or BF butterflys, K globes or angles, and V checks.
   4. Fuel Oil, No. 2 (FOS, FOR & FPD) 125 psig and Less, 1 inch and Less: A gates, J globes or angles, and S checks, with flared or ferrule copper tubing adapters.
   5. Gas - Natural, Manufactured or Mixed Fuel (G) 125 psig and Less:
      a. 2 inch and Less: AB plug valves.
      b. 2-1/2 inch and Up: AA plug valves.
   6. Hot Water (HWS & HWR) 125 psig and Less:

a. 3 inch and Less: A or D gates or BV balls, J or O globes or angles, and S or U checks.
b. 4 inch and Up: C gates or BF butterflys, K globe or angles, and V checks.

7. Instrument Air (IA) 60 psig and Less, 1 inch and Less: A gates, and J globes or angles, with flared or ferrule copper tubing adapters.

END OF SECTION

SECTION 230529

PIPE HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Companion high density filler pieces for installation over the top 180 degree surface of pipe or tubing, at points of support where a combination clevis hanger, insulation shield and high density insulating saddle are installed.

1.02 SUBMITTALS

A. Shop Drawings:
1. Details of trapeze hangers and upper hanger attachments for piping 4 inches in diameter and over. Include the number and size of pipe lines to be supported on each type of trapeze hanger.
2. Details of pipe anchors.
3. Details and method of installing restraints, anchors, and supports for grooved end piping systems

B. Product Data: Catalog sheets, specifications and installation instructions for each item specified except fasteners.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with the applicable requirements of the ASME B31 Piping Codes.
2. Unless otherwise shown or specified, comply with the requirements of the Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS) Standards SP-58, and SP-69.

PART 2 PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

A. Combination clevis hanger, pipe insulation shield and vapor barrier jacketed high density insulating saddle with companion high density filler piece.
1. Insulating saddles and filler pieces shall be of the same thickness and materials as the adjoining pipe insulation. Saddles shall cover the lower 180 degrees of the pipe or tubing, and companion filler pieces shall cover the upper 180 degrees of the pipe or tubing. Physical sizes, gages, etc. of the components of insulated hangers shall be in accordance with the following schedule:

PIPE OR TUBING SIZE	SHIELD LENGTH	SHIELD GAGE	SADDLE LENGTH	VAPOR BARRIER JACKET LENGTH

(Inches)	(Inches)		(Inches)	(Inches)
Up to 2-1/2	4	16	6	10
3 to 6	4	14	6	10
8 to 14	10	12	12	16
16 and up	10	10	12	16

B. Pipe Insulation Shields: Fabricated of steel, with a minimum arc of 180 degrees, unless otherwise indicated. Shields for use with hangers and supports, with the exception of combination clevis type hangers, shall be in accordance with the following schedule:

PIPE OR TUBING SIZE (Inches)	SHIELD LENGTH (Inches)	SHIELD GAGE
Up to 2-1/2	8	18
3 to 8	10	16
10 to 14	12	12
16 and up	18	10

C. Pipe Covering Protection Saddles: 3/16 inch thick steel, of sufficient depth for the insulation thickness specified, notched so that saddle contact with the pipe is approximately 50 percent of the total axial cross section. Saddles for pipe 12 inches in size and larger shall have a center support.

D. Pipe Hangers: Height adjustable standard duty clevis type, with cross bolt and nut.
   1. Pipe spreaders or spacers shall be used on cross bolts of clevis hangers, when supporting piping 10 inches in size and larger.

E. Adjustable Floor Rests and Base Flanges: Steel.

F. Hanger Rods: Mild, low carbon steel, fully threaded or threaded at each end, with two nuts at each end for positioning rod and hanger, and locking each in place.

G. Riser Clamps: Malleable iron or steel.

H. Rollers: Cast Iron.

I. Restraints, Anchors, and Supports for Grooved End Piping Systems: As recommended by the grooved end fitting manufacturer, and as required for seismic restraints.

2.02 ANCHORS AND ATTACHMENTS

A. Sleeve Anchors (Group II, Type 3, Class 3): Molly's Div./USM Corp. Parasleeve Series, Ramset's Dynabolt Series, or Red Head/Phillips AN, HN, or FS Series.

B. Wedge Anchors (Zinc Plated, Group II, Type 4, Class 1): Hilti's Kwik Bolt Series, Molly's Div./USM Corp. Parabolt PB Series, Ramset's Trubolt T Series, or Red Head/Phillips WS Series.

C. Self-Drilling Anchors (Group III, Type 1): Ramset's RD Series, or Red Head/Phillips S Series.

D. Non-Drilling Anchors (Group VIII, Type 1): Ramset's Dynaset DS Series, Hilti's HDI Series, or Red Head/Phillips J Series.

E. Stud Anchors (Group VIII, Type 2): Red Head/Phillips JS Series.

F. Beam Clamps: Forged steel beam clamp, with weldless eye nut (right hand thread), steel tie rod, nuts, and washers, Grinnell's Fig No. 292 (size for load, beam flange width, and rod size required).

G. Metal Deck Ceiling Bolts: B-Line Systems' Fig. B3019.

H. Continuous Slotted Type Concrete Insert, Galvanized:
1. Load Rating 800 lbs/ft: Kindorf's D-986.
2. Load Rating 1500 lbs/ft: Kindorf's D-980.
3. Load Rating 3000 lbs/ft: Hohmann & Barnard's Inc. Type CS-H.
4. Load Rating 4500 lbs/ft: Hohmann & Barnard's Inc. Type CS-HD.

I. Threaded Type Concrete Insert: Galvanized ferrous castings, internally threaded to receive 3/4 inch diameter machine bolts.

J. Wedge Type Concrete Insert: Galvanized box-type ferrous castings, designed to accept 3/4 inch diameter bolts having special wedge shaped heads.

2.03 VIBRATION ISOLATION FOR PIPING

A. Type: Combination rubber and spring type designed for insertion in a split hanger rod for isolating piping from the overhead construction.
1. Approved isolators: Amber Booth Type BSSR, Korfund Type VX, Mason Industries, Type DNHS, Vibration Eliminator Co. Type SNRC and Vibration Mountings and Controls Type RSH.

B. To ensure that piping weight is properly distributed and not being supported by equipment flanges, the first three rubber and spring isolators on the inlet shall be of the "position indicating" type.
1. Approved Isolators: Amber Booth Type PBSS, Korfund Type VXLS, Mason Industries Type PDNHS, Vibration Eliminator Co. Type PR2H and Vibration Mountings and Controls Type RSHP.

2.04 FASTENERS

A. Bolts, Nuts, Washers, Lags, and Screws: Medium carbon steel; size and type to suit application; galvanized for high humidity locations, and treated wood; plain finish for other interior locations. Except where shown otherwise on the Drawings, furnish type, size, and grade required for proper installation of the Work.

2.05 SHOP PAINTING AND PLATING

A. Hangers, supports, rods, inserts and accessories used for pipe supports, unless chromium plated, cadmium plated or galvanized shall be shop coated with metal primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper pipe or copper tubing.

B. Hanger supports for chromium plated pipe shall be chromium plated brass.

PART 3 EXECUTION

3.01 PREPARATORY WORK

A. Place inserts into construction form work expeditiously, so as not to delay the Work.

3.02 INSTALLATION

A. Do not hang or support one pipe from another or from ductwork.
1. Do not bend threaded rod.

B. Support all insulated horizontal piping conveying refrigerants or other fluids below ambient temperature, by means of hangers or supports with insulation shields installed outside of the insulation.

C. Space hangers or supports for horizontal piping on maximum center distances as listed in the following hanger schedules, except as otherwise specified, or noted on the Drawings.
1. For Steel, Alloy Steel, Threaded Brass Pipe and Fibrous Glass Reinforced Plastic Pipe (FRP):

PIPE SIZE (Inches)	MAXIMUM SPACING (Feet)
1 and under	8
1-1/4 and 1-1/2	9
2	10
2-1/2 and up	12

2. For Grooved End Steel Pipe:

PIPE SIZE (Inches)	MAXIMUM SPACING (Feet)
1-1/2 and under	7
2 through 4	10
5 and over	12

No pipe length shall be left unsupported between any two coupling joints.

3. For Copper Pipe and Copper Tubing:

PIPE OR TUBING SIZE (Inches)	MAXIMUM SPACING (Feet)
1-1/2 and under	6
2 and over	10

4. For Directional Changes: Install a hanger or support close to the point of change of direction of all pipe runs in either a horizontal or vertical plane.
5. For Concentrated Loads: Install additional hangers or supports, spaced as required and directed, at locations where concentrated loads such as in-line pumps, valves, fittings or accessories occur, to support the concentrated loads.
6. For Branch Piping Runs and Runouts Over 5 feet In Length: Install a minimum of one hanger, and additional hangers if required by the hanger spacing schedules.
7. Parallel Piping Runs: Where several pipe lines run parallel in the same plane and in close proximity to each other, trapeze hangers may be submitted for approval. Base hanger spacing for trapeze type hangers on the smallest size of pipe being supported. Design the entire hanger assembly based on a safety factor of five, for the ultimate strength of the material being used.

D. Size hanger rods in accordance with the following:

PIPE OR TUBING SIZE (Inches)	SINGLE ROD HANGER SIZE (Inches)		DOUBLE ROD HANGER SIZE (Inches)	
	PIPE	TUBING	PIPE	TUBING
1/2 to 2	3/8	1/4	3/8	1/4
2-1/2 and 3	1/2	3/8	3/8	1/4
4 and 5	5/8	1/2	1/2	3/8
6	3/4	1/2	5/8	1/2
8, 10 and 12	7/8	5/8	3/4	5/8

1. Size hanger rods, for piping over 12 inches in size and multiple line supports, based on a safety factor of five for the ultimate strength of the materials being used.
2. Secure hanger rods as follows: Install one nut under clevis, angle or steel member; one nut on top of clevis, angle or steel member; one nut inside insert or on top of upper hanger attachment and one nut and washer against insert or on lower side of upper hanger attachment. A total of four nuts are required for each rod, two at upper hanger attachment and two at hanger.

E. Vertical Piping:
1. Support vertical risers of piping systems, by means of heavy duty hangers installed close to base of pipe risers, and by riser clamps with extension arms at intermediate floors, with the distance between clamps

not to exceed 25 feet, unless otherwise specified. Support pipe risers in vertical shafts equivalent to the aforementioned. Install riser clamps above floor slabs, with the extension arms resting on floor slabs. Provide adequate clearances for risers that are subject to appreciable expansion and contraction, caused by operating temperature ranges.

2. Support extension arms of riser clamps, secured to risers to be insulated for cold service, 4 inches above floor slabs, to allow room for insulating and vapor sealing around riser clamps.
3. Install intermediate supports between riser clamps on maximum 6 foot centers, for copper tubing risers 1-1/4" in size and smaller, installed in finished rooms or spaces other than mechanical equipment machine or steam service rooms, or penthouse mechanical equipment rooms.

F. Floor Supports: Install adjustable yoke rests with base flanges, for the support of piping, unless otherwise indicated on the Drawings. Install supports in a manner, which will not be detrimental to the building structure.

3.03 UPPER HANGER ATTACHMENTS

A. General:
1. Secure upper hanger attachments to overhead structural steel, steel bar joists, or other suitable structural members.
2. Do not attach hangers to steel decks that are not to receive concrete fill.
3. Do not attach hangers to precast concrete plank decks less than 2-3/4 inches thick.
4. Do not use flat bars or bent rods as upper hanger attachments.

B. Attachment to Steel Frame Construction: Provide intermediate structural steel members where required by pipe support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of five.
1. Do not use drive-on beam clamps.
2. Do not support piping over 4 inches in size from steel bar joists. Secure upper hanger attachments to steel bar joists at panel points of joists.
3. Do not drill holes in main structural steel members.
4. Beam clamps. with tie rods as specified, may be used as upper hanger attachments for the support of piping, subject to clamp manufacturer's recommended limits.

C. Attachment to Concrete Filled Steel Decks:
1. New Construction: Install metal deck ceiling bolts.
2. Existing Construction: Install welding studs (except at roof decks). Do not support a load in excess of 250 lbs from any single welded stud.
3. Do not attach hangers to decks less than 2-1/2 inches thick.

D. Attachment to Cast-In-Place Concrete: Secure to overhead construction by means of cast-in-place concrete inserts.

E. Attachment to Existing Cast-In-Place Concrete:
1. For piping up to a maximum of 4 inches in size, secure hangers to overhead construction with self-drilling type expansion shields and machine bolts.

2. Secure hangers to wall or floor construction with single unit expansion shields or self-drilling type expansion shields and machine bolts.

F. Attachment to Cored Precast Concrete Decks (Flexicore, Dox Plank, Spancrete, etc.): Toggle bolts may be installed in cells for the support of piping up to a maximum of 2-1/2 inches in size.

G. Attachment to Hollow Block or Hollow Tile Filled Concrete Decks:
1. New Construction: Omit block or tile and pour solid concrete with cast-in-place inserts.
2. Existing Construction: Break out block or tile to access, and install machine bolt anchors at highest practical point on side of web.

H. Attachment to Waffle Type Concrete Decks:
1. New Construction: Install cast-in-place inserts.
2. Existing Construction: Install machine bolt expansion anchors at highest practical point on side of web.

I. Attachment to Precast Concrete Tee Construction:
1. New Construction: Tee hanger inserts between adjacent flanges, except at roof deck without concrete fill.
2. Existing Construction: Dual unit expansion shields in webs of tees. Install shields as high as possible in the webs.
   a. Exercise extreme care in the field drilling of holes to avoid damage to reinforcing.
   b. Do not use powder driven fasteners.

3.04 ANCHORS, RESTRAINTS, RIGID SUPPORTS, STAYS AND SWAY BRACES

A. Install pipe anchors, restraints and sway braces, at locations noted on the Drawings. Design anchors so as to permit piping to expand and contract freely in opposite directions, away from anchor points. Install anchors independent of all hangers and supports, and in a manner that will not affect the structural integrity of the building.

B. In grooved end piping systems, install restraints, and rigid supports as recommended by the manufacturer of the grooved end fittings to ensure proper support and alignment of the piping under operating and testing pressures (maximum hanger or support spacing shall be as previously specified).
1. Horizontal piping shall maintain a constant pitch without sags, humps, or lateral deflections.
2. Branch piping shall remain perpendicular to main piping and/or risers.
3. Vertical piping shall remain plumb without deflections.
4. Vertical piping shall be rigidly supported, or anchored at both top and bottom, and wherever necessary to prevent movement and/or shearing forces at branch connections.

3.05 PIPING IN TUNNELS

A. Support piping in tunnels on adjustable stanchions, fabricated in accordance with the details on the Drawings, unless otherwise indicated. Install, secure and be

responsible for the proper locations of all cast-in-place inserts and stanchion supports, in ample time so as not to delay construction Work. Secure tops of stanchions to overhead construction, as required and approved.

3.06 COMBINATION CLEVIS HANGER, PIPE INSULATION SHIELD AND VAPOR BARRIER JACKETED HIGH DENSITY INSULATING SADDLES

A. Install a combination clevis hanger, pipe insulation shield and vapor barrier jacketed high density insulating saddles, at all points of support for piping or tubing to be insulated for cold service. Furnish companion high density vapor barrier jacketed saddle pieces, of the same material, thickness and length, for installation over the top 180 degree surface of pipe or tubing, at each point of support where an insulated clevis hanger is utilized.

3.07 PIPE INSULATION SHIELDS

A. Unless otherwise specified, install a pipe insulation shield, at all points of support. Center shields on all hangers and supports outside of high density insulation insert, and install in such a manner so as not to cut, or puncture jacket.

3.08 PIPE COVERING PROTECTION SADDLES

A. Install pipe covering protection saddles at all points of support, for steel piping 6 inches in size and larger, insulated with hot service insulation. Weld saddles to piping to insure movement with pipe.

3.09 FIBROUS GLASS REINFORCED PLASTIC PIPE (FRP) SUPPORTS

A. Provide inserts between supports and FRP as detailed.

3.10 VIBRATION ISOLATION FOR PIPING

A. Install vibration isolation in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Piping: The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:
   1. Piping Connected to Vibration Isolated HVAC Equipment: For a distance of 50 feet or 50 pipe diameters, whichever is greater.
   2. Condenser Water: For the full length of the piping.
   3. Chilled and Hot Temperature Piping: For risers from pumps and for the first 20 feet of the branch connection of the main supply and return piping at each floor.
   4. Water Distribution Piping Application: Resiliently support piping with combination rubber and spring isolation hangers.
      a. Provide spring elements with 5/8-inch static deflection; install the hanger with spacing so that the first harmonic natural frequency is not less than 360 Hz. Provide double-deflection neoprene elements.

b. For the first two isolation hangers from the rotating equipment of 3-1/2 inch and smaller piping systems, ensure a deflection equal to the equipment-isolation static deflection.
c. For the first four piping isolation hanger supports from rotating equipment of 4-inch and larger piping systems, use resilient hanger-rod isolators at a fixed elevation regardless of load changes.
d. Incorporate an adjustable preloading device to transfer the load to the spring element within the hanger mounting after the piping system has been filled with water.

C. Horizontal Piping Runs Within Mechanical Equipment, Steam Service, Machine and Penthouse Mechanical Equipment Rooms: Provide combination rubber and spring type isolators, designed for insertion of a split hanger rod, for the following :
1. Chilled water supply and return;
2. Condenser water supply and return;
3. Heating hot water supply and return;
4. Primary and secondary supply and return water;
5. Steam and condensate piping.

END OF SECTION

SECTION 230553

PIPE AND VALVE IDENTIFICATION

PART 1 GENERAL

1.01 REFERENCES

A. ANSI A13.1 - Scheme for Identification of Piping Systems.

1.02 SUBMITTALS

A. Product Data: Catalog sheets, specifications and installation instructions for each item specified.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. W.H. Brady Co., Milwaukee, WI.

B. Emed Co., Buffalo, NY.

C. Panduit Corp., Tinley Park, IL.

D. Seton Nameplate Corp., New Haven, CT.

2.02 PIPE MARKERS AND ACCESSORIES

A. Snap-on Marker: One piece wrap around type constructed of precoiled acrylic plastic with clear polyester coating, integral flow arrows, legend printed in alternating directions, 3/4 inch adhesive strip on inside edge, and 360 degree visibility.

B. Strap-On Marker: Strip type constructed of precoiled acrylic plastic with clear polyester coating, integral flow arrows, legend printed in alternating directions, factory applied grommets, and pair of stainless steel spring fasteners.

C. Stick-On Marker: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating, and integral flow arrows for applications where flow arrow banding tape is not being used.

D. Pipe Marker Legend and Color Field Sizes:

OUTSIDE DIAMETER OF PIPE OR INSULATION (Inches)	LETTER SIZE (Inches)	LENGTH OF COLOR FIELD (Inches)

OUTSIDE DIAMETER OF PIPE OR INSULATION (Inches)	LETTER SIZE (Inches)	LENGTH OF COLOR FIELD (Inches)
3/4 to 1-1/4	1/2	8
1-1/2 to 2	3/4	8
2-1/2 to 6	1-1/4	12
8 to 10	2-1/2	24
Over 10	3-1/2	32

E. Banding Tapes: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating.
   1. Plain Tape: Unprinted type; color to match pipe marker background.
   2. Flow Arrow Tape: Printed type with integral flow arrows; color to match pipe marker background.

F. Pipe Size Labels: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating, vertical reading pipe size in inches, and legend size matching adjacent pipe marker.

2.03 PIPE SERVICE IDENTIFICATION TAGS

A. Type: No. 19 B & S gage brass, with 1/4 inch high pipe service abbreviated legend on one line, over 1/2 inch high pipe size legend in inches, both deep stamped and black filled; and 3/16 inch top hole for fastener.

B. Size: 2 inch square tag.

C. Fasteners: Brass "S" hook or brass jack chain of size as required for pipe to which tag is attached.

2.04 VALVE SERVICE IDENTIFICATION TAGS

A. Type: No. 19 B & S gage brass, with 1/4 inch high valve service abbreviated lettering on one line over 1/2 inch high valve service chart number, both deep stamped and black filled; and with 3/16 inch top hole for fastener.

B. Sizes:
   1. HVAC Use: 1-1/2 inch dia round.

C. Fasteners: Brass "S" hook or brass jack chain of size as required for valve stem or handle to which tag is attached.

2.05 VALVE SERVICE IDENTIFICATION CHART FRAMES

A. Type: Satin finished extruded aluminum frame with rigid clear plastic glazing, size to fit 8-1/2 x 11 inches valve chart.

PART 3 EXECUTION

3.01 PREPARATION

A. Complete testing, insulation and finish painting work prior to completing the Work of this Section.

B. Clean pipe surfaces with cleaning solvents prior to installing piping identification.

C. Remove dust from insulation surfaces with clean cloths prior to installing piping identification.

3.02 INSTALLATION

A. Install the Work of this Section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Stick-On Pipe Markers:
1. Install minimum of 2 markers at each specified location, 90 degrees apart on visible side of pipe.
2. Encircle ends of pipe markers around pipe or insulation with banding tape with one inch lap. Use plain banding tape on markers with integral flow arrows, and flow arrow banding tape on markers without integral flow arrows.

C. Pipe Size Labels: Install labels adjacent to each pipe marker and upstream from flow arrow. Install a minimum of 2 pipe size labels at each specified location, 90 degrees apart on visible side of pipe.

D. Pipe Service Identification Tags: Attach tags to piping being identified with "S" hooks or jack chains.

3.03 PIPING IDENTIFICATION SCHEDULE

A. Piping Identification Types:
1. Piping or Insulation under 3/4 inch od: Pipe identification tags.
2. Piping or Insulation 3/4 inch to 5-7/8 inch od: Snap-on marker or stick-on marker.
3. Piping or Insulation 6 inch od and Larger: Strap-on marker or stick-on marker.

B. Identify exposed piping, bare or insulated, as to content, size of pipe and direction of flow, with the following exceptions:
1. Piping in non-walk-in tunnels or underground conduits between manholes.
2. Piping in furred spaces or suspended ceilings, except at valve access panels where valves and piping shall be identified as specified for exposed piping systems.
3. Piping in finished spaces such as offices, class rooms, wards, toilet rooms, shower rooms and spaces as specified.

C. Locate piping identification to be visible from exposed points of observation.
   1. Locate piping identification at valve locations; at points where piping enters and leaves a partition, wall, floor or ceiling, and at intervals of 20 feet on straight runs.
   2. Where 2 or more pipes run in parallel, place printed legend and other markers in same relative location.

3.04 VALVE IDENTIFICATION SCHEDULE

A. Valve Service Identification Tags:
   1. Tag control valves, except valves at equipment, with a brass tag fastened to the valve handle or stem, marked to indicate service and numbered in sequence for the following applications:
      a. Domestic water valves controlling mains, risers and branch runouts.
      b. Gas valves controlling mains, risers, and branch runouts.
      c. Valves in heating, ventilating, air conditioning and refrigeration systems.

B. Valve Service Identification Charts:
   1. Provide 2 framed valve charts for each piping system specified to be provided with valve identification tags. Type charts on 8-1/2 x 11 inches heavy white bond paper, indicating valve number, service and location.
   2. Hang framed charts at locations as directed.

END OF SECTION

SECTION 230554

DUCT AND EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 DELIVERY, STORAGE AND HANDLING

A. Deliver paint to the Site in original, new unopened containers, bearing manufacturers' printed labels.

B. Store materials at the site where directed. Keep storage space clean and accessible to the Owner at all times.

PART 2 PRODUCTS

2.01 MATERIALS

A. Paint Type: Interior Acrylic Latex, Semigloss Enamel.
   a. Solids by Weight: 49.0 percent.
   b. Solids by Volume: 35.0 percent.
   c. Solvent: Water.
   d. Vehicle: Vinyl acrylic resin.
   e. Weight per Gallon: 10.0 lbs.
   f. Wet Film Thickness: 3.8 mils.
   g. Dry Film Thickness: 1.2 mils.
   h. Manufacturers: Benjamin Moore, ICI Dulux, Sherwin-Williams.

PART 3 EXECUTION

3.01 PREPARATION

A. Protection: Cover and protect surfaces to be painted, adjacent surfaces not to be painted, and removed furnishings and equipment from existing paint removals, airborne sanding particles, cleaning fluids and paint spills using suitable drop cloths, barriers and other protective devices.
   1. Schedule and coordinate surface preparations so as not to interfere with work of other trades or allow airborne sanding dust particle to fall on freshly painted surfaces. Do not perform the Work of this Section until testing, insulation and finish painting Work have been completed.
   2. Provide adequate natural or mechanical ventilation to allow surfaces to be prepared and painted in accordance with product manufacturer's instructions and applicable regulations.
   3. Provide and maintain "Wet Paint" signs, temporary barriers and other protective devices necessary to protect prepared and freshly painted surfaces from damages until Work has been accepted.

B. Clean and prepare surfaces to be painted in accordance with specifications, paint manufacturer's approved product data sheets and printed label instructions. In the event of conflicting instructions or directions, the more stringent requirements shall apply.
   1. Cleaners: Use only approved products manufactured or recommended by finish paint manufacturer. Unless otherwise recommended by cleaner manufacturer, thoroughly rinse with clean water to remove surface contaminants and cleaner residue.

3.02 DUCT IDENTIFICATION

A. Identify exposed ductwork, bare or insulated, directly connected to air handling apparatus, in the following spaces or rooms, by means of painted stenciled legends:
   1. Mechanical Equipment.
   2. Boiler.

B. Locate stenciled legends to be readily visible from any point of observation. Stencil identification along center line of duct, close to equipment. Where view is unobstructed from two directions, apply two sets of stenciling (both sides), visible from each direction.

C. Letter Size: 1-1/2 inches in height.

D. Samples of Ductwork Identification:
   1. Fresh Air Supply.
   2. Air Cond. Supply Air.
   3. Air Cond. Return Air.
   4. Recirc. Cond. Air.
   5. Exhaust Air.

E. Colors: Paint stenciled letters black. Where the background color is dark. paint background white before stenciling.

3.03 EQUIPMENT IDENTIFICATION

A. Identify mechanical equipment, bare or insulated, installed in the following spaces or rooms, by means of painted stenciled legends:
   1. Mechanical Equipment.
   2. Boiler.

B. Paint stenciled legends black, a minimum of 1-1/2 inches in height, located to be readily visible from a reasonable point of view. Place identification along center line of equipment, if possible.

C. Samples of Equipment Identification:
   1. Air Cond. Unit AC 1.
   2. Supply Fan S 1.
   3. Exhaust Fan E 1.
   4. Return Fan R 1.

3.04 APPLICATION OF PAINT

A. Stencil Painting: Apply with a brush or aerosol type spray can.

3.05 CLEANING

A. Clean adjacent surfaces of paint spatters resulting from the Work of this Section.

END OF SECTION

SECTION 230593

CLEANING AND TESTING

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Balancing of Systems: Section 230594.

1.02 SUBMITTALS

A. Quality Control Submittals
   1. Test Reports (Field Tests):
      a. Submit data for each system tested, and/or disinfected; include date performed, description, and test results for each system.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Perform factory testing of factory fabricated equipment in complete accordance with the agencies having jurisdiction.
   2. Perform field testing of piping systems in complete accordance with the local utilities and other agencies having jurisdiction and as specified.

1.04 PROJECT CONDITIONS

A. Protection: During test Work, protect controls, gages and accessories which are not designed to withstand test pressures. Do not utilize permanently installed gages for field testing of systems.

1.05 SEQUENCING AND SCHEDULING

A. Transmit written notification of proposed date and time of operational tests to the Owner at least 5 days in advance of such tests.

B. Perform cleaning and testing Work in the presence of the Owner.

C. Pressure test piping systems inside buildings, at the roughing-in stage of installation, before piping is enclosed by construction Work, and at other times as directed. Perform test operations in sections as required and directed, to progress the Work in a satisfactory manner and not delay the general construction of the building. Valve or cap-off sections of piping to be tested, utilizing valves required to be installed in the permanent piping systems, or temporary valves or caps as required to perform the Work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Test Equipment and Instruments: Type and kind as required for the particular system under test.

B. Test Media (air, gas, refrigerant, dry nitrogen, vacuum, water): As specified for the particular piping or system under test.

C. Cleaning Agent (chemical solution, steam, water): As specified for the particular piping, apparatus or system being cleaned.

PART 3 EXECUTION

3.01 PRELIMINARY WORK

A. Thoroughly clean pipe and tubing prior to installation. During installation, prevent foreign matter from entering systems. Prevent if possible and remove stoppages or obstructions from piping and systems.

B. Thoroughly clean compressed air, control air, refrigerant pipe and similar systems prior to pressure or vacuum testing.

1. Refrigerant Piping:
   a. Only use factory sealed refrigerant piping.
   b. Crimp and braze caps on ends of previously cleaned piping at end of the day if piping was cut.
   c. When brazing, purge lines with dry nitrogen.

3.02 PRESSURE TESTING OF PIPING

A. Piping shall be tight under test and shall not show loss in pressure or visible leaks. during test operations or after the minimum duration of time as specified. Remove piping which is not tight under test; remake joints and repeat test until no leaks occur.

B. General:

1. Pressure test piping systems inside buildings, at the roughing-in stage of installation, before piping is enclosed by construction Work. and at other times as directed.
2. Perform test operations in sections as required and directed, to progress the Work in a satisfactory manner and not delay the general construction of the building.
3. Valve or cap-off sections of piping to be tested, utilizing valves required to be installed in the permanent piping systems, or temporary valves or caps as required to perform the Work.
4. Isolate existing piping from pressure testing.
5. Pressure test only new piping unless otherwise specified or directed by Owner.

C. Water Systems:

1. Domestic water (potable cold, domestic hot and recirculation) inside buildings:
   a. Before fixtures, faucets, trim and accessories are connected, perform hydrostatic test at 125 psig minimum for 4 hours.

b. After fixtures, faucets, trim and accessories are connected, perform hydrostatic retest at 75 psig for 4 hours.

2. Circulating water systems, including propylene glycol solution systems and cold water make-up piping connections to heating, ventilating, air conditioning and refrigeration systems, unless otherwise specified:
   a. Before final connections are made perform hydrostatic test at 1-1/2 times the maximum working pressure, but not less than 125 psig, for 4 hours.
   b. After final connections are made perform hydrostatic retest at a pressure equal to maximum operating system design pressure, but not less than 30 psig, for 4 hours.
3. High temperature water systems (supply and return):
   a. Before final connections are made perform hydrostatic test at 450 psig for 4 hours.
   b. After final connections are made perform hydrostatic retest at a pressure equal to maximum operating design pressure, but not less than 250 psig for 4 hours.

D. Gas Piping: Before backfilling or concealment perform air test of duration and pressure as required by the local gas company. However, for gas piping designed for pressures of from 4 inches to 6 inches water column, air test at 15 inches Hg for one hour, without drop in pressure. Test gas piping with air only. Check joints for leaks with soap suds.

E. Air Piping:
   1. Control Air: Test with air at 50 psig for one hour.
   2. Check joints for leaks with soap suds.

F. Fuel Oil Piping (Suction and Return): Perform air test at 150 psig for one hour, followed by a vacuum test of 25 inches Hg for one hour, during which time the mercury shall remain stationary for the last 30 minutes of test.

3.04 TESTING OF EQUIPMENT, APPARATUS AND APPURTENANCES

A. Hot Water Boilers: Perform hydrostatic test at 30 psig, after installation, with piping connections shut-off.

B. Relief Valves: Increase pressure in equipment or apparatus to relief valve setting, to test opening of valves at required relief pressures.

3.05 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS - CLEANING AND OPERATIONAL TESTING

A. Circulating Heating Hot Water Water Systems in Buildings:
   1. Cleaning:
      a. Flush systems and apparatus, upon completion of pressure test(s).
      b. Completely open valves and flush each system with clean water, prior to chemical cleaning.
      c. Repeatedly flush at short intervals until twice the system water capacity has been flushed through.

d. Chemically clean systems immediately following flushing operations.
e. Circulate a solution consisting of trisodium phosphate, in a proportion of one pound of chemical to every 50 gallons of water in the system.
f. Completely fill system with cleaning solution; vent as required, and place in operation, with automatic controls operating and valves fully open.
g. Allow system to reach design operating temperature or an operating temperature designated by the Owner.
h. Circulate the solution through the system for a minimum of 4 consecutive hours; immediately drain system and flush with clean water until the pH at the farthest drain matches the clean water input.
i. Provide temporary pipe and /or hose required to drain system.
j. Keep strainers unplugged during cleaning operations. Remove and clean strainer screens prior to operational test.
k. Refill system with clean water and correct pH to 7.
l. Do not flush steam piping thru steam coils. Provide temporary steam supply and condensate piping to bypass steam coils.
m. Upon completion of flushing, remove temporary piping and reconnect steam coil.

2. Operational Test:
   a. Run system in an automatic mode for a minimum of 120 consecutive hours.
   b. During this time, make final adjustments, including the setting of the balancing valves.

B. Propylene Glycol Systems:
   1. Clean as specified for circulating water systems.
   2. Perform operational test as specified for circulating water systems with propylene glycol solution in system.

3.06 DISINFECTION OF POTABLE WATER SYSTEMS

A. Disinfect potable water pipe and equipment installed in the Work of this Contract.
   1. Completely fill the piping, including water storage equipment if installed, with a water solution containing 50 mg/L available chlorine, and allow stand for 24 hours.
   2. Operate all valves during this period to assure their proper disinfection.
   3. After the retention period, discharge the solution to an approved waste and flush the system thoroughly with water until substantially all traces of chlorine are removed.
   4. Drain and flush water storage equipment if installed.

B. Connect plumbing fixtures and equipment and place the system into service. Prevent recontamination of the piping during this phase of the Work.

3.07 REFRIGERATION SYSTEMS - TESTING, DEHYDRATION AND CHARGING

A. Leak Test Procedure:
   1. Refrigerant Piping Systems:
      a. Pressurize with dry nitrogen to 50 psig and test for leaks using a bubble type solution.
      b. Release this partial test pressure and correct deficiencies.
      c. Charge system with a trace of refrigerant to 15 psig, then add dry nitrogen until system test pressures are reached and retest for leaks with an electronic leak detector.
      d. Release pressure, repair leaks and retest as necessary until no leaks occur.
      e. Recover refrigerant used for leak testing.
   2. System Test Pressures:
      a. Charge system with dry nitrogen and trace of refrigerant (HFC 134A, HFC 245, HFC 404, HFC 407C, HFC 410A or HFC 507) to 350 psig and retest for leaks with an electronic leak detector. The system must stay at 350 psig pressure for 24 hours to pass the system test pressure test.
      b. Release pressure, repair leaks and retest as necessary until no leaks occur.
      c. Recover refrigerant used for leak testing.

B. Dehydration:
   1. Low and Ultra Low Temperature Refrigeration Systems (-30 degrees F to 32 degrees F:
      a. Following pressure tests, dehydrate each system with a vacuum pump.
      b. Draw and hold an initial vacuum of 800 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig. and change oil in vacuum pump.
      c. Draw and hold a second vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig. and change oil in vacuum pump.
      d. Draw and hold a third vacuum of 250 microns for 8 to 12 hours with an allowable maximum rise of 50 microns. Break this third vacuum by adding liquid refrigerant specified for the equipment to the high side of the system (liquid line).
      e. Verify vacuum obtained with an electronic vacuum gage.
   2. Medium Temperature Refrigeration Systems (33 degrees F to 55degrees F), and Air Conditioning Systems:
      a. Following pressure tests, dehydrate each system with a vacuum pump.
      b. Draw and hold an initial vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      c. Draw and hold a second vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      d. Verify vacuum obtained with an electronic vacuum gage.

C. Refrigerant Charging: Follow equipment manufacturer's printed charging directions unless otherwise specified.
   1. Introduce refrigerant of type and quantity required through a filter/drier installed in the temporary charging line.
      a. Purge small amount of liquid out of the system side of the charging hose.
      b. Prevent moisture and other contaminants from entering the system.
   2. Charge liquid refrigerant through a charging valve provided in the high pressure side of the system.
      a. Small amounts of gaseous refrigerant may be charged through the compressor suction service valve port.
   3. No bubbles shall appear at the moisture-liquid indicator when the system is fully charged and operational. Do not overcharge.
   4. Record the weight in pounds of refrigerant charged into each system and submit this record to the Director's Representative.

D. Compressor Oil Charge: Pump oil into the compressor after the last vacuum has been preformed. Follow all Manufactures Recommended for oil type and amount to be installed.

E. Adjustments and Operational Testing:
   1. Adjustments: Place the system in operation with automatic controls functioning. Adjust controls and apparatus for proper operation. Test thermometers and gages for accuracy over the entire range. Remove and replace items found defective.
      a. Check belts, fan blades, fittings, TXV bulbs, and electrical connections for tightness before start up.
      b. Check TXV bulb for proper location should be between 8 and 10 o'clock or 2 & 4 o'clock.
      c. Seal off all holes in the condition space as specified.
      d. Provide a point to point control check of the system to ensure that the specified inputs and outputs are receiving the signal from the proper sensors or controlling the proper device.
      e. Set pressure controls and safety controls.
      f. Close or de-energize all solenoids, and start up the system.
      g. Check that all controls and safety switches are operating properly.
      h. Adjust TXV for proper super heat back to the compressors.
      i. Clean TXV strainers as many times as required.
      j. After one week of run time, change the liquid cores if they are the replaceable type.
      k. After one month of run time, replace the liquid cores and compressor suction socks. Replace the liquid cores as required. Clean the TXV's as required.
   2. Operational Test:
      a. Place system in operation, with final connections to equipment and with automatic controls operating, and operate for a minimum of 120 consecutive hours.

b. Operational test shall prove to the satisfaction of the Director's Representative that the system can produce the cooling effect required by the drawings and the specifications.

END OF SECTION

SECTION 230594

BALANCING OF SYSTEMS

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Systems Cleaning, Pressure and Operational Testing: Section 230593.

1.02 SUBMITTALS

A. Quality Control Submittals:
   1. Testing, Adjustment and Balancing Reports:
      a. Submit final testing and balancing results on applicable report forms, as approved or furnished by the environmental systems balancing council or bureau, which is certifying the independent member agency performing the Work, required by this Section. Each final systems report form shall bear the signature of the person performing the Work and recording the data and the signature of the certified supervisor for the performing agency. Submit simultaneously with the final reports, a list of the instruments used with the last date of calibration for each instrument.

1.03 QUALITY ASSURANCE

A. Qualifications:
   1. Provide the services of a certified independent agency for the testing. adjustment and balancing of all air distribution and hydronic distribution systems complete with all connected apparatus and equipment. The agency shall be certified by the Associated Air Balance Council Bureau - AABC. Los Angeles. Cal. 90026 or by National Environmental Balancing Bureau - NEBB. Arlington. Va. 22209.
   2. The Work shall be performed by skilled mechanical technicians under the direct supervision of certified personnel in the employ of the independent agency. The supervisor shall be personally certified by the national council or bureau, as approved by the Owner.

1.04 SEQUENCING AND SCHEDULING

A. Scheduling:
   1. Perform environmental systems testing and balancing after cleaning, miscellaneous testing, adjustment and operational testing Work has been completed.
   2. Test and balance system during a period of time when outside temperature conditions will impose a significant load on the system; i.e., summer months for air conditioning system, winter months for heating system. Balance and adjust systems accordingly.

3. Send written notification to the Owner a minimum of five days prior to the performance of testing and balancing Work. Perform testing and balancing Work in the presence of the Owner.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. General Information: Test instruments are included in this specification for information only. Balancing of air and hydronic systems shall be performed by qualified personnel utilizing company owned test instruments, which will remain the property of the company. Use test instruments which are in first class operating condition, with individual calibration histories to guarantee their accuracy. Test instruments shall be of type and kind as required by the type of system installed. Trade names and manufacturer's names are mentioned in this section for descriptive purposes only; instruments of equivalent range and capabilities may be utilized.

B. Air Balancing Instruments:
1. Manometers: Inclined with ranges of 0 to 1/4 inch and 0 to 1 inch; Combination inclined and vertical with a range of 0 to 5 inches and U tube type, 18 inches.
2. Portable "Magnehelic" Draft Gages: Ranges 0 to 1/2 inch, 0 to 1 inch and 0 to 5 inches.
3. Anemometers: Deflecting vane type with a range of 100 to 3000 fpm, similar to Alnor Velometer Model 6000 BP and 4 inches diameter rotating vane type.
4. Pitot Tubes: ASHRAE standard type, stainless steel, 5/16 inch diameter, lengths as required.
5. Sling Psychrometer.
6. Smoke Candles and Smoke Generator.

C. Hydronic Balancing Instruments:
1. Calibrated Test Gages: Ranges 0 to 30 lbs.. 0 to 60 lbs.. 0 to 200 lbs.
2. Calibrated Test Gages (Compound Type): Ranges from -30 inches to 30 lbs. and -30 inches to 60 lbs.
3. U Tube Manometer: 36 inches.

D. Air and Hydronic Systems Balancing Instruments:
1. Thermometers: 12 inches mercury column type and dial type, with a range of -40 to +120 degrees F. and 0 to 220 degrees F. Total of four thermometers.
2. Universal Hand Tachometer: Herman H. Sticht Type UH.
3. Stop Watch.
4. Stroboscope.
5. Contact Pyrometer: Thermocouple type.
6. Volt-Ohm-Ammeter Test Kit, High Current Type: Sperry "Ohmprobe".
7. Volt-Ammeter: With leads for connecting to lugs.

PART 3 EXECUTION

3.01 PRELIMINARY WORK

A. Circulating Water Systems: Prior to balancing the system, bleed all air vents so as to completely flood the system; check pumps for proper rotation; clean strainers and set balancing and system stop valves in the full-open position.

B. Ventilating and Air Conditioning Systems: Prior to balancing the system, check fans for proper rotation; check filters for cleanliness and proper installation and set dampers in the normal operating position.

3.02 BALANCING OF CIRCULATING WATER SYSTEMS

A. Equipment Schedules and Report Sheets: Prepare itemized equipment schedules, listing all heating or cooling elements and equipment in the system to be balanced. List in order on equipment schedules, by pump or zone according to the design, all heating or cooling elements and all zone balancing valves or balancing devices. Break down schedules into zones to circuits, starting from the zone or circuit pump and terminating with the last item of equipment or transfer element in the respective zone or circuit. Include on schedule sheets, column titles listing the location, type of element or apparatus, design conditions and water balance readings. Prepare individual pump report sheets for each individual system or zone pump.

B. Balancing:
   1. Place system in full automatic operation, with automatic controls set in accordance with design conditions, and allow water to reach design temperature.
   2. Test pumps and balance flow. Record the following on pump report sheets:
      a. Suction and discharge pressure.
      b. Running amps and brake horsepower of pump motor under full flow and no flow conditions.
      c. Pressure drop across pump in feet of water and total gpm pump is handling under full flow conditions.
   3. Set zone or circuit balancing valve at each pump, to handle the design GPM.
   4. When the design incorporates the use of air handling units containing coils, check and adjust each unit to insure the proper volume of air is passing through the coils, while the balancing procedure is in progress.
   5. Check pumps for flow, after the system has been balanced.
   6. Record test readings, calculations and results.

3.04 FIELD QUALITY CONTROL

A. Inspection: Prior to the environmental testing and balancing of hydronic and air distribution systems, the certified supervisor in the employ of the testing and balancing agency shall inspect the installations and notify the Owner of any Work which must be performed or modified prior to initiating testing and balancing procedures.

B. Performance: Test and balance environmental hydronic and air distribution systems, including all connected equipment and apparatus, so as to conform to the design conditions. Perform the Work of this section in accordance with the published standards of the balancing council or bureau, which is certifying the member firm. Record all test readings, calculations and results.

END OF SECTION

SECTION 230719

INSULATION

PART 1 GENERAL

1.01 ABBREVIATIONS

A. FS: Federal Specification.

B. K: Thermal Conductivity, i.e., maximum Btu per inch thickness per hour per square foot.

C. pcf: Pounds per cubic foot.

D. PVC: Polyvinylchloride.

1.02 SUBMITTALS

A. Product Data:
1. Manufacturer's catalog sheets, specifications and installation instructions for insulation materials and jacket materials.
2. Materials Schedule: Itemize insulation materials and thicknesses for each specified application in Insulation Material Schedules in Part 3 of this Section. Where optional materials are specified, indicate option selected.

B. Quality Control Submittals:
1. Installers Qualification Data:
a. Name of each person who will be performing the Work, and their employer's name, business address and telephone number.
b. Furnish names and addresses of the required number of similar projects that each person has worked on which meet the qualifications.

1.03 QUALITY ASSURANCE

A. Qualifications: The persons installing the Work of this Section and their Supervisor shall be personally experienced in mechanical insulation work and shall have been regularly employed by a company installing mechanical insulation for a minimum of 5 years.

B. Regulatory Requirements:
1. Insulation installed inside buildings, including duct lining materials, laminated jackets, mastics, sealants and adhesives shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.

PART 2 PRODUCTS

2.01 INSULATION

A. Fibrous Glass (Mineral Fiber) Insulation: Composed principally of fibers manufactured from rock, slag, or glass, with or without binders, and asbestos free.

1. Preformed Pipe Insulation: Minimum density 3 pcf; ASTM C 547:
   a. Class 1 (Suitable for Temperatures Up to 450 degrees F): K of 0.26 at 75 degrees F.
   b. Class 2 (Suitable for Temperatures 451 to 650 degrees F): K of 0.46 at 300 degrees F.
   c. Class 3 (Suitable for Temperatures 651 to 1200 degrees F): K of 0.56 at 300 degrees F.
2. Premolded Fitting Insulation: Minimum density 4.0 pcf, K of 0.26 at 75 degrees F; ASTM C 547, Class 1.
3. Insulation Inserts for PVC Fitting Jackets: Minimum density 1.5 pcf, K of 0.28 at 75 degrees F; ASTM C 553, Type III.
   a. Suitable for temperatures up to 450 degrees F.
4. Block or Board Insulation: Minimum density 3.0 pcf and 6.0 pcf as specified; ASTM C 612:
   a. Type IA or IB (Suitable for Temperatures Up to 450 degrees F): K of 0.26 at 75 degrees F.
   b. Type II (Suitable for Temperatures 451 to 850 degrees F): K of 0.44 at 300 degrees F.
   c. Type III (Suitable for Temperatures 851 to 1000 degrees F): K of 0.44 at 300 degrees F.
   d. Type IV (Suitable for Temperatures 1001 to 1200 degrees F): K of 0.37 at 300 degrees F.
   e. Type V (Suitable for Temperatures 1201 to 1800 degrees F): K of 0.42 at 300 degrees F.
5. Thermal and Acoustic Board Insulation: Minimum density 3.0 pcf, K of 0.27 at 75 degrees F; ASTM C 1071, Type II.
   a. Air Stream Side: Erosion, temperature, and fire resistant type; NFPA 90-A and 90-B.
6. Blanket Insulation:
   a. For Ductwork (Suitable for Temperatures Up to 450 Degrees F): Minimum density 1.0 pcf, K of 0.31 at 75 degrees F; ASTM C 553, Type II.
   b. For Breeching (Suitable for Temperatures up to 1200 degrees F): Minimum density 8 pcf, K of 0.55 at 400 degrees F, metal mesh faced one side; ASTM C 553, Type VII.

B. Flexible Elastomeric Foam Insulation:

1. FM tested and approved, meeting the following:
   a. Maximum Water Vapor Transmission: 0.10 perm - inch based on ASTM E 96, Procedure A.
   b. K of 0.27 at 75 degrees F based on ASTM C 518 or C 177.
   c. Fire Spread/Smoke Developed Rating: 25/50 or less based on ASTM E 84.
2. Pipe Insulation: ASTM C 534, Type I.
3. Sheet Insulation for Ductwork and Equipment: ASTM C 534, Type II, smooth skin one side.

4. Polyethylene and polyolefin insulation is not acceptable.

C. High Density Jacketed Insulation Inserts for Hangers and Supports:
1. For Use with Fibrous Glass Insulation:
a. Cold Service Piping:
1) Polyurethane Foam: Minimum density 4 pcf, K of 0.13 at 75 degrees F, minimum compressive strength of 125 psi.
b. Hot Service Piping:
1) Calcium Silicate: Minimum density 15 pcf, K of 0.50 at 300 degrees F; ASTM C 533.
2) Perlite: Minimum density 12 pcf, K of 0.60 at 300 degrees F; ASTM C 610.
c. Ductwork: Fibrous glass board, minimum density 6 pcf, K of 0.26 at 75 degrees F, conforming to ASTM C 612, Type IA or IB.
2. For Use with Flexible Elastomeric Foam Insulation:
a. Ductwork and Piping: Hardwood dowels and blocks, length or thickness equal to insulation thickness, other dimensions as specified or required.

D. Cements:
1. Fibrous Glass Thermal Insulating Cement: Asbestos free; ASTM C 195.
2. Fibrous Glass Hydraulic Setting Thermal Insulating and Finishing Cement: ASTM C 449/C 449M.

2.02 JACKETS

A. Laminated Vapor Barrier Jackets for Piping and Ductwork: Factory applied by insulation manufacturer, conforming to ASTM C 1136, Types I and II.
1. Type I: Reinforced white kraft and aluminum foil laminate with kraft facing out.
a. Pipe Jackets: Furnished with integral 1-1/2 inch self sealing longitudinal lap, and separate 3 inch wide adhesive backed butt strips.
2. Type II: Reinforced aluminum foil and kraft laminate with foil facing out.
3. Laminated vapor barrier jackets are not required for flexible elastomeric foam insulation.

B. Canvas Jackets: Cotton duck, fire retardant, complying with NFPA 701, 4 oz or 6 oz per sq yd as specified.

C. Premolded PVC Fitting Jackets:
1. Constructed of high impact, UV resistant PVC.
a. ASTM D 1784, Class 14253-C.
b. Working Temperature: 0-150 degrees F.

D. Metal Jacketing:
1. Aluminum: ASTM B 209, Alloys 1100, 30003, 3105 or 5005, Temper H14, 0.016 inch thick.

a. Factory Pre-formed Sectional Pipe Jacketing:
   1) Smooth outer finish with integral bonded laminated polyethylene film - kraft paper moisture barrier underside.
   2) Pittsburg or modified Pittsburg longitudinal lock seams.
   3) 2 inch overlapping circumferential joints with integral locking clips, or butt joints sealed with 2 inch wide mastic backed aluminum snap bands.

b. Roll Jacketing: Smooth outer finish with integral bonded laminated polyethylene film - kraft paper moisture barrier underside.

c. Sheet Jacketing: Corrugated 1-1/4 inch x 1/4 inch deep with integral bonded laminated polyethylene film - kraft paper moisture barrier underside.

d. Fastening Devices:
   1) Strapping: Type 18-8 stainless steel, 0.020 inch thick, 1/2 and 3/4 inch wide as specified.
   2) Wing Seals: Type 18-8 stainless steel, 0.032 inch thick.
   3) Sheet Metal Screws: Panhead, Type A, hardened aluminum, and stainless steel.

2. Circumferentially Corrugated Aluminum Jacketing: Childer's Corrolon.
   a. Construction: 3/16 inch circumferentially corrugated embossed aluminum, ASTM B 209, Types 1100, 3003, 3105, or 505, H-14 temper, 0.016 inch thick.
   b. Moisture Barrier: Integrally bonded to jacket over entire surface in contact with insulation.
   c. Fastening Devices:
      1) Strapping: 0.020 inch thick by 1/2 inch wide. Type 3003, 3105, 5005, H-14 temper.
      2) Wing Seals: 0.032 inch thick Type 5005. H-14 temper aluminum.

2.03 ADHESIVES, MASTICS, AND SEALERS

A. Lagging Adhesive (Canvas Jackets): Childers' CP-50AMV1. Epolux's Cadalag 336. Foster's 30-36.

B. Vapor Lap Seal Adhesive (Fibrous Glass Insulation): Childers' CP-82, Epolux's Cadoprene 400, Foster's 85-60 or 85-20.

C. Vapor Barrier Mastic (Fibrous Glass Insulation): Permeance shall be .03 perms or less at 45 mils dry per ASTM E 96. Childers' CP-34, Epolux's Cadalar 670, Foster's 30-65 .

D. Adhesive (Flexible Elastomeric Foam): Armstrong's 520, Childers' CP-82, Epolux's Cadoprene 488, Foster's 85-75. 5 gallon cans only.

E. Adhesive (Fiberglass duct liner): Childers' Chil Quik CP-127. Foster Vapor Fas 85-60. Must comply with ASTM C 916, Type II

F. Weather Barrier Breather Mastic (Reinforcing Membrane): Childers' VI-CRYL CP-10/11, Foster's Weatherite 46-50.

G. Sealant (Metal Pipe Jacket): Non hardening elastomeric sealants. Foster Elastolar 95-44, Childers Chil Byl CP-76, Pittsburgh Corning 727.

H. Reinforcing Membrane: Childers' Chil Glas #10, Foster Mast a Fab, Pittsburgh Corning PC 79

2.04 MISCELLANEOUS MATERIALS

A. Insulation Fasteners for Ductwork and Equipment:
1. Acceptable Manufacturers: Duro-Dyne Corp.; Erico Fastening Systems, Inc.
2. Type: Weld pins, complete with self-locking insulation retaining washers.

B. Pressure Sensitive Tape for Sealing Laminated Jackets:
1. Acceptable Manufacturers: Alpha Associates, Ideal Tape, Morgan Adhesive.
2. Type: Same construction as jacket.

C. Wire, Bands, and Wire Mesh:
1. Binding and Lacing Wire: Nickel copper alloy or copper clad steel, gage as specified.
2. Bands: Galvanized steel, 1/2 inch wide x 0.015 inch thick, with 0.032 inch thick galvanized wing seals.
3. Wire Mesh: Woven 20 gage steel wire with 1 inch hexagonal openings, galvanized after weaving.

D. Metal Corner Angles: Galvanized steel, 2 x 2 inch 28 gage.

E. Reinforcing Membrane: Glass or Polyester. 10 x 10 mesh. Alpha Associates Style 59. Childer's Chil-Glas. Foster's MAST-A-FAB.

PART 3 EXECUTION

3.01 PREPARATION

A. Perform the following before starting insulation Work:
1. Install hangers, supports and appurtenances in their permanent locations.
2. Complete testing of piping, ductwork, and equipment.
3. Clean and dry surfaces to be insulated.

3.02 INSTALLATION, GENERAL

A. Install the Work of this Section in accordance with the manufacturer's printed installation instructions unless otherwise specified.

B. Piping Insulation: Provide continuous insulation and jacketing when passing thru interior wall, floor, and ceiling construction.
   1. At Through Penetration Firestops: Coordinate insulation densities with the requirements of approved firestop system being installed. See Section 078400.
      a. Insulation densities required by approved firestop system may vary with the densities specified in this Section. When this occurs use the higher density insulation.

C. Do not intermix different insulation materials on individual runs of piping.

3.03 INSTALLATION AT HANGERS AND SUPPORTS

A. Reset and realign hangers and supports if they are displaced while installing insulation.

B. Install high density jacketed insulation inserts at hangers and supports for insulated ductwork, piping, and equipment.

C. Insulation Inserts For Use with Fibrous Glass Insulation:
   1. Ductwork: Install 6 pcf density jacketed fibrous glass board, same thickness as adjoining insulation, sized for full bearing on supporting trapeze member, and as required to enable abutting to adjoining insulation and overlapping of jacketing.
   2. Piping: Where clevis hangers are used, install insulation shields and high density jacketed insulation inserts between shield and pipe.
      a. Where insulation is subject to compression at points over 180 degrees apart, e.g. riser clamps, U-bolts, trapezes, etc.; fully encircle pipe with 2 protection shields and 2 high density jacketed fibrous glass insulation inserts within supporting members.
         1) Exception: Locations where pipe covering protection saddles are specified for hot service piping, 6 inch and larger.

D. Insulation Inserts For Use with Flexible Elastomeric Foam Insulation:
   1. Ductwork: Install hardwood block, same thickness as adjoining insulation, sized for full bearing on supporting trapeze member and as required to abutt and seal vapor tight with adjoining insulation.
   2. Piping:
      a. Where clevis hangers are used, install insulation shields with hardwood filler pieces, same thickness as adjoining insulation, inserted in undersized die cut or slotted holes in insulation at support points.
      b. Contour hardwood blocks to match the curvature of pipe, and shield.
      c. Coat dowels and blocks with insulation adhesive, and insert while still wet.
      d. Vapor seal outer surfaces of dowels and blocks with adhesive after insertion.
      e. Install filler pieces as follows:

PIPE/TUBING SIZE	FILLER PIECES	POSITION
Thru 1-1/2"	2 dowel plugs	6 o'clock; in tandem
2" thru 4"	1 block 2 dowel plugs	6 o'clock, and 4 & 8 o'clock respectively
6" thru 8"	2 blocks 4 dowel plugs	6 o'clock; in tandem and 4 & 8 o'clock; in tandem

3.04 INSTALLATION OF FIBROUS GLASS COLD SERVICE INSULATION

A. Install insulation materials with a field or factory applied ASTM C 1136 Type I laminated vapor barrier jacket, unless otherwise specified.

B. Piping:
1. Butt insulation joints together, continuously seal minimum 1-1/2 inch wide self sealing longitudinal jacket laps and 3 inch wide butt adhesive backed strips.
   a. Substitution: 3 inch wide pressure sensitive sealing tape, of same material as jacket, may be used in lieu of butt strips.
2. Bed insulation in a 2 inch wide band of vapor barrier mastic, and vapor seal exposed ends of insulation with vapor barrier mastic at each butt joint between pipe insulation and equipment, fittings or flanges at the following intervals:
   a. Horizontal Pipe Runs: 21 ft.
   b. Vertical Pipe Runs: 9 ft.

C. Fittings, Valves, Flanges and Irregular Surfaces:
1. Insulate with mitre cut or premolded fitting insulation of same material and thickness as pipe insulation.
2. Secure insulation in place with 16 gage wire, with ends twisted and turned down into insulation.
3. Butt insulation against pipe insulation and bond with joint sealer.
4. Insulate valves up to and including bonnets, without interfering with packing nuts.
5. Apply leveling coat of insulating cement to smooth out insulation and cover wiring.
6. When insulating cement has dried, seal fitting, valve and flange insulation, by imbedding a layer of reinforcing membrane or 4 oz. canvas jacket between 2 flood coats of vapor barrier mastic, each 1/8 inch thick wet.
7. Lap reinforcing membrane or canvas on itself and adjoining pipe insulation at least 2 inches.
8. Trowel, brush or rubber glove outside coat over entire insulated surface.
9. Exceptions:
   a. In Mechanical Equipment Rooms, Steam Service Rooms, Machine Rooms, Boiler Rooms, Penthouses, Finished Rooms and Finished Spaces: Cover fittings, valves and flanges insulated with fibrous glass with an additional 6 oz canvas

jacket, lapped on adjoining insulation and pasted with lagging adhesive.

b. Type C and D Piping Systems: Valves, fittings and flanges may be insulated with premolded PVC fitting jackets, with fibrous glass insulation inserts.

1) Additional insulation inserts are required for services with operating temperatures under 45 degrees F or where insulation thickness exceeds 1-1/2 inches. The surface temperature of PVC fitting jacket must not go below 45 degrees F.

3.05 INSTALLATION OF FIBROUS GLASS HOT SERVICE INSULATION

A. Install insulation materials with field or factory applied ASTM C 1136 Type I laminated vapor barrier jacket unless otherwise specified.

B. Canvas Jackets on Piping, Fittings, Valves, Flanges, Unions, and Irregular Surfaces:
1. For Piping 2 inch Size and Smaller: 4 oz per sq yd unless otherwise specified.
2. For Piping Over 2 inch Size: 6 oz per sq yd unless otherwise specified.

C. Piping:
1. Butt insulation joints together, continuously seal minimum 1-1/2 inch wide self sealing longitudinal jacket laps and 3 inch wide adhesive backed butt strips.
   a. Substitution: 3 inch wide pressure sensitive sealing tape, of same material as the jacket, may be used in lieu of butt strips.
2. Fill voids in insulation at hanger with insulating cement.
3. Exceptions:
   a. Piping in Accessible Shafts, Attic Spaces, Crawl Spaces, Unfinished Spaces and Concealed Piping: Butt insulation joints together and secure minimum 1-1/2 inch wide longitudinal jacket laps and 3 inch wide butt strips of same material as jacket, with outward clinching staples on maximum 4 inch centers. Fill voids in insulation at hangers with insulating cement.
   b. Piping in Tunnels: Butt insulation joints together and secure minimum 1-1/2 inch wide longitudinal jacket laps and 3 inch wide butt strips, of same material as jacket, with outward clinching staples on maximum 4 inch centers and 16 gage wires a minimum of 4 loops per section. Fill voids in insulation with insulating cement.

D. Fittings, Valves, Flanges and Irregular Surfaces:
1. Insulate with mitre cut or premolded fitting insulation of same material and thickness as insulation.
2. Secure in place with 16 gage wire, with ends twisted and turned down into insulation.
3. Butt fitting, valve and flange insulation against pipe insulation, and fill voids with insulating cement.

4. Insulate valves up to and including bonnets, without interfering with packing nuts.
5. Apply leveling coat of insulating cement to smooth out insulation and cover wiring.
6. After insulating cement has dried, coat insulated surface with lagging adhesive, and apply 4 oz or 6 oz canvas jacket as required by pipe size.
   a. Lap canvas jacket on itself and adjoining pipe insulation at least 2 inches.
   b. Size entire canvas jacket with lagging adhesive.
7. Exceptions:
   a. In Types E, F and G Service Piping Systems: Valves, fittings and flanges may be insulated with premolded PVC fitting jackets, with fibrous glass insulation inserts.
      1) Additional insulation inserts are required for services with operating temperatures over 250 degrees F or where insulation thickness exceeds 1-1/2 inches. The surface temperature of PVC fitting jacket must not exceed 150 degrees F.
   b. In Types E, F, and G Service Piping Systems: Insulate fittings, valves, and irregular surfaces 3 inch size and smaller with insulating cement covered with 4 oz or 6 oz canvas jacket as required by pipe size.
      1) Terminate pipe insulation adjacent to flanges and unions with insulating cement trowelled down to pipe on a bevel.
   c. In Type H Service Piping System: Insulate fittings, valves, flanges, unions, and irregular surfaces 3 inch size and smaller with insulating cement covered with 4 oz or 6 oz canvas jacket as required by pipe size.
   d. Fittings, Valves, Flanges, and Irregular Surfaces In Concealed Piping, Piping in Accessible Shafts, Attic Spaces, Crawl Spaces, Unfinished Rooms, Unfinished Spaces, and Tunnels: Sizing of canvas surface is not required.

E. Equipment:
1. Secure fibrous glass block or board insulation in place with wire or galvanized steel bands.
   a. Small Areas: Secure insulation with 16 gage wire on maximum 6 inch centers.
   b. Large Areas: Secure insulation with 14 gage wire or .015 inch thick by 1/2 inch wide galvanized steel bands on maximum 10 inch centers. Stagger insulation joints.
   c. Irregular Surfaces: Where application of block or board insulation is not practical, insulate with insulating cement built-up to same thickness as adjoining insulation.
2. Fill joints, voids and irregular surfaces with insulating cement, to a uniform thickness.
3. Stretch wire mesh over entire insulated surface and secure to anchors, with wire edges laced together.
4. Apply finishing cement, total of 1/2 inch thick, in 1/4 inch thick coats.
   a. Trowel second coat to a smooth hard finish.

5. Neatly bevel insulation around manholes, handholes, cleanouts, ASME stamp, boiler manufacturer's name and catalog number.

3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC FOAM INSULATION

A. Where possible, slip insulation over the pipe, and seal butt joints with adhesive.
   1. Where the slip-on technique is not possible, slit the insulation and install.
   2. Re-seal with adhesive, making sure the mating surfaces are completely joined.

B. Insulate fittings and valves with miter cut sections. Use templates provided by the manufacturer, and assemble the cut sections in accordance with the manufacturer's printed instructions.
   1. Insulate threaded fittings and valves with sleeved fitting covers. Over lap and seal the covers to the adjoining pipe insulation with adhesive.

C. Carefully mate and seal with adhesive all contact surfaces to maintain the integrity of the vapor barrier of the system.

D. Insulated Covers for Pumps:
   1. Do not extend pump insulation beyond or interfere with stuffing boxes, or interfere with adjustment and servicing of parts requiring regular maintenance or operating attention.

E. Piping Exposed Exterior to a Building, Totally Exposed to the Elements:
   1. Apply flexible elastomeric foam insulation to piping with adhesive.
   2. Apply reinforcing membrane around piping insulation with adhesive or mastic.
   3. Adhesive Applied System: Apply 2 coats of finish. See Section 099103.
   4. Mastic Applied System: Apply another coat of mastic over reinforcing membrane.

3.07 INSTALLATION OF SHEET METAL JACKETING ON PIPING

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

B. Jacket exposed insulated fittings, valves and flanges with mitred sections of aluminum jacketing.
   1. Seal joints with sealant and secure with preformed aluminum bands.
   2. Substitution: Factory fabricated, preformed, sectional aluminum fitting covers or premolded polyvinylchloride fitting covers may be used in lieu of mitred sections of aluminum jacketing for covering fittings, valves and flanges.

3.08 INSTALLATION OF SMOKE BREECHING AND SMOKE FLUE PIPE INSULATION

A. Secure insulation in place with wire or galvanized steel bands unless otherwise specified.

1. Small Areas: Secure insulation with 16 gage wire on maximum 6 inch centers.
2. Large Areas: Secure insulation with 14 gage wire or 0.015 inch thick by 1/2 inch wide galvanized steel bands on maximum 10 inch centers.

B. Stagger insulation joints.

C. On irregular surfaces, where application of block or board insulation is not practical, insulate with insulating cement built-up to same thickness as adjoining insulation.

D. Fill joints, voids and irregular surfaces with insulating cement, to a uniform thickness.

E. Install aluminum roll jacketing on insulated surfaces of round smoke breeching, and smoke flue pipe.

F. Install aluminum sheet jacketing on insulated surfaces of rectangular breeching.

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

H. Secure jacketing in place with 1/2 inch by 0.020 inch thick stainless steel bands and stainless steel wing type seals, on maximum 12 inch centers.

I. Terminate exposed ends of insulation with insulating cement trowelled down to metal surface on a bevel.

J. Insulate exterior surfaces of smoke breeching, induced draft fans and gas uptake ducts from medium and high pressure steam boilers and high temperature water boilers to the breeching, and any portion of the gas outlet outside the boiler brickwork, as shown on the drawings.

K. Insulate vertical steel smoke stacks as shown in detail on the drawings.

3.09 INSTALLATION OF DUCTWORK INSULATION

A. Fibrous Glass Board Insulation Application:
1. Secure insulation to ductwork, with duct insulation fasteners spaced 3 inch in from all corners of ducts, with intermediate fasteners on maximum 16 inch centers in all directions.
2. Butt edges of insulation and fill voids with similar insulation.
3. Seal minimum 1-1/2 inch wide longitudinal jacket laps continuously with vapor seal adhesive.
4. Lap circumferential joints with 4 inch wide jacket material and seal laps continuously with vapor barrier lap adhesive, or seal continuously with minimum 3 inch wide pressure sensitive sealing tape, of same material as jacket.
5. Install metal corner angles over the jacketed insulated corners. Seal exposed ends of insulation with vapor barrier mastic.

6. Vapor seal breaks in vapor barrier jacketing, exposed surfaces of duct insulation fasteners and metal corner angles, with pressure sensitive sealing tape of same material as jacket or coat with vapor barrier mastic.
7. Field apply 6 oz canvas jacket over the vapor barrier jacketed insulation where indicated on Ductwork Service Insulation Material Schedule in Part 3 of this Section.
   a. Apply canvas jacket with lagging adhesive, with a 2 inch lap on circumferential and longitudinal seams.
   b. Outward clinching staples may be utilized for additional securement of canvas to bottom of ducts in excess of 48 inch in width.
   c. Apply heavy coat of lagging adhesive to entire canvas surface.
8. Place trapeze hangers, fabricated of steel rods and structural steel channels or angles, outside of jacketed insulated ducts.
   a. Install high density insulation inserts, of thickness equal to insulation, minimum of 4 inch in width by the bottom dimension of the duct, at points of support.
   b. Continuously jacket insulated ducts and filler pieces through supports.

B. Fibrous Glass Blanket Insulation Application:
1. Cut insulation to stretch-out dimensions as recommended by insulation manufacturer.
2. Remove 2 inch wide strip of insulation material from the jacketing on the longitudinal and circumferential joint edges to form an overlapping staple/tape flap.
3. Install insulation with jacketing outside so staple/tape flap overlaps insulation and jacketing on other end.
4. Butt ends of insulation tightly together.
   a. Rectangular and Square Ductwork: Do not compress insulation at duct corners.
5. Staple longitudinal and circumferential joints with outward clinching staples minimum 6 inches on center. and seal with pressure sensitive sealing tape.
6. Cut off pretruding ends of fasteners flush with insulation surface and seal with pressure sensitive sealing tape.
7. Install duct insulation fasteners on bottom side of horizontal duct runs, when bottom dimension of the duct is in excess of 24 inches in width.
8. Install duct insulation fasteners on sides of duct risers having a dimension over 24 inches in size.
9. Seal tears, punctures, and penetrations of insulation jacketing with sealing tape and coat with vapor barrier mastic.
10. Secure insulation to ductwork with fasteners spaced in accordance with the following schedule:

DUCT DIMENSION	SPACING OF FASTENERS (MINIMUM)
Up to 24 inches	None required.
24 inches to 48 inches	Horizontal Runs: 2 rows - 16 inches on center. Risers: 16 inches on center, all directions.
49 inches to 60 inches	Horizontal Runs: 3 rows - 16 inches on center.

DUCT DIMENSION	SPACING OF FASTENERS (MINIMUM)
	Risers: 16 inches on center, all directions.
61 inches and over	Horizontal Runs: 16 inches on center, all directions. Risers: 16 inches on center, all directions.

C. Bench Insulated Ductwork:
   1. Insulate ducts prior to erection in place when ducts are required to be installed proximate to walls, ceilings, equipment or other ductwork, which will not permit adequate space for installation of insulation after ducts are installed.

D. Flexible Elastomeric Foam Insulation on Ductwork Exposed to the Elements, Exterior to a Building:
   1. Apply 2 inch thick flexible elastomeric foam sheet insulation to ductwork with adhesive.
      a. Insulate sheet metal duct seams, angle bracing, and reinforcing with same insulation thickness specified for ductwork.
   2. Apply reinforcing membrane around ductwork insulation with adhesive or mastic.
   3. Adhesive Applied System: Apply 2 coats of finish. See Section 099103.
   4. Mastic Applied System: Apply another coat of mastic over reinforcing membrane.

3.10 FIELD QUALITY CONTROL

A. Field Samples: The Owner, may at his discretion, take field samples of installed insulation for the purpose of checking materials and application. Reinsulate sample cut areas.

3.11 PIPING AND EQUIPMENT INSULATION SCHEDULE

A. Insulate all cold service and hot service piping, equipment, and appurtenances except where otherwise specified.

B. Schedule of Items Not to be Insulated:
   1. Do not insulate the following cold service items:
      a. Actual heat transfer surfaces.
      b. Cold water piping buried in direct contact with ground.
      c. Chromium plated piping, unless otherwise specified.
      d. Flexible vibration eliminators.
      e. Refrigerant liquid piping, unless sub-cooled below 70 degrees F.
      f. Boiler water treatment equipment and piping.
      g. Water meters.
      h. Chemical feed piping.
      i. Boiler header drains.
   2. Do not insulate the following hot service piping:
      a. Plated or white metal piping.
      b. Exposed risers (hot water, low pressure steam and condensate return) in finished rooms.

c. Piping inside convector and finned tube radiation enclosures.
d. Short vertical and horizontal piping connections (less than 24 inches in length):
   1) Located exposed above floors in finished rooms or finished spaces.
   2) Serving one fixture, or one piece of equipment.
   3) Connected to horizontal mains, branch mains or riser mains.
   4) Conveying liquids or vapors at temperatures from 75 degrees F to 215 degrees F, unless otherwise specified.
e. Drains from heating equipment and appurtenances that flow to waste.
f. Fuel oil fill, fuel oil vent and other unheated fuel oil piping.
g. Gas piping.
h. Water and other fluids 81 degrees F to 104 degrees F.
i. Branch blow-down piping connections, from continuous blow-down piping to boiler sample water coolers.
j. Boiler blow-off and blow-down piping.
k. Discharge piping from relief valves.
l. Vent piping to atmosphere from installed exposed in Mechanical Equipment Rooms, Steam Service Rooms, Machine Rooms, Boiler Rooms, Penthouses and Power Plants, and connected to the following:
   1) Blow-off tanks.
   2) Flash tanks.
   3) Condensate tanks.

3. Do not insulate the following hot service fittings, valves, flanges and irregular surfaces:
   a. Flanges and unions in Type E. F and G service piping systems.
   b. Hydronic Specialties:
      1) Flow indicators.
      2) Zone control valves.
      3) Air vents.
      4) Air control fittings.
   c. Steam traps and cooling legs of steam traps.
   d. Pressure reducing valves and pilot lines.
   e. Safety and relief valves.
   f. Back pressure valves.
   g. Float chambers and level controllers.
   h. Boiler water columns.
4. Do not insulate the following hot service equipment:
   a. Actual heat transfer surfaces.
   b. Hot water pumps.
   c. Fuel oil pumps.
   d. Chemical feed pumps.
   e. Equipment manholes, handholes, and cleanouts.
   f. ASME stamps, nameplates with manufacturer's name and model number.
5. Do not insulate mechanical equipment with a factory applied insulated steel jacket.

3.12 COLD SERVICE INSULATION MATERIAL SCHEDULE

TYPE	SERVICE AND TEMPERATURES	INSULATION MATERIAL	PIPE SIZES (INCHES)	MINIMUM (NOMINAL) INSULATION THICKNESS (INCHES)
A & B	Refrigerants, Brine, and Fluids below 40 F.	Flex. Elastomeric Foam	1& less 1-1/4 and Up	1 1-1/2
C	Chilled Water and other fluids (except domestic cold water) 40 F to 80 F.	Flex. Elastomeric Foam or Fibrous Glass	1-1/2 & less Over 1-1/2	1 1-1/2
D	Domestic cold water, and as specified. 33 F to 80 F.	Flex. Elastomeric Foam or Fibrous Glass	All Sizes	1/2

A. **NOTES:**

1. Double the insulation thickness above for piping, installed in tunnels and conduits.
2. Equipment Insulation: Insula-tion thicknesses above also apply for flat, curved and irregular equipment surfaces.
   a. Insulate equipment with fibrous glass board insulation with minimum density 6 pcf.
   b. Insulate base mounted and unitary type pumps and other equipment specified, installed in potable water, ice water, chilled water and dual temperature water systems, with 3/4 inch thick sheet flexible elastomeric foam.
   c. Exceptions: Minimum insulation thickness for Type A service shall be a minimum of 1 inch thick for flat, curved and equipment irregular surfaces.
3. Type D Insulation Materials: In addition to the services shown on the schedule above, use Type D materials and thicknesses for the following:
   a. Condensate Drain Piping:
      1) Piping connected to drain pans under cooling coils within unit enclosure, except where over drain pans.
      2) Horizontal condensate drain piping outside unit enclosures.
      3) Vertical condensate drain piping of less than one story immediately following horizontal run.

3.13 HOT SERVICE INSULATION MATERIAL SCHEDULE

	SERVICE AND TEMPERATURES	INSULATION MATERIAL	PIPE SIZES (INCHES)	MINIMUM (NOMINAL) INSULATION THICKNESS (INCHES)

E	Water and other fluids 105 F to140 F.	Flex. Elastomeric Foam or Fibrous Glass	1-1/2 & Less Over 1-1/2	1 2
F	Water and other fluids 141 F to 250 F.	Fibrous Glass	6 & Less 8 & Up	2 2-1/2

A. **NOTES:**

1. Insulate piping in tunnels and conduits with insulation of thickness as follows:
   a. Types E, F, and G Service: Minimum 2 inch thick unless greater thickness is specified in Hot Service Insulation material Schedule above.
   b. Type H Service: Minimum 4 inch thickness.
2. Equipment Insulation:
   a. Insulate the following with fibrous glass block or board insulation:
      1) Heating hot water boilers.
      2) Instantaneous type domestic hot water heaters.
      3) Combination domestic hot water heater and storage tanks.
      4) Domestic hot water storage tanks.
   b. Insulate equipment with fibrous glass board insulation with minimum density 6 pcf.
   c. Minimum thickness for flat, curved and irregular equipment surfaces:
      1) 1-1/2 inch for E and F service.
      2) 3 inch for G service.
      3) 5 inch for H service.

3.14 SCHEDULE OF METAL JACKETING FOR INSULATED PIPE

A. Piping Exterior to Building: Jacket insulated piping with circumferentially corrugated aluminum jacketing.

1. Lap longitudinal and circumferential joints a minimum of 2 inches.
2. Secure jacketing in place with 1/2 inch x 0.020 inch thick aluminum bands secured with aluminum wing type seals, on maximum 12 inch centers.
3. Cover insulated fittings, valves, and offsets with mitered sections of jacketing. Seal joints with metal pipe jacket sealant, and secure with aluminum strapping and wing seals.
4. Factory fabricated, preformed fitting covers of same material as jacketing may be used instead of mitered jacketing.
5. Install jacketing so as to avoid trapping condensation and precipitation.

3.15 SMOKE BREECHING AND SMOKE FLUE PIPE INSULATION SCHEDULE

A. Do not insulate the following smoke breeching and smoke flue piping:
1. Factory fabricated insulated smoke flue pipe and smoke stacks.

B. Insulate the following with 2 inch thick ASTM C 612 Type V fibrous glass block or board insulation:
1. Exterior surfaces of smoke flue pipes 13 inch size and larger.
2. Smoke breeching connected to the following:
a. Low pressure heating hot water boilers.

3.16 DUCTWORK SERVICE INSULATION SCHEDULE

A. Insulate all ductwork service except where otherwise specified.

B. Do not insulate the following ductwork service items:
1. Exhaust ductwork, unless otherwise shown.
2. Return fans.
3. Exhaust fans.
4. Interior lined ductwork.
5. Flexible ductwork connections.
6. Interior lined air terminal units.
7. Sound absorbers.
8. Ductwork located within equipment.
9. Ductwork where design temperature difference between interior and exterior of duct or plenum does not exceed 15 degrees F.

3.17 DUCTWORK SERVICE INSULATION MATERIAL SCHEDULE

LOCATION	SERVICE	INSUL. MATERIAL	MINIMUM INSUL. THICKNESS	JACKET TYPE	MINIMUM REQUIRED R VALUE
Concealed, inside building insul. envelope in unconditioned spaces (in shafts, ceilings, walls, and floors)	Air Conditioning Supply and Returns Under 65 F. 100% Outside Air. Heating Supply Over 85 F.	Fibrous Glass Blanket	2	I or II	R-5
	Returns with Temp. Diff. With Ambient Greater than 15 degrees F	Fibrous Glass Board	1-1/2	I or II	
Exposed, inside building insul. envelope.	Air Conditioning Supply Under 65 F, 100% Outside Air, Heating Supply Over 85 F.	Fibrous Glass Board	1-1/2	I with Canvas Outer Jacket	R-5
Inside building but exposed to outside air temp., e.g., ventilated attic.	Air Conditioning Supply, Heating Supply, All Returns including returns mixed with outside air.	Fibrous Glass Blanket	2-1/2	I or II	R-8
		Fibrous Glass Board	2	I or II	
Exposed exterior to building.	Air Conditioning Supply, Heating Supply, All Returns including returns	Elastomeric Foam Sheet	2-1/2	None Required	R-8

LOCATION	SERVICE	INSUL. MATERIAL	MINIMUM INSUL. THICKNESS	JACKET TYPE	MINIMUM REQUIRED R VALUE
	mixed with outside air.				

A. **NOTES:**

1. Equipment: Insulate air handling equipment, not furnished with factory applied insulated jacket or internal insulation, with minimum 1-1/2 inch thick fibrous glass board with an ASTM C 1136 Type I jacket, installed and finished as specified for exposed ductwork in finished spaces.

END OF SECTION

SECTION 230924

MODIFICATIONS TO DIRECT DIGITAL BUILDING CONTROL SYSTEM

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Basic Electrical Materials and Methods for Direct Digital Building Control System: Section 260502.

1.02 DESCRIPTION OF EXISTING SYSTEM

A. The existing system is a Siemens BMS controlling the boilers only. All other building systems operate on pneumatic controls.

1.03 MODIFICATIONS TO EXISTING SYSTEM

A. Add new boiler and appurtenances.

1.04 SUBMITTALS

A. Preliminary Submittal: Existing system test report.

B. Submittals Package: Submit the shop drawings, product data, and quality control submittals specified below at the same time as a package.

C. Shop Drawings:
   1. Composite wiring and/or schematic diagrams of the modifications as proposed to be installed (standard diagrams will not be acceptable).

D. Product Data:
   1. Catalog sheets. specifications and installation instructions.
   2. Bill of materials.
   3. Detailed description of system operation.

E. Quality Control Submittals:
   1. Company Field Advisor Data: Include:
      a. Name, business address and telephone number of Company Field Advisor secured for the required services.
      b. Certified statement from the Company listing the qualifications of the Company Field Advisor.
      c. Services and each product for which authorization is given by the Company, listed specifically for this project.

F. Contract Closeout Submittals:
   1. System acceptance test report.
   2. Certificate: Affidavit, signed by the Company Field Advisor and notarized, certifying that the system meets the contract requirements and is operating properly.

3. Operation and Maintenance Data:
   a. Deliver 2 copies, covering the installed products, to the Owner. Include:
      1) Operation and maintenance data for each product.
      2) Complete point to point wiring diagrams of entire system as installed. Number all conductors and show all terminations and splices. (Numbers shall correspond to markers installed on each conductor.)

1.05 QUALITY ASSURANCE

A. Company Field Advisor: Secure the services of a Company Field Advisor from the Company of the existing system for a minimum of 24 working hours for the following:
   1. Render advice and witness test of existing system.
   2. Render advice regarding modifications to the system.
   3. Assist in reprogramming of the system.
   4. Witness final system test and then certify with an affidavit that the modifications were installed in accordance with the contract documents and are operating properly.

PART 2 PRODUCTS

2.01 CONTROL COMPONENTS

The following is a list of required devices, refer to the drawings for required quantities and submit components for approval which are compatible with the existing system.

A. Electronic Analog Sensors:

B. Binary Sensors:

C. Pneumatic Sensor/Controllers:

D. Field Panels and Points:

E. Electric Power Control Devices:

F. Damper Motors & Accessories:

G. Valves:

2.02 MARKERS AND NAMEPLATES

A. Markers: Premarked self-adhesive; W.H. Brady Co.'s B940, Thomas and Betts Co.'s E-Z Code WSL self-laminating, Ideal Industries' Mylar/Cloth wire markers, or Markwick Corp.'s permanent wire markers.

B. Nameplates: Precision engrave letters and numbers with uniform margins, character size minimum 3/16 inch high.

1. Phenolic: Two color laminated engraver's stock, 1/16 inch minimum thickness, machine engraved to expose inner core color (white).
2. Aluminum: Standard aluminum alloy plate stock, minimum .032 inches thick, engraved areas enamel filled or background enameled with natural aluminum engraved characters.
3. Materials for Outdoor Applications: As recommended by nameplate manufacturer to suit environmental conditions.

2.03 WIRING

A. See Section 260502.

2.04 ACCESSORIES

A. Include accessories required for the modifications to perform the functions specified and indicated on the drawings.

PART 3 EXECUTION

3.01 VERIFICATION OF CONDITIONS

A. Test of Existing System:
   1. Prior to modifying the system, test portions of the existing system to ascertain their operating condition. Specifically, test:
      a. Active points which will be modified.
      b. Primary operators station (POS) and distributed control processor (DCP) functions associated with the modifications.
   2. Prepare a written report for the Owner indicating the repairs required, if any, to make the existing system function properly.
   3. Repairs to the existing system are not included in the Work unless requested by Order on Contract.

3.02 INTERRUPTIONS TO EXISTING SYSTEM

A. Maintain the existing system in its present condition to the extent possible while installing new Work.

B. Prior to making changes relative to the existing system, notify the Owner and have procedures approved.

3.03 INSTALLATION

A. Install the Work in accordance with the Company's printed instructions unless otherwise indicated.

B. Reprogram the system to include new sensor and control points and update existing system program to include changes and additions requested by facility
   1. Obtain from the facility personnel through the Owner, a list of desired system program changes, additions, etc.

C. Identification, Labeling, Marking:
1. Identification of Circuits: Identify wires, cables, and tubing by system and function in interconnection cabinets, POSs and DCPs to which they connect with premarked, self-adhesive, wraparound type markers. Designations shall correspond with point to point wiring diagrams.

3.04 FIELD QUALITY CONTROL

A. Preliminary System Test:
1. Preparation: Have the Company Field Advisor adjust the completed system and then operate it long enough to assure that it is performing properly.
2. Run a preliminary test for the purpose of:
   a. Determining whether the system is in a suitable condition to conduct an acceptance test.
   b. Checking and adjusting equipment.

B. System Acceptance Test:
1. Preparation: Notify the Owner at least 3 working days prior to the test so arrangements can be made to have a Facility Representative witness the test.
2. Make the following tests:
   a. Test system operational functions associated with the modifications.
   b. Test each monitor and control device connected or added under this project.
3. Supply all equipment necessary for system adjustment and testing.
4. Submit written report of test results signed by Company Field Advisor and the Owner. Mount a copy of the written report in a plexiglass enclosed frame assembly adjacent to the POS.

END OF SECTION

SECTION 230993
SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1. DESCRIPTION OF WORK

A. The sequence of operation is hereby defined as the written manner and method by which HVAC systems and other building systems and equipment operate. This description includes automatic and manual control functions and includes operation(s), which are monitored, observed, trended, etc. and otherwise used to make decisions regarding system operation.

B. Operating equipment, devices, and system components required for control systems are also specified in other Division 23 Sections.

C. Adjustability of Settings: Declarations within the specifications of setpoints, differentials, times, alarm settings, and all other such settings are hereby understood to be field adjustable. Setting provided are intended as an initial operating condition for system startup and configuration unless otherwise noted. Final settings determined in conjunction with other trades, such as the Test & Air Balancing Contractor, and during system startup and calibration shall be included in final system backed-up, sequence of operations and included in the owner's manual and close-out documentation.

1.2 RELATED SECTIONS

A. Division 23 Sections

B. Division 26 Sections

1.3 SUPPLEMENTAL SUBMITTALS

A. Sequence of Operation: Submit Shop Drawings for each of the systems being controlled shall include a written sequence of operation as it appears in these specifications.

PART 2 - PRODUCTS

Not applicable to this section.

PART 3 – EXECUTION

3.01A CONSTANT VOLUME AIR HANDLING UNITS WITH ENERGY WHEEL, HOT WATER AND CHILLED WATER COILS, DX COIL AND DDC CONTROLS

A. Safety Devices:

Safeties shall be in force at all times and during all modes of operation.

1. Supply Duct Overpressure Control: A supply duct static pressure sensor switch shall be located downstream of the supply fan. If the static pressure in the supply duct exceeds the positive static pressure switch setpoint *(consult manufacturer's representative)* for any reason, the supply fan shall stop and the unit shall remain in the System-OFF Mode until the safety pressure switch is manually reset. After the alarm is cleared, the air handling unit shall resume its normal operation according to the appropriate mode. A change-of-state alarm shall be generated at the BACnet network and at the School Operating Console (SOC) and OEM HMI. Note that this fan safety shall be hardwired to shut the fan off in all modes of fan-control operation.

2. Exhaust Duct Suction Pressure Control: An exhaust duct static pressure sensor switch shall be located upstream of the exhaust fan. If the static pressure in the exhaust duct exceeds the negative static pressure switch setpoint *(consult manufacturer's representative)* the exhaust fan shall stop and the unit shall remain in the System-OFF Mode until the safety pressure switch is manually reset. After the alarm is cleared, the air handling unit shall resume its normal operation according to the appropriate mode. A change-of-state alarm shall be generated at the BACnet network and at the School Operating Console (SOC) and OEM HMI. Note that this fan safety shall be hardwired to shut the fan off in all modes of fan-control operation.

3. Filter Condition: Dial type filter pressure gauges shall indicate each and every filter pressure drop. Additionally, filter differential pressure transducers wired to the OEM controller for each and every filter shall indicate each and every filter pressure drop. The analog pressure drops for each filter bank shall be able to be passed out to the network. Clogged filter alarms shall be generated at the School Operating Console (SOC) and OEM HMI when the pressure drops exceed the maximum allowed pressure drops as recommended by the filter manufacturers. The OEM shall have these analog filter alarms annunciated at the Human Machine Interface (HMI).

4. Fire Alarm Shut Down: This sequence of operation shall be in force at all times and under all modes of operation. The Fire Alarm contractor shall furnish and the air handling unit manufacturer shall install the smoke detectors to shut down the system upon sensing smoke.

5. During a fire alarm condition, the Fire Alarm Control Panel (FACP) shall shut down the supply and exhaust fan and the system shall operate and remain in the System-OFF Mode until the alarm condition is cleared. When the unit fans are shut down by a fire alarm condition, all fire/smoke and smoke dampers shall close as commanded by the FACP. After the fire alarm shutdown is cleared, all smoke and fire/smoke dampers shall be commanded open by the FACP.

6. Smoke Isolation Dampers: For systems supplying 15,000 cfm or more, smoke isolation dampers shall be provided in both the supply and return paths. The smoke dampers shall be commanded open (by the fire alarm system) against their normally-closed, spring-returned actuators during all non-emergency operation. Per Section MC 606.4.3, fans or fan systems which have been automatically shut

down on activation of an automatic fire detecting device or fire alarm system shall be arranged and equipped so that they do not automatically restart when either the automatic fire detecting device or fire alarm system is reset. The manual means of restarting the fans or fan system shall function independently from the manual resetting of either the automatic fire detecting device or fire alarm system.

7. Fire alarm system activation initiated by manual pull station shall not shut down the unit supply and exhaust fans and shall not close the associated smoke and/or fire/smoke dampers.

8. Per Section MC 606.4.2, fans on systems that recirculate air less than or equal to 2,000 cfm or exhaust fans associated with 100 percent outside air systems shall not be shut down upon manual or automatic activation of the fire alarm system.

9. The air handling unit OEM shall provide duct smoke dampers (SD) with actuators and proof-of-open end-switches for units of 15,000 CFM and greater capacity. The FACP shall monitor all associated end-switches for proof-of-open on an individual or zone basis. The FACP shall indicate via a FACP mounted LED that a damper or zone of dampers has not proven open. Fire/smoke dampers associated with the post-fire smoke purge system and smoke control systems shall be monitored on an individual basis by the FACP.

10. Freeze Protection Lockout: The freeze protection device shall be wired into the supply fan and spill exhaust fan motor VFD to shutdown the supply fan all associated exhaust fans upon reaching its setpoint. Unit shall be sent to System Off Mode. OEM limit control freezestat with serpentine element located on the inlet of the chilled water cooling coil shall stop all fans to prevent cooling coil freeze-ups and to prevent cold air being distributed to the building thus avoiding potential building pipe freeze-ups. Set at 39°F (adjustable). Freezestat shall reset automatically unless any trip exceeds 30 seconds as measured by the integral timer. Trips exceeding 30 seconds shall require manual reset. At the same time an alarm signal is sent to the DDC controller and an alarm is displayed on the local operator display device.

11. 30% propylene glycol shall be provided in the chilled water system.

B. Operating Modes: The operating modes of the air handling unit shall be automatically determined by the combined actions of the DDC Scheduler which shall schedule the Occupied and Unoccupied time periods, the local air handling unit mounted HAND-OFF-AUTO (HOA) switch; control and safety devices and the Fire Alarm System. During times of supply and exhaust fan operation, the supply pre-filter MERV 7 and supply post filter MERV 13 filter bank differential pressure transducer signals as well as the return filter MERV 7 filter bank differential pressure transducer signal shall indicate the analog pressure drops which shall be sent to the SOC/HMI to allow monitoring of the filter pressure drops. For all modes, the energy wheel rotational speed shall be controlled by its variable frequency drive (VFD).

1. Mode Selection and Fan Operation:

a. The operator shall be able to manually select the operating mode through an H-O-A switch mounted in the air handling unit and wired into the OEM digital controller. In the "AUTO" position the air handling unit is indexed automatically by the DDC Scheduler or HMI between the various modes of operation described herein. In the "HAND" position the air handling unit shall remain in the Occupied Mode. In the "OFF" position the air handling unit shall remain in the System-OFF Mode. Note that the H-O-A switch is not the same as the manufacturer's service disconnect switch which shall shutdown the air handling unit.

b. When the H-O-A switch is placed into either the "HAND" or the "OFF" position an advisory is generated at the School Operating Console (SOC)and OEM HMI.

c. Exhaust air fan shall run concurrently with the supply fan when the unit is recirculating air during the occupied heating and occupied cooling modes. The exhaust fan shall be disabled when the unit recirculates air during the unoccupied heating, unoccupied cooling, warm up and pull down modes.

d. Summer/Winter Mode Selection: The air handling unit shall be manually indexed or automatically indexed to operate in either the Summer Mode or Winter Mode based on the readings of an outside temperature sensor and outside air relative humidity sensor that may be hard wired to each air handling controller or passed as network variables to each controller. Outside enthalpy conditions are used to determine if the air handling unit shall go into the economizer mode or the mechanical cooling mode. The outside enthalpy is calculated by the controller from the outside air temperature and outside air relative humidity. A global outside enthalpy may be passed as a network point if each controller of each air handling unit does not calculate its own outside enthalpy value based on its own hard wired inputs or network variable inputs for outside air temperature and outside air relative humidity.

1) Winter Mode: If the outside temperature is less than or equal to 50°F, the unit shall be indexed to the Winter Heating Mode.

2) If the outside temperature is greater than 50°F but less than 55°F, the unit shall be in whatever Mode was the last Mode of operation (Winter Heating or Summer Cooling).

3) Summer Mode: If the outside temperature is greater than or equal to 55°F but less than 65°F and the outside air enthalpy is less than the return enthalpy, the unit shall be indexed to the Summer Economizer Cooling Mode. If the outside temperature is greater than or equal to 55°F but less than 65°F and the outside air enthalpy is greater than the return enthalpy, the rooftop unit shall be indexed to Summer Mechanical Cooling Mode. If the

outside temperature is greater than or equal to 65°F, the unit shall be indexed to the Mechanical Cooling Mode.

4) Economizer Cooling Mode: In the Economizer Cooling Mode, the energy wheel and heat wheel rotation shall be stopped. The chilled and hot water valves shall be closed during the economizer cooling mode. The supply fan shall be energized and set to deliver its full flow as determined from its setpoint and the outside air damper shall modulate as required towards fully open. The two position exhaust damper shall remain open. The exhaust air fan VFD shall be modulated to exhaust 85% to 90% of the cumulative instantaneous outside air intake flow. The recirculation damper shall modulate as required towards fully closed. On a drop in return duct temperature to 76.0°F, the outside air, recirculation air and exhaust dampers shall be indexed back to the original occupied air flow settings. If in economizer cooling and the outside air damper has been modulated to the occupied flow settings and the return air temperature drops below 75°F, then the heat wheel speed shall be modulated to attempt to keep the return air temperature between 75°F to 78°F. The cooling economizer mode shall take priority over the cooling demand controlled ventilation mode.

5) Mechanical Cooling Mode: If the outside temperature is greater than or equal to 65°F, the unit shall be indexed to the Mechanical Cooling Mode.

6) Fan Acceleration/De-acceleration: When the supply and exhaust fans are started, the fans shall be slowly accelerated up to their required speed setpoints(*confirmed with facilities*) according to the ramp adjustments in the variable frequency drives. The ramp-up time shall be set to (30) seconds. When the fans are de-energized, they shall be de-energized immediately without de-acceleration.

7) The system shall have the ability to do a manual Summer/Winter changeover by selection at the School Operating Console (SOC). A network variable input shall be able to be sent to the Air Handling Unit controller to override the applicable automatically calculated HVAC mode.

8) Occupied return temperature setpoint control shall be provided for all constant volume air handling units and shall be adjusted from the SOC.

2. System-OFF Mode:

The air handling unit supply and exhaust fans shall be OFF; the wheel rotation shall be stopped; the air handling unit dampers shall be commanded to their

respective fail-safe positions: outside air and exhaust air dampers shall be closed, and recirculation air damper shall be open. The chilled water coil 2-way valve shall be closed during mechanical cooling between load cycles and closed in the unoccupied heating mode and warm up mode. The hot water coil 2-way valve shall remain closed between heating load cycles. 30% propylene glycol shall be provided in the hot water and chilled water systems. The hot water coil 2-way valve shall be closed during the economizer cycle and mechanical cooling mode.

3. Unoccupied Mode:

   a. Bypass Unoccupied Mode. During the unoccupied mode an authorized occupant shall be able to manually enter into the Bypass Mode by depressing the bypass button on the space sensor. Depressing the button shall temporarily place the air handling unit into the Occupied Mode for (120) minutes (adjustable). On all projects where the chiller is shut down during the unoccupied Summer Mode period, the DDC controller shall send an Occupied Command over the network to the chilled water system to become enabled during the Bypass Unoccupied Mode. After this time has elapsed the unit shall automatically return to the appropriate mode of operation and send a network command to send the chiller back into an unoccupied mode where it is shut down.

   b. Unoccupied Winter Mode:

      1) Between load cycles, the air handling unit shall be in the System-OFF mode.

      2) The air handling unit shall be cycled intermittently to maintain a night space set-back temperature setpoint of 55°F plus 0 minus 2°F as sensed by the space temperature sensor.

      3) When the space temperature falls below 53°F (nominal adjustable), the supply fan shall be started and ramped up to its setpoint flow; all associated space exhaust fans and air handling unit exhaust fan shall remain OFF; the dampers shall be in the full-recirculation position as follows: the recirculation damper open and the outside air and exhaust dampers closed. The energy wheel shall be de-energized since it is bypassed by the recirculation dampers.

      4) When the supply fan is on, the hot water coil valve shall be modulated to meet the space unoccupied setpoint (53°F cut-in, 55°F cut-out, nominal adjustable). The air handling unit shall maintain a maximum limit unit discharge temperature of 95°F plus 0 minus 2°F nominal adjustable. The hot water coil valve shall be fully closed (when the fans are off between load cycles). The heat wheel capacity shall be disabled by stopping the rotation of the wheel. The supply fan shall remain energized until the space temperature rises to the setpoint of 55°F

(nominal, adjustable), after which the supply fan shall de-energize. The hot water coil valve shall then fully close.

c. Unoccupied Summer Dehumidification/Cooling Mode:

1) On all projects where the chiller is shut down during the unoccupied Summer Mode period, the DDC controller shall send an Occupied Command over the network to the chilled water system to become enabled during the Unoccupied Summer Dehumidification/Cooling Mode. Outside air intake damper and exhaust air damper shall fully close and the recirculation damper shall fully open. The exhaust fan shall remain off considering the orientation of the exhaust port does not aid in the unoccupied recirculation mode. Hot water coil valve shall be closed. The supply fan may start if the space dewpoint conditions warrant for projects where there is chilled beam or displacement induction units in classrooms or space temperature conditions for projects with VAV boxes in classrooms. The flow station installed in the supply path shall send an analog control signal to the unit controller. The airflow control signal shall be used to control the speed of the supply fan to its flow setpoint. The energy wheel shall remain off during the unoccupied period since the energy wheel is bypassed in the recirculation mode by the recirculation dampers. The air handling unit shall be cycled to maintain space high-limit dewpoint as follows.

2) When the space dewpoint rises above 71°F (nominal, adjustable) for projects utilizing chilled beam or displacement induction units in classrooms or space temperature rises above 85°F for projects utilizing VAV boxes in classrooms, the supply fan shall be started. 71°F dewpoint is associated with a nominal adjustable setup setpoint of 85°F dry bulb and 65% relative humidity. The space temperature and relative humidity may vary during the unoccupied summer dehumidification mode providing the setup 71°F plus 0 minus 2°F dewpoint is maintained for projects utilizing chilled beam or displacement induction units in classrooms.

3) Upon proof of air flow, cooling shall be controlled by maintaining the cooling coil discharge temperature setpoint (nominally 55°F plus 0 minus 2 °F, adjustable

4) After the space dewpoint falls to 69°F for a period of time not less than (30) minutes for projects utilizing chilled beam or displacement induction units in Classrooms or space temperature drops below 85°F minus 2°F for projects utilizing VAV boxes in Classrooms, the chilled water valve shall close and the heat wheel rotation shall be stopped. The supply fan shall then be de-energized. Should the space conditions rise again during the

unoccupied dehumidification/cooling mode time period, the cycle shall repeat. The chiller shall be left enabled on as it may be required to provide additional cooling in a second summer dehumidification/cooling cycle.

4. Morning Warm-up:

   a. Pre-occupancy morning warm-up mode shall be required as sensed by the space temperature sensor before the system is indexed from the unoccupied to the occupied mode. Cycle start time shall be based on the difference between the current temperature and the occupied temperature setpoint for optimum start controls. Additionally, per Section 6.4.3.3.3 of ASHRAE 90.1-2013, the control algorithm shall also be a function of the outdoor temperature and the amount of time prior to scheduled occupancy.

   b. When the space temperature is below 70˚F (the occupied setpoint of nominal adjustable 72˚F less a differential of 2˚F) then the warm-up sequence shall be initiated (otherwise the air handling unit shall remain in the System-OFF mode until the beginning of the Occupied Mode). The supply fan shall be started and ramped up to its setpoint flow; all associated space exhaust fans and air handling unit exhaust fan shall remain OFF; the dampers shall be in the full-recirculation position as follows: the recirculation damper open and the outside air and exhaust dampers closed. The energy wheel shall be de-energized since it is bypassed by the recirculation dampers.

   c. When the supply fan is on, the hot water coil valve shall be throttled to meet the return duct occupied setpoint (70°F cut-in, 72°F cut-out, nominal adjustable). The air handling unit shall maintain a maximum limit unit discharge temperature of 95°F plus 0 minus 2°F nominal adjustable. The hot water coil valve shall be fully closed when the fans are off between load cycles. The heat wheel capacity shall be disabled by stopping the wheel rotation. The supply fan shall remain energized until the space temperature rises to the setpoint of 72°F (nominal, adjustable), after which the supply fan shall de-energize. The hot water coil valve shall then fully close.

   d. Between load cycles, the air handling unit shall be in the System-OFF mode. The morning warm-up cycle shall be terminated when the system is indexed from the unoccupied to the occupied mode.

5. Morning/Nighttime Purge and/or Pull-down: Pre-occupancy space cooling shall be required as sensed by both the space temperature and space relative humidity sensor before the system is indexed from the unoccupied to the occupied mode.

   a. Pre-Occupied Morning/Nighttime Purge Cycle:

      1) The DDC Controller shall compare the calculated space enthalpy determined from both the space temperature and space relative humidity sensor readings to the value of the calculated outside

air enthalpy. If the outside air enthalpy is less than the space enthalpy, a pre-occupancy Morning/ Nighttime Purge cycle shall be initiated for a (15) minute duration.

2) During the pre-occupancy Morning/ Nighttime Purge cycle, 100% outside air shall be introduced into the building to purge the building air before occupancy. The outside air and exhaust air dampers shall be indexed to their fully open position and the recirculation air damper shall be fully closed. The energy wheel and heat wheel shall not rotate. The hot water coil valve and chilled water coil valve shall be closed.

3) The air handling unit supply fan and exhaust fan shall be indexed to their occupied CFM setpoints with mechanical cooling locked out (by closing the chilled water valve) until the Morning/Nighttime Purge cycle is terminated. The pre-occupancy Morning/ Nighttime Purge cycle shall be terminated after a 15-minute cycle. The pre-occupancy morning purge cycle, if initiated, shall be followed by a pre-occupancy pull-down cycle.

After the initial 15 minute Unoccupied Nightime Purge cycle, the system shall be returned to the System-Off mode. The relative enthalpies will be rechecked in the System Off Mode and the Unoccupied Nighttime purge cycle shall be repeated for a 15 minute period if the outside air enthalpy is less than the space enthalpy. Unoccupied Nighttime purge cycle shall be terminated when the system is scheduled to the morning purge/pull down cycle.

b. Pre-Occupancy Pull-down Cycle:

1) After the morning purge cycle, or if the space dewpoint is greater than the space dewpoint setpoint of 57.5°F plus 0 minus 2°F (nominal, adjustable) for projects utilizing chilled beam or displacement induction units in Classrooms or space temperature greater than 78°F for projects utilizing VAV boxes in Classrooms, the Morning Purge cycle shall be locked-out and mechanical cooling shall be used in a pre-occupancy pull-down mode to bring the return air dewpoint temperature down from its unoccupied range of 69 to 71°F dewpoint (space temperature of 85°F for projects utilizing VAV Boxes in Classrooms) to its occupied setpoint of 57.5°F (plus 0 minus 2)°F dewpoint(space temperature of 78°F for projects utilizing VAV Boxes in Classrooms). Cycle start time shall be based on the difference between the current conditions and the occupied setpoint for optimum start controls. Additionally, the control algorithm shall also be a function of the outdoor conditions (dewpoint or temperature as applicable) and the amount of time prior to scheduled occupancy. The hot water coil valve shall be closed.

57.5˚F dewpoint is associated with the occupied space conditions of 78˚F dry bulb and 50% relative humidity.

2) During the pre-occupancy pull-down cycle, the outside and exhaust air dampers shall be fully closed and the recirculation damper shall be fully opened. The energy wheel shall remain off during the pre-occupancy pull-down cycle since the energy wheel is bypassed during the recirculation pull-down cycle by the recirculation dampers. The air handling unit supply fan shall be indexed to provide its occupied CFM. The exhaust fan shall remain off considering the orientation of the exhaust port does not aid in the recirculation mode. The air handling unit chilled water valve shall be modulated to provide the cooling coil discharge temperature setpoint (55°F plus 0 minus 2°F nominal, adjustable) while the DDC controller limits the discharge air temperature by modulating the heat wheel speed to be no less than 2˚F less than the calculated return duct dewpoint. The pull down cycle shall continue until the return air dewpoint is at or below 57.5˚F plus 0 minus 2˚F (space temperature of 78˚F for projects utilizing VAV Boxes in Classrooms) at which time the chilled water valve shall modulate closed and the fans shall de-energize. Should the space conditions rise again during the pull down cycle time period, the cycle shall repeat. The pre-occupied pull down cycle shall be terminated when the scheduler places the unit in the scheduled occupied mode.

6. Occupied Cooling Mode:

a. Once the pre-occupancy pull-down cycle is satisfied, the unit shall be indexed to occupied economizer cooling mode or occupied mechanical cooling/indirect dehumidification mode to maintain the required return air temperature setpoint (78°F plus 0 minus 2°F nominal adjustable). When the return air temperature exceeds 78˚F, the unit shall be indexed into the Mechanical Cooling Mode. In Mechanical Cooling mode, mechanical chilled water cooling valve shall be modulated to maintain a maximum 55˚F cooling coil discharge temperature and the heat wheel speed shall be modulated per the return air reset schedule to maintain the return duct temperature of 78˚F. On a drop in return duct temperature to 76.0°F, the cooling valve shall be closed. Mechanical cooling shall be re-enabled to allow chilled water coil modulation and heat wheel speed modulation to maintain a maximum 78˚F return temperature when the return air exceeds 78°F. If the cooling coil valve is fully closed and the return air temperature drops below 75°F, then the heat wheel speed shall be modulated to attempt to keep the return air temperature between 75°F to 78°F.

In the occupied cooling mode the hot water coil valve shall be closed. The energy wheel shall be set to run at its full RPM during the occupied mechanical cooling cycle. The DDC Controller shall compare the

controller's calculated return air enthalpy to the calculated global outside air enthalpy to determine if economizer cooling or mechanical cooling (by the chilled water valve) shall be initiated. If the outside temperature is greater than or equal to 55°F but less than 65°F when the calculated global outside air enthalpy is less than the controller's calculated return air enthalpy, the unit shall be indexed to the Economizer Cooling Mode and the wheel shall be turned off. On a rise in return duct temperature above the occupied setpoint by a differential of 2.0°F, the outside air damper and exhaust fan VFD shall be modulated past their minimum position and recirculation air damper shall be modulated towards closed to provide required cooling. On a drop in return duct temperature below the occupied setpoint by a differential of 2.0°F, the outside air and recirculation air dampers and exhaust fan VFD shall be indexed back to the original occupied air flow settings. If in economizer cooling and the outside air damper has been modulated to the occupied flow settings and the return air temperature drops below 75°F, then the heat wheel speed shall be modulated to attempt to keep the return air temperature between 75°F to 78°F. If the return air temperature exceeds 78°F for a time delay of 30 minutes (adjustable), the air handling unit shall be indexed to Mechanical Cooling Mode. The cooling economizer mode shall take priority over the demand controlled ventilation mode.

b. Demand Controlled Ventilation

The outside air damper and exhaust fan VFD shall be set to provide their outside air and exhaust flow setpoints per the below reset schedule based on the carbon dioxide differential. The recirculation damper shall be adjusted to provide the required total supply flow as determined by the total supply flow setpoint.

Outside Air Flow Setpoint Reset Schedule (Unit C2 and C3)

Differential (D) shall be defined to be the space CO_2 concentration minus the outside air CO_2 concentration in parts per million (ppm).

Differential (D) in ppm	Outside air flow setpoint (cfm)
0	500
When Differential (D) is between 0 and 900, Outside Air Damper shall modulate proportionally to the D value.	
D > = 900	2800

Note that the exhaust air flow setpoint shall be nominally 10% less than the outside air flow setpoint for positive pressurization purposes.

Outside Air Flow Setpoint Reset Schedule (Unit F2)

Differential (D) shall be defined to be the space CO_2 concentration minus the outside air CO_2 concentration in parts per million (ppm).

Differential (D) in ppm	Outside air flow setpoint (cfm)
0	300
When Differential (D) is between 0 and 1200, Outside Air Damper shall modulate proportionally to the D value.	
D > = 1200	5000

Note that the exhaust air flow setpoint shall be nominally 10% less than the outside air flow setpoint for positive pressurization purposes.

Other units that require Demand Control Ventilation shall be controlled via occupancy sensors in the room. Where unit serves multiple rooms, multiple sensors shall be provided in the space. Full Outside Air ventilation shall be provided when the space is occupied. All other times, area outside air ventilation is only required. See table below for specific Area and Full Outside Air Ventilation for the units that require Demand Control Ventilation.

Unit	Area Outside Air Airflow (CFM)	Full Outside Air Airflow (CFM)
E1	296	1050
E2	573	2925
E3	411	1850
E5	169	850
G1	280	1150

7. Winter Occupied Heating Control Sequence:

   a. The air handling unit controller shall be polled on 10 minute intervals to provide the hot water valve position to be used for primary hot water pump differential pressure reset logic. Controller network polling is not limited to 10 minute intervals. The heat wheel shall not rotate. On rise in return air temperature above 72°F, the hot water coil valve shall be closed. The wheel shall remain on at constant speed during all occupied heating control sequences. The modulating dampers and exhaust fan VFD shall be subject to an adjustable mixed-air low-limit control set to 55°F.

   b. On a drop in return air temperature below 70°F (i.e. 2°F below the nominal adjustable space heating setpoint of 72°F), the energy wheel RPM shall continue to remain on to provide the maximum wheel heating ability. The heating coil valve shall be modulated until the return air temperature equals the nominal adjustable return temperature of 72°F.

c. Chilled water coil valve shall be closed during the winter occupied heating control mode.

d. Demand Controlled Ventilation:

The supply fan VFD and exhaust fan VFD shall be set to provide their flow setpoints per the above TABLE A reset schedule based on the carbon dioxide differential.

e. Frost Protection: A frost control setpoint shall be defined as follows: exhaust path energy wheel exhaust temperature conditions of 35°F (adjustable). Whenever the energy wheel exhaust leaving air temperature is less than the exhaust air frost control temperature setpoint, the wheel speed shall be modulated as required to maintain the exhaust leaving air temperature above the exhaust air temperature for frost control setpoint.

C. Loss of Communication

1. Upon loss of communication with the network, the air handling unit DDC controller shall operate in the applicable seasonal occupied mode as determined by the outside air conditions (before the loss of communication).

D. Occupied Mode Fan Speed:

1. When the air handling unit DDC controller is indexed to the occupied mode, the unit supply and exhaust fans shall be started by their respective variable frequency drives (VFD) as follows.

a. The supply fan VFD speed shall be commanded to its fixed speed setpoint(*confirmed with facilities*). This setpoint may be adjusted and reset by the Test & Air Balance Contractor.

b. The exhaust fan VFD speed shall be commanded to its full occupancy speed setpoint(*confirmed with facilities*). This setpoint may be adjusted and reset by the Test & Air Balance Contractor.

c. If the fans do not prove ON as indicated by the flow sensors, an alarm shall be issued to the SOC/HMI.

E. DX Coil Cooling Sequence (where applicable, refer to Unit Schedule on Drawings):

The DX Coil shall operate during the summer months, where the need for chilled water can be utilized for other units. Coordinate with facilities for required setpoints on when DX coil to begin modulating.

1. System-OFF:

   a. When the RTU is OFF, the outside air and exhaust dampers shall be closed,the recirculation air damper shall be open, the fans shall be OFF, and all heating and cooling shall be de-energized.

2. Unoccupied Cycle:

   a. See B.3 above for unoccupancy mode sequence.

   b. Unoccupied Cooling:

      1) The RTU is cycled to maintain the unoccupied space night set-up (NSU) of 85°F. On a rise in space temperature above the NSU the fans are energized, the DX-cooling compressors are controlled in stages and sequenced to provide the desired return air temperature. Failure of the DX-cooling compressors to run after being commanded to run shall be alarmed at the SOC/HMI.

      2) On a drop in space temperature below the NSU by a differential of 5°F the DX-cooling compressors are cycled OFF and the fans are de-energized.

3. Occupied Cycle:

   a. See sequence above for fan operation for occupied cycle mode.

   b. Occupied Heating:

      1) See sequence above for Occupied heating mode.

   d. Occupied Cooling:

      1) If the outside temperature is greater than or equal to 65°F(adjustable), the unit shall be indexed to the Mechanical Cooling Mode. Mechanical DX cooling shall be controlled in stages and sequenced so as to maintain a maximum return duct temperature condition with a cooling setpoint of 78°F(adjustable). Failure of the DX-cooling compressors to run after being commanded to run shall be alarmed at the SOC/ HMI. On a drop in return duct temperature to 76.0°F, the compressors shall be sequentially staged off. If the outside temperature is greater than or equal to 55°F but less than 65°F when the calculated global outside air enthalpy is less than the controller's

calculated return air enthalpy, the rooftop unit shall be indexed to the Economizer Mode. On a rise in return duct temperature above 78.0°F, the outside air and exhaust dampers shall be modulated past their minimum position and recirculation air damper shall be modulated towards closed to provide required cooling. On a drop in return duct temperature to 76.0°F, the outside air, recirculation air and exhaust dampers shall be indexed back to the original occupied air flow settings. On a rise in return duct temperature above 78.0°F for a time delay of 30 minutes (adjustable), the Economizer Cooling Mode shall be deemed inadequate to meet the maximum acceptable conditions at which time the unit shall be commanded to the occupied Mechanical Cooling Mode and the outside air, exhaust air and recirculated air dampers shall be indexed back to the occupied air flow settings.

4. Communication

   a. Upon loss of communication with the network, the rooftop unit DDC Controller shall operate in the applicable seasonal occupied mode as determined by the outside air temperature (before the loss of communication).

   b. I/O Points: Provide the I/O points as specified.

END OF SECTION

* * *

LIST OF SUBMITTALS

SUBMITTED	DATE SUBMITTED	DATE APPROVED

Submittal Sections:

1. Control Shop Drawings & Sequences.
2. Engineering Cut Sheets.
3. Schedules.
4. TCC Certifications.

SECTION 232000

HVAC PIPING

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data:
   1. Catalog sheets and specifications indicating manufacturer name, type, applicable reference standard, schedule, or class for specified pipe and fittings.
   2. Material Schedule: Itemize pipe and fitting materials for each specified application in Pipe and Fittings Schedule in Part 3 of this Section. Where optional materials are specified indicate option selected.

B. Quality Control Submittals:
   1. Installers Qualification Data:
      a. Welder Qualification Data: Copies of certification; include names, home addresses.
      b. Welding Procedures:
         1) Copy of QW-482 "Suggested Format for Welding Procedure Specification (WPS)" for all welders for all weld types.
         2) Copy of QW-483 "Suggested Format for Procedure Qualification Record (PQR)" as specified in Welding Quality Assurance below for all weld types.
      c. Welders' Certificates:
         1) Copy of QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQ)" for all welders for all weld types.
      d. Brazer Qualification Data for Refrigerant Piping: State refrigerant piping brazing experience: include names, home addresses and social security numbers of brazers.
   2. Quality Control Submittals (for Hydraulic Press Joints, if used): Copy of hydraulic press fitting manufacturer's printed field inspection procedures for hydraulic press joints in copper tubing.
   3. Manufacturer's Data: Copy of mill certificates, laboratory test and manufacturing reports relating to chemical and physical properties of pipe, fittings, and related materials.
   4. Welding Procedure Submittals: Submit the following:
      a. Welding Procedure Specifications: Provide for each weld type.
         1) Recommended to use ASME Form E00006, QW-482 "Suggested Format for Welding Procedure Specification (WPS)".
      b. Procedure Qualification Records: Provide for each weld type.
         1) Recommended to use ASME Form E00007, QW-483 "Suggested Format for Procedure Qualification Record (PQR)".
   5. Contract Closeout Submittals:
      a. Copy of Final Hydrostatic Testing Record Log.

1.02 QUALITY ASSURANCE

A. Qualifications of Welding Procedures, Welders and Welding Operators: Comply with the following:
   1. American Welding Society Standard AWS B 2.1.

B. Welding Procedures:
   1. Record in detail, and qualify the Welding Procedure Specifications for every welding procedure that is proposed to be used for the Project.
   2. Develop procedures for all metals included in the work.
   3. Qualify the procedures for making transition welds between different materials, or between plates or pipes of different wall thickness.
   4. Qualification for each welding procedure shall conform to the requirements of ASME B31.1, and as specified herein.
   5. Describe the method for each system including the number of beads, the volts, the amperes, and the welding rod for various pipe thicknesses and materials.
   6. The welding procedures shall specify end preparation for butt welds including cleaning, alignment, and root openings.
   7. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified.
   8. Approval of any procedure does not relieve the Contractor of the sole responsibility for producing acceptable welds.
   9. Welding procedures shall be identified individually and shall be clearly referenced to the type of welding required for this project.
   10. These procedures shall be the same as those used for all pipe welder qualification tests, all shop welds, and all field welds.
   11. Provide procedure qualification records for all proposed Welding Procedure Specifications (WPS).

C. Welder Qualification:
   1. WPQs:
      a. Provide welder qualifications for each welder for each weld type.
      b. Recommended to use ASME Form E00008, QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Procedure Qualification Tests (WPQ)."
   2. Perform WPQs under the witness of an independent agency.
      a. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National Certified Pipe Welding Bureau.
      b. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS.
      c. Tests position shall be "6G" per ASME Section IX.
   3. Evidence of Continuity: Welder qualifications must be current.
      a. If the qualification test is more than 6 months old, provide record of welding continuity for each welder.
      b. Record of welding continuity shall show that the welder in question has performed welding to the procedure in question without a 6 month continuous span of inactivity since the date

that the welder qualification test was passed for the submitted welding procedure.

c. Record of welding continuity shall include, at a minimum, the welder's employer name and address, the date the welder qualification test was passed, and the dates indicating welding continuity including welding procedure for each date.

D. Weld Records:

1. For all welding within the scope of ASME B31.1, submit for approval an administrative procedure for recording, locating, monitoring, and maintaining the quality of all welds to be performed on the project.
   a. The weld record shall include but not be limited to drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date and WPS used.
2. After achieving qualification, but before being assigned work, each qualified person shall be assigned an identifying number by the Contractor to be used to identify all of his welds.
   a. A list of qualified persons with their respective numbers shall be submitted and maintained accurately with deletions and additions reported promptly.
3. Upon completing a joint, the welder shall mark the pipe not more than 6 inches from the weld with the identifying number and the last two digits of the year in which the work was performed.
   a. Make identification marks with a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the Owner that do not deform the metal.
   b. Place identification marks for seam welds adjacent to the welds at 3-foot intervals.
   c. Identification by die stamps or electric etchers is not acceptable.
   d. Provide required markers. Substitution of a map of welds with welders' names is not acceptable.
4. Maintain a constantly updated log available to the Owner at all times.

E. Qualifications of Brazers: Comply with the following:

1. Certification of brazing operators by recognized authorities which require a qualification test.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Pipe Storage:

1. Upon the receipt of each shipment of pipe on the job, maintain the pipe marking, and store pipe in accordance with ASTM material specifications, and method of manufacture (seamless, etc.) of each length of pipe.
2. Pipe markings shall be clearly readable at the time of pipe installation.
3. If at the time of its installation, any length of pipe not readily identifiable will be subject to rejection, or arbitrary downgrading by the Owner to the lowest grade which has been received on the job to that date.
4. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, bell and-spigot, and clay pipe.

a. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

PART 2 PRODUCTS

2.01 STEEL PIPE AND FITTINGS

A. Standard Weight Schedule 40 or Extra Heavy Weight Schedule 80, Black or Galvanized Steel: ASTM A 53, Grade B, Type E or S, or ASTM A 135.

B. Bending, Coiling, Flanging and Other Special Services: ASTM A 53, Grade A, Type E or S, or ASTM A 135.
1. Applications over 400 psig: ASTM A 106.

C. Grooved End Type: Schedule 40, ASTM A 53, Grade B, Type F for sizes 3/4 inch to 1-1/2 inch, and Type E or S for sizes 2 inch to 24 inch; or ASTM A 135.

D. Flanges, Welding Neck Type, Same Pressure Rating as Adjoining Pipe: ASME B16.5.

E. Weld Fittings, Carbon Steel:
1. Butt Welding Type: ASME B16.9.
   a. Allied Piping Products Co., Inc.'s Branchlets, Type 1 or 2.
   b. Bonney Forge Corp.'s Weldolets.
2. Socket Welding Type: ASME B16.11.
   a. Allied Piping Products Co., Inc.'s Branchlets, Type 1 or 2.
   b. Bonney Forge Corp.'s Thredolets or Sockolets.

F. Malleable Iron, Steam Pattern Threaded Fittings:
1. 150 lb Class: ASME B16.3.
2. 300 lb Class: ASME B16.3.

G. Cast Iron Fittings:
1. Drainage Pattern, Threaded: ASME B16.12.
2. Steam Pattern, Threaded: ASME B16.4.
   a. Standard Weight: Class 125.
   b. Extra Heavy Weight: Class 250.
3. Flanged Fittings and Threaded Flanges: ASME B16.1.
   a. Standard Weight: Class 125.
   b. Extra Heavy: Class 250.

H. Unions: Malleable iron, 250 lb class, brass to iron or brass to brass seats.

I. Couplings: Same material and pressure rating as adjoining pipe, conforming to standards for fittings in such pipe. Use taper tapped threaded type in screwed pipe systems operating in excess of 15 psig.

J. Nipples: Same material and strength as adjoining pipe, except nipples having a length of less than one inch between threads shall be extra heavy.

2.02 COPPER AND BRASS PIPE, TUBING AND FITTINGS

A. Copper Tube, Types K, L and M: ASTM B 88.

B. Wrot Copper Tube Fittings, Solder Joint: ASME B16.22.

C. Cast Copper Alloy Tube Fittings, Solder Joint: ASME B16.18.

D. Flanges: Conform to the Standards for fittings used in systems.
   1. Brazing Flanges: ASME B16.24, hubs modified for brazing ends.

E. Unions: Cast bronze, 150 lb Class, bronze to bronze seats, threaded or solder joint.

F. ACR Tube: ASTM B 280

G. Flared Tube Fittings:
   1. Refrigerant Tube Type: SAE J513.

2.03 HYDRAULIC PRESS FITTINGS FOR COPPER TUBING

A. Acceptable Fittings:
   1. ProPress by Viega, 301 N. Main, Wichita, KS 67202, (877) 843-4262, www.viega.com.

B. Operating Conditions:
   1. Maximum Operating Pressure: 200 psi.
   2. Operating Temperature Range: 0-250 degrees F.
   3. Maximum Test Pressure: 600 psi.
   4. Maximum Vacuum: 29.2 inches hg @ 68 degrees F.

C. Features:
   1. Fittings: Copper and copper alloy conforming to material requirements of ASME B16.18 or ASME B16.22.
      a. Stainless Steel Grip Ring: Adds strength to the joint without collapsing the interior passageway.
   2. No flame for soldering required for installation of fittings and valves.
   3. Unpressed connections identified during pressure testing when water flows past sealing element.
   4. Sealing Elements: Factory installed, EPDM.
   5. Fittings that have been pressed can be rotated. If rotated more than 5 degrees, the fitting must be repressed to restore its resistance to rotational movement.
   6. Extended fitting end lead allows for twice the retention grip surface, and assists with proper tube alignment.
   7. Soldered adapter fittings are not allowed.

2.04 COUPLINGS AND FITTINGS FOR GROOVED END PIPE

A. Couplings: Gustin-Bacon Inc.'s No. 100 Gruvagrips, or Victaulic Co.'s Style 77, having pressure rating of:
1. 1000 psi for 3/4 inch to 6 inch.
2. 800 psi for 8 inch to 12 inch.
3. 300 psi for 14 inch to 24 inch.

B. Fittings: By same manufacturer as couplings, having pressure ratings equal to or greater than couplings. Comply with the following standards:
1. Steel: ASTM A 53 or A106, Grade B.
2. Malleable Iron: ASTM A 47.
3. Ductile Iron: ASTM A 536.

2.05 JOINING AND SEALANT MATERIALS

A. Thread Sealant:
1. LA-CO Industries', Slic-Tite Paste with Teflon.
2. Loctite Corp.'s No. 565 Thread Sealant.
3. Thread sealants for potable water shall be NSF approved.

B. Thread Sealant (Natural Gas Piping): Rectorseal Corp.'s T Plus 2 non-hardening pipe dope with teflon.

C. Fuel Resistant Thread Sealant:
1. Rectorseal Corp.'s Rectorseal No. 5.
2. EMCO Wheaton Inc.'s Joint Seal.

D. Solder: Solid wire type conforming to the following:
1. All Piping except Refrigerant. Type 3: Lead-free tin-silver solder (ASTM B 32 Alloy Grade E, AC. or HB); Engelhard Corp.'s Silvabrite 100, Federated Fry Metals' Aqua Clean. or J.W. Harris Co. Inc.'s Stay-Safe Bridgit.
2. All Refrigerant Piping: Type 2: Lead-free tin-silver solder (ASTM B 32 Alloy Grade Sn 96): All-State Welding Products Inc.'s 430. Engelhard Corp.'s Silvabrite. or J.W. Harris Co. Inc.'s Stay-Brite.

E. Soldering Flux for Soldered Joints: All-State Welding Products Inc.'s Duzall, Engelhard Corp.'s General Purpose Liquid or Paste, Federated Fry Metals' Water Flow 2000, or J.W. Harris Co. Inc.'s Stay-Clean.

F. Brazing Alloys:
1. Type 1: AWS A5.8, Class BCup-5, for brazing copper to brass, bronze, or copper; Engelhard's Silvaloy 15, J.W. Harris Co. Inc.'s Stay-Silv 15, and Handy & Harman's Sil-Fos.
2. Type 2: AWS A5.8, Class BAg-7, for brazing copper to steel or stainless steel; Engelhard's Silvaloy-56T, J.W. Harris Co. Inc.'s Safety-Silv 56, and Handy & Harman's Braze 560.

G. Brazing Flux: AWS Type FB3A; Handy & Harman's Handy Flux or J.W. Harris Co. Inc.'s Stay-Silv.

H. Electrodes and Welding Rods:
1. Electrodes for Use in Arc Welding: Heavily coated, not larger than 3/16 inch diameter exclusive of coating, unless otherwise approved.
2. Welding Rods: Free flowing when fused, so as to avoid excessive puddling.
3. Electrodes for Welding Stainless Steels: Coated and used with reverse polarity.
4. Filler material shall conform to the appropriate AWS-ASTM specification.

I. Flange Gasket Material:
1. For Use With Cold Water or Chilled Water: 1/16 inch thick rubber.
2. For Use With Hot Water, or Air: Waterproofed non-asbestos mineral or ceramic fiber, or a combination of metal and waterproofed non-asbestos mineral or ceramic fiber, designed for the temperature and pressures of the piping systems in which installed.
3. For use with Steam, Feedwater, Blow-Off and Natural Gas: Spirally wound, Type 304 stainless steel with non-asbestos filler material, and carbon steel outer ring.
   a. Maximum Operating Pressure: 600 psi at 700 degrees F.
   b. Thickness: 1/16 thick, conforming to the flange face on which they are used.
   c. Acceptable Gaskets: Flexitallic Style CG with Flexite Super Filler by Flexitallic Inc., Deer Park, TX; (281) 479-3491.
4. For use with Fuel Oil: Non-asbestos, compressed sheet, nitrile binder.
   a. Maximum Operating Pressure: 600 psi at 700 degrees F.
   b. Thickness: 1/16 thick, conforming to the flange face on which they are used.
   c. Acceptable Manufacturers: Sepco, or Sur-Seal.

J. Flange Bolts, Washers and Nuts
1. Bolts: High strength, ASTM A 193 B7.
2. Washers: ASTM F436 Structural Type 1 hardened steel flat hot dipped galvanized.
3. Nuts: ASTM A194 2H.

K. Gaskets For Use With Grooved End Pipe and Fittings: Type and materials as recommended and furnished by the fitting manufacturer, for the service of piping system in which installed.

L. Anti-Seize Lubricant: Bostik Inc.'s Never Seez or Dow Corning Corp.'s Molykote 1000.

2.06 PACKING MATERIALS FOR BUILDING CONSTRUCTION PENETRATIONS

A. Oiled Oakum: Manufactured by Nupak of New Orleans, Inc., 931 Daniel St., Kenner, LA 70062, (504)466-1484.

B. Mechanical Modular Seals: Thunderline Corp.'s Link Seal wall and floor seals designed for the service of piping system in which installed.

2.07 DIELECTRIC CONNECTORS

A. Dielectric Fitting: Bronze ball valve with end connections and pressure rating to match associated piping.
   1. Nipples with inert non-corrosive thermoplastic linings are not acceptable.

B. Flange Electrical Insulation Kit: Consisting of dielectric sleeves and washers, and dielectric gasket.
   1. Water Applications:
      a. Heating Hot Water: Rated 150 psi at 250 degrees F: ANSI Class 300, full faced durlon gasket with bolt holes, double durlon washers, and durabla sleeves; Model 300 by APS, Lafayette, LA 70596, (337) 233-6116.
      b. Potable Water: Rated 150 psi at 250 degrees F: ANSI Class 150, full faced neoprene gasket with bolt holes, double phenolic washers, and mylar sleeves; Model 150 by APS, Lafayette, LA 70596, (337) 233-6116.

2.08 PIPE SLEEVES

A. Type A: Schedule 40 steel pipe.

B. Type B: No. 16 gage galvanized sheet steel.

C. Type C: Schedule 40 steel pipe with 1/4 inch steel collar continuously welded to pipe sleeve. Size steel collars as required to span a minimum of one cell or corrugation, on all sides of the rough opening thru the metal deck.

D. Type D: No. 16 gage galvanized sheet steel with 16 gage sheet steel metal collar rigidly secured to sleeve. Size metal collars as required to span a minimum of one cell or corrugation, on all sides of the rough opening thru the metal deck.

2.09 FLOOR, WALL AND CEILING PLATES

A. Cast Brass: Solid type with polished chrome plated finish, and set screw.
   1. Series Z89 by Zurn, 929 Riverside Drive, Grosvenordale, CT 06255, (800) 243-1830.
   2. Model 127XXXX by Maguire Mfg., Cheshire CT 06410, (203) 699-1801.

B. Stamped Steel: Split type, polished chrome plated finish, with set screw.
   a. Figures 2 and 13 by Anvil International, Portsmouth, NH 03802, (603) 422-8000.

C. Cast Iron or Malleable Iron : Solid type, galvanized finish, with set screw:
   1. Model 395 by Anvil International, Portsmouth, NH 03802, (603) 422-8000.
   2. Model 900-016XX by Landsdale International, Westville, NJ 08093, (800) 908-0523.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

A. Install piping at approximate locations indicated, and at maximum height.

B. Install piping clear of door swings, and above sash heads.

C. Make allowances for expansion and contraction.

D. Allow for a minimum of one inch free air space around pipe or pipe covering, unless otherwise specified.

E. Install vertical piping plumb.

F. Use fittings for offsets and direction changes, except for Type K soft annealed copper tube.

G. Cut pipe and tubing ends square; ream before joining.

H. Threading: Use American Standard Taper Pipe Thread Dies.
   1. Thread brass pipe with special threading dies.

I. Make final connections to equipment with unions, flanges, or mechanical type joint couplings.

3.02 WATER PIPING SYSTEMS

A. Pitch:
   1. Pitch horizontal piping 1/8 inch per 10 feet in direction indicated on drawings. When direction of flow is not indicated, pitch supply piping up in direction of flow and return piping downward in direction of flow.
   2. Pitch single pipe systems up in direction of flow 1/8 inch per 10 feet.

B. Air Vents: Install air vents at locations indicated on the drawings. and at each high point in system. Use manually operated air vents. unless otherwise indicated.

C. Drains:
   1. Install piping to be completely drainable. Provide drains at low points, consisting of a 1/2 inch valve with a hose bibb connection, and at the following locations and equipment:
      a. In each section of piping separated by valves.
      b. For each riser, where riser or runout to riser has a valve installed.
      c. For each heating cooling unit, having valves in supply and return connections.
      d. In low point of piping to each down fed convector or radiator.

D. Runouts: Connect runouts to upfeed risers to top of mains, and runouts to downfeed risers to bottom of mains.

3.03 NATURAL GAS PIPING SYSTEMS

A. Install in compliance with the National Fuel Gas Code-NFPA 54 and as required by the serving gas supplier.

B. Use non-hardening pipe dope on threads. Do not use thread seal tape.

3.04 FUEL OIL SYSTEM PIPING

A. Piping Inside Building:
   1. Pitch horizontal piping downward from wall 1/8 inch per foot minimum.
   2. Where copper tubing is used, install in continuous lengths to burning apparatus and gage display.

3.05 PIPE JOINT MAKE-UP

A. Threaded Joint: Make up joint with a pipe thread compound applied in accordance with the manufacturer's printed application instructions for the intended service.

B. Soldered Joint: Thoroughly clean tube end and inside of fitting with emery cloth, sand cloth, or wire brush. Apply flux to the pre-cleaned surfaces. Install fitting, heat to soldering temperature, and join the metals with type solder specified. Remove residue.

C. Flanged Pipe Joint:
   1. Install threaded companion flanges on steel pipe; flanges on galvanized pipe are not required to be galvanized.
   2. Provide a gasket for each joint.
      a. Hot Water Pipe Gasket: Coat with a thin film of oil before making up joint.
      b. Compressed, Control, and Instrument Air Pipe Gasket: Coat with a thin film of oil before making up joint.
   3. Flange Bolt Installation:
      a. Clean and coat nuts, bolt threads and washers with anti-seize lubricant before making up joint.
      b. With each bolt: one hardened steel washer is required under the nut.
      c. With each stud; one hardened steel washer is required under the nut at each end.
      d. Torque Requirements: Stress bolts to 30,000 psi.
      e. Check torque with a calibrated breaking action torque wrench on the final torque round.
      f. Bolts shall be cold and hot torqued.
      g. Torque Pattern: Cross or star pattern with at least four passes. Limit each pass to 30 percent of full torque increases.
      h. Hot torque: Re-torque the flange bolts with the system at normal operating pressure, and operating temperature for minimum of 12 to 15 hours.
   4. Coat bolt threads and nuts with anti-seize lubricant before making up joint.

D. Grooved Pipe Joint: Roll groove pipe ends, make up joint with grooved end fittings and couplings, in conformance with the manufacturer's printed installation instructions.
   1. Cut grooved end piping is not acceptable.

E. Welded Pipe Joint:
   1. General:
      a. Weld pipe joints only when ambient temperature is above 0 degree F where possible.
      b. Bevel pipe ends at a 37.5 degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
      c. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inches to 20 inches.
      d. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass.
      e. Eliminate valleys at center and edges of each weld.
      f. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
      g. Do not weld-out piping system imperfections by tack-welding procedures. Refabricate as required to comply with requirements.
      h. If piping component ends are bored, such boring shall not result in the finished wall thickness after welding less than the minimum design thickness.
      i. Align the inside diameters of piping components to be butt-welded as accurately as is practicable within existing commercial tolerances on diameters, wall thickness and out of roundness.
      j. Preserve alignment during welding. The internal misalignment of the ends to be joined shall not exceed 0.05 inch.
   2. Welding Processes:
      a. All welding on metal piping systems shall be performed using qualified welding procedures and qualified welders and welding operators in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.
      b. All welding shall be performed by a process that is compatible with the work being welded and the working conditions. Shielded metal-arc welding (SMAW) shall not be used on work less than 3/16 inch thick.
      c. Welding shall be performed by using only one of the following processes:
         1) Shielded Metal Arc Welding (SMAW), also know as "Stick" Welding.
         2) Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc Welding.
         3) Submerged Arc Welding (SAW).
      d. Where a specific welding process is called for in the piping group, it shall govern.
      e. All stainless steel work less than 3/16 inch thick shall be welded by the gas tungsten-arc (GTAW) process with the back side

purged with argon. Work thicker than 3/16 inch shall have a root pass by the GTAW Process with the back purged with argon and the balance of the weld may be completed by SMAW Process or any other suitable process.

3. Welding Grooves:
   a. Bevel the ends of steel pipe and fittings to be erected with butt welded joints to form welding grooves in accordance with ANSI B16.25, except where otherwise noted herein, or on the Contract Drawings.
   b. Bevel welding grooves for butt welded joints in pipe of unequal wall thickness in accordance with ASME Code for Pressure Piping B31.1 - latest edition, latest revision and section that is applicable.
4. Backing Rings: Backing rings or consumable inserts are not acceptable.
5. Cleaning of Welding: Completely remove all slag or flux remaining on the bead of welding before laying down the next successive bead and at the completion of the weld.
   a. Wire brush all completed welds a minimum of 2 inches on both sides and coated with one coat of high temperature (minimum rated 500 deg. F) primer prior to being insulated.
6. Preheating of Welded Joints: Pipe adjacent to joints before and during welding shall be preheated by any suitable method in accordance with the qualified welding procedure, and in all cases shall be in accordance with ASME B31.1, Paragraph 131.
7. Weld Quality:
   a. All welds shall have full penetration and complete fusion with a minimum of weld metal protruding on the inside of the pipe.
   b. The finished weld contour shall be uniform, with the toe or edge of the weld merging smoothly into the base material.
   c. Butt welds shall have a slight reinforcement build-up gradually from the toe or edge toward the center of the weld.
   d. The limitation on butt weld reinforcement shall be in accordance with ASME B31.1. Table 127.4.2 and shall apply separately to both inside and outside surfaces of the joint.
   e. Fillet welds may be slightly concave on the furnished surface.
8. Identification of Welders:
   a. Upon completing a joint, the welder shall mark the pipe not more than 6 inches from the weld with the identifying number and the last two digits of the year in which the work was performed.
   b. Make Identification marks with a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the Owner that do not deform the metal.
   c. Place identification marks for seam welds adjacent to the welds at 3-foot intervals.
   d. Identification by die stamps or electric etchers is not acceptable.
   e. Provide required markers. Substitution of a map of welds with welders' names is not acceptable.
9. Postheat Treatment of Welded Joints In Carbon and Ferritic Alloy Steel Pipe:
   a. Postheat treatment of welded joints in carbon and ferritic alloy steel piping shall be in accordance with ASME B31.1, as

specified in the piping group, or on the Contract Drawings, except the cooling rate for stress relieving shall not exceed 200 degrees F per hour down to 600 degrees F.

1) In each case, the temperature given is a minimum and where a higher temperature is called for in the welding procedure, the welding procedure shall govern.

b. Perform stress relieving by one of the following methods:

1) Electrical resistance or induction coil heating is the preferred method for field use.

a) Record the temperature by pyrometer from the start of the heating operation until 600 degrees F. is reached during cooling.

2) The gas, natural or liquid petroleum, torch stress relieving procedure may be used only where approved by Owner.

a) Maintain temperature record from the start of the heating operation until 600 degrees F. is reached during cooling.

b) Place two measuring thermocouples 180 degrees apart at the centerline of the weld and two measuring thermocouples each placed 90 degrees away from the centerline thermocouples at a distance from the centerline of the weld equal to three times the wall thickness.

3 Furnace postheat treatment may be employed when desirable to treat several welded or formed assemblies simultaneously.

a) Temperature range, heating conditions, holding time, and cooling conditions shall be as outlined above but shall satisfy the requirements for the thickest section, etc. of the load.

b) When this method is used, adequately support pipe and pipe assemblies to minimize distortion.

10. Socket Welding Joints:

a. Where socket welding valves or fittings are used, space pipe with a minimum of 1/16 inch clearance between the end of the pipe and the socket so that no stresses will be imparted to the weld due to "bottoming" of the pipe in the socket.

b. The fit between the socket and the pipe shall conform to applicable standards for socket weld fittings and in no case shall the inside diameter of the socket exceed the outside diameter of the pipe by more than 0.075 inches.

F. Brazed Joint: Thoroughly clean tube end and inside of fitting with emery cloth, sand cloth, or wire brush. Apply flux to the pre-cleaned surfaces. Install fitting, heat to brazing temperature, and join the metals with brazing alloy. Remove residue.

G. Mechanical Joint: Make up joint in conformance with the manufacturer's printed installation instructions, with particular reference to tightening of bolts.

H. Hydraulic Pressed Joint: Follow manufacturer's printed installation instructions.

I. Dissimilar Pipe Joint:
1. Joining Bell and Spigot and Threaded Pipe: Install a half coupling on the pipe or tube end to form a spigot, and caulk into the cast iron bell.
2. Joining Dissimilar Threaded Piping: Make up connection with a threaded coupling or with companion flanges.
3. Joining Dissimilar Non-Threaded Piping: Make up connection with adapters recommended by the manufacturers of the piping to be joined.
4. Joining Galvanized Steel Pipe and Brass Pipe or Copper Tubing: Make up joint with a dielectric connector.
5. Joining FRP and Threaded Pipe: Make up connection with adapters as recommended by manufacturers of piping being joined.

J. Refrigerant Pipe Joint:
1. Hard Drawn Tubing, Brazed Joint: Make up joint with appropriate type of brazing alloy. Sweep piping interior with dry nitrogen at a rate of 1 to 3 cfm during brazing operation.
2. Hard Drawn Tubing, Soldered Joint: Solder joints with Type 2 solder at valves, controls, and other locations where brazing temperatures could cause damage.

3.08 PIPING PENETRATIONS

A. Sleeve Schedule: Unless otherwise shown, comply with the following schedule for the type of sleeve to be used where piping penetrates wall, floor, or roof construction:

	CONSTRUCTION	SLEEVE TYPE
1.	Frame construction.	None Required
2.	Foundation walls.	A*
3.	Non-waterproof interior walls.	B*
4.	Non-waterproof interior floors on metal decks.	D*
5.	Non-waterproof interior floors not on metal decks.	B*
6.	Floors not on grade having a floor drain.	A
7.	Floors over mechanical equipment, steam service, machine, and boiler rooms.	A
8.	Floors finished or to be finished with latex composition or terrazzo, and on metal decks.	D*
9.	Floors finished or to be finished with latex composition or terrazzo, and not on metal decks.	A
10.	Earth supported concrete floors.	None Required
11.	Exterior concrete slabs on grade.	A

12.	Fixtures with floor outlet waste piping.	None Required
13.	Metal roof decks.	C
14.	Non-metal roof decks.	A
15.	Waterproof floors on metal decks.	D
16.	Waterproof floors not on metal decks.	A
17.	Waterproof walls.	A

*Core drilling is permissible in lieu of sleeves where marked with asterisks.

B. Diameter of Sleeves and Core Drilled Holes:
   1. Unless otherwise specified, size holes thru floors and walls in accordance with the through penetration fire stopping system being used.
   2. Size holes thru exterior walls or waterproofed walls above inside earth or finished floors, and exterior concrete slabs in accordance with the following:
      a. Uninsulated (Bare) Pipe: Inside diameter of sleeve or core drilled hole 1/2 inch greater than outside diameter of pipe, unless otherwise specified.
      b. Insulated Pipe: Inside diameter of sleeve or core drilled hole 1/2 inch greater than outside diameter of insulation, unless otherwise specified.
      c. Mechanical Modular Seals: Size holes in accordance with the manufacturer's recommendations.

C. Length of Sleeves (except as shown otherwise on Drawings):
   1. Walls and Partitions: Equal in length to total finished thickness of wall or partition.
   2. Floors, Finished: Equal in length to total finished thickness of floor and extending 1/2 inch above the finished floor level, except as follows:
      a. In furred spaces at exterior walls, extend sleeve one inch above the finished floor level.
   3. Exterior Concrete Slabs: Equal in length to total thickness of slab and extending 1/2 inch above the concrete slab.
   4. Roofs: Equal in length to the total thickness of roof construction, including insulation and roofing materials, and extending one inch above the finished roof level.

D. Packing of Sleeves and Core Drilled Holes:
   1. Unless otherwise specified, pack sleeves or cored drilled holes in accordance with Section - FIRESTOPPING.
   2. Pack sleeves in exterior walls or waterproofed walls above inside earth or finished floors with oakum to within 1/2 inch of each wall face, and finish both sides with sealant. See Section 079200.
      a. Sealant Types:
         1) Piping Conveying Materials up to 140 degrees F other than Fuel Oil System Piping: Type 1C (one part).
         2) Piping Conveying Materials over 140 degrees F: Type 4.
         3) Fuel Oil System Piping: Type 1C (2 part).
      b. Mechanical modular seals may be used in lieu of packing and sealant for sleeves and core drilled holes.

3. Pack sleeves in exterior concrete slabs with oakum to full depth, and within 1/2 inch of top of sleeve and finish the remainder with sealant. .
   a. Sealant Types:
      1) Piping Conveying Materials up to 140 degrees F other than Fuel Oil System Piping: Type 1C (one part).
      2) Piping Conveying Materials over 140 degrees F: Type 4.
      3) Fuel Oil System Piping: Type 1C (2 part).
   b. Mechanical modular seals may be used in lieu of packing and sealant for sleeves and core drilled holes.

E. Weld metal collars of Type C and D sleeves to the upper surface of the metal deck. Seal voids under the metal collar as recommended by the manufacturer of the metal deck.

3.09 FLOOR, WALL AND CEILING PLATES

A. Install plates for exposed uninsulated piping passing thru floors, walls, ceilings, and exterior concrete slabs as follows:
   1. In Finished Spaces:
      a. Piping 4 Inch Size and Smaller: Solid or split, chrome plated cast brass.
      b. Piping Over 4 Inch Size: Split, chrome plated cast brass.
   2. Unfinished Spaces (Including Exterior Concrete Slabs): Solid, unplated cast iron.
   3. Fasten plates with set screws.
   4. Plates are not required in pipe shafts or furred spaces.

3.10 PIPE AND FITTING SCHEDULE

A. Abbreviations: The following abbreviations are applicable to the Pipe and Fitting Schedule:

BS	Black steel.
CI	Cast iron.
FRP	Fibrous glass reinforced plastic piping.
GE	Grooved end.
GGE	Galvanized grooved end.
GMI	Galvanized malleable iron.
GS	Galvanized steel.
HDPE	High density polyethylene pipe.
MI	Malleable iron.
PE	Polyethylene pipe.
SE	Screwed end.
ST	Steel.
SW	Standard weight.
WE	Weld end.
XH	Extra heavy weight.

B. Where options are given, choose only one option for each piping service. No deviations from selected option will be allowed.

C. Schedule of Pipe and Fittings for the different piping services is as follows:
1. Boiler Blow Off (BO & CBD) 250 psig & less: XH BS pipe with WE XH steel fittings.
2. Boiler Trim 250 psig and less:
   a. 1-1/2 inch and less: XH BS pipe, with SE XH CI fittings, or WE XH ST fittings.
   b. 2 inch and up: XH BS pipe with WE XH ST fittings.
3. Cold Water (CW) 125 psig and less:
   a. 3 inch and less: Type L hard drawn copper tubing with wrot copper or cast copper alloy solder fittings, and Type 3 solder, or hydraulic press joints.
4. Domestic Hot Water and Circulating (DHW & DHWC) 125 psig and less:
   a. 3 inch and less: Type L hard drawn copper tubing, with wrot copper or cast copper alloy solder fittings, and Type 3 solder, or hydraulic press joints.
   b. 4 inch and up: Type L hard drawn copper tubing, with GE fittings.
5. Piping for No. 2 Fuel Oil:
   a. Vent Piping:
      1) Above Ground: SW BS pipe, with SE 150 lb MI fittings, and fuel resistant thread sealant.
   b. Fuel Oil Product Piping (FOS and FOR):
      1) Inside Building (125 psig and less):
         a) 3/4 Inch and Less: Type K soft annealed copper tubing with automotive tube type flared fittings.
         b) 1 Inch and Up: SW BS pipe, with SE 150 lb MI fittings and fuel resistant thread sealant, or WE SW ST fittings.
      2) Inside Building (126 to 300 psig):
         a) 1-1/2 inch and Less: XH BS pipe, with SE 300 lb. MI fittings and fuel resistant thread sealant, or WE XH ST fittings.
         b) 2 inch and Up: XH BS pipe with WE XH ST fittings.
6. Hot Water Supply and Return (HWS & HWR) 125 psig and less:
   a. 3 inch and less: SW BS pipe with SE SW CI fittings, or Type L hard drawn copper tubing with wrot copper or cast copper alloy solder fittings and Type 3 solder, or hydraulic press joints.
   b. 4 inch Size: SW BS pipe, with SE SW CI fittings, or WE SW ST fittings, or GE fittings.
   c. 5 inch and up: SW BS pipe, with WE SW ST fittings, or GE fittings.
7. Instrument (Control) Air (IA) 175 psig and Less: Type L hard drawn copper tubing, with refrigerant tube type flared fittings; or wrot copper or cast copper alloy solder fittings, and Type 3 solder.
8. Natural Gas (G) including associated vent, 125 psig and less:
   a. 1-1/2 inch and Less: SW BS pipe, with SE 150 lb. MI fittings, or WE SW ST fittings.
   b. 2 inch and up: SW BS pipe with WE SW ST fittings.

9. Drain Piping:
   a. Condensate Drain Piping: Type M hard drawn copper tubing with wrot copper or cast copper alloy solder fittings, and Type 3 solder.
   b. Drain Piping other than Condensate: SW BS pipe, with SE SW CI fittings, or WE SW ST fittings.

10. Refrigerants (RS, RL, HG & RD) 350 psig and less:
   a. All Sizes: Type ACR hard drawn copper tubing with wrot copper fittings, and brazing alloy, unless otherwise specified.

END OF SECTION

SECTION 232001

STRAINERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets, specifications, and installation instructions for each type strainer.

PART 2 PRODUCTS

2.01 STRAINERS

A. Body:
   1. Type:
      a. Y.
      b. Simplex basket.
      c. Duplex basket.
   2. Materials: Any of the following:
      a. ASTM A 126 Grade B cast iron.
      b. ASTM A 216 WCB cast steel.
      c. ASTM B 62 cast bronze may be used in systems operating at a maximum of 125 psig steam or 175 psig water.

B. Pressure Ratings:
   1. 125 psig WSP, 175 psig WOG.

C. End Connections:
   1. Threaded ends for use in threaded piping 3 inch size and smaller.
   2. Flanged ends in piping 4 inch size and larger.
   3. Solder ends or threaded ends with solder adapters in copper tubing.

D. Screens/Baskets: Fabricate from 18-8 stainless steel or monel metal.
   1. Perforation Sizes:
      a. Water and Condensate Return Piping:
         1) 3 inch and Smaller: 1/16 inch perforations.
         2) Over 3 inch: 1/8 inch perforations.
   2. Minimum Free Screen/Basket Area: Double the internal cross sectional area of the inlet pipe.

E. Caps and Covers:
   1. Strainers 3 inch size and Smaller: Any of the following:
      a. Faced and gasketed screen retaining cap.
      b. Straight thread bushing with a blow-out proof gasket.
      c. Internally milled tapered gasketed bushing.
   2. Strainers 4 inch size and Larger: Bolted gasketed screen cover.
   3. Gasket Material: Graphited non-asbestos mineral or ceramic fiber.

PART 3 EXECUTION

3.01 INSTALLATION

A. Strainers in Water Piping (1-1/2 inch size and larger): Provide with a full size drain valve with integral hose bibb connection, and chained cap, rated for 450 degrees F.

B. Install a short nipple and pipe cap in the blow-off outlets of strainers not specified or shown to have a blow-off valve or drain.

C. Install strainers, indicated or specified to be installed in the suction or discharge piping connections to pumps as shown on the drawings.

END OF SECTION

SECTION 232002

BACKFLOW PREVENTERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data:
   1. Manufacturer's catalog sheets, specifications, and installation instructions for each type backflow preventer and test kit.

1.02 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with the State Department of Health Sanitary Code for Cross Connection Control, and the other standards listed in Part 2 of this section.
   2. Where conflicts occur between the referenced standards, the most stringent requirements shall apply.

1.03 MAINTENANCE

A. Special Tools (as furnished or recommended by the backflow preventer manufacturer). Deliver to the Owner:
   1. Test Kit A: Portable, packaged in a substantially built, compartmented carrying case, containing hose, gauge, and fittings required for testing backflow preventer for proper operation, and printed procedure for conducting test.

PART 2 PRODUCTS

2.01 BACKFLOW PREVENTERS

A. Type A: Reduced Pressure Zone Principle device, with atmospheric vent, conforming to ASSE Standard 1013, AWWA C-511, USC specifications manual for Cross Connection Control, and listed as acceptable in the State Department of Health, Environmental Health Manual.
   1. Performance: 150 psig, and 130 degrees F maximum working conditions.
   2. Assembly: Strainer and gate valve on inlet side, gate valve on outlet side, and four test cocks, all as furnished or recommended by the backflow preventer manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions.

B. Atmospheric Vent: Pipe vent to spill over closest point of drainage, as directed, maintaining a minimum 12 inch air gap above the drain.
   1. Install air gap fitting when shown, or if atmospheric vent must be connected to drainage line.

3.02 FIELD QUALITY CONTROL

A. Operation Test: Test kit as specified under Part 1 of this section may be used. Conduct test in the presence of the Owner.
   1. Type A Backflow Preventer: Test the device with the test kit in accordance with the manufacturer's test procedures.
   2. Type B Backflow Preventer: Test the device with the test kit in accordance with the manufacturer's test procedure.
   3. Type C Backflow Preventer: Test at 125 psi hydrostatic pressure, and hold for four hours; check for leaking.

B. Re-testing: Repair or replace any device failing the operation test, and repeat the test.

END OF SECTION

SECTION 232003

THERMOMETERS AND GAUGES

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets, specifications and installation instructions for each item specified.

1.02 QUALITY ASSURANCE

A. Regulatory Requirements: Where Federal, NSF, ASME or other standards are indicated or required, products shall meet or exceed the standards established for material, quality, manufacture and performance.

PART 2 PRODUCTS

2.01 MANUFACTURERS/COMPANIES

A. Dresser Instruments.

B. Marsh Bellofram.

C. Moeller Instrument Co.

D. Taylor Precision Products.

E. H.O. Trerice Co.

F. Weksler Instruments Corp.

2.02 THERMOMETERS

A. General Design Features:
   1. Scale Ranges: 1-1/2 times actual working temperature required for the particular application, as approved.
      a. Maximum of two degrees between graduations and ten degrees between numerals.
      b. When scale ranges are in excess of 100 degrees, maximum range between numerals may be 20 degrees, or as otherwise approved for the particular application.
   2. Direct Reading Thermometers: Bimetallic actuated, dial type, straight pattern, angle pattern, or adjustable angle pattern as required.
   3. Remote Reading Thermometers: Vapor tension actuated, or gas actuated type, with extension capillary tube of length as required for the particular application.
      a. Case type as required for the particular mounting application.

4. Thermometers for Sensing Liquid Temperature: Furnish with separable sockets.
   a. Sockets for Use in Insulated Piping, Insulated Tanks or Similar Equipment: Extension lagging neck type, of length as required to compensate for insulation thickness, and proper immersion..

2.03 THERMOMETERS FOR MEASURING LIQUID TEMPERATURE

A. Bimetallic Actuated Thermometers: Comply with ASME B40.3, Accuracy Grade A.
   1. Construction: Type 304 stainless steel, all welded construction, with clear acrylic plastic or shatterproof glass crystal.
   2. Dial: White enamel background with bold black figures and graduations.
   3. Head Size:
      a. Installation in Piping: 3inch diameter.
      b. Installation in Tanks and Similar Equipment: 5 inch diameter.
   3. Stem: Length as required for proper immersion, and to compensate for insulation thickness, with threaded connection for socket.
   4. External Calibration Device.
   5. Separable Socket:
      a. Water Service: Brass or bronze.

B. Vapor Tension or Gas Actuated Capillary Thermometers: Adjustable type, with micrometer type pointer or external calibration device, of design and materials as follows:
   1. Case and Ring: Stainless steel or non-ferrous material as approved, with clear acrylic or shatterproof glass lens. Provide case of type as required for the particular mounting application. Case adjustable, allowing rotation of 360°, and stem adjustment of at least 180°. Provide set screw for locking case in desired position.
   2. Movement: Brass with bronze bearings.
   3. Dial: White enamel background, with bold black graduations, numerals and pointer; 3-1/2 inch diameter.
   4. Capillary: Stainless steel.
   5. Bulb: Copper with union well connection.
   6. Separable Socket:
      a. Water Service: Brass or bronze.

2.04 THERMOMETERS FOR MEASURING AIR TEMPERATURE

A. Bimetallic Actuated Thermometers: Comply with ASME B40.3, Accuracy Grade A.
   1. Construction: Type 304 stainless steel, all welded construction, with clear acrylic plastic or shatterproof glass crystal.
   2. Dial: White enamel background with bold black figures and graduations.
   3. Head Size: 5 inch diameter.
   4. Stem: Length as required for average duct cross sectional sensing of air temperature, and to compensate for insulation thickness.
   5. External calibration device.

B. Vapor Tension or Gas Actuated Capillary Thermometers: Adjustable 3-1/2inch dial type, with micrometer type pointer or external calibration device, of design and materials as follows:
   1. Case and Ring: Stainless steel or non-ferrous material as approved, with clear acrylic or shatterproof glass lens. Case adjustable allowing rotation

of 360°, and stem adjustment of at least 180°. Provide set screw for locking case in desired position.
2. Movement: Brass with bronze bearings.
3. Dial: White enamel background, with bold black graduations, numerals and pointer; 3-1/2 inch diameter.
4. Capillary: Stainless steel.
5. Bulb: Copper air sensing bulb with split flange mounting device.

2.05 PRESSURE AND COMPOUND GAUGES

A. Type: Adjustable dial type with micrometer type pointer, or external calibration device, bronze bourdon tube, and bronze bushed rotary movement.

B. Dial: White enameled background, and bold black graduations, numerals and pointer; 3-1/2 inch diameter.
1. Scale Range:
a. Standard Gauges: Double normal operating pressure.
b. Compound Gauges: From 30" Hg vacuum to double normal operating pressure.

C. Case: Cast aluminum, brass, or black finished phenolic.

D. Accuracy: Guaranteed of within 1 percent in middle third of dial range.

2.06 PRESSURE SNUBBERS AND IMPULSE DAMPERS

A. Pressure Snubbers: H.O. Trerice Co. Model 872.

PART 3 EXECUTION

3.01 INSTALLATION

A. Thermometers:
1. Install in accordance with the manufacturer's printed installation instructions.
2. Install direct reading thermometers, when the application requires installation 6 feet or less above the floor or bottom of space in which installed, and remote reading type when the installation is over 6 feet.

B. Pressure and Vacuum Gauges:
1. Install in accordance with the manufacturer's printed installation instructions.
2. For Measuring Liquid Pressure: Install gauges complete with stop cocks and drain cocks.

C. Pressure Snubbers and Impulse Dampers:
1. Install pressure snubbers in the piping connections to gauges installed in suction and discharge piping connections to close coupled and base mounted circulating pumps driven by motors under 10 HP.

END OF SECTION

SECTION 232004

AIR GAP FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. Comply with the applicable requirements of ASME A112.36.2M - Cleanouts, and ASME A112.1.2 - Drainage Funnels and Air Gaps.

1.02 SUBMITTALS

A. Product Data: Catalog sheets, specifications, and installation instructions for each item specified except fasteners.

PART 2 PRODUCTS

2.01 AIR GAP FITTING

A. Coated cast iron body with air gaps, set screw or threaded inlet, and outlet connection to match piping option selected.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

END OF SECTION

SECTION 232006

HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data: Catalog sheets, specifications, and installation instructions for each item specified.

B. Contract Closeout Submittals:
   1. Operation and Maintenance Data: Deliver 2 copies, covering the installed products, to the Owner.

PART 2 PRODUCTS

2.01 AIR CONTROL FITTINGS

A. Top Outlet Boiler Fittings: Cast iron body and copper dip tube.
   1. Maximum Working Pressure: 175 psig.
   2. Maximum Operating Temperature: 250 degrees F.

B. In-Line Type Tank Fitting (Expansion Tanks 100 Gallons and Larger): Cast iron body with bolted and gasketed cast iron cover, internal copper U tube, stainless steel ball check, and separate dip type air vent fitting.
   1. Maximum Working Pressure: 125 psig.
   2. Maximum Operating Temperature: 240 degrees F.

2.05 AIR VENTS

A. Type A: Manual Coin Operated Vent: ITT Bell and Gossett Model 4V.
   1. Construction: Brass.
   2. Maximum Working Pressure: 150 psig.
   3. Maximum Operating Temperature: 212 degrees F.

B. Type D: Automatic High Capacity Float Operated Vent; Sarco Model 13W, or ITT Bell and Gossett Model 107.
   1. Construction: Cast iron body with bolted and gasketed cover, and stainless steel float mechanism, and 3/8 inch drain connection.
   2. Maximum Working Pressure: 150 psig.
   3. Maximum Operating Temperature: 250 degrees F.

2.06 SUCTION DIFFUSER

A. Type: Angle pattern flow straightening fitting as manufactured by Bell & Gossett.

B. Features:
1. Body and Cover: Cast iron.
2. Straightening Vanes: Full length, steel.
3. Diffuser Strainer Orifice Cylinder: Steel with 3/16 inch perforations.
4. Start Up Strainer: 16 mesh bronze.
5. O-Ring Seal: EPDM.
6. End Connections: Threaded or flanges as required.
7. Adjustable support foot.
8. Replaceable internal components.
9. Maximum Working Pressure: 175 psig.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the Work of this Section in accordance with the manufacturer's printed installation instructions.

END OF SECTION

SECTION 233113

METAL DUCTWORK

PART 1 GENERAL

1.01 REFERENCES

A. American Conference of Governmental Industrial Hygienists (ACGIH).

B. National Fire Protection Association (NFPA).

C. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).

1.02 PERFORMANCE REQUIREMENTS

A. Design ductwork and supports to withstand all seismic loads. Refer to seismic loading criteria on the Contract Drawings.

B. Seismic Performance: Design and install ductwork to assure continued performance of their intended function when subjected to the specified seismic forces.

C. Seismic Performance: Design and install ductwork to assure that they remain in place with no separation of any parts when subjected to the specified seismic forces.

D. The design of the ductwork and supports shall be performed by a professional engineer experienced in the seismic design ofductwork.

1.03 SUBMITTALS

A. Shop Drawings:
1. Layouts for areas in which it may be necessary to deviate substantially from layout shown on the Drawings. Show major relocation of ductwork and major changes in size of ducts. Minor transitions in ductwork. if required due to job conditions. need not be submitted as long as the duct area is maintained.
2. Layout and fabrication details for cooking equipment exhaust ductwork.
3. Layouts of mechanical equipment rooms and penthouses.
4. Details of intermediate structural steel members required to span main structural steel for the support of ductwork.
5. Method of attachment of duct hangers to building construction.
6. Coordinate shop drawings with related contracts prior to submission.
7. Drawings identifying seismic locations with corresponding details of pre-approved seismic restraints, with seismic loads and seismic force level (Fp) calculations; pre-engineered and stamped by a NYS Licensed Professional Engineer experienced in seismic restraint systems.

B. Product Data: Material, gage, type of joints, sealing materials, and reinforcing for each duct size range, including sketches or SMACNA plate numbers for joints, method of fabrication and reinforcing. Include ACGIH figure numbers for hoods if applicable.

C. Quality Control Submittals:
1. Seismic Restraint Manufacturer's Qualifications Data:
   a. Name of firm producing the seismic restraints, business address and telephone number.
   b. Period of time firm has been in the business producing seismic restraints, and names and addresses of 3 similar projects that the manufacturer has produced seismic restraints for during the past 5 years.
2. Company Field Advisor Data:
   a. Name, business address and telephone number of Company Field Advisor secured for the required services.

b. Certified statement from the Company listing the qualifications of the Company Field Advisor.
c. Services and each product for which authorization is given by the Company, listed specifically for this project.

3. Manufacturer's Certificate of Compliance for Seismic Restraints: Certificate from seismic restraint manufacturer stating that the restraint and its mounting system or anchorage has been tested or analyzed and meets the requirements of NYS Building Code (Section 1621).

1.04 QUALITY ASSURANCE

A. SMACNA: Gages of materials, fabrication, reinforcement, sealing requirements, installation, and method of supporting ductwork shall be in accordance with the following SMACNA manuals, unless otherwise shown or specified:
1. HVAC Duct Construction Standards.
2. Round Industrial Duct Construction Standard.
3. Rectangular Industrial Duct Construction Standard.
4. Seismic Restraint Manual Guidelines for Mechanical Systems.

B. Unless otherwise shown or specified, follow the Hood Design Data, and Construction Guidelines for Local Exhaust Systems from the ACGIH Industrial Ventilation Manual.

C. Conform to the applicable requirements of NFPA 90A, 90B, 91, 96, and 101.

D. Regulatory Requirements:
1. Seismic components shall be UL listed or California OSHPD (Office of Statewide Health Planning and Development) approved.
2. Seismic restraints for ductwork shall conform with Appendix B of the SMACNA Seismic Restraint Manual Guidelines for Mechanical systems.

E. Seismic Restraint Manufacturer's Qualifications: The firm producing the seismic restraints shall be experienced in seismic restraint work and shall have produced seismic restraints on minimum of 3 similar projects over the past 5 years.

F. Company Field Advisor: Secure the services of a Company Field Advisor from seismic restraint manufacturer for the following:
1. Render advice regarding installation and final adjustment of seismic restraint system.
2. Render advice on the suitability of each seismic restraint for its particular application.
3. Inspect completed installation of seismic restraint system and certify with an affidavit that the system is installed in accordance with the Contract Documents and is operating properly.
4. Train facility maintenance personnel on the installation of seismic restraint system and routine maintenance of the system.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sheet Metal:
1. Aluminum: ASTM B-209, Alloy 3003, Temper H-14.
2. Copper: ASTM B-370.
3. Galvanized Steel: ASTM A653, Class LFQ (lock forming quality), coating designation G-90.
4. Monel: ASTM B-127.
5. Stainless Steel: AISI Types 302, 304 and 316, as specified.

B. Duct Hangers:
1. Strap Hangers: Same material as ducts, except that hangers for stainless steel ducts in unfinished spaces may be galvanized steel.
2. Rod Type Hangers: Mild low carbon steel, unless otherwise specified; fully threaded or threaded each end, with 2 removable nuts each end for positioning and locking rod in place. Unless stainless steel, galvanized or cadmium plated; shop coat with metal primer.

C. Miscellaneous Fasteners and Upper Hanger Attachments:
1. Sheet Metal Screws, Machine Bolts and Nuts: Same material as duct, unless otherwise specified.
2. Concrete Inserts: Steel or malleable iron, galvanized; continuously slotted or individual inserts conforming with MSS SP-58, Types 18 & 19, Class A-B.
3. C Clamps: Fee & Mason Co.'s 255L with locking nut, and 255S with retaining strap.
4. Metal Deck Ceiling Bolts: B-Line Systems, Inc.'s Fig. B3019.
5. Welding Studs: Erico Fastening Systems, capacitor discharge, low carbon steel, copper flashed.
6. Structural (carbon) Steel Shapes and Steel Plates: ASTM A36, shop primed.
7. Stainless Steel Shapes and Plates: ASTM A276 and ASTM A666.
8. Machine Bolt Expansion Anchors:
   a. Non-caulking single unit type: FS FF-S-325, Group II, Type 2, Class 2, Style 1.
   b. Non-caulking double unit type: FS FF-S-325, Group II, Type 2, Class 2, Style 2.
   c. Self-drilling type: FS FF-S-325, Group III, Types 1 and 2.

2.02 FABRICATION - GENERAL

A. Fabricate ductwork from galvanized sheet metal, except as follows:
1. Fabricate the following ductwork from aluminum:
   a. Inlet and discharge ductwork connected to cooling towers and evaporative condensers.
   b. Exhaust ductwork from shower, locker, can washing and steam service rooms, and swimming pool areas.
2. Fabricate the following ductwork from stainless steel:
   a. Supply, return, and recirculated air ductwork connected to inlet or outlet devices installed in surgical operating, surgical scrub-up, surgical recovery and surgical work rooms. Use AISI Type 302 or 304 stainless steel.
   b. Exhaust ductwork connected to cooking equipment, dishwashing, and other scullery equipment hoods. Install stainless steel from the individual hood to its respective fan and from the fan to the point of discharge to the outside air. Use AISI Type 302 or 304 stainless steel.
   c. Exhaust ductwork connected to laboratory exhaust fume hoods. Install stainless steel from the individual hood to its respective fan and from the fan to the point of discharge to the outside air. Use AISI Type 316 stainless steel.
   d. Use stainless steel with a No. 4 finish where installed exposed in finished rooms and No. 2B finish in other locations. Use stainless steel fasteners for ductwork installed exposed in finished rooms and where fastener penetrates duct. Galvanized fasteners may be used in unfinished spaces for non-penetrating service.

B. Dissimilar Metals: Separate dissimilar metals used for ductwork with 12 oz vinyl coated woven fiberglass duct connector fabric, such as Duro Dyne's Glasseal. No separation is required between screws or rivets and the materials in which they are inserted.

2.03 FABRICATION OF STAINLESS STEEL DUCTS

A. Use minimum No. 18 gage for exhaust ducts connected to cooking equipment hoods. Use minimum No. 20 gage for exhaust ducts connected to other hoods.

B. Use stainless steel reinforcing members for ducts in finished spaces and galvanized steel in unfinished spaces.

C. Longitudinal Seams For Dishwashing, and Other Scullery Equipment Exhaust Ducts: Form double corner seams, or Pittsburgh lock seams.
1. Fabricate elbows and transitions with Pittsburgh lock seams.
2. Fabricate double compounded elbows and other complex fittings with double corner seams.

3. Locate seams in horizontal ducts at top corners of ducts, unless otherwise approved in writing.
4. Locate seams in vertical ducts at rear corners of ducts.

2.04 REGISTERS AND GRILLES INSTALLED IN EXPOSED DUCTWORK

A. Frames are not required for registers and grilles installed directly in uninsulated exposed ductwork.

B. Cut openings in ducts, forming a double thickness of metal, to attach registers or grilles with sheet metal screws. Bend back edges of openings into duct, on all 4 sides, a minimum of 1 inch to provide the thickness of metal stated above. Provide felt or sponge rubber gasketing, all 4 sides of duct openings, for supply grilles and supply registers.

2.05 AIR DIFFUSERS INSTALLED IN EXPOSED DUCTWORK

A. Frames are not required for diffusers installed directly in uninsulated exposed ductwork.

B. Cut and form openings in ducts, to accommodate the specified volume control damper and adjustable equalizing grid assembly. Reinforce openings as required and approved. Provide felt or sponge rubber gasketing, around duct opening, for supply diffuser assemblies.

2.06 VIBRATION ISOLATION FOR DUCTWORK

A. Type: Combination rubber and spring type designed for insertion in a split hanger rod for isolating ductwork from the overhead construction.
   1. Approved isolators: Amber Booth Type BSSR, Korfund Type VX, Mason Industries, Type DNHS, Vibration Eliminator Co. Type SNRC and Vibration Mountings and Controls Type RSH.

2.07 SEISMIC RESTRAINT SYSTEM FOR DUCTWORK

A. General:
   1. Coordinate all structural attachments with the Director's Representative.
   2. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
   3. Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
   4. Design seismic restraint devices to accept without failure the forces calculated per the applicable building code and as specified.
   5. Construct seismic supports so that support engagement is maintained.
   6. Stamp seismic supports with manufacturer's name and part number for identification.
   7. Design seismic supports specifically for mitigation of seismic force loads.
   8. Design the stiffness of seismic restraints for mechanical equipment so that the load path for the restraint performs its intended function.
   9. Where possible, utilize components designed with tamper resistant break-off bolt heads or break-off nuts to assure visual verification of proper installation.
   10. Attachment components shall be UL Listed catalog components with published loads designed specifically for seismic application.

B. Type: Pre-engineered seismic restraint system designed to support and restrain ductwork to meet applicable lateral force requirements.

C. Acceptable Manufacturers:
   1. B-Line.
   2. Mason Industries.
   3. TOLCO Inc.

D. Strut/Channel Bracing: 12 gauge solid steel with no holes. 1-5/8 inches wide x 1-5/8 inches deep of single lengths or stitch-welded back-to-back configurations.

E. Pipe Bracing: Schedule 40 steel pipe.

F. Cable Bracing: Pre-stretched galvanized aircraft cable 7 x 19 strand core.

G. Rigid Seismic Braces For Single Hung Duct Systems: A12 strut channel or schedule 40 steel pipe
1. Maximum Brace Length: 13 feet 1 inches.

H. Rigid Seismic Braces For Trapeze Supported Duct Systems: A12 strut channel or schedule 40 steel pipe
1. Maximum Brace Length: 13 feet 1 inches.

I. Cable Seismic Braces For Single Hung Duct Systems: Pre-stretched aircraft cable 7 x 19 core.

J. Cable Seismic Braces For Trapeze Supported Duct Systems: Pre-stretched aircraft cable 7 x 19 core.

K. Structural Attachments for Rigid and Cable Seismic Braces for Single Hung and Trapeze Supported Duct Systems:
1. Structural attachments shall be positive.
2. Do not make structural attachments to the bottom of a bar joist.
3. Supplemental steel shall be installed for all pre-cast decks less than 4 inches thick
4. Do not use concrete inserts or continuous concrete insert strut to attach brace.
5. Wedge type anchors are permitted. The size and embedment depth will be determined by the manufacturer, and as approved..

L. Vertical Brace Component (up-thrust protection):
1. Reinforce Vertical Hanger Rod when lengths exceed the following
a. 3/8 inch dia rod: 19 inches.
b. 1/2 inch dia rod: 25 inches.
c. 5/8 inch dia rod: 31 inches.
d. 7/8 inch dia rod: 43 inches.
e. 1 inch dia rod: 50 inches.
f. 1-1/4 inch dia rod: 62 inches.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

A. Install ductwork to allow maximum headroom. Properly seam. brace. stiffen. support and render ducts mechanically airtight. Adjust ducts to suit job conditions. Dimensions may be changed as approved. if cross sectional area is maintained.

B. Pitch horizontal ducts connected to hoods downward toward hood not less than 1 inch in 10 feet.

C. Provide necessary transformation pieces. and flexible fabric connections for ductwork connected to air handling equipment or air inlet and outlet devices.

3.02 SEALING SEAMS, JOINTS, AND PENETRATIONS

A. Seal ductwork in accordance with the SMACNA Manual except for the following:
1. Ductwork Specified to be Insulated: Conform with Seal Class A for all pressure classes.
2. Cooking Equipment Exhaust Ductwork: Conform with NFPA 96.
3. Horizontal Ductwork for Dishwashing, and Other Scullery Equipment Exhausts:
a. Continuously solder transverse joints vaportite along bottom, and up both sides 2 inches minimum.
b. Continuously solder longitudinal seams vaportite if seams are approved to be located at bottom of duct.

B. Duct Sealants: Water based. non-fibrated: Foster 32-19. Childers CP-146. Duro Dyne SAS.

3.03 HANGERS FOR DUCTS, UNDER 2 INCHES W.G.

A. Install hangers for ducts as specified in the SMACNA Manual, with the following exceptions:

1. Rectangular ducts up to 42 inches wide, not having welded or soldered seams, and supported from overhead construction; extend strap hangers down over each side of the duct and turn under bottom of duct a minimum of 2 inches. Secure hanger to duct with 3 full thread sheet metal screws, one in the bottom and 2 in the side of the duct.
2. Rectangular ducts 43 inches wide and over, and all sizes of duct with welded or soldered seams, and supported from overhead construction; use trapeze hangers.
3. Prime coat plain steel rods threaded at the site immediately after installation with metal primer.

3.04 HANGERS FOR DUCTS, 2 INCHES W.G. AND OVER

A. Install hangers for ducts as specified in the SMACNA Manual, with the following exceptions:
1. Support rectangular ducts, regardless of size, by means of trapeze hangers, framed all four sides. Provide minimum 1 x 1 x 1/8 inch angle iron framing for duct having a maximum side dimension up to and including 36 inches in size. Install framing snug to all four sides of duct.

3.05 UPPER HANGER ATTACHMENTS

A. General:
1. Secure upper hanger attachments to structural steel or steel bar joists wherever possible.
2. Do not use drive-on beam clamps, flat bars or bent rods, as upper hanger attachments.
3. Do not attach hangers to steel decks which are not to receive concrete fill.
4. Do not attach hangers to precast concrete planks less than 2-3/4 inches thick.
5. Avoid damage to reinforcing members in concrete construction.
6. Metallic fasteners installed with electrically operated or powder driven tools may be used as upper hanger attachments. in accordance with the SMACNA Manual, with the following exceptions:
   a. Do not use powder driven drive pins or expansion nails.
   b. Do not attach powder driven or welded studs to structural steel less than 3/16 inch thick.
   c. Do not support a load, in excess of 250 lbs from any single welded or powder driven stud.
   d. Do not use powder driven fasteners in precast concrete.

B. Attachment to Steel Frame Construction: Provide intermediate structural steel members where required by ductwork support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of 5.
1. Secure upper hanger attachments to steel bar joists at panel points of joists.
2. Do not drill holes in main structural steel members.

C. Attachment to Concrete Filled Steel Decks:
1. New Construction: Install metal deck ceiling bolts.
2. Existing Construction: Install welding studs (except at roof decks).
3. Do not attach hangers to decks less than 2-1/2 inches thick.

D. Attachment to Existing Cast-In Place Concrete:
1. Secure hangers to overhead construction with self drilling type expansion anchors and machine bolts.
2. Secure hanger attachments required to be supported from wall or floor construction with single unit expansion anchors or self drilling type expansion anchors and machine bolts.

E. Attachment to Cored Precast Concrete Decks (Flexicore, Dox Plank, Spancrete, etc.): Toggle bolts may be installed in cells for the support of ducts up to a maximum of 60 inches in width.

F. Attachment to Hollow Block or Hollow Tile Filled Concrete Decks:
1. New Construction: Omit block or tile and pour solid concrete with cast-in-place inserts.
2. Existing Construction: Break out block or tile to access. and install machine bolt anchors at highest practical point on side of web.

G. Attachment to Waffle Type Concrete Decks:
1. New Construction: Install cast-in-place inserts.

2. Existing Construction: Install machine bolt expansion anchors at highest practical point on side of web.

H. Attachments to Precast Concrete Tee Construction:
1. Secure hangers to tees by any of the following methods:
   a. Tee hanger inserts between adjacent flanges.
   b. Install double unit expansion anchors and machine bolts at highest practical point on side of web.

I. Attachment to Wood Construction:
1. Secure strap hangers to the sides of wood beams with one No. 18 x 1-1/2 inch long (minimum) wood screws or 2 No. 16 x 1-1/2 inch long (minimum) drive screws. Do not hammer in wood screws.
2. Secure rod hangers to angle iron clip angles, bolted or screwed to the sides of the wood beams with 3/8 inch bolts or 3/8 inch lag screws. Install hanger rods with a threaded end through a hole in the angle, secured with a double nut, one above and one below the angle. Do not use lag screws in wood beams, having a nominal face width under 2 inches. Install bolts or lag screws in the side of beams at mid-point or above.
3. Pre-drill holes for lag screws 1/8 inch in diameter less than the root diameter of the lag screw thread.
4. Where wood trusses are approved to support ductwork, hangers may be attached only to the bottom chord. Method of attachment must be specifically approved.
5. Do not secure hanger attachments to nailing strips resting on top of steel beams.

3.06 DUCT RISER SUPPORTS, UNDER 2 INCHES W.G.

A. Support vertical round ducts by means of double-ended split steel pipe riser clamps bearing on floor slabs or adjacent structural members. at every other floor through which the riser passes.

B. Unless otherwise specified or shown on the drawings, support vertical rectangular ducts by means of two steel angles, secured to duct and resting on floor slab or adjacent structural steel member, at every other floor through which the duct passes. Size supports as follows:

MAX. SIDE DIMENSION (inches)	SUPPORT ANGLE (inches)	SECURE TO DUCT WITH	MIN BEARING AT EACH END (inches)
36	1 x 1 x 1/8	Screws	2
48	1-1/2 x 1-1/2 x 1/8	Bolts	3
60	2 x 2 x 1/8	Bolts	3
61 - up	2-1/2 x 2-1/2 x 3/16	Bolts	4

3.07 DUCT RISER SUPPORTS, 2 INCHES W.G. AND OVER

A. Support vertical round ducts by means of double-ended split steel pipe riser clamps welded to the ducts and bearing on floor slabs or adjacent structural members, at every other floor through which the riser passes.

B. Support vertical rectangular ducts by means of two steel angles or channels, anchor bolted to floor slab or adjacent structural member at every other floor through which the riser passes. Secure steel angles or channels to a transverse joint by means of 3/8 inch bolts, or by welding. Size supports as follows:

MAXIMUM SIDE DIMENSION (inches)	SUPPORT ANGLE (inches)	SUPPORT CHANNEL (inches)	MINIMUM BEARING AT EACH END (inches)
36	1 x 1 x 1/8	1 x 1/2 x 1/8	2
48	1-1/2 x 1-1/2 x 1/8	1-1/2 x 3/4 x 1/8	3
60	2 x 2 x 1/8	2 x 1 x 1/8	3
61 - up	2-1/2 x 2-1/2 x 3/16	2 x 1 x 3/16	4

MAXIMUM SIDE DIMENSION (inches)	SUPPORT ANGLE (inches)	SUPPORT CHANNEL (inches)	MINIMUM BEARING AT EACH END (inches)

3.08 VIBRATION ISOLATION FOR DUCTWORK

A. Install vibration isolation in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. High Velocity Ductwork Installed within Mechanical Equipment, Machine and Penthouse Mechanical Equipment Rooms: Provide combination rubber and spring type isolators, designed for insertion in a split hanger rod for overhead supported ductwork and double rubber-in-shear isolators for floor supported ductwork. Provide isolators designed for a static deflection of 1/2 inch.

3.09 SEISMIC RESTRAINT SYSTEM FOR DUCTWORK

A. General:
1. Do not use powder-actuated fasteners for seismic restraint anchorage in tension applications.
2. Install seismic restraints in accordance with seismic restraint manufacturer's printed installation instructions and guidelines unless otherwise specified.
3. Laterally support vertical risers with riser clamps at each floor unless otherwise specified.
4. When systems cross building seismic separation points, pass between buildings, or are supported from different portions of the building, install to allow differential support displacements without damaging the duct, equipment or support connections.
5. Do not brace seismic bracing to different parts of the building that may respond differently during seismic activity.
6. Provide adequately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire stopping in fire-rated walls.
7. Seismic restraint installations shall not cause any modifications in the positioning of equipment or piping resulting in stresses or misalignment.
8. No rigid connections between equipment, piping, duct, or conduit shall be made to the building structure that degrades the noise and vibration-isolation system specified.
9. Bracing attached to structural members may present additional stresses. Submit loads to the Director's Representative for approval.
10. Provide vertical stiffening components to support rods when necessary to accept compressive loads. Welding of components to vertical support rods is not acceptable.
11. Notify Director's Representative if any discrepancies between the specifications and field conditions prior to installation.

B. Seismic Restraints for Ductwork:
1. Provide seismic restraint of ductwork systems in accordance with the latest edition of the seismic Restraint Manual.
2. Provide seismic restraint on all ductwork systems:
3. Ductwork not requiring Seismic restraints include the following:
   a. Ducts suspended by individual hangers 12 inches or less in length from the top of the duct to supporting structure, providing the hangers are detailed to avoid significant bending of the hangers and their connections.
   b. Ducts having a cross-sectional area of less than 6 square feet.
4. Provide longitudinal and transverse seismic restraints in accordance with the Contract Drawings, with members sized in accordance with tables for seismic Level __, as defined in the latest edition of SMACNA Seismic Restraint Manual.
5. Brace trapeze assemblies supporting ducts considering the total weight of the duct on the trapeze.
6. Provide transverse bracing at 30 ft. maximum spacing for duct.
7. Provide longitudinal bracing at 60 ft. maximum spacing for duct.
   a. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section of the same size perpendicular to it if the restraint is

installed within 24-inches of the elbow centerline or tee or combined stresses are within allowable limits at longer distances.

b. Brace duct running perpendicular to or over the top of fire suppression and or hazardous piping as required if its failure can cause damage to those systems.

8. Equipment installed in-line with the duct system (ex. Fans, humidifiers, etc) with an operating weight greater than 75 lbs. shall be supported and laterally braced independently of the duct system and shall meet the force requirements of Section 1621.1.4 of Building Code of New York State.
9. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the seismic restraint systems.
10. Friction clips shall not be used for anchorage attachments.
11. Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction and vertical restraints shall be provided to resist overturning.
12. Brace vibration isolated duct with cables to allow flexibility.

END OF SECTION

SECTION 234100

AIR FILTERS

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Air Handling Units: Section 237313.

1.02 REFERENCES

A. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

B. UL 900 - Test Performance of Air Filter Units.

C. ASHRAE 52.2 - Method of Testing Air Cleaning Devices used in General Ventilation for Removing Particulate Matter.

D. IEST: Institute of Environmental Science & Technology, Recommended Practice, IEST-RP-CC001.4, Testing HEPA/ULPA Filters.

1.03 DEFINITIONS

A. MERV: Minimum Efficiency Reporting Value.

1.04 SUBMITTALS

A. Product Data: Catalog sheets and specifications for each type filter.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Supply air filters that are UL listed. Class 2.

B. Regulatory Requirements: Supply air filters that are UL listed. Class 1.

1.06 MAINTENANCE

A. Extra Materials: One spare set of air filters for each air handling unit utilizing air filters. Deliver spare filters to the Director's Representative in the manufacturer's original boxes. labeled as to filter usage.

PART 2 PRODUCTS

2.01 AIR FILTER TYPES

B. Pleated Air Filters: Extended surface medium efficiency air filter having a MERV of 7 when tested in accordance with ASHRAE Standard 52.2.
   1. Maximum Initial Pressure Drop:
      a. 1 inch thick filters: 0.45 inch wg at 500 fpm.
      b. 2 inch thick filters: 0.28 inch wg at 500 fpm.
      c. 4 inch thick filters: 0.27 wg at 500 fpm.
   2. Construction (UL Class 2 Filters):
      a. Filter Media: Non-woven blend of cotton and synthetic fibers bonded on the air exiting side to welded wire support grid formed to maintain pleat configuration.
      b. The wire grid support treated for corrosion resistance.

c. Enclosing Frame: Constructed of high wet-strength moisture resistant beverage board or chipboard, with diagonal support members bonded the apex of each pleat on the air entering and air exiting sides of filter pack.
d. Filter pack bonded to enclosing frame around the entire periphery of the frame.

3. Acceptable Filters (UL Class 2 Filters):
   a. Airguard: Type DP-2-40.
   b. American 300X.
   c. Camfil Farr 30/30.
   d. Flanders/Precisionaire Pre-Pleat HV.
   e. Glasfloss Z-Line HV.
   f. Purolator Mark 80.
4. Construction (UL Class 1 Filters):
   a. Filter Pack: Constructed of microfiber glass laminated to an all-glass mesh backing material.
   b. Media: Formed into tapered radial pleats and bonded to a welded wire support grid formed to maintain pleat configuration.
   c. Enclosing Frame: Constructed of non-flammable board with diagonal support members bonded to each pleat apex on both sides of filter pack; or a galvanized expanded metal media support retainer on the downstream side.
   d. Filter pack bonded to enclosing frame around entire inside periphery of frame.
5. Acceptable Filters (UL Class 1 Filters):
   a. Airguard: Type DP Class 1.
   b. American AmAir HT.
   c. Camfil Farr 30/30 UL Class 1.

2.02 MULTIPLE FILTER BANK ASSEMBLIES (BUILT UP FILTER BANKS)

A. Filter Holding Frame: Constructed of 16-gauge galvanized steel, assembled from two corner sections, and welded to assure a rigid and durable frame assembly.

B. The filter holding frame to include the following:
   1. Pre-punched lances for filter fastener attachment.
   2. Filter fasteners capable of installation without use of tools, nuts, or bolts.
   3. Lance penetrations upstream of filter flange to assure leak-free integrity.
   4. Filter centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.
   5. Filter-Sealing Flange: Integral component of the holding frame with flush mitered corners, 3/4 inch wide.
   6. Filter Sealing Flange Gasket: Permanently mounted polyurethane foam on the filter sealing flange to assure filter to frame sealing integrity.

2.03 SIDE LOADING FILTER HOUSINGS

A. Housing: Weatherproof type suitable for rooftop/outdoor installation, and capable of two stages of filtration without requiring any modification to the housing.
   1. Construction: 16-gauge galvanized steel with pre-drilled standing flanges to facilitate attachment to other system components.
   2. Corner Posts: Z-channel construction shall ensure dimensional adherence.
   3. Filter Track: Integral component of housing, constructed of aluminum, and capable of accommodating any of the following:
      a. 2" deep prefilter.
      b. 6" or 12" deep rigid final filter.
      c. Bag filter with header.
   4. Dual Access Doors: Swing-open type with high-memory sponge neoprene gasket to facilitate a door-to-filter seal, adjustable and replaceable positive sealing UV-resistant star-style knobs, and replaceable door hinges.
   5. Universal Holding Frame: Constructed of 18-gauge galvanized steel, equipped with centering dimples, multiple fastener lances, and polyurethane filter sealing gasket to facilitate installation of high-efficiency filters.
   6. Pneumatic Fitting: Allows for the installation of a static pressure gauge to evaluate pressure drop across a single filter or any combination of installed filters.
   7. Housing Performance: Leakage at rated airflow.

1. Upstream to Downstream of Filter, Holding Frame, and Slide Mechanism: Less than 1% at 3.0" wg
2. Leakage into or out of the Housing: Less than 0.5% at 3.0" wg

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Air Handling Unit Filter Schedule. Install set of filters in each air-handling unit listed below:

Unit Tag(s)	Filter Arrangement	Filter Depth	Filter Type	MERV Rating	Filter Quantity	Filter Size
C-2	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
C-3	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
E-1	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
E-2	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
E-3	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
E-5	Angled filter	4 in	No prefilter	-	-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
F-2	Angled filter	4 in	No prefilter		-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
H-2	Angled filter	4 in	No prefilter		-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
G-1	Angled filter	4 in	No prefilter		-	-
			Pleated media - run set	MERV 14	8 8	20in.x20in. 20in.x25in.
K-1	Angled filter	4 in	No prefilter		-	-
			Pleated media - run set	MERV 14	6 18	16in.x20in. 16in.x25in.

END OF SECTION

ASHRAE 52.1-1992 EFFICIENCY	ASHRAE 52.2-1999 MERV
<20%	MERV 1-5
20-25%	MERV 6
25-30%	MERV 7
30-35%	MERV 8
40-45%	MERV 9
50-55%	MERV 10
60-65	MERV 11
70-75%	MERV 12
80-90	MERV 13
90-95%	MERV 14
~95%	MERV 15
>95%	MERV 16

MERV	TYPICAL CONTAMINANT	TYPICAL APPLICATION
1 Thru 5	Particle Size: Larger than 10 microns; pollen, Spanish moss, dust mites, sanding dust, paint spray, dust, textile and carpet fibers.	Minimum filtration, residential window air conditioners.
6 thru 8	Particle Size: 3.0 to 10 microns; mold, spores, hair spray, cement dust, snuff, powdered milk.	Commercial and industrial buildings, better residential buildings, paint spray booths.
9 thru 12	Particle Size: 1.0 to 3.0 microns; Legionella, lead dust, milled flour, coal dust, auto emissions, welding fumes.	Commercial buildings, superior residential buildings, hospital laboratories, welding shops.
13 thru 16	Particle Size: 0.3 to 1.0 microns: all bacteria, most tobacco smoke, droplet nuclei, cooking oil, copier toner dust, face powder, paint pigment.	Hospital inpatient care, general surgery, smoking lounges, superior commercial buildings.

END OF INFORMATION

SECTION 235116

SMOKE FLUE PIPE AND BREECHING

PART 1 GENERAL

1.01 DEFINITIONS

A. Combustible Material: Material made of or surfaced with wood, compressed paper, plant fibers, plastics, or other material that will ignite and burn, whether flameproofed or not, or whether plastered or unplastered.

1.02 SUBMITTALS

A. Shop Drawings:
   1. Fabrication drawings for breeching installations involving two or more boilers.
   2. Details of the method of support.

1.03 QUALITY ASSURANCE

A. Qualifications: Sheet metal and structural steel Work: Performed by skilled mechanics regularly engaged in their respective trades.

B. Regulatory Requirements: Comply with the applicable requirements of the National Fire Protection Association and the Sheet Metal and Air Conditioning Contractors National Association, unless otherwise shown or specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sheet Metal:
   1. Galvanized Sheet Steel: Lock forming quality ASTM A 653, coating designation G-90.
   2. Hot Rolled Sheet Steel: Carbon steel, commercial quality - ASTM A 569.

B. Sheet Metal Accessories: Same material as the sheet metal.

PART 3 EXECUTION

3.01 FABRICATION

A. Round Flue Pipe:
   1. 12" Diameter and Under: No. 18 gage galvanized sheet steel, longitudinal groove type seam, slip fit circumferential joints with 4" engagement between sections.

2. 13" to 18" Diameter: No. 16 gage sheet steel, welded seams and joints.
3. 19" in Diameter and Over: No. 12 gage sheet steel, welded seams and joints.

B. Rectangular Breechings: No. 12 gage sheet steel, welded construction.

3.02 INSTALLATION

A. Precautionary Measures: Cover combustible material within 24" of the flue pipe and breeching with 20 gage galvanized sheet metal. Maintain a 1" air space between the covering and the combustible materials. Do not install the flue pipe and breeching within 12" of combustible material.

B. Single Unit Installation: Connect flue pipe to chimney and support from the overhead construction, as required and approved.

C. Multiple Unit Installation:
1. Provide a common breeching interconnecting flue pipes from boilers to chimney. Install expansion joint in breeching between each pair of boilers and elsewhere if shown. Weld steel angle around breeching perimeter at chimney connection. Secure angle to chimney with expansion shields and bolts on 6" centers. Seal angle to chimney joint with cement mortar. Provide hinged blow-back proof cleanout door near free end of breeching or main flue pipe, and additional doors where indicated, or required for damper access.

END OF SECTION

SECTION 235223

CAST IRON BOILER

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets, specifications and installation instructions.

B. Quality Control Submittals:
   1. Certificates: Affidavit required under Quality Assurance Article.
   2. Company Field Advisor Data:
      a. Name, business address and telephone number of Company Field Advisor secured for the required services.
      b. Certified statement from the Company listing the qualifications of the Company Field Advisor.

C. Contract Closeout Submittals:
   1. Department of Labor Certification of Inspection: Deliver 2 copies to the Owner.
   2. Operation and Maintenance Data: Deliver 2 copies, covering the installed products to the Owner.
   3. Service Organization Data: Written notification from boiler manufacturer specifying the name, address, telephone number, and available service programs of fully equipped and authorized service organization.

1.02 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Boiler shall be constructed. tested and stamped in accordance with the ASME Code for Low Pressure Heating Boilers, and shall be IBR rated.
   2. Boiler shall comply with the requirements of Part 4 of Title 12 Rules and Regulations of the State of New York Industrial Code Rule No. 4 (12NYCRR4).
   3. Boiler shall comply with New York State Department of Environmental Conservation Law 6NYCRR, Parts 200, 201, 227 and 231.

B. Certification: Affidavit by the Company Field Advisor, certifying that the boiler meets the contract requirements and is operating properly.

D. Company Field Advisor: Secure the services of a Company Field Advisor for a minimum of 24 working hours for the following:
   1. Render advice regarding installation and final adjustment of the boiler.
   2. Visit the Site upon completion of boiler to inspect the Work, and to notify the Owner of any Work which must be done or modified prior to NYS Department of Labor inspection.

3. Witness final system test and then certify with an affidavit that the boiler is installed in accordance with the Contract Documents and is operating properly.
4. Train facility personnel on the operation and maintenance of the system (minimum of two 4 hour sessions).
5. Explain available service programs to facility supervisory personnel for their consideration.

1.03 MAINTENANCE

A. Maintenance Service: A fully equipped service organization authorized by boiler manufacturer and capable of guaranteeing response within 8 hours to service call, shall be available 24 hours a day, 7 days a week to service completed Work.

B. Special Tools: Deliver the following tools for each boiler to the Owner.
1. Tools for opening access plates.
2. Tools for adjusting and cleaning burners.
3. Brushes for cleaning flue and smoke hood.

PART 2 PRODUCTS

2.01 CAST IRON BOILER

A. Cast iron sectional unit, with insulated steel jacket, and capable of developing full IBR gross output capacity at 100 percent firing rate.
1. Type:
   a. Field assembled unit.
2. Allowable Working Pressures:
   a. Hot Water: 80 psig.
3. Design boiler to fire the following:
   a. Commercial No. 2 fuel oil (CS 12-48).
   b. Natural gas rated at 1000 BTU pcf.
4. Factory paint boiler assembly with enamel finish.

B. Water Boiler Trim:
1. ASME pressure relief valve.
2. Combination pressure/temperature gauge.
3. Hi-limit temperature control with manual reset.
4. Lo-limit operating control.
5. Blowoff pipe and valve.
6. U.L. labeled low water fuel cut-off with manual reset and alarm.
7. Built in air eliminator.
   a. Boilers without built-in air eliminators may be submitted for approval if separate combination system strainer and air eliminator is provided. See Section 232006.

C. Burners: UL labeled, pressurized atomized with flame retention, fuel control equipment, valves, pumps, and operating and safety controls.

D. Burner Fuel Trains: Manufacturer designed and listed, as part of the packaged unit, conforming to UL, FM, IRI or CSD-1 standards.

E. Combination Gas/Oil Burner Control:
1. Ignition: Electric-gas ignition with proven interrupted gas pilot for either fuel, and air flow switch.
2. Operation Controls:
a. Full modulation with pre-purge, proven low fire start, high fire run, with post-purge and modulating fire control.
1) Prewired control panel incorporating electronic combustion safeguard primary control with pre-purge and post-purge programming, modulating sub-panel with manual potentiometer, ultraviolet sensitive electronic flame detector, motor starter relay, manual fuel transfer switch, remote fuel oil pump set, and dual automatic gas valves.

2.02 ENERGY MANAGEMENT CONTROL SYSTEM

A. UL listed microprocessor control system which operates boiler based on system temperature and outdoor temperature.
1. Adjustable ratio indoor/outdoor reset control for up to 8 on-off boilers or up to 4 low-high-low boilers.
2. Two adjustable indoor/outdoor reset ratios.
3. Digital display manually steps thru set points and system data.
4. LED display indicates lead stage and boiler operating status.
5. Anticipates heating load demand by calculating rate of change of system water temperature.
6. System temperature fine-tuning allows flexible heat adjustment (+ 40 degrees F).
7. Manual or auto lead lag rotates lead boiler daily.
8. On-Auto-Off switch for each stage allows removal of boiler from sequence without rewiring.
9. Minimum Water Reset Temperature: 140 degrees F.
10. Outdoor temperature starter.
11. Outdoor Temperature Sensor: Field installed solid state thermistor.
12. System Water Temperature Sensor: Solid state thermister with control well.
13. Stage sequencer and plug-in relay for each boiler.
14. Terminal strips with minimum of 2 N.O. (DPST) contacts for each boiler.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install boiler in accordance with manufacturer's printed instructions.

B. Arrange to allow sufficient room for cleaning and servicing all components.

C. Provide framed glass holder for NYS Department of Labor certificate of inspection, and post near the boiler prior to operation of the boiler.

D. Attach to boiler, identification number assigned by NYS Department of Labor Commissioner.

3.02 FUEL FOR START-UP AND TESTING

A. Oil:
1. Connect to existing fuel oil piping.

B. Gas:
1. Connect to existing gas piping.

3.03 FIELD QUALITY CONTROL

A. Preliminary Requirements:
1. Employ the services of Company Field Advisor to complete duties specified in Quality Assurance Article.

B. Boiler Start Up:
1. Arrange with NYS Department of Labor for inspection of boiler upon completion of installation.
   a. Do not operate boiler until NYS Department of Labor inspection is made and a Certificate of Inspection is posted.
   b. Pay application and inspection fees required by NYS Department of Labor.
   c. Prepare boiler for internal inspection or hydrostatic pressure test on the date specified by the Department of Labor inspector.
      1) Remove handhole plates, and washout plugs in the water column connection.
      2) Remove as directed by the NYS Department of Labor inspector, brick work and insulation.
      3) Remove gages for testing if required by NYS Department of Labor inspector.
      4) Stop leaks of steam or hot water into the boiler being inspected from the other components.
      5) Make available to the NYS Department of Labor inspector a competent person to be placed under the inspector's supervision to disassemble, reassemble, test, adjust, operate or forcible handling any part of the boiler.
2. Preliminary System Tests:
   a. Preparation: After the State Department of Labor Certificate of Inspection has been posted, fire the boiler for the purpose of checking general operation, proving mechanical and electrical controls, and making necessary adjustments. Operate the system long enough to assure that it is performing properly.
   b. Run preliminary test for the purpose of:
      1) Determining whether the boiler and appurtenances are in suitable condition to conduct the acceptance test.
      2) Checking the adjusting equipment.

3) Training Facility personnel.

3. System Acceptance Test:
   a. Preparation: Notify the Owner at least 3 working days prior to the test so arrangements can be made to have a Facility Representative witness the test.
   b. Make the following tests:
      1) Operate boiler, appurtenances, and fine tune adjustable devices.
      2) Test alarm indicating devices.
      3) Operate for a sufficient period of time to demonstrate satisfactory overall performance of the heating system.
   c. Supply equipment necessary for system adjustment and testing.
   d. Submit a typewritten report of the test results, signed by the Company Field Advisor and the Owner. Enclose a copy of the report in a metal frame covered with plastic sheet glazing and mount it adjacent to the control panel.

END OF SECTION

SECTION 237313

AIR HANDLING UNITS

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Air Filters: Section 234100.
B. Motors and Motor Controllers: Section 260221.

1.02 PERFORMANCE REQUIREMENTS (NOT USED)

1.03 SUBMITTALS

A. Waiver of Submittals: The "Waiver of Certain Submittal Requirements" in Section 013300 does not apply to this Section.

B. Product Data:
1. Catalog sheets, brochures, performance charts, standard schematic drawings, specifications and installation instructions for each air handling unit.

C. Contract Closeout Submittals:
1. Operation and Maintenance Data: Deliver 2 copies, covering the installed products, to the Owner.

1.03 QUALITY ASSURANCE

A. Source Quality Control: Factory test units in accordance with ARI Standard 430 - Central-Station Air-Handling Units.

B. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.

C. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance requirements and dimensional requirements.

D. If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:
1. Structural supports for units
2. Size and location of concrete bases/housekeeping pads
3. Location of roof curbs, unit supports and roof penetrations
4. Ductwork sizes and connection locations
5. Piping size and connection/header locations
6. Interference with existing or planned ductwork, piping and wiring
7. Electrical power requirements and wire/conduit and over current protection sizes.
8. Trap height requirements

E. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

1.04 REFERENCES

A. AMCA 99 – Standard Handbook
B. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
C. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters
D. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating

E. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
F. ANSI/UL 900 – Test Performance of Air Filter Units
G. ARI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment
H. ARI 410 – Forced-Circulation Air Cooling and Air Heating Coils
I. ARI 430 – Testing and Rating of Central-Station Air Handling Units
J. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
K. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality
L. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
M. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.
N. NFPA 70 – National Electric Code (conductors, equipment and raceways)
O. NFPA 90A – Installation of Air Conditioning and Ventilation Systems
P. SMACNA – HVAC Duct Construction Standards
Q. UL-181 – Mold Growth and Humidity Test
R. UL-1995 – Standard for Safety for Heating and Cooling Equipment

1.05 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's recommendations for handling, unloading and storage.

B. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

C. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

D. Seal openings to protect against damage during shipping, handling and storage.

E. Provide shrink-wrap around unpainted units. The membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Tarping is not acceptable.

F. Shrink-wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

G. Tarp painted units to protect against rain and road debris during shipping.

H. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.06 EXTRA MATERIALS

A. Provide one set of filters for balancing, and one additional set for final turnover to owner.

B. Provide one extra set of belts, in addition to the factory-installed set.

1.07 WARRANTY

A. Provide warranty for 18 months from date of shipment. Warranty shall cover manufacturer defects. Warranty shall include labor for 12 months from date of shipment. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician. Service technician must be based within 50 miles of job site.

B. Include factory-provided controls in the parts and labor warranties.

C. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

1.08 SYSTEM STARTUP

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. TRANE
B. YORK Solution
C. Carrier
D. Daikin
E. Or Approved Equal

2.02 GENERAL DESCRIPTION

A. Air Handling Unit (AHU) consists of a structural base, insulated casing, access doors, fans, motors, motor controls, coils, filters, dampers, controls, components, and accessories; as shown on drawings, schedules, and specifications.

B. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.

C. AHU shall maintain structural integrity when wall panels are removed.

D. Provide internal components and accessories as specified and scheduled. Components and accessories shall be installed by the AHU manufacturer in an ISO- 9002 certified facility.

E. Ship units in one piece. Split units only where necessary for shipping and installation.

F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.

G. For AHU segments that must be broken down for rigging and installation: segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.

H. Manufacturer shall perform a field leakage test to confirm 1% leakage per section 2.25.

I. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

2.03 STANDARD COMPLIANCE

A. The manufacturer units must comply and meet or exceed with ratings and certifications referenced in this specification.

2.04 BASE RAIL

A. Provide a structural base rail factory installed by manufacturer, min. 6" height under the full perimeter of the unit, formed from mill galvanized steel.

B. Provide clearance for proper external trapping of drain pans steam condensate.

C. Provide base rail and lifting lug system that does not require additional support for rigging. Include base rail lifting lugs at each side shipping splits and at unit corners.

2.05 CASING

A. Provide double wall AHU casing. Gage: Double Wall Exterior: Minimum No. 18 USS sheet steel. Finish: Powdered Aluminum. Contractor to coordinate with Architect and Owner regarding finish type and color for the AHU casing. Exposed insulation is not acceptable.

B. Panel assembly shall meet UL standard 1995 for fire safety. Panel assembly shall comply with the requirements of NFPA 90A.

C. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

D. Encapsulate insulation with sheet metal so that air does not contact insulation. Panels insulated with fiberglass shall be sealed at each corner and around their entire perimeter, to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.

E. Unit Insulation should be a minimum as follows. Double Wall: Minimum 2 inch thick insulation material. Insulation minimum 1-1/2 pound density.

F. Provide casing with minimum thermal resistance (R-value) of 12 hr-ft2-°F/ BTU.

G. Roof, wall, floor, and access door panels shall be galvanized or stainless steel, min. No. 18 USS stainless steel.

H. Provide perforated liner in the fan section and other sections as shown on the drawings. The perforated panel shall enclose matte-faced fiberglass insulation.

I. Provide a unit frame of galvanized steel that provides the overall structure of the unit and does not rely on the casing panels for structural integrity. Insulate frame in the same manner as panels, roof, and floors.

J. Provide AHU casing that leaks no more than 1% of design airflow at +/-8" w.g.

K. Provide wall panels and access doors that deflect no more than L/240 when subjected to +/- 8" w.g. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

L. Provide floors and roofs that deflects no more than L/240 when subjected to a 300 lb load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint. M. Provide outdoor AHUs with a roof system that deflects no more than L/240 when subjected to a snow load of 30 lb/ft2. 'L' is defined as the panel-span length and 'L/240' is the deflection at the panel midpoint.

M. Provide outdoor AHUs with a roof sloped at a minimum pitch of 1/4" per foot. The roof shall overhang side and end panels by a minimum of 2".

2.06 PRIMARY DRAIN PANS

A. Provide drain pans that comply with requirements for the AHU casing.

B. Comply with the stated intent of ASHRAE Standard 62.

C. Provide a drain pan under each cooling coil. Drain pans for cooling coils shall meet the requirements of ASHRAE 62.

D. Provide drain connection made of same material as drain pan. Do not use dis- similar metals because of the risk of galvanic corrosion. Weld connection to the drain pan.

E. Drain pan shall be insulated double wall galvanized steel construction with an R-value of 12 hr-ft2-°F/BTU. The entire area of the drain pan shall have this level of thermal performance.

F. Insulate plumbing associated with drain pan drains and connections.

G. Provide drain pan under the complete width and length of cooling coil section.

H. Drain pan shall allow visual inspection and provide inspection door for physical cleaning on 100% of the pan surface with or without removal of the coil.

I. Provide a minimum of 1" clearance between the drain pan and any coil casing, coil support or any other obstruction.

J. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

K. Provide drain pan sloped by at least 1/8" per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.

2.07 ACCESS DOORS

A. Provide access door(s) that meet requirements for the AHU casing.

B. Provide industrial style stainless steel hinges that permit 180 degrees of door swing.

C. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or "paw" latches are not acceptable.

D. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle.

E. Provide access doors with a locking hasp to accommodate a lockout device.

F. Provide double-pane viewing windows as shown on the elevation view drawings. Windows shall be a non-condensing type consisting of an integrated silica desiccant dehumidification layer. Minimum dimension shall be 3" x 8".

2.08 ROOF CURBS AND ADAPTER CURBS

A. Provide custom 2-piece fabricated galvanized steel roof curb for outdoor units. Roof curb shall support the full-perimeter of the air handling equipment.

B. Match adapter roof curb to existing roof curb and roof slope. Curb surface shall be level in both axes.

C. Provide adequate supports for unit to prevent unit in supporting adapter curb to existing roof curb. Contractor to adhere to manufacturer's installation instructions.

D. Ship roof curb loose for field installation prior to unit placement.

2.09 FANS

A. Provide double width double inlet (DWDI) housed fans, multi-blade centrifugal type or single width single inlet (SWSI) plenum fans as equipment schedule and drawings.

B. Airfoil fans shall comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA Seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.

C. Provide fans with true airfoil blades unless otherwise scheduled.

D. Provide fans with the following accessories:
   1. Fan inlet screens in the inlets of fan housing (REQUIRED on SWSI plenum fans)
   2. Access door inlet screen (on AHU casing)
   3. OSHA-compliant belt guard enclosing the fan motor and drive.

E. Provide airfoil fans with blades formed of extruded aluminum, as scheduled. Bent sheet metal blades are not acceptable.

F. Provide an access door in the fan scroll, as shown on drawings.

G. Provide fans with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.

H. Provide fan motor on an adjustable base to allow adjustable and consistent belt tension.

I. Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame. Manufacturers not complying with this requirement must submit detailed structural and weight data to a licensed structural engineer for review and stamped certification. The mechanical engineer shall review these engineers' final reports prior to submittal approval.

J. The fan and motor assembly shall be internally isolated from the unit casing. Provide vibration isolation springs with 1" or 2" static deflection. Internally Mounted: Spring isolators by manufacturer. The isolation system shall be designed to resist loads produced by external forces, such as earthquakes, and conform to the current IBC seismic requirements.

K. Connect DWDI fans to the unit casing or bulkheads with canvas flexible connection.

L. Provide horizontal thrust restraints between AHU casing and fan housings with end discharge. This requirement applies to the following cases:
1. SWSI fans operating at greater than 3" of total static pressure
2. DWDI airfoil fans operating at greater than 6" of total static pressure
3. DWDI airfoil fans operating at greater than 3" of total static pressure

2.10 BEARINGS AND DRIVES

A. Provide bearings complying with ANSI/AFBMA 9 for fatigue life ratings.

B. Provide fan bearings with an average life L50 of at least 200,000 hours.

C. Provide fan bearings with an average life L10 of at least 200,000 hours, as scheduled.

D. Provide permanently lubricated bearings on forward curved fans smaller than 18." On other fans, provide re-greaseable bearings with hydraulic grease fittings and lube lines extended to the motor side of the fan or to the exterior of the unit (primary access side).

E. Provide plenum fans with direct-drive transmissions.

F. Provide drives selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Provide a fixed pitch sheave on the motor.

G. Provide fixed pitch sheaves on both the fan and motor. Fans with motors rated at 15 hp or less may be field balanced using variable pitch sheaves. Provide fixed pitch sheaves when final balance is complete. Air balancer shall select and provide final set of sheaves.

H. Provide multiple belt drives on belt driven fans with motors 10 hp or greater. Belts shall be V-type, precision molded, raw edge construction, anti-static, oil- resistant and heat-resistant.

2.11 ELECTRICAL MOTORS

A. Provide fan motors built in accordance with the latest standards of the NEMA and IEEE. See Section 260221 - MOTOR AND MOTOR CONTROLLERS.

B. Provide AHU and fan motors in compliance with the latest NYS Energy Conservation Code or ASHRAE 90.1.

C. Provide fan motors with the following characteristics:
1. 60 hertz, 1750 rpm operation
2. Service factor of 1.15
3. Premium efficiency, or as required to meet ASHRAE 90.1
4. NEMA design ball bearing type

5. Rated for continuous duty at full load in a 104°F (40°C) ambient
6. Open drip proof (ODP) or totally enclosed, fan cooled (TEFC) as scheduled

2.12 FAN MOTOR DISCONNECTS

A. Provide UL or ETL listed fan-motor disconnects and associated components, as scheduled and shown on drawings. Disconnects shall comply with applicable provisions of the National Electric Code.

B. Provide fused or non-fused fan-motor disconnects in NEMA 1, NEMA 3R, NEMA 4, or NEMA 12 enclosures, as scheduled and shown on drawings.

C. Mount disconnects on the primary access side of the associated fan segment.
1. Mount unit main disconnect (on units with single point power) on the primary access side of supply fan section.

D. Disconnect shall be suitable for use as an OSHA lockout/tagout disconnect when applied in accordance with part IV, Department of Labor OSHA 29 CFR Part 1910, Control of Hazardous Energy Source (lockout/tagout): final rule.

E. Disconnect handles shall be lockable in the "off" position with up to three pad- locks. Switch mechanism shall be directly lockable in the "off" position via padlock when door is open.

F. Provide disconnects with integral ground lug.
1. Provide two (2) #14 ground wires on 16A to 100A disconnects.
2. Provide one (1) #6-250 ground wire on 200A to 400A disconnects.

G. Provide auxiliary contacts, as scheduled.

2.13 HEATING AND COOLING COMPONENTS

A. Provide coils manufactured by AHU manufacturer.

B. Coils shall meet or exceed performance scheduled on drawings. When applicable. Provide coils with performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at design flow.

C. Provide cooling coils with a maximum face velocity of 550 fpm or 500 fpm or 450 fpm. Face velocity calculations shall be based on the finned area of the coil.

D. Provide cooling coil drain pan that is sufficient to contain coil condensate.

E. Provide coil segment casing to accommodate full-face or reduced-face coils as scheduled. Provide face and bypass coil segments with factory installed bypass damper.

F. Provide at least 18" or 24" or 30" of access between coils. Provide an easily operable access panel or door, as shown on drawings.

G. Provide coil segment casing that meets or exceeds casing performance of the unit.

H. Provide panels that are easily removable with no special tools.

I. Locate access doors to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.

J. Provide coils built in their own full perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing and support members shall not block finned area.

K. Provide a single intermediate vertical coil support on coils with a finned length greater than 62". Provide two vertical supports on coils with a finned length greater than 100", and three vertical supports on coils with a finned length greater than 141".

L. Extend coil connections through AHU casing. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow complete draining and venting when installed. Vent and drain connections shall be on the coil connection extension outside of the unit casing.

M. Insulate gap between coil stub out connection and AHU casing with a spool- shaped sleeve grommet. Adhesive rings applied the casing walls are not accept- able.

N. Water and glycol coils shall be operable at 250 psig working pressure and up to 300° F. Factory test water and glycol coils with 200 psig compressed air under water.

O. Direct expansion (DX) coils shall conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a maximum refrigerant pressure of 250 psig. Factory test DX coils with 325 psig compressed air under water.

P. Provide water, glycol and DX coils with a tube OD of 5/8" or 1/2". Mechanically expand tubes to form fi n bond and provide burnished, work-hardened interior surface. Tubes shall have a minimum tube wall thickness of 0.020" or 0.025" or 0.035" or 0.049" for 5/8" tubes, and 0.016" or 0.020" or 0.032" for 1/2" tubes.

Q. Provide coils with copper tube return bends with the following final minimum thicknesses: 1. 0.035" for 5/8" diameter tubes 2. 0 .032" for 1/2" diameter tubes with 0.020" or 0.032" tube wall thicknesses 3. 0.020" for 1/2" diameter tubes with 0.016" tube wall thickness.

R. Provide water. glycol coil headers made of seamless copper or brass tubing. Pipe connections shall be steel or red brass. Header connections (tubes and piping connections) shall be silver-brazed or TIG welded.

S. Provide DX coils with brass distributor and solder-type connections. Suction and discharge connections shall be on the same end regardless of coil depth. Mount refrigerant specialties outside of unit. Provide DX coils with a hot gas bypass port on distributor.

T. Provide coils with die-formed. continuous aluminum or copper fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.006" or 0.008 or 0.01" thick.

2.14 FILTERS

A. Provide filter segment and filters for each AHU. see Section 234100 - AIR FILTERS.

2.15 DAMPERS

A. Provide dampers tested in accordance with AMCA 500.

B. Provide factory-installed dampers. as per manufacturer. Dampers shall modulate the volume of the outdoor, return, or exhaust air.

C. Dampers shall have double skin airfoil blades, extruded vinyl edge seals on all blades, and flexible metal compressible jamb seals. Blades shall rotate on stainless steel sleeve bearings.

D. Dampers shall have a maximum leakage rate of 3 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1.

E. Damper blades shall be parallel or opposed blade configuration, as per manufacturer.

F. Damper blades shall be galvanized steel or aluminum.

2.16 DIFFUSERS

A. Provide diffuser segments as shown on drawings.

B. Diffuser plates shall ensure proper air flow across components downstream of DWDI fans.

2.17 APPURTENANCES

A. Provide hoods on outdoor unit air intakes and exhaust.

B. Provide moisture screens on outdoor air inlet hoods. Provide bird screen on outdoor air exhaust hood.

C. Provide safety grates over bottom openings inside unit. Safety grates shall be capable of supporting a 300 lb. center load.

2.18 FINISHES

A. Contractor shall coordinate and confirm with Architect and Owner regarding the type and color finish of all AHUs as specified on drawings.

B. Manufacturer shall clean the exterior surfaces of units prior to finishing, painting, or shipment.

C. Manufacturer shall paint outdoor units prior to shipment.
1. All Exposed Surfaces: Factory applied baked enamel, or galvanized finish in accordance with ASTM A 653, coating designation G90.

1.19 TESTS AND INSPECTIONS

A. Manufacturer shall dynamically balance fan/motor/base assembly.
1. Balance constant volume fan assemblies at design RPM.
2. Balance variable volume fan assemblies from 10% to 100% of design RPM.
3. Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
4. Take filter-out measurements in the horizontal, vertical, and axial axes on the drive and opposite-drive side of fan shafts.
5. Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils. Filter-out measurements shall not exceed 6 mils in the horizontal and vertical axes, and 7 mils in the axial axis.

B. Manufacturer shall hipot test wiring intended to carry voltages greater than 30Vac.

2.20 REMOTE AIR COOLED CONDENSER

A. Provide an air-cooled refrigerant condenser of the draw-through vertical discharge type. Provide unit complete with a multiple circuit coil: direct driven electric motor operated propeller fans, all totally protected by a heavy duty sheet metal casing, complete with a structural metal stand and wire fan guards. Provide unit completely factory assembled and with all the necessary control and accessories, for operation in ambient air temperatures down to 0°F.

B. Fabrication:

1. Casing: Heavy gage galvanized steel or aluminum sheet metal, reinforced and bolted or welded to assure rigidity. Provide gasketed access panels as required for servicing the motors and all components.

2. Fan Assembly: Propeller type fans arranged for vertical discharge, with aluminum blades and center hubs of zinc coated steel with a corrosion-resistant coating. Coat fan shafts with a weather-resistant coating. Provide drip-proof fan motors, resiliently mounted and designed for year-round operation, with permanently lubricated ball bearings.

3. Coil: Multiple circuit high capacity type, fabricated of seamless copper tubing with aluminum fins mechanically bonded to tubing. Provide a maximum fin spacing of 10 per inch.

4. Finish: Provide all exposed surface of condenser with a factory applied corrosion-resistant baked enamel finish.

C. The maximum radiated sound power levels shall be as per manufacturer sound power data.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the Work of this Section in accordance with the manufacturer's printed instructions.

B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.

C. Install AHUs on existing roof curb and adapter curb as per manufacturer's instructions.

D. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal. Clearances shall be maintained around all components so as to permit inspection, servicing, repair, replacement and visibility of all gauges. When units are installed or replaced, clearance shall be provided to allow access for inspection, maintenance and repair. Passageways around all sides of the units shall have an unobstructed width as required by the manufacturer.

E. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of transfer to owner.

F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions. Provide all piping and electrical connections to units through knock-out openings in bottom of units.

G. Air Cooled Condenser:

1. DX Coil Piping: Connect liquid and hot gas piping to unit as indicated on the Drawings. The refrigerant lines between the air- cooled condenser and DX coil shall be tested according to the requirements defined in Section 230593, Cleaning and Testing.

2. Drain Piping: Connect unit drain to nearest indirect waste connection. Provide trap at drain pan: construct at least 1" deeper than fan pressure in inches of water.

3. Piping shall be as specified in Section 232000: HVAC Piping.

H. Unless otherwise shown or specified, install the Work of this Section in accordance with the manufacturer's printed installation instructions.

3.02 FIELD QUALITY CONTROL

A. Rig and lift units according to manufacturer's instructions. Contractor is responsible to pay all permits and costs related to rigging. Contractor is to follow all safety protocols.

3.03 AHU INSPECTION

A. The following items shall be inspected prior to startup of unit. Manufacturer representative may be present to ensure installation of AHU is installed properly.
1. Damage of any kind
2. Level installation of unit
3. Proper reassembly and sealing of unit segments as shipping splits.
4. Tight seal around perimeter of unit at the roof curb/adapter curb.
5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators, if applicable.
6. Completion and tightness of electrical, ductwork and piping connections.

7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
8. Supply of electricity from the building's permanent source.
9. Integrity of condensate trap for positive or negative pressure operation.
10. Condensate traps charged with water.
11. Removal of shipping bolts and shipping restraints.
12. Tightness and full motion range of damper linkages.
13. Complete installation of BMS/control system including end devices and wiring.
14. Cleanliness of AHU interior and connecting ductwork
15. Proper service and access clearances
16. Proper installation of filters
17. Filter gauge set to zero

B. The following inspection shall be completed to confirm the AHU fan assembly is installed properly.
1. Fan isolation base and thrust restraint alignment
2. Tight set screws on pulleys, bearings and fan
3. Tight fan bearing bolts
4. Tight fan and motor sheaves
5. Tight motor base and mounting bolts
6. Blower wheel tight and aligned to fan shaft
7. Sheave alignment and belt tension
8. Fan discharge alignment with discharge opening
9. Fan bearing lubrication
10. Free rotation of moving components (rotate manually)

3.04 STARTUP SERVICE AND OWNER TRAINING

A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Contractor shall submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer's functional performance tests have been successfully completed. Technician shall perform the following steps as a minimum:
1. Energize the unit disconnect switch
2. Verify correct voltage. phases and cycles
3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
4. Re-check damper operation: verify that unit cannot and will not operate with all dampers in the closed position.
5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.

B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include AHU controls. motor starter. VFD. and AHU.

C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.

D. Submit a startup report summarizing any problems found and remedies performed. The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer's start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer's pre-start up and start up procedures have been successfully completed.

E.

3.05 FIELD PERFORMANCE VERIFICATION

A. Leakage: Pressurize casing to +/-8" w.g. and measure leakage. Pressurize casing to –8"w.g. and measure leakage. If leakage exceeds 1% of design airflow. seal leakage points with a permanent solution. Repeat test. If the AHU still does not pass, contact the manufacturer to seal unit.

B. Submit a field test report with testing data recorded. Include description of corrective actions taken

3.06 CLEANING

A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.

B. Clean exterior prior to transfer to owner

3.07 DOCUMENTATION

A. Provide Installation, Operation & Maintenance Manuals in the supply fan section of each unit. Provide six additional copies for owner's project system manual.

B. Provide six copies of Spare Parts Manual for owner's project system manual

3.08 COMMISSIONING OF PACKAGED HEATING AND COOLING UNITS

A. HVAC Contractor shall comply with the Commissioning Requirements for packaged heating and cooling units.

B. All testing for refrigerant piping shall be completed prior to commencement of the commissioning process.

END OF SECTION

SECTION 237314

VARIABLE FREQUENCY DRIVES

I.GENERAL

A. This specification covers all variable frequency drives (VFDs) designated on the drawing schedules. All standard and optional features detailed herein shall be included within the VFD panel.

The VFD shall be factory installed by the HVAC original equipment manufacturer. The VFD shall have been evaluated by UL and found acceptable for mounting in a plenum or other air handling compartment. Manufacturer shall supply a copy of the UL plenum evaluation upon request.

B. The VFD shall be tested to UL 508C and bear the appropriate UL label. VFDs designated for use in Canada shall have C-UL certifications.
C. The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
D. The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating either in the instruction manual or with a drive marking, in accordance with UL.
E. The VFD manufacturer shall supply the VFD and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years.
F. VFD shall be manufactured in ISO 9001, 2000 certified facilities.

II.PRODUCTS

A. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor de-rating. Additionally, the VFD shall have the capability to control non-salient permanent magnet (PMAC) motors up to 22kW (30 HP).

When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

B. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.
C. The VFD shall be capable of full output current at frequencies in the range of 0 to 120 Hz without de-rating.
D. The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The DC link reactors shall be non-saturating. DC link reactors using swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.
E. The VFD shall be able to provide full rated output current continuously and up to 110% of rated output current for 60 seconds.
F. The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed de-rating or low speed excessive magnetization. as would occur if a constant torque V/Hz curve was used at reduced speeds. Breakaway current of 130% shall be available for 0.5 seconds.
G. A programmable automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.
H. The VFD must be able to operate a direct drive fan through its full operating range.
I. VFD shall be capable of controlling multiple induction motors simultaneously. Multiple motor operation will require additional protective devices per motor.
J. Input and output power circuit switching shall be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
K. An automatic motor adaptation algorithm shall be provided in the VFD to measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test.
L. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.
M. All VFDs rated at 480V and below shall contain integral EMI filters to attenuate radio frequency interference conducted to the AC power line.
N. Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes. current surges. and ground loop currents.

III.PROTECTIVE FEATURES

A. A minimum of Class 20 I2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

B. The VFD shall provide protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.
C. The VFD shall be protected from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
D. The VFD shall be protected from under voltage. The VFD shall provide full rated output power with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output power, without faulting, with an input voltage as low as 85% of the nominal voltage as required by EN/IEC 61800-3.
E. The VFD shall be protected from over voltage. The VFD shall continue to operate without faulting with a momentary input voltage higher than 110% of the nominal voltage.
F. VFD design shall comply with IEC Part 34-17 to prevent breakdown of the motor winding insulation.
G. The VFD shall incorporate a programmable motor preheat feature which provides the motor stator with a controlled level of current to keep the motor warm and prevent condensation build up in idle motors operating in damp environments. .
H. VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.
I. VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.
J. VFD shall be capable of catching a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.
K. Selectable over-voltage control shall be provided to protect the VFD from power regenerated by the motor while maintaining control of the driven load.
L. VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.
M. If the temperature of the VFD's heat sink rises to approximately 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high. The VFD shall automatically increase the carrier frequency and current limit to normal values as the heat sink temperature decreases.
N. The VFD shall store in memory the last 10 alarms. A description of the alarm and the relative sequences of the alarms shall be recorded.

IV. INTERFACE FEATURES

A. Hand, Off and Auto keys shall be provided to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.
B. The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
C. The VFD shall be provided with a keypad with alphanumeric, backlit display. The display shall be capable of remote mounting up to 10 ft. from the VFD. Main Menu password protection shall be provided to guard against unauthorized parameter changes.
D. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
E. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.
F. Display shall be programmable to communicate in multiple languages including English, Spanish and French.
G. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
H. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD.
I. A two-feedback PI controller to control the speed of the VFD shall be standard.
   a) This controller shall accept up to two feedback signals. It shall be programmable to follow the sum of the feedback signals, a preset reference (common set point or up to 8 individual setpoints), or the sum of both. It shall also be possible to calculate the controlling feedback signal as the average, maximum, minimum or the difference between two feedback signals. The VFD shall be able to apply scaling to the feedback signal.
   b) For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.
   c) The VFD's PI controller shall be able to actively adjust its set point based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.
J. Customized meter displays shall be available. They shall include at a minimum, speed/flow, pressure, and power units relative to motor speed.
K. Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PI controller, it shall be possible to

program a "wake-up" feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.

L. A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.

M. VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on estimated motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

N. Standard Control and Monitoring Inputs and Outputs
   i. Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
   ii. Two terminals shall be programmable to act as either as digital or analog outputs.
   iii. Two programmable relay outputs, Form C 250 VAC, 3 A, shall be provided for remote indication of VFD status.
      a) Each relay shall have an adjustable on delay / off delay time.
   iv. Two programmable analog inputs shall be provided that can be either direct- or reverse-acting.
      b) Each shall be independently selectable to be used with either an analog voltage or current signal.
      c) The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.
      d) A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
   v. Two programmable analog current outputs (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of the outputs.
   vi. It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.
   vii. It shall be possible to command all digital and analog output through the serial communication bus.

O. Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

P. The VFD shall be able to store load profile data such as counters for operating hours, running hours, and kilowatt-hours, to assist in analyzing the system demand and energy consumption over time.

Q. The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:
   i. Comparators of VFD analog values to programmed trigger values
   ii. Logic operators to combine up to three logic expressions using Boolean algebra
   iii. Delay timers
   iv. A 20-step programmable structure

V.SERIAL COMMUNICATIONS

A. The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
   i. BACnet MS/TP
   ii. Johnson Controls Metasys N2
   iii. Modbus RTU
   iv. Siemens FLN P1
   v. FC protocol

VI.ADJUSTMENTS

A. The VFD shall have a manually adjustable carrier frequency that can be adjusted in 1 kHz increments up to 6 kHz, 2 kHz increments up to 12 kHz, and 4 kHz up to 16 kHz to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

B. Two independent setups shall be provided.

C. Eight preset references per setup shall be provided for a total of 16.

D. Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds. The shape of these ramps shall be automatically contoured to ensure no-trip acceleration and deceleration.

E. Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.

F. The number of restart attempts shall be selectable from 0 through 20 or infinity and the time between attempts shall be adjustable from 0 through 600 seconds.

G. An automatic "start delay" may be selected from 0 to 10 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.
H. Three programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.
I. When incorporated in the air handler's design with an optional electro-mechanical bypass, provide a manual 2-contactor bypass consisting of a door interlocked main disconnect pad lockable in the off position, a built-in motor starter and a three position DRIVE/OFF/BYPASS switch controlling two contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. The VFD can be remotely controlled in this position with a pilot relay and analog signal or can be controlled manually using the hand function on the VFD LCD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed form the AC power line. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode.

VII.SERVICE CONDITIONS

A. Ambient temperature, continuous, full speed, full load operation:
   i. VFD shall be available in enclosure types: UL Type 1 (NEMA 1) and IP20.
   ii. VFD shall be able to operate at full output current in the temperature range of 0 to 40°C (32 to 104°F).
   iii. VFD must be capable of operation at 50°C (122°F). The nameplate shall indicate any reduced VFD output current.
   iv. VFD shall be capable of operation to a minimum of -10°C (14°F) with reduced performance.
B. VFD shall be capable of operation in an environment with a relative humidity of 0% to 95%, non-condensing.
C. VFD shall be capable of operation up to an elevation to 1000m (3,280 feet) without de-rating.
D. VFD shall be capable of full output current with an AC line voltage variation of -10 to +10% from nominal input voltage.
E. All VFDs shall be plenum rated.
F. VFD shall require no side clearance for cooling. All power and control wiring shall be done from the bottom.

VIII.QUALITY ASSURANCE

A. To ensure quality, the VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

IX.SUBMITTALS

A. This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.
B. Total harmonic distortion level estimation. If requested, the manufacturer shall perform an analysis to initially demonstrate the supplied equipment will meet the IEEE 519-1992 recommendations after installation. In such instances, the owner or engineer shall provide the manufacturer with detailed electrical power single line diagram showing all impedances in the power path to the VFDs. Analysis shall provide the estimated total harmonic distortion levels. Point of common coupling shall be the secondary of the utility transformer. Any additional harmonic filtering equipment required to meet the IEEE 519-1992 recommendations shall not be the responsibility of the HVAC manufacturer.

X.EXECUTION

A. Start-up Service - The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.
B. Warranty - The VFD shall be warranted by the manufacturer for a period of 36 months from initial start-up or 42 months from date of shipment, whichever is less. The warranty shall include replacement equipment or parts as well as a labor allowance for expenses incurred by the manufacturer to provide factory authorized on-site service.

SECTION 238223

UNIT VENTILATORS AND FAN COIL UNITS

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data: Catalog sheets, specifications, color chart, and installation instructions for each unit ventilator.

B. Contract Closeout Submittals:
1. Operation and Maintenance Data: Deliver 2 copies, covering the installed products, to the Owner.

1.02 MAINTENANCE

A. Extra Material: Furnish 2 spare sets of filters for each unit ventilator. Box and label spare filters. Store at the site where directed.

PART 2 PRODUCTS

2.01 MATERIALS

A. Galvanized Sheet Steel: Zinc coated carbon steel, commercial quality, ASTM A 653, coating designation G90.

B. Cold Rolled Steel: Carbon steel, commercial quality - ASTM A 366. Degrease, clean and phosphatize sheet steel in the factory of the unit manufacturer or use mill phosphatized.

2.02 UNIT VENTILATORS

A. General: Provide combination heating, cooling, and ventilating units complete to be used with the existing air intake box. Furnish units complete with return and outlet air grilles, dampers and required duct connections.

B. Unit Casing: Fabricate casing from No. 14 gage sheet steel, formed, reinforced and braced for rigidity, with removable ends and front panel to allow access for installation and servicing. Provide fixed discharge air grilles integral with the casing and removable air grilles for access to filters. In addition, provide openings in the bottom and knockouts where required for piping and electrical connections. Provide security type heads (Allen head wrench type or equivalent as approved) on all exposed cabinet fasteners and leveling legs under both ends of the unit.

C. Fan Assembly:
1. Fan Board Assembly: Provide assembly of the blow through design, complete with multiple centrifugal fans with steel or non-ferrous wheels

and acoustically treated fan scrolls, mounted on a solid steel shaft supported on lubricated type bearing assemblies, connected to an electric motor located outside the air stream. Mount fan and shaft assembly on a formed No. 12 gage sheet steel fan board. Provide isolation devices between fan board and unit casing.

2. Electric Motor: Provide variable speed, electronically commutated motor. Provide isolation devices between motor and support.

D. Coil: Provide two-pipe heating-cooling coils of the plate fin type, designed for a working pressure of 200 psig and a 300 psig air pressure test underwater. Pitch coils at a minimum 30 degrees angle from the vertical to ensure proper drainage of condensate from coil surface to drain pan. Provide minimum No. 18 gage galvanized steel drain pans, insulated on the inside surfaces with a corrosion resistant material and pitched for complete drainage to a drain opening. Provide an auxiliary drain pan under valving.

E. Filter Section: Provide a built-in filter frame installed in front of unit, allowing easy removal of disposable type filters without removal of front panel.

F. Dampers: Provide factory installed dual blade mixing dampers, with a continuous divider plate between the blades, to positively separate the fresh air compartment from the return air. In addition, provide tight sealing by-pass dampers.

G. Factory Finish: Furnish all exposed surfaces of units with a factory applied two coat baked enamel finish, unless otherwise indicated. Colors to be selected by the Owner from the unit manufacturer's standard color charts.

H. Accessories: Provide accessories as noted on the drawings, the products of the same manufacturer as the equipment. Furnish accessories fabricated of the same materials and with a finish to match the equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Floor Mounted Units: Install, level and align units as required by the particular installation.

B. Air Intake Box: Connect the unit ventilator to the existing air intake box as detailed on the drawings.

C. Accessories: Install accessories of type, quantity and in location indicated on drawing.

END OF SECTION