Project Manual for

The Texas A&M University System - Polo Garage
260 Polo Road, College Station, Texas 77840
Bid Package #2

PGAL Project No.: 1003840
TAMUS Project No.: 02-3254

95% Construction Documents

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SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for 1-phase and 3-phase electric motors with NEMA frame machines sized through 200 horsepower and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation. Unless otherwise specified, provide motors meeting the basic requirements for general purpose alternating current motors, as defined in ANSI/NEMA MG 1-1.05.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.3 REFERENCES

A. ANSI/IEEE 117 - Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.

B. ANSI/NEMA MG 1 - Motors and Generators.

C. ANSI/NEMA MG 2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors.

D. ANSI/UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations.

E. ANSI/UL 1004 - Electric Motors.

F. Energy Conservation Design Standard for New State Buildings.

1.4 SUBMITTALS

A. Provide the following information for each motor:

1. Manufacturer.
2. Rated full load horsepower.
3. Rated volts.
4. Number of phases.
5. Frequency in hertz.
6. Full load amperes (FLA).
7. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
8. Nominal speed at full load (rpm).

9. Service factor.
10. NEMA design letter.
11. NEMA machine type (ODP, WP-I, TEFC, etc).
12. Motor space heater voltage, wattage and number of wires (where applicable)

B. For motors 3/4 horsepower and larger, include the following additional information:

1. NEMA frame size.
2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance with the intent of paragraph 2.3C.
3. Maximum ambient temperature for which motor is designed.
4. Time rating.
5. Bearing type.
6. Efficiency at full load.

C. For motors 20 horsepower and larger, include the following additional information:

1. No load amperes.
2. Efficiency at 1/2 and 3/4 load.
3. Power factor at no load, 1/2, 3/4 and full load.
4. Full load amperes.
5. Maximum guaranteed slip at full load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements for integral horsepower motors, provide products by one of the following:

1. General Electric.
2. Baldor/Reliance.
3. Toshiba
4. TECO Westinghouse.

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

2.3 MOTOR CHARACTERISTICS

A. Speed and Size:

1. Speed and approximate horsepower ratings are specified in the driven equipment specification Sections or are indicated on the Drawings. 1800 rpm (4 pole) and 3600 rpm (2 pole) motors are acceptable

2. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity.
3. Size motors so as not to overload at any point throughout the normal operating range.
4. Provide motors designed and rated for variable frequency drive applications where required.

B. Voltage:

1. Single phase: 115 volts for 120-volt nominal system voltage and 277 volts (refer to mechanical schedules).
2. Three phase: 460 volts for 480-volt nominal system voltage.

C. Frequency: 60 hertz.

D. Service Factor: According to NEMA MG 1-12.47 but not less than 1.15.

E. Acceleration Time: For integral horsepower motors, the calculated acceleration time of the combined motor and driven load shall not exceed 4 seconds at 90 percent of rated voltage.

F. Efficiency:

1. Provide single-speed NEMA Design B Premium efficiency induction motors having minimal full-load motor efficiency no less than those listed in the latest edition of NEMA MG 1 Section 12.60 (EFFICIENCY LEVEL OF PREMIUM EFFICIENCY ELECTRIC MOTORS). Motors and manufacturers shall be officially listed and labeled by the NEMA Premium program.
2. Base motor efficiencies on a statistically valid control procedure conforming to ANSI/IEEE 112-84, Test Method B (Dynamometer), using NEMA MG 1).
3. For motors rated at a horsepower not listed in the NEMA guidelines the motors shall conform to the next higher nominal motor horsepower efficiency rating.

2.4 DESIGN TYPE

A. Motors Smaller than 1/6 Horsepower: Single-phase squirrel-cage induction motors with integral thermal protectors.

B. Motors 1/6 through 1/2 Horsepower: Single-phase NEMA Design Letter N, squirrel-cage induction motors with integral thermal protectors.

C. Motors Larger than 1/2 Horsepower: 3-phase, NEMA Design Letter B, squirrel-cage induction motors.

D. Motor Driven by Variable Frequency Drives (VFDs): Motors driven by VFDs shall be per NEMA MG1, part 31.

2.5 MOTOR INSULATION

A. Class. Use Class F insulation system meeting the requirements of NEMA MG Part 31 and made of non-hygroscopic materials for motors 10 HP and larger.

B. Use Class B Temperature Rise: NEMA MG 1-12.41 for fractional horsepower motors and NEMA MG 1-12.42 for integral horsepower motors.

C. Outdoor Suitability:

1. Where motors must be suitable for outdoor installation, insulation must withstand 1 full week (168 hours) of testing in a chamber maintained at 100 percent relative humidity and 40°C ambient temperature.
2. Immediately after the test period, insulation system must have a minimum resistance of 1.5 megohms.
3. Coat inside circumference of the stator and the outside circumference of the rotor and shaft with the same moisture-resistant insulation system.

D. VFD Motors: Inverter duty type and capable of withstanding repeated peaks of 1600 volts at 0.1 microsecond rise time. Comply with NEMA MG-1 Part 31.

2.6 LEADS

A. Use not less than ASTM B 173, Class G, stranded copper conductors with insulation the same as or better than specified in the preceding Motor Insulation paragraph.

B. Provide permanent identification numbers on leads according to NEMA MG 1-2.02.

C. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.

2.7 ENCLOSURE

A. Indoors:

1. Open drip-proof (ODP).
2. Use steel frame for motors smaller than 3/4 horsepower and up to 1 HP, and cast-iron frame for motors over 1 horsepower.

B. Outdoors: Completely enclosed, fan cooled (TEFC), with a corrosion-resistant drain plug at the lowest point of the motor for draining. Use cast-iron frame.

C. Motors 1 HP and greater that are driven by variable frequency drives, provide motor with factory mounted shaft grounding ring. Shaft grounding device shall be accessible for inspection and replacement without disassembling the motor.

2.8 BEARINGS

A. Motors Smaller than 1/6 Horsepower: Motor manufacturer's standard bearing is acceptable.

B. Motors 1/6 Horsepower and Larger:

1. Antifriction:

a. Supply motors with grease-lubricated antifriction ball bearings conservatively rated for long life under the total radial and thrust loads produced by the actual combination of motor-driven equipment.
b. Provide each motor with suitable lubrication fittings and pressure relief devices suitable for in-service lubrication.
c. Bearing calculated L10 life must be at least 250,000 hours for direct coupled applications.

2. Oil Lubricated: If the driven equipment Section specifies oil-lubricated bearings for motors, include a suitable sight gauge on each bearing with maximum and minimum levels clearly indicated.

2.9 HARDWARE

A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength steel. Use only hexagon-head bolts and hexagon nuts.

B. Use corrosion-resistant materials or protect hardware from corrosion by hot-dip galvanizing, chrome plating, or cadmium plating.

2.10 NAMEPLATES

A. Main Nameplate: Provide each motor with a stainless steel nameplate meeting the requirements of NEMA MG 1-10.38, and the National Electrical Code, Section 430-7. Identify energy-efficient motors in accordance with MG-1-12.54.2.

B. Bearings Nameplate: When bearings are oil lubricated, include oil type information on a suitable nameplate. Indicate bearing data if nonstandard.

C. Attachment: Attach the nameplates to the motor with stainless steel fastening pins or screws.

2.11 CONDUIT BOX

A. For each motor not supplied with a cord and plug, provide a conduit box suitably sized for the motor lead terminations, in accordance with the National Electrical Code, Section 430-12. Include a grounding lug for motors 1/6 horsepower and larger. Supply a gasket suitable for the motor enclosure type and application.

2.12 PAINT

A. Manufacturer's standard shop paints for prime and finish coats are acceptable.

2.13 NOISE

A. Provide integral horsepower motors with overall sound power levels meeting the requirements of MG 1-12.49.

2.14 STARTERS

A. Provide starters for any motor not equipped with VFD.

2.15 MOTOR HEATERS

A. Provide motor heaters on all motors larger than 5 HP that are located in exterior, unconditioned, or semi conditioned spaces. Heaters shall be controlled off a normally closed contact from the motor starter.

1. Type. Electric resistance, silicon rubber clad or equivalent non-oxidizing exterior, with maximum surface temperature of 130ºC(266ºF). Alternatively, provide two stainless steel sheathed conventional space heaters, each with the rated watts at the specified voltage equal to twice the required value, and connected in series.
2. Wattage. As required to avoid condensation during shutdown, but not less than twice the value given in the Appendix of IEEE Standard 43, paragraph A 1.3 (twice the length in feet multiplied by the diameter in feet divided by 35).
3. Voltage. 230 volts, single phase, 60 hz but operated at 120V

PART 3 - EXECUTION

3.1 INSTALLATION

A. Properly install and align motors in the locations as shown on Drawings. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equivalent.

B. Nameplate must be in full view when motor and equipment are installed.

C. If a motor horsepower rating larger than indicated is offered as a substitute and is accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches, and other related items at no change in contract price.

3.2 FIELD TESTING

A. Provide instruments, labor and personnel required to perform motor inspection and testing.

B. Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase identification, and cleanliness. Report abnormalities to Owner’s Representative before energizing.

C. Megger test all motors 20 horsepower and larger in accordance with IEEE Report No. 43, “Recommended Practices for testing Insulation Resistance of Rotating Machinery” to determine insulation resistance.

D. Measure full load current and full load voltage.

E. Complete and submit Motor Test Report forms to Owner’s Representative.

F. After installation has been thoroughly checked and found to be in proper condition with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.

END OF SECTION

SECTION 23 05 15 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish complete the variable frequency drive (VFD) units as specified herein. All features described shall be included within the VFD enclosure.

1.2 RELATED WORK

A. Section 23 00 10, Mechanical General Provisions.

B. Section 23 05 13, Common Motor Requirements for HVAC Equipment.

C. Section 23 21 23, Hydronic Pumps.

D. Section 22 34 13, Fans.

E. Section 23 73 13, Air Handling Units.

F. Section 26 00 00, Electrical General Provisions.

G. Section 28 31 00, Fire Alarm System.

1.3 SUBMITTALS

A. Submit complete product data, shop drawings, and wiring diagrams, including the rated input current of the VFD. Data shall clearly indicate the current distortion produced by the VFD (submittal will not be approved prior to receiving this information). See paragraph 2.2E for requirements. Make submittals under the provisions of Section 23 00 00 and Division 01.

B. Product Data:

1. Provide literature that indicates dimensions, weights, capacities, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
2. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring. Coordinate submittal with Direct Digital Controls supplier for interface with building control system.
3. Ratings, including voltage and continuous current or horsepower.

C. Shop Drawings:

1. Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

2. Dimensioned drawings. Outline dimensional drawings of each size and type of variable frequency drive (VFD) proposed for use on this project. Include top and bottom views showing conduit entry and exit space, front and side elevations showing arrangement of devices, ventilation and cooling provisions, required clearances, and connection details. Include weight of each size and type of VFD proposed for use on this project, and mounting provisions.

D. Prior to Installation, Startup, and Testing:

1. Submit manufacturer's written installation instructions.
2. Submit written procedures for field testing to be performed under Part 3 of this Section. Procedures shall include prerequisite and initial conditions, a list of required test instruments, and forms for documentation of test results. Testing forms shall include the range of acceptance values for each recorded parameter.
3. Operation and Maintenance Manuals. Submit O&M manuals in accordance with the requirements of Section 23 00 00 and Division 01. Include instructions for routine service, spare parts lists, and wiring diagrams.

E. Following Installation, Startup, and Testing. Submit the following information for record purposes in accordance with the requirements of Division 01, Submittals, prior to Owner acceptance.

1. Records. Final as-built drawings and information for items listed in paragraph 1.3B and 1.3C, this Section.
2. Certified factory production test reports, as specified in Part 3, this Section.
3. Manufacturer’s Field Start-up Report and Certification, as specified in Part 3, this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. UL Compliance:

1. Comply with UL 508,
2. Comply with UL 60947-4-1A for Motor Starters and Contactors.

C. IEEE Compliance:

1. Comply with IEEE 112-B, Test Procedure for Polyphase Induction Motors and Generators.
2. Comply with IEEE 519, Harmonic Control in Electrical Power Systems.
3. Comply with ANSI/IEEE C62.41, Surge Voltages in Low-Voltage AC Power Circuits.

D. NEMA Compliance:

1. Comply with NEMA ICS 7.0, AC Adjustable Speed Drives.

2. Comply with NEMA MG-1 for Motors.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. ABB.

B. Danfoss Graham.

C. Emerson

D. Yaskawa.

2.2 VFD UNIT

A. The variable frequency drive (VFD) motor controller shall convert 480 Volt, three-phase, 60 Hertz power to adjustable voltage (0 - 480V) and frequency (0 - 60 Hz.) three-phase, AC power for stepless motor speed control with a capability of 10:1 speed range.

B. The adjustable frequency controller shall be a space vector sine-coded Pulse-Width Modulated (PWM) or IGBT design. Modulation methods which incorporate "gear-changing" techniques are not acceptable.

C. The controller shall be suitable for use with any standard NEMA-B squirrel-cage induction motor(s) having a 1.15 Service Factor. At any time in the future, it shall be possible to substitute any standard motor (equivalent horsepower, voltage and RPM) in the field.

D. The variable frequency control shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500 volt microseconds, or when other VFD's are operated from the same bus.

E. Individual or simultaneous operation of VFD’s shall not add more than the total harmonic voltage distortion and no more than the total harmonic current distortion allowed by the latest edition of IEEE 519 to the normal bus.

1. VFD manufacturer shall perform harmonic analysis based on the electrical one-line diagram.
2. The VFD manufacturer shall provide calculations specific to this installation, showing total harmonic voltage distortion is less than the maximum allowed by the latest version of IEEE 519.
3. Input line filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE Standard 519. The resultant power factor with the addition of the filter shall be a minimum of 97%. All VFD’s shall include a minimum of 5 percent impedance reactors, no exceptions.

F. The VFD shall be provided with a harmonic filter that limits the current distortion to 5% or less. The resultant power factor with the addition of the filter shall be a minimum of 97%.

1. Assume the following input power conditions:

a. 98% power factor.
b. Nominal voltage and frequency.

G. Any inverter that generates sufficient electrical line noise to interfere with operation of sensitive building equipment (including computers) shall be field modified or replaced by the inverter supplier at no additional cost to the Owner.

H. The VFD shall be provided with a DDC System BacNet Interface.

I. The VFD shall include RFI/EMI filters to prevent high frequency noise interference from migrating back onto the power system and RFI interference with other equipment.

2.3 SCHEDULE

A. In general, capacities of equipment and electrical characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. One controller shall control the speed of one motor only. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the Owner.

B. Where rating of driven equipment furnished for this project is larger than scheduled or indicated on Drawings, provide variable speed drive suitable for driven equipment. Coordinate submittal data and unit selections with submittal data for driven equipment.

C. Provide VFDs as follows unless otherwise specified on the equipment schedule:

1. For equipment that is redundant provide VFD without a constant speed bypass.
2. For equipment that is not redundant provide VFD with a constant speed bypass.

D. Refer to the Drawing Schedules for sizes and ratings of the motors. Refer to other Sections for description of motors and their use.

2.4 BASIC DESCRIPTION

A. The controller shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz. despite incoming voltage variations.

B. The controller shall have a continuous output current rating of 100 percent of motor nameplate current.

C. The VFD shall be of the Pulse-Width Modulated type and shall consist of a full-wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The Pulse Width Modulation strategy shall be of the space vector type implemented in a microprocessor which generates a sine-coded output voltage.

D. The inverter output shall be generated by Darlington power transistors which shall be controlled by six identical base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. The drive shall produce an output volts/Hertz pattern to produce adequate starting torque under all conditions and operate smoothly at all operating speeds on variable torque load.

2.5 FEATURES

A. The door of each power unit shall include a "POWER ON" light, a VFD fault light, a VFD run light, stop pushbutton, start pushbutton, a fault reset pushbutton, a "HAND-OFF-AUTOMATIC" selector switch, and a manual speed control potentiometer.

B. The VFD shall be software programmable to provide automatic restart after any individual trip condition resulting from overcurrent, overvoltage, undervoltage, or overtemperature. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of three attempts within a short time period.

C. A speed droop feature shall be included which reduces the speed of the drive on transient overloads. The drive is to return to set speed after transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive is to automatically compensate to prevent drive trip.

D. Automatic restart after drive trip or utility failure. Software selectable if not desired.

E. Speed profile. Individual adjustable settings for start, stop, entry, slope, and minimum and maximum speed points.

F. Process signal inverter. Software selectable to allow speed of drive to vary inversely with input signal.

G. A critical speed avoidance circuit will be included for selection of two critical speeds with a rejection band centered on that speed. The drive will ignore any speed signals requiring drive operation within the rejection band.

H. Proportional and integral setpoint process controller with menu driven selection and programming via door-mounted keypad.

I. Pick up a spinning load. The VFD shall be able to determine the motor speed and resume control of a motor which is spinning in either direction without tripping.

J. A door-mounted membrane keypad with integral 2-line, 24-character LCD display shall be furnished, capable of controlling the VFD and setting drive parameters, and shall include the following features:

K. The digital display must present all diagnostic message and parameter values in English engineering units when accessed, without the use of codes.

L. The digital keypad shall allow the operator to enter exact numerical settings in English engineering units. A plain English user menu shall be provided in software as a guide to parameter setting, (rather than codes). Drive parameters shall be factory set in EEPROM and resettable in the field through the keypad. Means of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards.

M. Input circuit breaker, interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power.

N. Constant speed bypass shall be provided to allow the motor to run across the line in the event of VFD shutdown. The transfer from the VFD to the line shall be accomplished manually by means of a selector switch. The bypass circuitry shall be enclosed separate from the VFD in a NEMA-1 cabinet.

O. The bypass cabinet shall include a door-interlocked input circuit breaker, a VFD output contactor, a full-voltage starting contactor (both contactors electrically interlocked), a thermal overload relay to provide motor protection, a phase loss/undervoltage relay and a control power transformer. Mounted on the cabinet door shall be a two line LCD display to indicate status of the bypass operation (i.e. VFD output contactor failure or bypass contactor failure, etc), VFD bypass selector switch, motor fault light, power "ON" light, motor "ON" VFD light, and motor "ON LINE" light. The VFD and the bypass shall both be provided with a BacNet Protocol interface. The bypass shall have four digital inputs for individual safety interlocks, damper end switch interface and provide voltage and current reading on all 3 phases as well as KW.

P. The drive shall be provided with two isolated form C alarm contacts to indicate VFD failure and run status to the DDC.

Q. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

R. Normally the digital display shall simultaneously display:

1. Speed demand in percent.
2. Output current in amperes.
3. Frequency in Hertz or RPM.
4. Control Mode: Manual/Automatic.
5. Total three-phase KW or output volts.\

S. At the factory with compatible motor, provide at least three lock-out ranges (50 rpm maximum each), two of which can be used to correct any run test problems.

T. The VFD shall include a motor preheat function to prevent motor condensation during shut down periods.

U. The operator panel shall contain a clock with a battery backup. The clock provides the date and time for use in the fault logger and timer functions.

2.6 SERVICE CONDITIONS

A. The controller shall be designed and constructed to operate within the following service conditions:

1. Elevation. To 3300 Feet.
2. Ambient Temperature Range. 0°C to 40°C.
3. Atmosphere. Non-Condensing relative humidity to 95 percent.
4. AC Line Voltage Variation. -30 percent to +10 percent.
5. AC Line Frequency Variation. 3 Hertz.
6. Output Frequency. Shall be able to operate at the rated motor horsepower up to 90 hertz without damage to the VFD.

2.7 ENCLOSURE

A. VFD components shall be factory mounted and wired on a dead front, grounded, NEMA-1 enclosure. NEMA 12 enclosure is acceptable in lieu of NEMA 1 enclosure. Enclosure shall be UL listed as a plenum rated VFD.

B. Finish. Apply a finish to enclosure cabinet, trim, and doors. Exterior and interior metal surfaces shall be cleaned and finished with electrostatically applied "powder coat" thermoset enamel baked over a rust-inhibiting phosphatized coating.

2.8 PROTECTIVE FEATURES AND CIRCUITS

A. The controller shall include the following protective features:

1. Single phase fault or 3-phase short circuit on VFD output terminals without damage to any power component.
2. Static instantaneous overcurrent and overvoltage trip with inverse overcurrent protection.
3. Static overspeed (overfrequency) protection.
4. Line loss and undervoltage protection.
5. Power unit overtemperature protection.
6. Electronic motor overload protection.
7. Responsive action to motor winding temperature detectors or thermostatic switches.
8. Isolated operator controls.
9. Input line circuit breakers.
10. Be insensitive to incoming power phase sequence.
11. Have desaturation circuit to drive inverter section transistor base current to zero in event of controller fault.
12. Have DC bus discharge circuit for protection of operator and service personnel with an indicator lamp.
13. Input line noise suppression with line reactor.
14. Individual transistor overcurrent protection.

2.9 PARAMETER SETTINGS

A. The following system configuring settings shall be provided, without exception, field adjustable through the keypad/display unit or via the serial communication port only.

B. Motor Nameplate Data:

1. Motor frequency.
2. Number of poles.
3. Full load speed.
4. Motor volts.
5. Motor full load amps.
6. Motor KW.
7. Current minimum.
8. Current maximum.

C. VFD Limits:

1. Independent accel/decel rates.
2. No load boost.
3. Vmin, Vmax, V/Hz.
4. Full load boost.
5. Overload trip curve select (Inverse or Constant).
6. Min/Max speed (frequency).
7. Auto reset for load or voltage trip select.
8. Slip compensation.
9. Catch-A Spinning-Load select.
10. Overload trip time set.

D. VFD Parameters:

1. Voltage loop gain.
2. Voltage loop stability.
3. Current loop stability.

E. Controller Adjustments:

1. PID control enable/disable.
2. Setpoint select.
3. Proportional band select.
4. Reset time select.
5. Rate time select.
6. Input signal scaling.
7. Input signal select (4-20mA/0-5 Volts).
8. Auto start functions: On/Off, Delay On/Off, Level Select On/Off.
9. Speed Profile: Entry, Exit, Point Select.
10. Min, Max Speed Select.
11. Inverse profile select (allows VFD speed to vary directly or inversely with input signal.)

2.10 DIAGNOSTIC FEATURES AND FAULT HANDLING

A. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions. Microprocessor systems must be products of the same manufacturer as the VFD (to assure single source responsibility, availability of service and access to spare parts).

B. A "FAULT LOG" shall record, store, display and print upon demand, the following for the 3 most recent events:

1. VFD mode (Auto/Manual).
2. Date and Time stamped for each fault
3. Elapsed time (since previous fault).
4. Type of fault.
5. Reset mode (Auto/Manual).

C. A "HISTORIC LOG" shall record, store, display and print upon demand, the following control variables at 2.7 M/Sec. intervals for the 10 intervals immediately preceding a fault trip:

1. VFD mode (manual/auto/inhibited/tripped/etc.).
2. Speed demand.
3. VFD output frequency.
4. Drive inhibit (On/Off).
5. Feedback (motor) Amps.
6. VFD output volts.
7. Type of fault:

a. Inverter O/Temp.
b. Over Voltage.
c. Detection Error.
d. Earth Leakage.
e. Watchdog.
f. PSU Power Fail.
g. Manual Test.
h. Out of Sat 1-6.
i. Software Fault.
j. Waveform Gen.
k. Remote Watchdog.
l. Thermistor.
m. Sustained O/L.
n. Bypass SCR Trip.

D. The fault log record shall be accessible via a RS485 serial link as well as line by line on the keypad display.

2.11 SYSTEM OPERATION

A. With the H-O-A switch in the "HAND" position, the drive shall be controlled by the manual speed potentiometer on the drive door.

B. With the H-O-A switch in "AUTOMATIC", the drive shall start remotely through the EMS and its speed shall be controlled by a 4-20mA, internally isolated signal from the local Powers Control Panel.

C. With the H-O-A switch in the "OFF" position, the run circuit will be open and the VFD will not operate.

2.12 QUALITY ASSURANCE AND FACTORY TESTS

A. The controller shall be subject to, but not limited to, the following quality assurance controls, procedures and tests:

1. Power transistors, SCR's and diodes shall be tested to ensure correct function and highest reliability.
2. Controller will be functionally tested with a motor to ensure that if the drive is started up according to the instruction manual provided, the unit will run properly.

B. Manufacture of VFD shall certify in shop drawings that VFD and equipment motors are compatible. Contractor shall provide VFD manufacturer complete motor data prior to submittal of shop drawings.

C. Manufacturer shall provide a 3 year warranty on parts and labor to owner for each VFD from date of acceptance by Owner.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under the provisions of Section 23 00 00.

B. Deliver products on site in factory fabricated protective containers, with factory installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean dry place, elevated above grade, and protected from weather, sunlight, dirt, moisture, corrosion, and construction traffic.

D. Handle carefully to avoid damage to components, enclosures, and finish. Use only lifting eyes and brackets provided for that purpose. Damaged products shall be rejected and shall not be installed on the project.

3.2 PREPARATION

A. Verify that surfaces are ready to receive Work.

B. Verify that field measurements are as shown on Shop Drawings and as instructed by manufacturer.

C. Verify that required utilities are available, in the proper location, and ready for use.

3.3 INSTALLATION

A. Install VFD in accordance with manufacturer's published, printed instructions.

B. Mounting.

1. Mount VFD on unistrut frame anchored to 4-inch thick concrete pad or on unistrut attached to the wall.
2. Height. In general, mount units so that operating handle is approximately 60 inches above finished floor. Where grouped, align tops of units.
3. Ensure that proper clearance is provided for enclosure as required per NEC Table 110.26(A)(1) for working clearance and dedicated equipment space. Ensure that proper clearance is provided for enclosure as required by manufacturer for proper cooling of VFD.

C. Coordinate with Division 26 to complete raceway, power wiring, and grounding in accordance with the requirements of the NEC and the recommendations of the VFD manufacturer as outlined in the installation manual.

D. Contractor shall verify the existence and proper installation and operation of auxiliary contact on all disconnects located between the load and the drive. Auxiliary contact shall command the VFD to shut down as required to protect the VFD from damage. Any disconnects found lacking this function shall be corrected prior to the startup of the equipment.

E. Interface:

1. Controls. Coordinate with the controls supplier to accomplish proper interface with the building automation system (BAS) direct digital controls (DDC). Refer to Division 23 for Direct Digital Controls.
2. Fire Alarm. Coordinate with Division 28 and the fire alarm supplier to accomplish proper interface with the fire alarm system, as indicated on the Drawings. Refer to Division 28, Fire Alarm System.
3. Shutdown. Coordinate with other divisions to accomplish proper interface for shutdown of VFD, as indicated on the Drawings and as specified in the construction documents.

F. Immediately prior to final acceptance, replace all air filters in VFD and clean inside of drives.

G. Manufacturer shall provide start-up services and training as follows:

1. Start-up for Contractor to verify correct installation and proper operation, including power and controls wiring connections..
2. Start-up for Controls Vendor to verify that VFD correctly responds to control command functions and provides alarm condition to control center.
3. Provide a report for each VFD indicating start-up is complete and/or noting any deficiencies found with the installation. VFD report must be provided to engineer prior to substantial completion.

4. Provide minimum two-day training, four (4) hours per day for up to twelve (12) people. The course shall be classroom instruction complete with visual aids, documentation, circuit diagrams and hands-on training. This course shall not be construed as a sales meeting, but rather as a school to familiarize the Owner with the care, troubleshooting, and servicing of the VFD.

END OF SECTION

SECTION 23 05 19 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes the following for hydronic piping:

1. Thermometers.
2. Gauges.
3. Pressure and Temperature Taps.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, submit detailed shop drawings and manufacturer's data, including:

1. Measurement tolerances.
2. Range.
3. Accuracy.
4. Device dimensions and connection sizes (include schedule indicating stem length versus pipe diameter).
5. Scales.
6. Materials of construction.
7. Valves that will be used for isolating gauges.

B. Submit a schedule for each device to be installed, including:

1. Location.
2. Pressure or temperature range of device and fluid measured.
3. Temperature or pressure of fluid.
4. Pipe size and bulb length of thermometers.
5. Type of valve used with the Pressure Gauge.

C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Thermometers: Calibrate against standards traceable to the NIST and guaranteed accurate to plus or minus one scale division.

B. Pressure Gauges: ASME B40.1 Grade 2A accuracy 0.5 percent of scale range.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:

1. Thermometers: Ashcroft, Dwyer, Marsh Instrument, Trerice, Weiss, Weksler
2. Pressure Gauges: Ashcroft, Dwyer, Trerice, Weiss, Weksler
3. Pressure/Temperature Taps: Peterson Engineering Company, Sisco or Trerice

2.2 GLASS THERMOMETERS

A. Construction: Provide mercury free liquid in glass thermometer with a molded Valox polyester or cast aluminum case. .

B. Window: Plastic or Glass.

C. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

D. Scale: 9-inches long, white scale with black graduations and figures..

E. Stem: Aluminum or Stainless steel, thermowell installation, ¼-inch diameter, minimum 3-1/2 inch straight or angle form of length to suit installation.

F. Accuracy: Plus or minus 1 percent of full scale.

G. Furnish thermometers for services in the following ranges and divisions:

1. Chilled Water: 0 to 100 degrees F, 1 degree divisions
2. Heating Hot Water: 30 to 240 degrees F, 2 degree divisions
3. Condenser Water: 30 to 130 degrees F, 1 degree divisions
4. Process Chilled Water: 0 to 100 degrees F, 1 degree divisions

2.3 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Brass or stainless steel with pressure and temperature ratings suitable for their application. Wells for insulated piping shall have a 2-1/2 inch lagging protrusion. Locate thermometer wells so the sensing bulb will give a true and correct reading. Install thermometer so as not to cause undue restriction in small piping. Where wells are located in pipelines 1-1/2 inch and smaller, provide a section of pipe of such diameter that the net area of the pipeline will not be reduced by the thermometer well.

2.4 PRESSURE GAUGES

A. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.

1. Case: Liquid-filled type, polypropylene case, 4-1/2 inch diameter, solid front with blow-out back.
2. Bourdon Tube: Bronze or 316 stainless steel with brass or stainless steel socket.
3. Movement: 300 series stainless steel rotary type with stainless steel bushings
4. Dial: White face with black figure.
5. Pointer: Red or black, micro adjustable.
6. Window: Molded Acrylic.
7. Ring: Fiberglass polypropylene.
8. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
9. Gauge Ranges

a. Provide 0 - 160 psi gauges for 150 psi chilled/hot water service.
b. Provide 0 - 160 psi gauges for condenser water service
c. Provide 0 - 100 psi gauges for process chilled water service.

10. Provide liquid filled gauges for all pressure gauges upstream and downstream of pumps.

B. Pressure-Gauge Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Siphons: NPS 1/4 coil of brass or stainless steel tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 PRESSURE AND TEMPERATURE TAPS:

A. Taps. Provide 1/2" solid brass fittings which will receive either a pressure or temperature probe, with valve core of Nordel and fitted with a color coded cap and gasket. P/T Taps shall be rated for 275 degrees F. and 1000 psig. Provide long stem type for insulated pipe.

B. Instruments. Provide two each, No. 500 "Pete's Plug" pressure gauge adapters with four gauges and probes and four each 5" stem pocket thermometers: Two each, thermometers for chilled water, heating and domestic hot water systems, when applicable. Applicable meaning the system is being installed as part of the project. “Pete’s Plugs” to match insulation thickness.

PART 3 - EXECUTION

3.1 THERMOMETER INSTALLATIONS

A. Provide thermometers and thermometer wells in the following locations:

1. Inlet and outlet of each air handling unit coil connection.
2. Inlet and outlet of for supply and return connections of each heat exchanger.
3. As shown on Drawings and control schematics.

B. Install direct-mounting thermometers and adjust vertical and tilted positions.

C. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees where thermometers are indicated.

3.2 GAUGE INSTALLATIONS

A. Provide pressure gauges in the following locations:

1. Suction and discharge side of each pump.
2. Each hydropneumatic tank.
3. Inlet and outlet of each air handling unit coil.
4. Supply and return piping connections of coils (where shown on details).
5. Inlet and outlet of each heat exchanger vessel.
6. As shown on Drawings and control schematics.

B. Install direct-mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.

C. Install needle-valve in piping for each pressure gauge for fluids.

D. Install snubber for gauges associated with pumps.

E. Provide fittings as necessary to install pressure gauge in the vertical position.

3.3 PRESSURE AND TEMPERATURE TAP INSTALLATIONS

A. Provide pressure and temperature taps at the following locations:

1. Inlet and outlet of each coil connection.
2. Inlet and outlet of each hydronic control valve
3. Inlet and outlet of for supply and return connections of each heat exchanger.
4. Where shown in details on mechanical drawings.

B. Provide liquid filled gauges upstream and downstream of all pumps.

3.4 CONNECTIONS

A. Install thermometers and gauges adjacent to machines and equipment to allow service and maintenance for thermometers, gauges, machines, and equipment. Thermometer

3.5 ADJUSTING

A. Adjust faces of meters and gauges to proper angle for best visibility.

END OF SECTION

SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for furnishing and installing heating water, chilled water piping and appurtenances, including fittings and strainers.

B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Section 23 05 53, Identification for HVAC Piping and Equipment, for valve tags and schedules.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data showing compliance with requirements of Part 2. Clearly indicate piping, equipment, materials of construction, pressure rating and which options are to be provided.

B. Victaulic products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions.

B. Piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

1.4 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

C. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Provide only domestically manufactured piping and fittings.

B. Refer to HVAC valve schedule articles for applications of valves.

C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

F. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Ball Valves: Provide an insulated stem extension.
2. Butterfly Valves: With extended neck.

G. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Check Valves: Apco, Crane, Keckley, Kitz, Mission, Milwaukee, Mueller, Nibco, Powell, Southern California Valve, Stockham, Titan and Weco.
2. Butterfly Valves: Bray, Clow, Demco, DeZurik, Crane, Kitz, Milwaukee, Nibco, Pratt, or Stockham.
3. Ball Valve: Apollo, Crane, DeZurik, Kitz, Milwaukee, Nibco, or Watts.
4. Strainers: Armstrong, Keckley, Mueller Spirax or Watts.
5. Underground Resilient Wedge Gate Valves: Clow
6. Where grooved piping is allowed, check valves, butterfly valves, ball valves and strainers as manufactured by Victaulic.
7. Coil Packs: IMI Hydronic Engineering Inc., Nexus, Nibco, Pro Hydronic Specialties.

2.3 CHECK VALVES

A. For pipe 2 inches in diameter and smaller, furnish 150-pound (class 150) screwed, horizontal, swing check valve, all bronze construction, with screwed cap.

B. For pipe 2-1/2 to 10 inches in diameter, provide 125-pound (class 125), lugged style, drill and tapped, or retainerless wafer lug style, double door valve, with cast iron or cast steel body and aluminum bronze doors, Buna-N seat, and Type 316 stainless steel spring. At Contractor's option, a tapped double flange valve may be provided.

2.4 BUTTERFLY VALVES

A. For pipe 2-1/2 through 12 inches in diameter, furnish 200-pound flanged or tapped lug type butterfly valve with ductile iron body, stainless steel stem, aluminum-bronze disc with EPDM liner. Provide lever-operated valves 6 inches and smaller. Furnish valves 8 inches and larger with totally enclosed worm gear operators. Provide valves with enclosed worm gear operators with chain wheel and chain on valves installed higher than 96 inches above floor. Use valves designed for drip-tight shutoff in dead end service against 200 psi.

B. Where balancing valve is shown, provide butterfly valve with position lock operator (memory stop) for valves 6 inches and smaller and worm gear operator with memory stop for valves 8 inches and larger.

2.5 BALL VALVES

A. For pipe 2 inches in diameter and smaller, provide 600 psi WOG screwed, two piece bronze or forged brass body, Teflon seat, full port, stainless steel stem and ball. Provide extension stem and insulated handle for valves installed in insulated piping. Where ball valves are used as balancing valves, provide valve with memory stop.

2.6 STRAINERS

A. For pipe 2 inches in diameter and smaller, use 125-pound (class 125) cast bonze screwed Y-type strainer with 12-mesh stainless steel screen. Provide full size blowoff ball valve where shown on drawings.

B. For pipe 2-1/2 inches and larger, provide 150-pound (class 150) cast steel or iron flanged Y-type strainer with 0.045 inch stainless steel screen through 4, and 1/8 inch stainless steel screen for 6 inches and larger. Provide full size blowoff ball valve where shown on drawings.

2.7 UNDERGROUND RESILIENT WEDGE GATE VALVE

A. For pipe sizes 2 inches up to and including 20 inches:

1. Provide 250-pound-test AWWA Standard C509 or C515 resilient seated gate valves for water supply service. The valves shall have an iron or ductile body, bonnet, and O-ring plate. The wedge shall be totally encapsulated with rubber. The sealing rubber shall be permanently bonded to the wedge per ASTM D429. Valves shall be supplied with O-ring seals at all pressure retaining joints. No flat gaskets shall be allowed.

2. The valves shall be non-rising stem or rising stem, opening by turning left or right, and provided with 2" square operating nut with the word "Open" and an arrow to indicate the direction to open. Stems shall be cast copper alloy with integral collars in full compliance with AWWA. All stems shall operate with copper alloy stem nuts independent of wedge and of stem (in NRS valves). All stems shall have two O-rings located above thrust collar and one O-ring below. Stem O-rings shall be replaceable with valve fully opened and subjected to full pressure. The stems shall also have a low torque thrust bearing located above and below the stem collar to reduce friction during operation.
3. Waterway shall be smooth, unobstructed and free of all pockets, cavities and depressions in the seat area. Valves 2" and larger shall accept a full size tapping cutter.
4. The body, bonnet and O-ring plate shall be fusion-bonded epoxy coated, both interior and exterior on body and bonnet. Epoxy shall be applied in accordance with AWWA C550 and be NSF 61 Certified.
5. Each valve shall have maker's name, pressure rating, and year in which it was manufactured cast in the body. Prior to shipment from the factory, each valve shall be tested by hydrostatic pressure equal to the requirements of AWWA C509 (and UL/FM where applicable).

B. General

1. All external bolting materials shall be stainless steel and have hexagonal heads.
2. Include for valves 10 inches and smaller a 2-piece screw-type extension valve box. Include for valves larger than 10 inches a 3-piece, screw-type extension valve box. Use cast iron boxes with screw or locking slide adjustment and flared base. Minimum thickness of metal shall be 3/16 inch. Provide each valve box with a cover with cast-in identification of "Chilled Water" or "Hot Water".

2.8 VALVES FOR GROOVED PIPING SYSTEMS

A. Check Valves

1. For grooved piping systems, 2" through 12" Sizes Spring Assisted: Black enamel coated ductile iron body, ASTM A-536, Grade 65-45-12, stainless steel non-slam tilting disc or elastomer encapsulated ductile iron disc suitable for intended service, stainless steel spring and shaft, welded-in nickel seat, 300 psi. Victaulic Series 716 or 779 (with venturi).
2. For grooved piping systems 14" to 24" 230 psi, AGS grooved ends, spring-assisted dual disc check valve. ASTM A-536, Grade 65-45-12 coated ductile iron body, EPDM seat bonded to the valve body, 304 stainless steel disc, and 300 series stainless steel spring and shaft. Victaulic Series W715.

B. Butterfly Valves

1. For grooved piping systems, 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be aluminum bronze with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF-61.) Victaulic Vic®-300 MasterSeal™.
2. For grooved piping systems, 14” through 24” Sizes: 300 psi, AGS grooved ends, polyphenylene sulfide (PPS) coated ductile iron body (ASTM A-536, Grade 65-45-12), PPS coated ductile iron disc (ASTM A-536), and two piece 17-4 PH S/S stem design. Seat and seal material to suit intended service. Reinforced PTFE bearings and gear operator. Bubble tight, dead-end, or bi-directional service. With memory stop for throttling, metering or balancing service. Victaulic Vic®-300 AGS.

C. Ball Valves

1. For Vic-Press Sch. 10S 2 inches and smaller, CF8M stainless steel body, ball, and stem, PTFE seats, 304 stainless steel handle, nut, and stem washer, with Schedule 10S stainless steel type 316 Vic-Press™ and/or grooved ends. Rated for services to 400 psi. Victaulic Series P569. The valves shall have a blow-out proof stem and self-adjusting floating ball which provides uniform sealing. The full port design minimizes pressure drop for maximum flow efficiency. Valves shall be three-piece swing-out design to permit easy in-line maintenance.

D. Strainers

1. For grooved piping systems 2” through 18” sizes, 300 PSI Y-Type Strainer shall consist of ductile iron body, ASTM A-536, Grade 65-45-12, Type 304 stainless steel perforated metal removable baskets with 1/16" diameter perforations 2"-3" strainer sizes, 1/8" diameter perforations 4"-12" strainer sizes, and 0.156” diameter perforations 14” -18” strainer sizes. Victaulic Style 732 and W732.

2.9 VALVES FOR FAN COIL UNITS AND TERMINAL BOXES (COIL PACK)

A. General. The following products are for terminal boxes and fan coil units with pipe sizes 2-inches and less.

B. Combination Ball Valve w/PT Test Port and Strainer w/blowdown valve. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼” tapped ports for test plugs or other accessories and union end. Valve shall have blowout proof stem with stainless steel ball. Strainer shall have 20 mesh Type 304 stainless steel screen and ¾” hose bib & cap.

C. Combination Ball Valve w/Memory Stop and PT Test Port. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼" tapped ports for test plugs or other accessories and union end. Valve shall have blowout proof stem with stainless steel ball.

D. Combination PT Test Port w/Manual Air Vent. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼" tapped ports for test plugs or other accessories and union end.

E. PT Test Ports. Shall be rated for 1000 psi, 325F with brass body, Nordel check plugs and sealed cap.

F. Stainless Steel Flex Hoses.

1. Stainless steel flex hoses are not allowed.

G. Manual Air Vents. Shall be of brass construction and rated at 400 psi, 325F.

H. Shaft extensions (2" and smaller). For insulated pipe shall be at least 2¼" tall and constructed of brass with a stationary external shaft housing to ensure vapor barrier seal.

PART 3 - EXECUTION

3.1 STORAGE:

A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions. All piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

3.2 EXAMINATION

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

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.3 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

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

C. Provide clearance for access to valves, fittings and equipment for operation and maintenance.

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

E. Install valves in position to allow full stem movement and with operators and stems upright or horizontal.

F. Install chainwheels on operators for butterfly gate and globe valves NPS 4 and larger and more than 84 inches above floor. Extend chains to 60 inches above finished floor.

G. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

H. All piping shall be clean when it is installed.

I. Check Valves. Install lugged check valves between flat flange and full-face gasket. Install check valves a minimum three to four pipe diameters downstream of pump discharge or elbows to avoid flow turbulence.

3.4 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.

B. At air handling units, where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge and thermometer well and a balancing valve (with memory stop) for balancing, and valves for isolation of each coil.

3.5 DRAIN VALVES AND VENTS

A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.

B. Install 2 inch drain for 2 inch pipes and larger.

C. Install a line size drain valve for pipes smaller than 2 inches.

D. Provide hose adapter and cap on all drain lines.

E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.6 TESTING

A. Apply a hydraulic pressure 1-1/2 times the operating pressure, 150-psig minimum, and carefully check for leaks.

B. Remove or isolate valves, expansion joints, strainers and equipment that are rated at pressures less than test pressure.

C. Repair all leaks and retest the system until proven leak tight.

3.7 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.8 TRAINING

A. A Victaulic factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. A Victaulic representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products. Refer to 23 21 13 Hydronic Piping and Fittings for Warranty requirements.

END OF SECTION

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for furnishing and installing supports, anchors, hangers, sleeves, and concrete equipment pads for all direct and isolated suspended and floor mounted HVAC equipment.

B. See Division 05 Section, Metal Fabrications, for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

C. See Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment, for vibration isolation devices.

D. See Section 23 31 13, Ductwork, for duct hangers and supports.

1.2 DEFINITIONS

A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

B. Outdoor piping: Any piping exposed to unconditioned outside air. This includes any piping in the crawlspace and chilled water service yard.

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer’s catalog data, dimensional drawings and construction materials for the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Equipment supports.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers as applicable:

1. Anvil Intl., Inc.
2. Superstrut, Mult-A-Frame, Unistrut and Power-Strut pipe support systems
3. Specified Technologies, Inc.
4. Pipe Shields, Inc.

2.2 CONCRETE

A. Provide minimum 3,000 psi concrete. Reinforce slab with minimum No. 4 rebar on 12-inch centers each way, centered in slab unless otherwise indicated on Drawings.

2.3 STRUCTURAL METAL

A. Furnish structural metal as specified in Division 05 and as shown on Drawings.

2.4 PIPE HANGERS AND SUPPORTS

A. Provide hangers for insulated and non-insulated pipes, provide galvanized carbon steel adjustable clevis hangers. Anvil Fig. 260 or equal.

B. Multiple Hot Pipes and insulated cold pipes supported by a trapeze hanger, provide cast iron roll with galvanized finish cast iron roll beneath each pipe.

C. Multiple or Trapeze Hangers: Provide Galvanized steel channels with welded spaces and hanger rods; cast iron roll with galvanized finish and stand for sizes 4 inches and large for heating and chilled water piping.

D. Wall supports: Provide galvanized welded steel brackets and galvanized wrought steel clamp, galvanized adjustable steel yoke and cast iron roll. Anvil Fig. 194, 195, 199 as required by pipe size and weight. Submit to structural engineer for approval detailing method of attachment to wall.

E. Vertical Support: Provide galvanized riser clamp with field welded shear lugs. Anvil Fig 261 or Fig 40 as required by installation and loads to be supported. Refer to mechanical details for main riser supports.

F. Floor supports for Pipe sizes to 4 inches and all cold pipe sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange and steel support. Anvil Figures 264 or 265 as required.

G. Floor supports for Hot pipe 6 inches and larger: Provide adjustable cast iron roll and stand, adjusting screws and steel support all galvanized. Anvil Fig. 274.

H. Copper Piping Supports and Hangers: Provide copper plated carbon steel clevis hanger. Anvil Fig. Anvil CT-65.

I. Provide galvanized hangers and supports for all piping and ductwork located in pipe shafts and chases and above suspended ceiling spaces.

1. Provide hanger rods, bolts and nuts and all metal parts coated with same material as hangers.
2. Prime coat and paint exposed steel hangers and supports.

J. Outdoor Piping Supports. All pipe hangers and supports used outdoors shall be stainless steel. Provide hanger rods, bolts and nuts and all metal parts with same material as hangers.

2.5 PIPE SHIELDS

A. Provide pipe shields for piping 2 inches and smaller fabricated of 20 gauge galvanized steel over insulation in 180 degree segments, minimum 12-inches long.

B. Provide pipe shields for piping 2-1/2 inches and larger fabricated of galvanized steel over insulation in 180 degree segment as follows:

PIPE SIZE	METAL GAUGE	SHIELD LENGTH
2-1/2 to 6 inches	18	12 inches
8 to 16 inches	16	18 inches
18 inches and larger	12	24 inches

C. Provide high density segment of insulation at shields at least two inches longer than shield. Foamglas blocks (HLB 1600) or factory made insulation shields as made by Pipe Shields, Inc. are acceptable. High density insulation segment shall be of sufficient compressive strength to prevent indentation of insulation jacket. Submit data indicating compressive strength of insulation segment. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).

D. Secure insulation shields to insulation jacket with adhesive as recommended by insulation manufacturer or 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals.

E. Outdoor pipes. All pipe shields used for outdoor piping shall be stainless steel.

2.6 HANGER RODS

A. Provide cadmium plated steel, threaded both ends continuous sized for supported load.

B. Outdoor Piping: All hanger rods for outdoor piping shall use stainless steel rods.

2.7 INSERTS

A. Provide malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded rods. Submit data to structural engineer for approval. Anvil Fig. 282.

2.8 SLEEVES

A. Fit with sleeves all pipes passing through gyp board, masonry and concrete construction. Provide sleeves in floors and walls of mechanical rooms, pump rooms, etc. constructed of schedule 40 steel with galvanized finish. Sleeves outside mechanical room type spaces shall be galvanized EMT conduit for 2 inch diameter sleeves. Sleeves outside mechanical room type spaces over 2 inch and thru walls shall be rolled 20 gauge galvanized steel with welded seam. All galvanizing shall be done after welding.

B. Sleeves in floors shall be provided with a 1-1/2 inches wide center flange welded to sleeve and centered in slab. Refer to Drawings for additional requirements.

C. Sleeves thru roofs: schedule 40 galvanized steel pipe.

D. Caulk all sleeves water and air tight. Provide firestop compound at all penetrations of floor slabs and fire rated walls.

E. Sleeves below grade in outside walls are detailed on drawings. Provide Link Seal casings at sleeves at all exterior walls above and below grade. Use stainless steel retainers, nuts and bolts in sleeves below grade. Size sleeves in accord with Link Seal recommendations.

F. Size sleeves one pipe size larger than the pipe it serves including insulation thickness as appropriate.

G. Extend each sleeve through the floor or wall. Cut the sleeve 1/2 inch beyond flush from each surface, except that in exposed locations, extend floor sleeves 2 inches above finished floor line.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections for piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use copper hangers with copper pipe and nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing. As an alternate, tape copper pipe at all points contacting steel hangers, structural members or sleeves. Use a dual wrap of polyvinyl tape.

E. Use padded hangers for piping that is subject to scratching.

3.2 PIPE HANGER AND SUPPORT INSTALLATION

A. Support horizontal steel piping on center as follows:

PIPE SIZE	MAX HANGER SPACING
1/2 to 1-1/4 inches	6 feet
1-1/2 to 2 inches	10 feet
2-1/2 to 6 inches	10 feet
6 to 12 inches	10 feet
14 inches and larger	10 feet

B. Place a hanger within 6 inches of each elbow.

C. Provide hangers with vertical adjustment of 1-1/2 inches minimum.

D. For copper piping up to 1-inch place hangers not more than 5 feet apart, for 1-1/4 inch to 1-1/2 inch piping, place hangers not more than 7 feet – 0 inch apart and for 2-inch to 3-inch piping not more that 9 feet 0 inches apart.

E. Larger Sizes: Support as recommended by manufacturer.

F. Submit manufacturer’s support and hanging recommendations.

G. Support piping from structure independent from other piping installed above.

H. Support risers as detailed on drawings at each floor and independently from connected horizontal pipe.

I. Where insulation occurs, design hangers to protect insulation from damage. Pipe saddles and insulation shields, where required, are specified above.

J. Perforated bar hangers, straps, wires or chains are not permitted.

K. Support piping from precast and pan joist structure as detailed on drawings.

L. Powder actuated anchors are not permitted.

M. Sleeves penetrating beams must be submitted for approval by Structural Engineer.

3.3 CONCRETE PADS

A. Pour 6-inch pads on roughened floor slabs unless otherwise noted.

B. Extend outer edges of pads minimum 2 inches beyond equipment.

C. Chamfer edges of pads.

D. Secure equipment with anchor bolts in accordance with equipment installation instructions.

E. Air handling units shall be installed on concrete pads with adequately sized neoprene isolation pads at each air unit support point.

F. Verify that housekeeping pads for air handling units are high enough to provide a condensate drain trap deep enough to override the air handler static pressure.

G. Install pump inertia bases on 6 inch pads.

H. Install expansion tanks on 6 inch pads.

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Bolt floor stands to 4 inch thick concrete pads or as shown on Drawings.

C. Grouting: Place grout under supports for equipment and make smooth bearing surface.

D. Provide lateral bracing, to prevent swaying, for equipment supports.

E. Hot dip galvanize after fabrication.

3.5 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.

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

C. Hot dip galvanize after fabrication.

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ROOF CURBS

A. Provide prefabricate curbs for roof mounted equipment.

B. Furnish curbs suitable for slope of roof to ensure equipment is set level.

3.7 ADJUSTING

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

3.8 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 23 05 48 - VIBRATION ISOLATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for furnishing, installing, and adjusting vibration isolation, for mechanical equipment and piping, including bases of structural steel and concrete, with steel pouring forms and concrete reinforcing bars.

B. Related Sections Include:

1. Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.
2. Section 23 21 23, Hydronic Pumps.
3. Section 23 21 13, Hydronic Piping and Fittings.
4. Section 23 34 13, Fans.

1.2 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 125 miles per hour.
2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.3 SUBMITTALS

A. Product Data: Submit product data showing type, size, load, deflection, and other required information. Include clearly outlined procedures for installing and adjusting isolators. Submit Drawings for each item of equipment with complete isolation installation information.

B. Submit detailing of inertia bases and locations of vibration, including weight of inertia base.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code - Steel.”

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Include copies of approved submittals and any submittal comments.

C. Provide tab for each major type of equipment (fan coil units, pumps, piping, fans, etc.). Provide schedule of vibration isolator type with location and load on each. Include data on each isolator type that corresponds to:

1. Spring diameter.

2. Deflection.
3. Compressed spring height.
4. Point location of each isolator.
5. Calculated load at each point.
6. Field static deflection.

D. Include copy of written certification from factory representative as required in Part 3 of this specification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Korfund Dynamics
4. Mason Industries.
5. Metraflex
6. Vibration Eliminator Co., Inc.

2.2 ISOLATOR DESIGN

A. Materials:

1. Design and treat vibration isolators for resistance to corrosion.
2. Steel components shall be PVC coated or phosphatized and painted with industrial-grade, corrosion-resistant enamel.
3. Furnish zinc-electroplated or cadmium plated nuts, bolts and washers.
4. All isolators exposed to the weather shall have the steel parts hot dip galvanized and a PVC coating.
5. Clean steel bases thoroughly of welding slag and prime with zinc-chromate or metal etching primer.

B. Design:

1. Unless otherwise instructed, use spring-type vibration isolators for all equipment driven by motors of 3 horsepower and larger.
2. The isolator manufacturer must calculate the amount of spring deflection required for each isolator to achieve optimum performance and to prevent the transmission of objectionable vibration and noise.
3. Isolators must be sized for starting torque of equipment motors.

4. The following minimum spring deflections apply unless noted otherwise in the specifications:

BELT DRIVEN EQUIPMENT

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 – 10	1"	1"
15 – 30	1-1/2”	1”
40 – 75	2”	1-1/2”

DIRECT DRIVEN EQUIPMENT

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 – 20	1”	1”
25 – 75	1”	1”

5. All spring isolators must be completely stable in operation and must be designed for not less than 30 percent reserve deflection beyond actual operation conditions.
6. Height saving brackets used with isolators having 2-1/2 inch deflection or greater shall be of the precompression type to limit exposed bolt length.

2.3 ISOLATOR TYPES

A. Design of isolator types listed is based on model numbers manufactured by Kinetics Noise Control, unless otherwise indicated. Subject to compliance with requirements provide named product.

B. Type FDS: Adjustable, freestanding, open-spring mounting with combination leveling bolt and equipment fastening bolt. The spring mounting to base plate and compression plate must be rigid. Bond neoprene pad with a minimum thickness of 1/4 inch to the base plate. Base isolator shall have provisions for bolting the isolator to the supporting structure. A minimum horizontal-to-vertical spring rate of 1.0 is required.

C. Type FRS: Similar to Type FDS, but with addition of bottom load plate and restraint assembly for vertical restraint for wind loads or large torqueing forces.

D. Type SH: Spring hanger consisting of a rectangular steel box, coil spring, spring retainers, neoprene-impregnated fabric washer, and steel washer.

E. Type SRH: Combination spring and rubber hanger consisting of a rectangular steel box, coil spring, spring retainers, and an elastomeric mounting designed for 1/2 inch deflection.

F. Type SLP: Adjustable, open-spring isolator having one or more coil springs attached to a top compression plate and a base plate. Bond neoprene pad with a minimum thickness of 1/4 inch to the base plate. The spring assembly must fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolator includes restraining bolts for connecting the top plate and lower housing to prevent the isolated equipment from rising when drained of water.

G. Type NGS: Pad-type mounting consisting of two layers of 3/8 inch thick ribbed or waffled neoprene pads bonded to a 16-gage galvanized steel separator plate. Size pads for approximately 20 to 40 psi load and a deflection of 0.1 inch to 0.16 inch.

H. Type RH: Elastomeric hanger consisting of a rectangular steel box and an elastomeric isolation element of neoprene. A high-quality synthetic rubber may be used if it contains anti-ozone and antioxidant additives. Design elements for approximately 1/2 inch deflection and load so that the deflection does not exceed 15 percent of the free height of the element.

I. Type SS: Type 321 stainless steel hose and Type 304 stainless braid sheath, with carbon steel threaded fittings for pipe sizes 2 inches and less, and carbon steel flanges for pipe sizes 2-1/2 inches and greater. Hose shall have a maximum working pressure of 200 psi at 70°F through 4”, 155 psi at 70°F through 12”.

J. Type REJ: Flexible pump connectors/expansion joints shall be of the molded twin spherical type. Provide neoprene with nylon construction or EPDM. Unit shall be rated at 225 PSI and maximum temperature of 225°F. Provide 150# flanges and galvanized aircraft cable or control rods.

K. Expansion Loop: Flexible expansion loop consisting of two Series 300 stainless steel hoses and braids, two 90 degree carbon steel elbows, and a 180 degree return. Provide drain plug and flanged connections. Rate 10 inch expansion loop for 220 psi at 70°F. Rate 6 inch expansion loop for a minimum of 200 psi at 70°F.

2.4 ISOLATION BASES

A. Type CIB-L: Mount equipment on concrete inertia blocks which weigh at least twice the weight of equipment supported. Obtain equipment assembly information from the equipment manufacturer and include with submittal, including dimensional data. Vibration isolation manufacturer shall furnish steel concrete pouring forms for floating concrete bases. Size each inertia base to extend a minimum of 4 inches outside the equipment base. In the case of belt-driven equipment, extend the base 4 inches beyond the end of the drive shaft. Provide T-shaped inertia bases where necessary to conserve space. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a minimum 1" clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable. Install vibration isolation, as specified, between inertia blocks and equipment (housekeeping) pads.

B. Type SFB: A structural steel fan and motor base with NEMA standard motor side rails and holes drilled to receive the fan and motor. The steel members shall be adequately sized to prevent distortion and misalignment of the drive. Suspended equipment shall be designed to spread the base area of equipment for increased stability and to permit suspension with hanger rods.

C. Structural bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Install motor driven equipment with vibration isolators as indicated in schedule below.

F. Isolate pumped water-piping systems with spring-type vibration isolators as indicated in schedule.

G. All open-type spring isolators shall be restrained as recommended by the manufacturer.

H. Install full line size flexible connectors at the suction and discharge connection of each piece of equipment as indicated in schedule below. All connectors to be suitable for use at the pressure and temperature encountered at point of operation. Do not insulate Type REJ flex pump connectors installed in heating hot water systems.

I. Isolation Bases

1. The isolated equipment and its driving motor shall be mounted on a common inertia base and the base, in turn, shall be mounted on the scheduled vibration isolator type to prevent transmission of vibration and noise to the building structure.
2. For floor mounted equipment, provide an equipment (housekeeping) pad under the isolation base.
3. In general, all inertia bases shall be formed and poured in place onto a hard, flat surface from which the base can be separated when cured. The base shall be shimmed, using flat material, to the intended final height prior to equipment mounting and piping connection.

4. After piping connections are made and the system filled with water and ready to put into service, the isolator adjustment bolts shall be extended until the shim blocks can be removed. Isolators may then be backed down slightly to restore the intended height. The locknuts should then be tightened on the isolators. Jack bolts shall be trimmed to a length that will allow no more than 1 inch of additional height adjustment. After final adjustment, the inertia base shall not support any piping load. All springs supporting piping that is connected to a piece of isolated equipment shall be sized for static deflection equal to that of the isolated equipment.

3.2 APPLICATION

A. The following is a schedule of equipment and piping on a typical project that requires vibration isolation and base isolators of the types specified. Refer to Drawings for equipment scheduled for the Project. Any equipment, system or condition that may be altered, added, or changed; or that is not specifically described in the Contract Documents shall be isolated in a manner specified for similar equipment, system or condition in order to comply with these Specifications.

B. Provide isolation for the following equipment:

Equipment	Isolator Type	Minimum Deflection (inches)
Air Handling Units:		
Floor/Roof Mounted – up to 15 HP	FDS* and NGS	1 0.1 – 0.16
Floor/Roof Mounted – 20 HP and over	FDS* and NGS	2 0.1 – 0.16
*Type FDS by AHU Manufacturer		
Fan Coil Units:		
Suspended	SRH	1
Belt Drive - Suspended	SRH	1
Floor Mounted	NGS	0.1 – 0.16
Inline Fans:		
Suspended – up to 15 HP Provide thrust restraints as required	SRH	1
Suspended – 15 HP and over Provide thrust restraints as required	SRH	2
Pumps:		
Up to 5 HP	FDS/CIB-L	1
5 HP, 7-1/2 HP	FDS/ CIB-L	1
10 HP and over	FDS/CIB-L	2

C. Provide isolation for the following piping systems:

Piping Systems	Isolator Type	Minimum Deflection (inches)
Piping in Pump Rooms:		
Chilled Water Piping – First two hangers adjacent to pumps	SH	Equal to Equipment Isolation
Chilled Water Piping – All piping 1-1/2 inches and larger, except first two hangers adjacent to pumps	SH	1
Heating Hot Water Piping – First two hangers adjacent to pumps	SH	Equal to Equipment Isolation
Heating Hot Water Piping – All piping 1-1/2 inches and larger, except first two hangers adjacent to pumps.	SH	1
Pumps Suction/Discharge:		
Chilled Water Pump	REJ	
Hot Water Pump	REJ	
Air Handling Units:		
Supply/Return piping connections	REJ	
First two hangers adjacent to equipment]	SH	1

3.3 STOCK REQUIREMENTS

A. The isolation manufacturer's representative must maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 FACTORY REPRESENTATION:

A. After installation, furnish factory-trained representative of the isolation manufacturer to check various isolators and report measured versus anticipated deflection on all isolators. Have the representative submit written certification that the isolators have been installed in accordance with the specifications, manufacturer's recommendations and approved submittals

END OF SECTION

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.
7. Duct labels.

1.2 SUBMITTAL

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.3 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.4 RELATED WORK

A. Painting. Division 09.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Valve Tags

1. Each service shall be individually tabbed in the binder.]

2. Provide valve charts listing functions of each valve in a metal frame and behind glass placed as directed by Owner
3. For each valve tag, indicate service, function, valve position (NC or NO), floor, room location and nearest column numbers.

C. Equipment Labels

1. Provide three ring binder including equipment label information (8-1/2 x 11 inch paper).
2. Each type of equipment (pumps, AHUs, etc) shall be individually tabbed in the binder.
3. For each item of equipment to be labeled, provide equipment identification number, floor, room location, and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufactures: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Marking Services, Inc.
3. Seton Identification Products.

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032 inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 x 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: Background to contrast with letter color.
4. Maximum Temperature: Able to withstand temperatures up to 160°F.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 inch x 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

2.3 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black. (Similar to Sherwin-Williams SW 4090)

C. Background Color: Background to contrast with letter color.

D. Maximum Temperature: Able to withstand temperatures up to 160°F.

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

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering 2/3 to 3/4 the size of principal lettering.

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

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

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches high.
3. Standardized Sizes: Tags shall be at least 1-1/2 inches in diameter, with depressed block characters 1/4 inch high. Titles shall be lettered on bands. Uppercase letters and Arabic numerals shall be used. Where pipes or conduits are too small or not readily accessible for such application securely fasten a brass identification tag at appropriate locations. Identification of the material contained in piping and conduits in accordance with the table below:

BAND AND LETTER SIZE ALL DIMENSIONS IN INCHES

Outside Diameter of Pipe Covering	Width of Color Band	Size of Letters and Numerals
1/2 to 1-1/4	**8**	**1/2**
1-1/2 to 2	8	3/4
2-1/4 to 3-1/4	10	1
3-1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
Over 10	32	3-1/2

4. Pipe Identification: Identify pipe at wall penetrations, machine or tank connections, and at not over 50 foot intervals. Marker identification should be visible from the floor. Mark each pipe circuit with stencil. Stencil shall include flow arrow and identification marks as follows:

SERVICE	MARK
Chilled Water Supply (air conditioning)	Ch-W-S
Chilled Water Return (air conditioning)	Ch-W-R
Heating Water Supply	Ht-W-S
Heating Water Return	H-W-R
Refrigerant Suction Line	CU # Suction
Refrigerant Liquid Line	CU # Liquid

2.5 DUCT LABELS

A. Identify ductwork with stencil.

B. Letter Color: Black. (Similar to Sherwin-Williams 4090)

C. Lettering Size: At least 1-1/2 inches high.

D. Paint: Shall meet VOC requirements per Division 09 painting specification.

E. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

2.6 VALVE TAGS

A. Provide valves with 1 1/2 inch diameter stainless steel or brass valve tag with stamped and black-filled numbers. Service designations shall be 1/4 inch letters, and valve numbers shall be 1/2 inch letters. Service designations shall be approved by Architect/Engineer. Secure tags to valves by use of brass "S" hooks and brass chain. Secure chain to valve by use of copper or monel meter seals.

B. Direct Underground Valves. Provide a stainless steel nameplate minimum 23 gauge thickness for all direct buried underground valves that indicates valve number, service and equipment or building served by the valve.

2.7 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

A. Provide detectable aluminum foil backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping.

1. Tape shall be detectable by an electronic detection instrument.
2. Provide tape in rolls, three inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning identification shall be as follows:

UTILITY	WARNING MESSAGE
Chilled Water	CHILLED WATER
Heating Water	HEATING WATER

B. Use permanent code and letter color unaffected by moisture and other substances contained in trench backfill material.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment. Use fasteners for all equipment labels where possible. Where it is not possible to use fasteners, use adhesive.

B. Locate equipment labels where accessible and visible.

3.3 VALVE TAG

A. Install valve tags for all major valves. This shall include branch isolation and balancing valves, isolation valves for equipment such as air handling units, pumps, chillers, etc.

B. Do not provide valve tags for isolation valves directly adjacent to fan coil units and terminal boxes.

C. Direct Underground Valves. Affix nameplate to concrete pad adjacent to valve cover with a minimum of two stainless steel anchors.

3.4 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. Do not label drain piping where the floor drain is located adjacent to the equipment.

B. Underground Piping:

1. Bury tape with printed side up at a depth of 12 inches below the top surface of earth or top surface of subgrade under pavements.

C. Provide pipe labels for the following piping systems:

1. Chilled Water Systems
2. Heating Hot Water Systems
3. Drain lines
4. Refrigerant Piping

3.5 DUCT LABEL INSTALLATION

A. Identify ductwork with stencil.

B. Identify exhaust fan number, air handling unit number, service and area served.

C. Locate identification at air handling unit or fan, at each side of penetration of structure or enclosure at each obstruction, every 20 feet on long horizontal runs. Provide identification for the following ductwork:

1. All exhaust (restroom, laboratory, kitchen, etc) and relief ductwork.
2. All supply air ductwork served by Air Handling Units
3. All outside air ductwork, including pretreated outside air ducts.
4. All return air ductwork, not including return air boots and transfer ducts.

D. In addition to the information indicated above, identify the following specialty supply and exhaust risers with the following additional information:

1. Grease Exhaust Duct
2. Dryer Exhaust Duct
3. Crawlspace Supply
4. Crawlspace Exhaust

END OF SECTION

SECTION 23 07 00 - INSULATION - GENERAL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section specifies the general requirements for furnishing and installing insulation. These requirements apply to all other Mechanical Division sections specifying insulation.

B. All the ductwork and piping in pump rooms, mechanical rooms and equipment rooms including areas without ceilings is to be considered as exposed piping or ductwork. This also includes crawl spaces.

1.2 RELATED WORK

A. Internal insulation for air units is specified in the sections on air handling units. The units do not require external insulation.

B. Insulation. Refer to specific sections on individual insulation types.

C. Section 09900 or 09901, Painting.

1.3 FIRE HAZARD RATING

A. All equipment, duct and piping insulation used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements.

1.4 QUALITY ASSURANCE

A. Applicator shall be a company specializing in insulation application with minimum 5 years' experience.

B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Owner. Use materials indicated for the completed Work. Mockups shall include piping insulation, ductwork insulation and equipment insulation.

1.5 SUBMITTALS

A. Product Data. Submit product data on each insulation type, adhesive and finish to be used in the work. Include manufacturer's installation instructions, list of materials and thickness for equipment scheduled.

B. Samples. Make an application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with the work.

C. Shop Drawings: Show details for the following:

1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Attachment and covering of heat tracing inside insulation.
3. Insulation application at pipe expansion joints for each type of insulation.
4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Removable insulation at piping specialties, equipment connections, and access panels.
6. Application of field-applied jackets.
7. Application at linkages of control devices.
8. Field application for each equipment type.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are listed under individual specification sections.

2.2 INSULATION

A. Insulate in accordance with appropriate specification section.

PART 3 - EXECUTION

3.1 COMMON INSULATION REQUIREMENTS

A. All materials shall be delivered to the site shall be dry, undamaged and maintained in good condition throughout the progress of the project.

B. Insulation shall not be installed until all testing and inspection of pipe, duct, vessel, etc. has been completed and approved by Engineer/Owner’s representative.

C. Insulate valves, fittings, flanges and special items in accordance with appropriate specification section.

D. Replace insulation damaged by either moisture or other means. Insulation which has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also replace any damage caused by the condensation.

E. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

F. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

G. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

H. Install insulation with longitudinal seams at top and bottom of horizontal runs.

I. Install multiple layers of insulation with longitudinal and end seams staggered.

J. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

K. Keep insulation materials dry during application and finishing.

L. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

M. Install insulation with least number of joints practical.

N. Where vapor barrier is indicated, seal joints, duct wrap seams, vapor retarder (ASJ) film seams and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier coating/mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier coating/mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

O. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

3.2 ACCESSORIES

A. Installation of accessories such as jacketing, bands, adhesives, insulation shields, coatings, finishes, etc. is specified under individual specification sections.

3.3 PAINTING OF INSULATION

A. Where indicated on the architectural construction documents, paint ductwork or piping in exposed areas, not including mechanical and equipment rooms. Do not paint insulation located in return air plenums.

B. FSK Jacket. Prior to painting, wipe clean insulation with FSK jacket with a mild cleaning solution that will not leave a residue and allow to dry completely. Paint FSK jacket with oil based or solvent based paint in accordance with manufacturer's recommendations and as required in Specification 09 90 00.

C. ASJ Jacket. Prior to painting, dry wipe clean insulation with ASJ jacket to remove dust and loose dirt. Paint ASJ jacket with water based (latex) paint in accordance with manufacturer's recommendations and as required in Specification 09 90 00.

END OF SECTION

SECTION 23 07 13 - EXTERNAL DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides for furnishing and the installation of external insulation on concealed and exposed ductwork, including single wall supply ductwork, outside air ductwork, and relief and return air duct work in non air conditioned spaces and other miscellaneous ductwork. It also includes insulating the tops of all supply diffusers.

B. This Section provides for furnishing and the installation of external insulation on grease exhaust ductwork.

C. All the ductwork exposed to view in public spaces, in mechanical and pump rooms, crawl space and equipment rooms including all areas without ceilings is to be considered as exposed ductwork.

D. Consider space above ceilings air conditioned if floor above is air-conditioned or if the space is a return air plenum. Consider exterior vertical chases and vertical chases leading to spaces not air-conditioned as un-air conditioned spaces.

E. No lined ductwork is allowed on the project unless specifically noted on drawings or in the specifications.

1.2 RELATED WORK

A. Section 23 07 00, Insulation - General.

B. Section 23 31 13, Ductwork.

1.3 REFERENCES STANDARDS

A. ASTM C 411 - Temperature Range.

B. ASTM C 553 - Mineral Fiber Blanket and Felt Insulation.

C. ASTM C 612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM C 1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts

E. ASTM E 96 Procedure A - Jacket Vapor Transmission.

F. ASTM E 119 – Standard Method of Fire Test of Building Construction and Materials.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fiberglass:

1. CertainTeed.
2. JohnsManville.
3. Owens-Corning.
4. Knauf Insulation.

B. Ceramic Fiber

1. A.P. Green
2. Premier
3. 3M
4. Thermal Ceramics
5. FyreWrap
6. CertainTeed

C. Flexible Elastomeric

1. Armacell

2.2 INSULATION

A. Type D1, Flexible Glass Fiber Insulation: Provide flexible glass fiber insulation with factory-applied, reinforced foil scrim kraft (FSK) facing vapor barrier, 1.0- pound per cubic foot density. A “K” factor of 0.27 at 75°F mean is required. Shall comply with ASTM C553 and C1290.

B. Type D2, Semi-Rigid Glass Fiber Insulation: Provide semi-rigid glass fiber insulation adhered to UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface, 2.5 pound per cubic foot density. A K factor of 0.24 at 75°F mean is required.

C. Type D3, Rigid Glass Fiber Insulation: Provide rigid board glass fiber duct insulation with integral, UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface, minimum density of 6 pounds per cubic foot. A “K” factor of 0.23 at 75°F mean is required.

D. Type D4, Fire-Rated Insulation: Provide 1-1/2 inch thick, 6-pound density, ceramic fiber blanket, aluminum foil laminated on both sides, suitable for continuous temperatures of 1900°F. Insulation shall provide 2-hour fire rating and be suitable for zero clearances to combustibles at any location. Include installation and hanger support requirements in submittal.

E. Type D5, Outdoor (Exterior) Duct Insulation: Provide closed cell flexible elastomeric insulation with 13-ply laminate membrane, minimum density of 3.0 pound per cubic foot. A K factor of 0.25 at 75°F mean is required. Insulation shall have 10 year warranty against UV light.

F. Type D6, Duct Insulation: Provide closed cell flexible elastomeric insulation with 13-ply laminate membrane, minimum density of 3.0 pound per cubic foot. A K factor of 0.25 at 75°F mean is required.

2.3 COATINGS AND ADHESIVES

A. Glass Fiber Insulation

1. Coating. Foster 30-80 or Childers CP-38 vapor barrier coating. Permeance shall be 0.05 perms or less as tested by ASTM E96, Procedure A at 47 mils dft or 0.08 perms or less as tested by ASTM F1249. Coating must comply with MIL-PRF-19565C, Type II and be QPL listed.
2. Adhesive. Fosters 85-60 or Childers CP-127 adhesive. Product must comply with ASTM C916 and ASTM E84 25/50 requirements.

B. Reinforcing Mesh. Fiberglass or polyester, 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10.

C. Flexible Elastomeric.

1. Adhesive. Armaflex 520 BLV Low VOC Adhesive, Foster 85-75 or Childers CP-82.

D. Outdoor Insulation

1. Foster 30-90 or Childers CP-35. White
2. Adhesive. Armaflex 520 or Low VOC Spray Adhesive.

E. Crawlspace Ductwork Insulation

1. Coating. Childers Encacel X or Foster Monalar 60-90.
2. Adhesive. Same as for Glass Fiber Insulation..

PART 3 - EXECUTION

3.1 GENERAL

A. Do not apply insulation until ductwork has been tested.

B. Verify surfaces are clean, foreign material removed, and dry.

C. Where trapeze hangers are used, provide strip of non-compressible insulation between ductwork and hanger.

3.2 FIRE SAFETY REQUIREMENTS

A. Do not extend duct coverings through walls or floors required to be fire stopped or required to have fire resistance rating. Interrupt duct coverings in the immediate vicinity of heat sources such as electric resistance or fuel-burning heaters.

3.3 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air ductwork.
2. Indoor, exposed supply and outdoor air ductwork.
3. Indoor, concealed or exposed return and exhaust ductwork located in nonconditioned spaces.
4. Indoor, concealed & exposed return air ductwork, from connection of outside air ductwork to air handling unit.
5. Kitchen Exhaust Ductwork
6. Return and exhaust ductwork in chases located on exterior walls.

B. Air Devices:

1. Supply Diffuser.
2. Uninsulated Plenums on Slot Diffusers and Linear Bar Grilles.

C. Items Not Insulated:

1. Indoor, concealed return air ductwork (in chases, above ceilings, except as noted above).
2. Indoor, exposed return air ductwork (in chases, mechanical rooms except as noted above).
3. Flexible connectors.

D. Definitions

1. Oval ductwork shall be insulated the same as round ductwork.
2. Outside air duct shall be considered ductwork (or plenum) from louver or intake hood to air handling unit.
3. Pretreated outside air shall be insulated the same as supply ductwork.

3.4 DUCTWORK INSULATION APPLICATION AND THICKNESS SCHEDULE

A. Provide insulation with minimum thickness and installed “R” valves in accordance with ASHRAE Standard 90.1-2013 Tables 6.8 2A & B, but not less than thickness specified in this specification and as required to prevent condensation:

Ductwork System	Application	Insulation Type	Insulation Thickness
Supply & Outside Air – Rectangular/Round (Hot, Cold, Combination)	Concealed Ductwork	D1	2”
Supply & Outside Air – Rectangular (Hot, Cold, Combination)	Exposed Ductwork	D3	2”
Supply & Outside Air – Round (Hot, Cold, Combination)	Exposed Ductwork	D2	2”

Ductwork System	Application	Insulation Type	Insulation Thickness
Air Devices	Where Scheduled	D1	1"
Return Air, Relief Air, and Exhaust Air – Rectangular/Round	Concealed, Where Scheduled	D1	1"
Return Air, Relief Air, and Exhaust Air – Rectangular	Exposed, Where Scheduled	D3	1"
Return Air, Relief Air, and Exhaust Air - Round	Exposed, Where Scheduled	D2	1"
Kitchen Grease Hood Exhaust Air	All	D4	3"
Supply, Return, Exhaust Duct	Outdoor Environment	D5	2”
Supply Air	Back of House Corridor	D6	2”

3.5 TYPE D1, FLEXIBLE GLASS FIBER INSULATION

A. Insulation shall be wrapped, in accordance with manufacturer's recommendations, on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2 inches.

B. Adhere insulation to ductwork with 4 inch wide strips of adhesive at 8 inches on center. In addition, secure insulation to the bottom of rectangular horizontal ductwork and on vertical ductwork over 24 inches wide by the use of mechanical fasteners at no more than 18 inches on center. Weld stick clips to duct work to secure insulation. Adhesive applied stick pins are not acceptable.

C. On circumferential joints, the 2 inch flange on the facing shall be stapled with outward clinching steel staples on 2 inch centers, and taped with a minimum 3-inch-wide strip of reinforcing mesh and vapor barrier coating. Cover all seams, joints, pin penetrations and other breaks with two coats of vapor barrier coating reinforced with reinforcing mesh. Coating shall completely cover and conceal mesh.

3.6 TYPE D2, SEMI-RIGID GLASS FIBER INSULATION

A. All exposed ductwork in public areas and mechanical rooms shall be wrapped in accordance with manufacturer's recommendations. Firmly butt all joints together and seal longitudinal laps of factory-applied vapor barrier jacket with adhesive. Cover butt joints with a 4 inch wide strip of factory-supplied vapor barrier jacket facing adhered with adhesive. Cover all seams, joints, pin penetrations and other breaks with two coats of vapor barrier coating and reinforcing mesh.

3.7 TYPE D3, RIGID GLASS FIBER INSULATION

A. Exposed ductwork shall be covered with rigid board insulation in accordance with manufacturer's recommendations.

B. Fill and point up all joints, perforations and exposed edges with two coats of vapor barrier coating reinforced with reinforcing mesh. Coating shall completely cover and conceal mesh.

C. Securely fasten insulation to metal surface with adhesive and mechanical fasteners on 12 inch centers.

D. Sheet metal screws and discs or other approved fasteners may be used. In addition, secure insulation to the bottom of rectangular horizontal ductwork and on vertical ductwork over 24 inches wide by the use of mechanical fasteners at no more than 18 inches on center. Weld stick clips to duct work to secure insulation. Adhesive applied stick pins are not acceptable.

3.8 TYPE D4, FIRE-RATED INSULATION

A. External duct wrap system requires two (2) 1.5-inch layers of lightweight, flexible wrap overlapped to provide an effective fire barrier. Install per manufacturer' recommendations. Insulation pins are welded in certain locations to maintain the fire barrier material up against the duct

B. Insulate around access doors to maintain 2-hr rating and provide access to access door in accordance with manufacturer's recommendations.

C. Where ducts penetrate walls and floors, maintain insulation through penetration. Annular space between insulation and penetration shall be sealed with firestop compound.

D. Exterior insulation is not required on prefabricated insulated grease exhaust ductwork.

E. The Contractor shall coordinate any special manufacturer's hanger requirements for ductwork with fire rated insulation with sheetmetal contractor. If hanger rods and angles do not meet manufacture's requirements for fire rating, insulate hanger supports per manufacturer's installation instructions.

3.9 TYPE D5, OUTDOOR (EXTERIOR) DUCT INSULATION

A. Horizontal ductwork located outdoors shall be sloped at a minimum 2-degree angle to prevent the accumulation of water on top of the finished insulated duct. Support members that connect directly to the ductwork are to be insulated with this same material. Keep compression or sharp creases of outdoor insulation to a minimum by distributing the weight of the duct resting on horizontal duct support members.

B. Adhere insulation to clean, oil-free surfaces with adhesive.

C. Seams must be installed in compression and sealed with adhesive, then covered with seal tape.

D. Follow the insulation manufacturer's installation instructions and procedures to assure the ductwork is properly insulated and that the insulation will meet the manufacturer's warranty requirements. The duct insulation shall be constructed from the bottom up, with the top insulation sized to extend over the side insulation.

3.10 TYPE D6, DUCT INSULATION

A. Adhere insulation to clean, oil-free surfaces with adhesive.

B. Seams must be installed in compression and sealed with adhesive, then covered with seal tape.

C. Follow the insulation manufacturer's installation instructions and procedures to assure the ductwork is properly insulated and that the insulation will meet the manufacturer's warranty requirements. The duct insulation shall be constructed from the bottom up, with the top insulation sized to extend over the side insulation.

3.11 STANDING SEAMS

A. Insulate standing seams and stiffeners which protrude through insulation with 3-pound density, 1-1/2 inch thick, faced duct insulation, flexible blanket or rigid insulation to match duct insulation. As a vapor seal on exposed edges, use glass cloth with vapor barrier coating. Insulation should not prevent adjustment of damper operators.

3.12 AIR DEVICES

A. Insulate backside of diffusers and uninsulated plenums on slot diffusers as indicated in application schedule.

B. All edges of insulation should be taped to diffuser backpan with pressure-sensitive aluminum foil tapes listed and labeled under UL 181A, Part I.

3.13 TRANSFER DUCTS

A. Line return air transfer ducts with 1/2 inch dual density type acoustical insulation. Coat exposed edges of insulation with sealant.

B. HEATING COILS

C. Install insulation on terminal box heating coil casings same as specified for adjacent ductwork.

3.14 FIRE, FIRE/SMOKE AND SMOKE DAMPERS

A. Insulation Installation at Fire Rated Wall and Partition Penetrations: Terminate insulation at fire, fire/smoke and smoke damper sleeves for fire rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches. Seal insulation to wall.

B. Insulation Installation at Fire Rated Floor Penetrations: For penetrations through fire rated assemblies, terminate insulation at fire and fire/smoke damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches. Seal insulation to floor.

3.15 CRAWL SPACE DUCTWORK

A. Install insulation indicated in this Section in the same method as for exposed ductwork on all supply duct as well as general exhaust ductwork.

B. Provide vapor barrier coating with reinforcing mesh. Install in strict accordance to manufacturer's guidelines.

C. Ductwork serving crawl space ventilation fans is not to be insulated.

END OF SECTION

SECTION 23 07 16 - EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section provides for furnishing and installing insulation for both high and low temperature vessels and equipment.

B. High temperature installations include hot water storage tanks and heaters, converters, heat exchangers, expansion tanks, air eliminators and other vessels containing liquids or gases above 85°F.

C. Low temperature installations include chilled water pumps, heat exchangers, expansion tanks, air eliminators, chilled water storage (buffer) tanks and other vessels containing liquids and gases below 60°F.

1.2 RELATED WORK

A. Section 23 21 13, Water Specialties.

B. Section 23 07 00, Insulation - General.

1.3 SUBMITTALS

A. Provide Submittals in accordance with Section 23 07 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fiberglass (Type E1)

1. Knauff.
2. Owens-Corning.
3. Johns Manville.

B. Flexible Elastomeric (Type E2)

1. Armacell
2. K-Flex USA.

2.2 INSULATION

A. Type E1, Semi-Rigid Glass Fiber Insulation: Provide semi-rigid glass fiber insulation adhered to UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface, 2.5 pound per cubic foot density. A K factor of 0.24 at 75°F mean is required.

B. Type E2, Flexible Elastomeric insulation: Provide closed-cell expanded rubber materials complying with ASTM C534, Type 1 for tubular materials or ASTM C534, Type 2 for sheet materials. Insulation shall have a maximum "K" factor of 0.28 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.

2.3 CEMENT AND COATINGS

A. High Temperature:

1. Cement. Provide Ryder One Coat cement to seal insulation for high temperature vessels.
2. Coating. Furnish Childers CP-50AHV2 or Foster 30-36 lagging adhesive/coating to provide a finish coat and to secure glass cloth for high temperature vessels.

B. Low Temperature:

1. Adhesive: Furnish Armaflex 520 BLV Low VOC Adhesive, Foster 85-75 or Childers CP-82 to seal longitudinal labs and to adhere butt joint covers.
2. Finish: Furnish Armaflex WB or Foster 30-64 water based latex enamel finish.

C. Reinforcing Mesh:

1. Reinforcing Mesh: Fiberglass or polyester. 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10

PART 3 - EXECUTION

3.1 GENERAL

A. Pressure test all piping prior to insulating equipment.

B. Clean surfaces prior to installation and remove all dirt.

3.2 EQUIPMENT INSULATION APPLICATION AND THICKNESS SCHEDULE

Service	Application	Insulation Type	Insulation Thickness-Inches
Air Separators, Expansion Tanks	Hot Water System	E1	1-1/2
Air Separators, Expansion Tanks, Storage (Buffer) Tanks	Chilled Water System	E2	1-1/2
Chilled Water Pump	Chilled Water System	E2	1
Chiller Cold Surfaces	Areas not factory insulated subject to condensation	E2	Two 3/4" layers.

3.3 TYPE E1, SEMI-RIGID GLASS FIBER INSULATION

A. Apply insulation to the equipment surface with the joints firmly butted and as close as possible to the equipment surface. Secure the blocks in place with mechanical fasteners, wire or stainless steel bands wrapped on 12-inch centers and a maximum of 3-inches from each edge.

B. Apply cement in two coats to a total thickness of 1/2 inch. After cement is dry, prime with 50% diluted lagging adhesive and apply a final finish lagging adhesive/coating with reinforcing per manufacturer's instructions.

3.4 TYPE E2, FLEXIBLE ELASTOMERIC INSULATION

A. Adhere sheet insulation to clean, oil-free metal surfaces by compression fit method and full coverage of adhesive. Seal butt joints with same adhesive. Where two layers are used, stagger joints.

B. Apply finish to cover insulation.

C. Pumps.

1. The pump must be started up with vibration testing completed prior to insulating.
2. Clean pump prior to installation and remove all dirt. Carefully measure and sheets for direct application on chilled water pumps. Apply adhesive to pump and to back side of insulation. Allow adhesive to dry to touch but remain tacky before joining surfaces. Spread butt seams and apply adhesive to both butt edges. Align carefully and join butt edges. Refer to manufacturer’s instructions for further information and details.
3. Provide removable insulation (friction fit) for accessible areas of pump. Ensure pump shaft is insulated on opposite side of motor. Insulation shall not be applied directly to moving surfaces.
4. Apply a finish to the cover as specified above.
5. Install equipment identification nameplate and "spare" manufacturer's pump performance nameplate on pump inertia base with corrosion resistant fasteners.

END OF SECTION

SECTION 23 07 19 - PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Piping insulation for Chilled and Heating Water Piping within building envelope, other than Crawl Spaces and wet areas.
2. Primary and Secondary chilled water piping shall be considered chilled water piping in these specifications.
3. Furnishing and installation of insulation.
4. Jackets and accessories.
5. Chilled and Heating Water piping in crawl spaces is specified in Section 23 07 19.16, Piping Insulation (Foamglas).
6. Pre-Insulated direct buried chilled water piping is specified in Section 23 21 13.13, Pre-Insulated Chilled and Heating Water Piping.
7. Refrigerant piping insulation.
8. Energy recover water piping shall be insulated the same as chilled water piping.

1.2 REFERENCES

A. ANSI/ASTM C 195 - Mineral Fiber Thermal Insulation Cement.

B. ANSI/ASTM- C 547 - Mineral Fiber Preformed Pipe Insulation.

C. ANSI/ASTM C 552 - Cellular Glass Block and Pipe Thermal Insulation.

D. ASTM B 209 - Aluminum and Aluminum-alloy Sheet and Plate.

E. ASTM C 449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

1.3 QUALITY ASSURANCE

A. Applicator. Company specializing in piping insulation application with five years minimum experience.

B. Materials. UL/ULC Classified per UL 723 or Flame spread/fuel contributed smoke developed rating of 25/50 in accordance with ASTM E84.

1.4 SUBMITTALS

A. Refer to Specification 23 07 00.

B. Submit product data on insulating materials, including manufacturer's safety and installation instructions.

C. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Fiberglass

a. Owens-Corning.
b. JohnsManville.
c. Knauff Insulation

2. Flexible Elastomeric

a. Armacell; AP Armaflex.
b. RBX Corporation.

3. Phenolic Foam

a. Dyplast
b. Resolco Insulphen
c. ITW

2.2 INSULATION

A. Type P1: Furnish fiberglass insulation with factory applied, all service reinforced vapor barrier (ASJ) jacket having integral laminated aluminum vapor barrier and self sealing labs. Jacketing shall have a maximum water vapor permeance of 0.02 perms. Insulation shall be in accordance with ANSI/ASTM C 547 with a "K" factor of 0.23 BTU-in/hr-ft2-°F at 75°F. Insulation shall be certified by Greenguard Gold.

B. Type P2. Furnish closed-cell expanded rubber materials complying with ASTM C534, Type 1 for tubular materials or ASTM C534, Type 2 for sheet materials. Insulation shall have a maximum “K” factor of 0.28 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.

C. Type P5. Furnish minimum 2.5-pound density rigid closed-cell phenolic foam insulation with factory applied all service reinforced vapor barrier (ASJ) jacket having integral laminated aluminum vapor barrier. Insulation shall be in accordance with ASTM C-1126 with a maximum “K” factor of 0.18 BTU-in/hr-ft2-°F at 75°F.

2.3 INSULATION SHIELDS AND SADDLES

A. Field Fabricated:

1. Use high compression strength Phenolic Foamglas blocks (HLB 1600) that will support the bearing area at hangers and supports.
2. Further support insulation at hangers and supports with a shield of galvanized metal extending not less than 2 inches on either side of the support bearing area, covering at least half of the pipe circumference, and conforming to the schedule below.

3. When pipe is guided at top and bottom, metal shields should cover the whole pipe circumference.
4. Adhere metal shield to insulation so that metal will not slide with respect to insulation. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).

Pipe Diameter	Insulated Section Length in Inches	Minimum U.S. Standard Gauge of Metal Shield
2 1/2” and smaller	14	16
3” to 4”	14	16
6” to 12”	24	14
14” and larger	24	12

5. At Contractor's option, factory-made insulation shields may be provided as made by Anvil Fig 168, equivalent by Pipe Shields, Inc., or equal. Insulation should extend at least 1 inch beyond metal. Select proper shield for service and pipe span.
6. For Type P2 insulation, factory-made insulation shields such as Armafix IPH may be used at Contractor’s option.
7. For Type P5 insulation, use minimum 5 pound density insulation or denser as required by manufacturer at all pipe supports.

B. Saddles: Fit piping 2 inches through 10 inches operating at high temperatures with Anvil Figure 161 through 164 protection saddles, or similar saddles of proper design for specified insulation thickness. Fit pipe sizes over 10 inches with Anvil Figure 163A through 165A or similar saddle as required by insulation thickness specified.

C. All shields are to be secured by 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals

2.4 JACKETS

A. PVC Jackets: Provide molded or mitered covers for flanges, valves and fittings similar to Schuller Zeston 2000.

B. Canvas or Glass Jackets and Lagging Adhesive/Coating: UL listed treated cotton fabric, 6 ounce/square yard or low odor glass cloth, Childers CP-50AMV1, Fosters 30-36 lagging adhesive or approved equal.

2.5 SEALANT, ADHESIVE AND FINISH

A. Fiberglass - High Temperature (Above 100ºF):

1. Lap Adhesive. Same as low temperature.
2. Finish: Furnish Childers CP-10/11 or Foster 46-50 weather barrier mastic with reinforcing mesh.
3. Cement: Furnish Ryder One Coat on insulated fittings, flanges and valves.
4. Primer and Finish. Furnish Childers CP-50A MV1 diluted 50% with water to prime cement prior to applying coating.

5. Lagging Adhesive: Used in conjunction with canvas or glass lagging cloth to protect equipment/piping indoors. Foster 30-36 Sealfas, Childers CP-50AMV1 Chil Seal or approved equal.

B. Flexible Elastomeric

1. Adhesive: Furnish Armaflex 520 BLV Low VOC Adhesive, Foster 85-75, or Childers CP-82 to seal longitudinal labs and to adhere butt joint covers.
2. Finish: Furnish Armaflex WB or Foster 30-64 water based latex enamel finish.

C. Phenolic Foam - Low Temperature (Below 70ºF):

1. Flashing Sealant: Furnish Childers CP 76 or Foster 95-44 elastomeric sealant at valve covers, anchors and hangers.
2. Lap Adhesive: Furnish Childers CP-82 or Foster 85-20 to seal longitudinal laps of the vapor barrier jacket and to adhere butt joint covers.
3. [Vapor Barrier Coating: Furnish Childers CP-38 or Foster 30-80 with reinforcing mesh on all insulated fittings, flanges, and valves. Coating permeance shall be no greater than 0.013 perms at 43 mils dry as tested by ASTM E96. Coating must comply with MIL-C-19565C, Type II and be QPL listed. All ASJ seams shall be coated with vapor barrier coating to prevent moisture ingress. Outdoors: Foster 30-90; Childers CP-35 only. White]

D. Reinforcing Mesh: Fiberglass or polyester. 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10

2.6 FITTINGS

A. Provide pre-molded fittings and elbows molded in two matching half sections of same insulation thickness as adjoining piping. As an alternative, provide mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs. No insert or blanket insulation allowed.

2.7 PRIMER

A. Polyguard RG-CHW for surface temperatures less than 130F, RG-2400 LT for piping with surface temperatures between 130F and 250F. Application thickness shall be 25 mils.

B. Global Encasement Rust Inhibition Primer. Application thickness shall be minimum 3 mils (dry)

C. Sherwin Williams Pro-Cryl Universal Acrylic Primer. Application thickness shall be minimum 3 mils (dry).

2.8 ALUMINUM JACKET

A. Piping. Furnish for finishing interior insulated pipe, a prefabricated jacket of ASTM B209 aluminum, 0.020 inch thick, with factory-applied 2-mil moisture barrier.

B. Valves, Fittings and Flanges. Provide complete coverage of all valves, fittings and flanges, provide aluminum covers, 0.020 inch thick, ASTM B209 aluminum.

C. Straps and Seals. Furnish 1 inch x 0.010 inch, ASTM B209 aluminum strapping and seals for applying aluminum jacket and covers to provide completely weather tight covering of all insulation including caps, flanges and end of lines.

D. Metal Jacketing Sealant: Furnish 1/8" bead of Foster 95-44 or Childers CP-76 underneath all metal jacketing laps to prevent water entry on outdoor applications.

2.9 LAMINATED JACKETING SYSTEM

A. Piping. Provide waterproofing/vapor barrier membranes composed of cross-laminated high strength polyethylene film laminated to embossed natural aluminum foil and then coated with a proprietary rubberized asphalt compound. Maximum permeance of 0.0053 Perms per ASTM E96-00.

B. Valves, Fittings and Flanges. Provide complete coverage of all valves, fittings and flanges using same product as for piping.

PART 3 - EXECUTION

3.1 PIPE

A. Pressure testing of piping systems shall be complete prior to application of insulation.

B. Prior to insulating piping,

1. Remove all oil, grease, cutting oils, dirt and other contaminants. Use suitable solvents, steam cleaning with detergent, or fresh water wash with detergent. Follow with thorough fresh water rinse.
2. Provide primer coat on all chilled and [heating hot water] steel piping in accordance with manufacturer's recommendations, to include field welds and over factory applied paint/coating, in total compliance with mechanical identification section and compatible with and approved by the insulation manufacturer. Painting must be completed and approved prior to installation of insulation.

C. Butt insulation joints firmly together. Seal longitudinal laps and butt strips with sealant.

D. P5 Phenolic Foam - Low Temperature:

1. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating vapor seal shall be formed between the vapor barrier jacket and the bare pipe by liberal application of the vapor barrier sealant to the exposed joint faces carried continuously down to and along 4 inches of pipe and up to an along 2 inches of the jacket.

E. Type P2.

1. Provide finish as specified on all insulation.

3.2 VALVES, FLANGES AND FITTINGS

A. Low Temperature:

1. Insulate all valves, flanges and fittings with molded fitting covers secured with wire. Thickness of insulation shall be equal to that adjoining piping.
2. Finish with two coats vapor barrier coating reinforced with reinforcing mesh. The application shall provide a minimum dry film thickness of 37 mils.

B. High Temperature:

1. Omit insulation at screwed unions and at valves smaller than 1-1/2 inches.
2. On concealed (other than mechanical and pump rooms) piping, insulate fittings and valves 2-1/2 inches IPS and larger, with pre-molded fitting covers. Thickness of insulation shall be equal to that of adjoining pipe. Finish with mastic reinforced with reinforcing mesh.
3. On concealed piping, insulate fittings and valves 2 inches IPS and smaller with pre-molded fitting covers with a thickness equal to or greater than adjoining straight pipe. Finish with mastic reinforced with reinforcing mesh.
4. In exposed (mechanical, pump and equipment rooms) area, insulate all fittings, flanges and valves with pre-molded fitting covers. Thickness of insulation shall be equal to that of adjoining pipe. Finish with mastic reinforced with reinforcing mesh.
5. Omit insulation on heating hot water flexible pump connectors or expansion joints.

3.3 CONTROL VALVE COVERS - LOW TEMPERATURE SERVICE ONLY

A. Fabricate special covers, complete with troweled-on vapor seal, shaped to accommodate the valve stem. Insulation thickness shall be same thickness as adjoining pipe.

B. Seal covers to valve insulation proper with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve. Finish valve cover with two coats of vapor barrier coating and reinforcing mesh.

3.4 SHIELDS AND HANGERS

A. When the insulation is jacketed in aluminum, install a length of 40-pound roofing felt 1/2 inch longer than the insulation shield between shield and jacket.

B. Where piping hangers or anchors must be in direct contact with pipe, seal off the pipe insulation on both sides of the hanger by carrying the vapor seal down to the bare pipe. Apply insulation around the hanger ring or anchor and pipe and carry vapor barrier upward and outward along the hanger rod or anchor members to a point not less than 12 inches from the adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges, and seal over adjacent vapor barrier jacket.

3.5 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Continue insulation with vapor barrier through penetrations.

C. In exposed piping areas, locate insulation and cover seams in least visible locations. For outdoor installations seal jacket lap with 1/8" bead of metal jacketing sealant underneath each lap to prevent infiltration of water beneath jacket. On horizontal piping place over lap at side of pipe arranged so that water will run off of jacket and not into seam lap.

D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. Neatly finish insulation at supports, protrusions, and interruptions. Use 1-1/2 inch Type P2 insulation to insulate drains gauges, thermometers, and strainers.

3.6 PIPING INSULATION APPLICATION AND THICKNESS SCHEDULE

A. Provide insulation with minimum thickness and conductivity values in compliance with ASHRAE standard 90.1-2013, Table 6.8.3-1,2, but not less than thicknesses specified in this specification and as required to prevent condensation. Where multiple materials are listed for a single service and location, it is the Contractor's option to choose from the allowable insulations.

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
Chilled Water	Interior	P5	1-1/2" and smaller	1
Chilled Water	Interior	P5	2" to 6"	1-1/2
Chilled Water	Interior	P5	8" and larger	1-1/2
AHU/FCU Condensate Drains	Interior	P2	All sizes	1
Heating Hot Water	Interior	P1	1-1/4" and smaller	1-1/2
Heating Hot Water	Interior	P1	1-1/2" to 4"	2
Heating Hot Water	Interior	P1	6" and larger	2-1/2
Supports, protrusions, drains, gauges, thermometers and strainers	Interior/ Exterior	P2	All Sizes	1-1/2
Flexible Pump Connector	Chilled Water	P2	All Sizes	1-1/2
Refrigerant Suction Piping	Interior/ Exterior	P2	All Sizes	1

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
AHU chilled and heating hot connection (from isolation valve to coil connection)	Mechanical Room	P2	All Sizes	1-1/2
Chilled and Heating Hot Water	Crawl Space/ Exterior		Refer to Section 23 07 19.19	
Chilled and Heating Hot Water	Below Grade		Refer to Section 23 07 19.19	

3.7 ALUMINUM JACKET

A. Apply aluminum jacket and covers according to manufacturer's recommendations, using aluminum strapping and metal jacketing sealant to provide completely weathertight covering. Completely encapsulate insulation on all piping, valves, flanges, reducers, etc.

B. Provide aluminum jacket for all piping within 84 inches of finished floor in air handler mechanical rooms, pump rooms, penthouses and exposed occupied spaces in the building. Do not install jacketing on AHU Condensate drains unless noted otherwise. Do not install jacketing on flexible pump connectors or expansion joints.

3.8 EXTERIOR JACKET

A. Apply aluminum jacketing and covers according to manufacturer's recommendations. For stainless steel jacket, use stainless steel strapping and metal jacketing sealant to provide completely weathertight covering. Completely encapsulate insulation on all piping, valves, flanges, reducers, etc.

B. Provide exterior jacket for all insulated piping located outdoors.

END OF SECTION

SECTION 23 07 19.16 - PIPING INSULATION (FOAMGLAS)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Piping insulation for Chilled and Heating Water piping in crawl spaces.
2. Piping insulation for Exterior Chilled and Heating Water piping.
3. Pre-Insulated direct buried chilled water piping is specified in Section 23 21 13.13, Pre-Insulated Chilled and Heating Water Piping.
4. Primary and Secondary chilled water piping shall be considered chilled water piping in these specifications.
5. Furnishing and installation of insulation.
6. Jackets and accessories.

1.2 REFERENCES

A. ANSI/ASTM C 552 - Cellular Glass Block and Pipe Thermal Insulation.

B. ASTM B 209 - Aluminum and Aluminum-alloy Sheet and Plate.

C. ASTM C 449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store materials (insulation, jacketing, sealant) in an area protected from the weather. Keep all materials dry before and during installation. Handle all materials carefully to prevent damage to insulation or jacketing.

1.4 QUALITY ASSURANCE

A. Applicator. Company specializing in piping insulation application with five years minimum experience.

B. Materials. Flame spread/fuel contributed smoke developed rating of 25/50 in accordance with ASTM E84.

1.5 SUBMITTALS

A. Refer to Specification 23 07 00.

B. Submit product data on insulating materials, including manufacturer's safety and installation instructions, and as required by Section 1.5D.

C. Include product description, list of materials and thickness for each service, and locations.

D. Product Data:

1. Submit product data on each insulation type, adhesive and finish to be used in the work. Include manufacturer's installation instructions, list of materials and thickness for piping scheduled.
2. Submit insulation jacket surfaces temperatures by pipe size based on job site operating conditions. Indicate potential for condensing moisture on jacket.
3. Consider crawlspace temperatures equivalent to outside conditions.
4. Refer to equipment schedules for fluid temperatures.

E. Shop Drawings: Show details for the following:

1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Insulation application at pipe expansion joints for each type of insulation.
3. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Removable insulation at piping specialties, equipment connections, and access panels.
5. Application of field-applied jackets.
6. Application at linkages of control devices.
7. Field application for each equipment type.

F. Samples: Make an application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with the work.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. These specifications are based on products and data of Pittsburgh Corning Corporation and designate the type and quality of work intended under this Section. Products of other manufacturers proposed as equivalent quality must be submitted for written approval. Supporting technical data, samples, published specifications must be submitted for comparison. The Contractor should warrant that proposed substitutions, if accepted, will provide performance equal to the materials specified herein.

2.2 INSULATION

A. Type P3: Foamglas One Insulation with a "K" factor of 0.29 BTU-In/Hr.-degree F at 75°F manufactured by Pittsburgh Corning Corporation and fabricated by a Pittsburgh Corning Corporation-approved fabricator. Water vapor permeability shall be 0.00 perm-in.The insulation shall comply with ASTM C 552 Type II, furnished in half sections up to 36 inches long or segments 18 inches long.

2.3 FLANGES AND FITTINGS

A. Provide Foamglas One pre-molded insulation at flanges, valves, and fittings.

B. Provide fiberglass blanket insulation to fill small voids around flanges and valves as required.

2.4 INSULATION SHIELDS AND SADDLES

A. Field Fabricated:

1. Use high compression strength Foamglas blocks (HLB 1600) that will support the bearing area at hangers and supports.
2. Further support insulation at hangers and supports with a shield of galvanized metal extending not less than 2 inches on either side of the support bearing area, covering at least half of the pipe circumference, and conforming to the schedule below.
3. When pipe is guided at top and bottom, metal shields should cover the whole pipe circumference.
4. Adhere metal shield to insulation so that metal will not slide with respect to insulation. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).

Pipe Diameter	Insulated Section Length in Inches	Minimum U.S. Standard Gauge of Metal Shield
2 1/2” and smaller	14	16
3” to 4”	14	16
6” to 12”	24	14
14” and larger	24	12

5. At Contractor's option, factory-made insulation shields may be provided as made by Anvil Fig 168, equivalent by Pipe Shields, Inc., or equal. Insulation should extend at least 1 inch beyond metal. Select proper shield for service and pipe span.
6. For Type P2 insulation, factory-made insulation shields such as Armafix IPH may be used at Contractor’s option.

B. Saddles: Fit piping 2 inches through 10 inches operating at high temperatures with Anvil Figure 161 through 164 protection saddles, or similar saddles of proper design for specified insulation thickness. Fit pipe sizes over 10 inches with Anvil Figure 163A through 165A or similar saddle as required by insulation thickness specified.

C. All shields are to be secured by 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals

2.5 JACKETS

A. Provide aluminum jacketing meeting requirements of Section 23 07 19.13.

B. Underground Piping: Provide Pittwrap CW Plus 50 mil thick self-sealing, modified bituminous membrane on piping operating below 140°F. Provide Pittwrap 125 mil thick bituminous resin reinforced with a woven, glass fabric, an integral aluminum foil layer and a protective plastic fill coating on piping operating above 140°F. Jacketing shall provide a complete encapsulation of all insulation including end flanges and reducers.

2.6 BANDING

A. Aluminum Steel bands, 1/2 inch wide by 0.0015 inch thick with matching seals.

B. Reinforced tape for insulation, 3/4 inch with fiber reinforcement, Scotch Brand No. 880 by 3M, or equal.

2.7 SEALANT AND PRIMER

A. FoamGlas:

1. Sealant: Pittseal 444N Sealant by Pittsburgh Corning Corperation.
2. Primer: Foster 60-26 or other rust-inhibitive primer.

PART 3 - EXECUTION

3.1 PIPE

A. Insulation shall be applied to piping with all joints tightly fitted to eliminate voids. For systems operating at or below 55°F, all joints must be sealed full-depth with sealant. Sealant shall not be used to fill voids or cracks.

B. Insulation sections shall be secured with stainless steel bands. Two strips of reinforced tape may be used in place of bands or wire if exterior bands are used with jacketing. The tape shall overlap itself by 50 percent.

C. Piping in Crawl Space or Outside of the Building Envelope: Aluminum jacketing shall be applied with all laps positioned to shed water and seams filled with silicone sealant. All laps shall be a minimum of 2 inches. Aluminum jacketing shall be secured using bands and seals as specified. Band spacing shall be two bands equally spaced per section of insulation. This will usually mean 9 inches or 12 inches on center.

D. Underground Piping: Apply jacketing for field insulated underground piping as indicated in Part 2.

E. Insulate valves, flanges, and fittings in a manner similar to that for piping using materials in Part 2.

F. Refer to 23 07 19.13 for insulation requirements to insulate gauges, thermometers, strainers, and protrusions.

3.2 PREPERATION

A. Tests of the piping system shall be completed prior to insulation application.

B. All piping shall be cleaned of foreign substances and free of surface moisture prior to insulation application.

C. All steel piping shall be primed with rust-inhibitive primer prior to insulating. Ductile iron piping shall have asphaltic coating on the exterior of the pipe.

3.3 CONTROL VALVE COVERS

A. Fabricate special covers, complete with troweled-on vapor seal, shaped to accommodate the valve stem. Insulation thickness shall be same thickness as adjoining pipe.

B. Seal covers to valve insulation proper with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve.

3.4 SHIELDS AND HANGERS

A. When the insulation is jacketed in aluminum, install a length of 40-pound roofing felt 1/2 inch longer than the insulation shield between shield and jacket.

B. Where piping hangers or anchors must be in direct contact with pipe, seal off the pipe insulation on both sides of the hanger by carrying the vapor seal down to the bare pipe. Apply insulation around the hanger ring or anchor and pipe and carry vapor barrier upward and outward along the hanger rod or anchor members to a point not less than 12 inches from the adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges, and seal over adjacent vapor barrier jacket.

3.5 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Continue insulation with vapor barrier through penetrations.

C. In exposed piping areas, locate insulation and cover seams in least visible locations. For outdoor installations seal jacket lap with suitable outdoor silicone sealant to prevent infiltration of water beneath jacket. On horizontal piping place over lap at side of pipe arranged so that water will run off of jacket and not into seam lap.

D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. Neatly finish insulation at supports, protrusions, and interruptions. Refer to Section 23 07 19.13 Piping Insulation (Fiberglass).

3.6 PIPING INSULATION APPLICATION AND THICKNESS SCHEDULE

A. Provide insulation with minimum thickness and conductivity values in compliance with ASHRAE standard 90.1-2013, Table 6.8.3A&B, but not less than thicknesses scheduled below.

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
Chilled Water	Crawl Space/ Exterior	P3	4” and smaller	3

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
Chilled Water	Crawl Space/ Exterior	P3	6” and larger	3-1/2
Heating Hot Water	Crawl Space/ Exterior	P3	4” and smaller	3
Heating Hot Water	Crawl Space/ Exterior	P3	6” and larger	3-1/2
Supports, protrusions, drains, gauges, thermometers and strainers	Interior/ Exterior		Refer to Section 23 07 19.13	
Refrigerant Suction Piping	Interior/ Exterior		Refer to Section 23 07 19.13	
Chilled and Heating Hot Water	Interior		Refer to Section 23 07 19.13	
Chilled and Heating Hot Water	Below Grade (Pre-Insulated)		Refer to Section 23 21 13.13	

3.7 ALUMINUM JACKET

A. Apply aluminum jacket and covers according to manufacturer’s recommendations, using aluminum strapping and seals to provide completely weathertight covering. Completely encapsulate insulation on all piping, valves, flanges, reducers, etc.

B. Provide aluminum jacket for all piping within 84 inches of finished floor in air handler mechanical rooms, pump rooms and penthouses. Do not install jacketing on AHU Condensate drains unless noted otherwise.

C. Provide aluminum jacket for all piping in crawl space, and exterior to the building envelope.

END OF SECTION

SECTION 23 08 00 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes commissioning process requirements for HVAC systems, assemblies, and equipment.

1.2 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend commissioning coordination meetings.

C. Attend construction phase controls coordination meeting.

D. Attend testing, adjusting, and balancing review and coordination meeting.

E. Participate in HVAC systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Provide information requested by the CxA for final commissioning documentation.

G. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.3 CXA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.4 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of readiness, signed by the Contractor, certifying that HVAC&R systems, assemblies, equipment, components, and associated controls are ready for testing.
5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
6. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.
7. Test and inspection reports and certificates.
8. Corrective action documents.
9. Verification of testing, adjusting, and balancing reports.

1.5 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC testing shall include entire HVAC installation. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC Contractor, testing and balancing Contractor, and HVAC Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.4 HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Sections. Provide submittals, test data, inspector record, and certification to the CxA.

B. HVAC Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Sections 23 09 00, Instrumentation and Control for HVAC, and Section 23 09 93, Sequence of Operations for HVAC Controls. Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

3.5 SYSTEMS TO BE COMMISSIONED

A. Mechanical Systems (refer to Project Specification Division 23):

1. Air Handling Units AHU-1, AHU-2, AHU-3
2. VAV Terminal Units (25% sample)
3. Fan-Coil Units – Chilled Water and DX with Condensing Units
4. Fans
5. Chilled Water Pumps CHP-1, CHP-2
6. Heating Water Pumps HWP-1, HWP-2
7. Energy Recovery Systems – AHU-1, AHU-3
8. DDC Control System

END OF SECTION

SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Refer to the Construction Documents for Sequences of Operations for HVAC Controls, for requirements that relate to this Section.

C. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure.

1.2 WORK INCLUDED

A. Provide a temperature control/energy management system and control function for the entire building. The system shall include a Direct Digital Control (DDC) System that shall communicate & be integrated to the Johnson Controls or Siemens front end Building Automation System (BAS) at the TAMU Utilities & Energy Services through an owner furnished Ethernet network.

B. The BAS system must be compatible with the existing Johnson Controls or Siemens campus system. Systems or building components to be monitored and/or controlled by the central campus systems include, but are not limited to, the following: temperature control, fire alarm, outside building lighting, and the start and stop of major equipment. Provide metering of primary building utilities as shown on the drawings, which may include chilled water, heating hot water, domestic cold water and irrigation water utilizing a WAGES and electrical metering system / Square D ION metering software with indication and totalization capabilities

C. The bidding and Contract Requirements and General Requirements apply to this work.

D. Furnish and install all components but not limited to all temperature, pressure, and flow sensors, transmitters, relays, switches, wire, and all DDC panels. Also furnish all controls, operators, power supplies, control valves, air and water flow measuring stations, transducers and wiring to connect components. Submit for approval, appropriate product data cut-sheets for all material/components intended for use prior to beginning work. Where BAS is used in specifications and drawings, it is understood to be same as DDC.

E. The Contractor shall provide Direct Digital Control (DDC) panels complete with all microprocessors, software, terminal strips, transducers, relays, and regulated power supply with battery backup at the mechanical room field equipment controllers and supervisory engines.

F. The Contractor shall furnish a HVAC Terminal Equipment Controller (TEC), electronic damper actuator(s), and electronic HW valve and actuator for installation on each VAV terminal unit and fan coil unit, as applicable, by the terminal equipment manufacturer. These DDC devices shall be delivered to the manufacturer's factory in sufficient time for the terminal equipment manufacturer to meet their scheduled delivery obligations.

G. The terminal equipment manufacturer shall provide for each VAV box an inlet flow sensor suitable for interfacing with a pressure transducer, and for VAV boxes and all other terminal equipment (fan coil units, etc.) a 24 vac, 40 va transformer, any necessary pilot control relays, and factory mount and connect these devices and the DDC controller as required for proper operation as required under this Section. The cost of factory mounting shall be included in the cost of the terminal equipment.

H. The BAS Contractor shall provide for each TEC, a 24 vac, 40 va power source, and mount and connect these devices and the DDC controller as required for proper operation as required under this Section. All other wiring and terminations related to the TEC shall be provided by the BAS contractor.

I. Room temperature, CO2 sensors and humidity sensors and mounting plates shall be provided and installed by the BAS Contractor.

J. Temperature controls and non-DDC accessories that are standard catalog products as manufactured by Siemens Building Technologies, Inc. or Johnson Controls, Inc., will be acceptable. Industrial instrumentation supplied shall be standard catalog products of Rosemount, Honeywell, Bristol, Foxboro, Leeds and Northrup, Taylor or Brown. All coordination and execution of work pertaining to the installation, service, and guarantee, under this Section of the specifications, shall be the sole responsibility of the BAS Contractor.

K. All controls to be installed, calibrated and adjusted by trained instrument technicians in the full-time employ of the BAS Subcontractor & low voltage electrical subcontractor.

L. Submit engineering/wiring drawings and receive approval prior to beginning work. These drawings shall be submitted in a timely manner to provide sufficient time to review drawings so as not to hold up the project.

M. The DDC field panels will be located in mechanical rooms or AHU vestibules as shown on the drawings or to maximize the architecture of the system provided. All sensor and start/stop wiring will be brought back to the panel responsible for controlling/monitoring the mechanical/electrical equipment for which the sensor, start/stop wiring is directly related. The location of these panels may not be shown on the drawings. The DDC panels in the mechanical room shall be provided with a UPS to allow operation of the panels during switchover to emergency power. The UPS shall provide a minimum of 500 va, be similar to an Invensys Powerware 120, and be installed in a NEMA 1 hinged, lockable cabinet.

N. Division 26 shall provide power to a duplex receptacle inside each panel. Power shall be provided from a breakered, 20 amp dedicated circuit on emergency power having an insulated ground wire from the power panel ground buss wired to the duplex receptacle.

O. The BAS Control System will perform all Sequence of Operations as required by the Design Engineer. Furnish and install a network communications trunk (N.C.T.) between DDC panels, and each terminal unit controller (or group of controllers) back to the DDC panel associated with the AHU which serves the terminal units, housed on the same relay switch. Trunks shall be connected to the panels with CAT-6 conductors and required components (switches). In addition, the N.C.T. trunk shall be extended from the nearest Panel to an Owner-provided, network drop(s) location. All terminal unit controllers shall communicate to BAS network via BACnet/IP directily.

P. Remote Notification Paging System:

1. The BAS system shall be configured to send out text messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition. This includes alarms for the building MEP systems as specified in the points list on the mechanical drawings.
2. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
3. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
4. Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
5. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
6. Message detail shall be configurable on a per user basis.
7. During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
8. BAS System/Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
9. BAS System/Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
10. The Contractor shall have a meeting with the TAMU UES prior to substantial completion to identify which users shall receive which alarms and what type of alarm they are to receive. All alarms must be programmed prior to substantial completion.

Q. The Owner shall provide the dedicated network connection between the drop(s) location and the Campus Energy Management System.

R. Provide graphics for all new work compatible with existing campus front end system.

S. All exposed wiring shall be in conduit (1/2” minimum), as per Division 26 Sections. Concealed wiring shall be plenum rated. All active Ethernet switches, hubs, and routers shall be Contractor-provided and installed. The conduit/wiring system required for the Energy Management System shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted.

T. A Square D Model #PM870 WAGES utility metering panel will be provided by Division 26, complete with all microprocessors, software, programming, point data base, trends, terminal strips, and regulated power supply with battery backup. The WAGES panel will require sensor wiring from the panel to temperature sensors located in the primary supply and return piping on the Chilled Water, Heating Hot Water, and Domestic Hot Water, to be included as part of the BAS Contractor's responsibilities. Provide all wiring from the flow meters to the WAGES panel. This WAGES panel will require a dedicated 110 volt, 20 amp, single phase standby electric circuit source installed by Division 26. This WAGES panel will require a category 6 Ethernet cable installed by Division 27. A meeting between the TAMU UES and the BAS contractor will be held as early as possible, prior to installation, to review the installation and finalize panel and wiring locations. The WAGES system will require start-up by the square D vendor.

U. Integration of the WAGES system to the UES Metering Software shall include loading of the TAMU WAGES program into each WAGES panel, connecting to the UES meter software, as well as five Graphic screens that represent each commodity that is being metered in the WAGES system. Electric Meters by the Square D, Schneider Electric Vendor will include connecting to the UES meter software, logging of meter data as required by UES, as well as many Graphic screens required to represent the electrical system and the meters that are included in the project.

V. The BAS contractor will be responsible for the connection from the Energy Management System to the campus (University). The Contractor will be responsible for programming the DDC panels with operational sequences and set-points as specified.

W. Refer to Division 23 00 10 for additional commissioning requirements.

X. During the duration of the warranty period, All DDC panels shall be updated to the latest firmware update available by the control manufacturer.

1.3 RELATED WORK

A. All work of this Division shall be coordinated and provided by the single Building Automation System (BAS) Contractor (Also known as DDC Contractor).

B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 23 Sections for details.

C. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

D. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

E. Section 01 91 13, Commissioning

1.4 SUBMITTALS

A. General.

1. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance, prior to installation.
2. All product data in the submittal shall reference the paragraph number in the specification for the corresponding equipment.
3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BAS work.
4. Owner & A/E Submittal Review

    a. Two weeks after submittal has been issued the Contractor, Owner and A/E will have a meeting to review and discuss A/E and Owner's comments. The submittal will be returned approximately one week after the controls meeting.

B. Product Data: For each control device specified.

C. Shop Drawings:

1. Schematic flow diagrams & graphic display.
2. Power, signal, and control wiring diagrams.
3. Details of control panel faces.
4. Damper schedule.
5. Valve schedule.
6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
7. Control System Software: Schematic diagrams, written descriptions, and points list.
8. Sequences of operation.
9. Software and firmware operational documentation.
10. Samples of Graphic Display screen types and associated menus.
11. Field quality-control test reports.
12. Operation and maintenance data.

1.5 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BAS provided:

    a. Table of contents.
    b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
    c. Manufacturer's product data sheets or catalog pages for all products including software.

d. Archive copy of all site-specific databases and sequences.
e. BAS network diagrams.
f. Interfaces to all third-party products and work by other trades.

2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.
3. Submit list of all alarm points indicating alarm, user being alarmed and type of alarm.

1.6 ENERGY MANAGEMENT SYSTEM WIRING

A. All wiring and conduit shall be installed in accordance with related Specification Section Division 26, Electrical.

B. The conduit/wiring system required for the BAS specification Input/Output summary:

1. Digital Input (D.I.) wiring (Class 2) may be run in a common conduit with Digital Output (D.O.) wiring (Class1) where local codes permit.
2. Analog Input (A.I.), Analog Output (A.O.), Digital Input (D.I.), and Network Communications Trunk (N.C.T.) wiring may be run in a common conduit.
3. Digital Output (D.O.) wiring run in a common conduit with Analog Input (A.I.), Analog Output (A.0.), or Network Communications Trunk (N.C.T.) is not permitted under any circumstances.
4. AC line power to DDC panel shall be #12 THHN.
5. Digital Output (D.O.) wiring shall be #14 THHN.
6. Digital Input (D.I.), Analog Input 4-20 mA (A.I.), and Analog Output (A.0.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
7. Analog Input/Thermistor/or voltage types (A.I.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).

C. Wiring between DDC Panels:

1. Furnish, install and terminate individual CAT-6 cable assemblies to interconnect each mechanical room in a star configuration. Data is passed through the switch before continuing to its destination to other main building panels and to the front end. Each cable shall originate and terminate within one designated DDC panel in each mechanical room. Additionally, furnish, install and terminate individual Cat-6 cable assemblies to connect each DDC panel within the mechanical room(s) with others in that same room, as engineered by the BAS Contractor.
2. All cable runs between mechanical rooms and /or DDC panels shall be no longer than allowed as specified in Division 27. Where runs are required that will be longer than Division 27, furnish and install an additional enclosure near the midpoint (coordinate location wit architect), to be used as a network junction box, complete with 120VAC emergency power source. Terminate and label the cables within this junction box as directed for each DDC panel.
3. Furnish, install and make connections of all interlock, power for sensors (if required), line and low-voltage wiring external and internal to DDC panels. All wiring shall be clearly and permanently labeled as outlined below.

D. Field devices requiring a 4-20 mA DC input signal shall be non-ground referenced.

E. All exposed wiring shall be in conduit (3/4" minimum), as per Division 26 Sections. A conduit size of ½" minimum is acceptable for branch runs made for end devices and/or temperature sensors. Concealed wiring shall be plenum rated. All active Ethernet switches, hubs, and routers shall be Contractor-provided and installed. The conduit/wiring system required for the Energy Management System shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted

F. All conduit shall enter BAS panels and WAGES enclosures from the bottom of the panel or enclosure.

G. All wiring in mechanical rooms, electrical rooms, inaccessible areas, or located in areas exposed to occupant view shall be run in conduit. Plenum rated wiring shall be acceptable for installation in concealed, accessible locations. Conduit fill limit shall not exceed 40% in any portion of the conduit system.

H. In order to facilitate maintenance, where multiple sensors or devices are connected to a common raceway or conduit, each sensor or device shall be individually connected to a common (non-sensor or device) junction box, which shall then be attached to the common conduit. Under no circumstances shall sensor or device wiring or tubing be routed through any other sensor or device's specific enclosure or junction box.

I. All wiring shall be labeled at both ends and at any spliced joint in between. Wire and tubing shall be tagged using a system similar to the Panduit P1 Self Laminating System that utilizes a thermal transfer (or equivalent) printer with a minimum font size of Arial 10. In addition to tagging at field device end and at spliced joints, a tag shall be placed 6 inches after entering each DDC panel. Identification and tag information shall be included in engineering/wiring submittal which must be submitted for Owner approval prior to beginning work. Tag information shall coincide with equipment/point information as written in the specification input/output summary

1.7 SYSTEM VERIFICATION--PROCEDURE TO BE FOLLOWED

A. Provide minimum 2 week written notice for all inspections.

B. Upon completion of all external sensor mounting, terminations, and wiring into and out of the DDC panels (and WAGES panel), the Owner shall inspect and approve this work. The BAS Subcontractor shall make his Representative(s) available and coordinate with the Owner during this inspection process. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete. BAS Subcontractor, General Contractor and Owner's Rep shall sign. This should be filed with Project Commissioning/ Startup documents.

C. Upon such approval being achieved, the BAS Contractor shall make terminations within the DDC panels and WAGES panel.

D. Following completion of the work and the DDC panel and WAGES Panel tie-in, a performance test shall be conducted by the Owner in the presence of the BAS Contractor and his appropriate Subcontractors.

E. The BAS Contractor shall be present for the testing of proper operation of each and every physical system point to which the Contractor has provided devices, wiring, in order to verify the equipment and installation provided by them (their portion of the work), i.e., when the Owner commands a point, the Contractor verifies in the field that the commanded point operates properly. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete, calibrated and functioning properly per the specified sequences of operation. An electronic and paper copy of which will be provided to UES for signature by the BAS Subcontractor, General Contractor and Owner's Representative. This should be filed with Project Commissioning/Startup documents. A representative of the BAS Contractor that can revise control sequences shall be available on site as necessary to make changes during the system verification.

F. Owner's Representative shall attend initial inspection and verification of completed punch list for items in paragraphs 1.5C and 1.5F of this Section. Further inspections required due to incomplete/incorrect work shall be at Contractor's expense.

G. Upon conclusion of final checkout and acceptance, the Contractor's responsibility reverts to warranty of materials and installation herein specified. System shall be warranted for a period of two (2) years. All DDC panels shall be updated to the latest firmware prior to the termination of the warranty period.

H. The Contractor shall coordinate and include the Commissioning Agent as required for the above activities. Commissioning agent will coordinate ant witness functional performance test procedures. Refer to 01 91 13 for additional details.

1.8 COORDINATION OF EFFORT

A. It is the responsibility of the Contractor to schedule and coordinate with the installer of all furnished equipment.

B. It is the Contractor's responsibility to schedule the accomplishment of these activities to allow for nominal system checkout, performance tests and balancing within the contract performance period.

1.9 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.10 SYSTEM GRAPHICS

A. Provide a cover page for the project to include graphic links including, but not limited to:

1. Air Handling Equipment
2. Chilled and Heating Water Pumps
3. Domestic Water Pumps
4. Fans
5. Outside Air Handling Equipment
6. Supply Air Floor Plan

7. Exhaust Air Floor Plan
8. Schedules
9. Other items as indicated on the construction documents

B. Floor plans shall show the following:

1. Show room numbers or list of group of rooms within the colored areas
2. Colored areas indicate different graphic links such as 1st floor North, etc.
3. Links to other floors along with chilled and heating water system links.
4. Links to sequence of operations
5. Links to any operations schedules

C. Floor Plan of supply shall show the following:

1. Indicate room numbers on plan
2. Indicate different AHU coverage with different colored cloud
3. Indicate VAV box locations along with ductwork
4. Indicate room temperatures for each zone

D. Typical VAV box shall show the following:

1. AHU serving VAV box
2. Supply CFM and damper position
3. Reheat valve position
4. Box status, heat or cool
5. Fan proof
6. Room temperature and set point
7. Damper position
8. Occupancy sensor state (if available)
9. All VAV system air flow set points.

E. Exhaust fan floor plan layout shall show the following:

1. Indicate room numbers on plan
2. Indicate with different colored bubble or cloud the boundaries of each exhaust fan.
3. Link to each exhaust fan that is shown on that floor

F. Schematic of outside air units shall show the following:

1. Schematic indicating what other AHU’s the outside air handler serves
2. Indicate flows to each AHU

G. Air Handling Unit (and PTOA) shall show the following:

1. Provide feedback on devices, but not limited to items such as temperatures, fan speed, static pressure set point and actual, valve position, filter status, airflow measuring station CFM, etc.
2. Graphics to be a true representation of the actual field equipment.

H. Chilled and Heating Water systems shall show the following:

1. Pumps along with their speed and proof of status
2. Flow meters
3. Temperature and pressure sensors and their values
4. Building control valve
5. Heat Exchanger
6. Where pumps are lead / lag set up, indicate run time in hours for each pump

I. Other

1. Refer to construction documents for other systems that require graphics.
2. Graphics shall include feedback on all devices including set point and actual values.
3. Graphics shall include damper and valve actuator position for all actuators.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The Building Automation System (BAS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other Owner provided networks.

B. The Building Automation System shall consist of the following:

1. Standalone Network Automation Engine(s).
2. Field Equipment Controller(s).
3. Input/Output Module(s).
4. Local Display Device(s).
5. Portable Operator’s Terminal(s).
6. Distributed User Interface(s).
7. Network processing, data storage and communications equipment.
8. Other components required for a complete and working BAS.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices.

D. System architectural design shall eliminate dependence upon any single device for control execution:

1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
2. The System shall maintain all settings and overrides through a system reboot.

E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

F. Integration with Existing Johnson Controls or Siemens BAS:

1. The BAS Contractor for this new project shall provide the following:

a. The BAS contractor shall provide any and all necessary connectivity licenses within the cost of the bid. Licenses shall allow specified BAS point information to be broadcast out of the BAS expansion to the existing Johnson Controls or Siemens BAS.

2.2 ACCEPTABLE CONTRACTORS

A. Mechanical contractor shall not serve as BAS contractor. Acceptable BAS contractors, provided they comply with these specifications, are:

1. Siemens Building Technologies, Inc. (branch office)
2. Johnson Controls, Inc. (branch office)
3. No exceptions

2.3 FIELD DEVICES

A. Temperature Sensors: Platinum Resistance Temperature Detector, 0°F to 400°F range, 100 ohms at 0°C, 316 stainless steel sheath, single element, ¼ inch diameter sheath. For water sensing provide 316 stainless steel thermowells. Use 304 stainless steel extension fitting to extend assemblies through insulating materials. Provide spring-loaded sensors to ensure good surface contact in thermowells. Provide matched sensor/transmitter assemblies, to be accurate to within ±0.1 degrees F from 20 degrees F to 70degrees F for chilled water monitoring, accuracy of + / - 0.5 degrees F from 30 degrees F to 250 degrees F for condenser water, hot water, or domestic water monitoring, and accuracy of + / - 0.5 degrees F from 20 degrees F to 120 degrees F for all other temperature monitoring. Install on chilled water lines such that condensation does not collect in connection head.

B. Immersion Sensors For Piping

1. Acceptable Manufacturers:

a. Dwyer Series TTE Explosion Proof RTD Temperature Probe with Dwyer Series W 316 Stainless Steel Thermowells.
b. Rosemount.

2. The above Immersion Temperature Sensors shall be equal/better to the specifications below:

a. Temperature Sensor: RTD using a Pt1000, or Pt 100.
b. Output Temperature Ranges: User selectable any range between -30 to 250 deg.f. with minimum span of 40 deg.f.
c. Temperature Limits: Ambient: 0 – 158 deg.f. Process: -30 to 250 deg.f.
d. Accuracy: Transmitter: +/- 0.1%F.S. Probe: +/- 0.3% F.S.
e. Thermal Drift Effects: +/-0.02% deg.C max.
f. Response Time: 250 ms.
g. Wetted Materials: 316 Stainless Steel.

h. Process Connection: ½" male NPT.
i. Conduit Connection: ½" female NPT.
j. Probe Length: 2" to 18" depending on model.
k. Pressure Limits: 2000 PSI.
l. Power Requirements: 10 to 35 VDC.
m. Output Signal 4-20mA.
n. Display: 2 lines X 8 character LCD.
o. Enclosure Rating: NEMA 4X (IP66) and explosion proof for Class I , Groups B, C, D; Class II, Groups E, F, G; Class III.
p. Agency Approvals: FM, CE.

3. Thermowells shall be equal/better to the specifications below

a. Hardware: 316SS Sheath.
b. Taper/Bore: Straight/0.260.
c. Inside Threads: ½ NPSF.
d. Process Connections: ½" NPT.
e. Mounting: Threaded.
f. Lag: None.
g. Sheath O.D. Base/Taper: ½" Straight.
h. Length: From 4" to 24" as needed to fit Temperature sensor length required for tip of probe to be in center of piping

C. Duct temperature sensors shall be averaging type. Water sensors shall be provided with a separable stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield. Accuracy of transmitter shall be unaffected by wiring distances up to 700 feet. Siemens Building Technologies, Johnson Controls, Minco, or Hy-Cal only.

D. Room Sensors:

1. Each room temperature sensor shall come complete with a terminal jack and override switch integral to the sensor assembly. The terminal jack shall be used to connect the portable operator's terminal to control and monitor all hardware and software point associated with the terminal unit.
2. The Humidity Sensor shall provide a 0 to 100% range corresponding to an isolated 4 to 20 Ma output. Accuracy of ±2% RH, with maximum drift of 1% per year.
3. An override switch will initiate override of the night setback or unoccupied mode to normal (day) operation when activated by the occupant. The switch function may be locked out, canceled or limited as to time or temperature in software by an authorized operator or a central or remote operator's terminal.
4. Space temperature sensors may be Thermistor or 4-20 mA output RTD. The room sensor shall be firmly attached to the wall using approved construction techniques. Double-sided adhesive tape in lieu of screws is not acceptable.
5. The room sensor shall be accurate to within ±.5°F and have a setpoint adjustment range of 45°Fto 85°F.
6. Room carbon dioxide shall provide a range from 0 to 2,000 ppm CO_2, and be accurate to within ±100 ppm. The CO_2 sensor shall experience less than 1% drift per year for the first two years of operation and negligible drift thereafter, no calibration of the CO_2 sensor is necessary.
7. Room sensors shall be full featured cover in all areas.

E. Water Flow Sensors:

1. Acceptable Manufacturers

a. Rosemount Series 8705 Magnetic Flowmeter Flow Tube with Rosemount 8712E Remote Mount Magnetic Flow Meter Transmitter.
b. Yokogawa AXF Magnetic Flow Meter with AXFA11G Magnetic Remote Converter.
c. Siemens Mag 5100 W with MAG 5000/6000 Remote Transmitter

2. Water flow sensors shall be magnetic flowmeter flow tubes shall be furnished by BAS. Each sensor shall be sized specifically for the pipe in which it is to be installed. Sensor shall have ±0.5% accuracy from 1 to 30 feet/second, with Class 150 carbon steel flanges, exterior painted with polyurethane, grounding electrode, Teflon (PTFE) lining, and Type 316L stainless steel electrodes. Contractor shall furnish Rosemount Model 8712 C remote mounted magnetic flowmeter transmitters, with 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface.

F. Temperature Transmitters: Temperature transmitters shall be designed for 4-20 mA DC output for Platinum RTD millivolt input sensor (as specified above). Accuracy shall be the same as specified for the temperature sensors. Stability shall be ±0.2% of calibrated span for 6 months. Transmitter shall be a part of the temperature sensor assembly and shall be in a moisture-proof housing with a moisture-proof seal between the sensor and transmitter. Immersion sensors for piping shall be Dwyer Series TTE explosion-proof RTD temperature transmitter with fully configurable ranges and display options or equal by Rosemount.

G. Humidity Transmitter Space: Sensor shall provide a 0 to 100 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Accuracy of + / - 2 percent RH, with maximum drift of 1 percent per year. Sensor shall be equipped with LCD display. Siemens model number QFA3000 or Johnson Controls number HC-7603.

H. CO2 Duct-Stat Indoor AQ Sensor: C02 sensor shall be Siemens model number QPA63 or Johnson Controls model number CD-P00-00. The unit shall be self-contained for wall mounting application. The unit shall have a fast response and shall have 0-1 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Visual alarm is not to be provided. The monitor shall utilize the photo acoustic sensor with VOC sampling capability.

I. Electric Room Thermostats: Provide line voltage room thermostats with cover. Set point must be adjustable from approximately 50 to 100 Deg. F. Minimum rating is 6 amps at 120 VAC. Provide removable setting knob. Housings shall not contain thermometers.

J. Duct Relative Humidity Sensor: Duct relative humidity sensors used in the calculation of enthalpy shall be Siemens QFM Series Duct Relative Humidity or similar. The sensor shall have an accuracy of +/- 2% RH. Provide unit with housings suitable for return air plenum installations. Filter material shall be Teflon. The unit shall be operating range of 0 to 100% RH and have a 4 to 20 mA or 0 to 10 Vdc linear output.

K. Flow Transmitters: Flow transmitters shall provide a 4-20 mA DC signal output proportional to flow. Accuracy of ±0.25% of calibrated span. Temperature Limits: -40°F to +220°F. Stability of ±0.25% of upper range limit for 6 months. Range of transmitter shall match flow conditions. Flow transmitter shall be Rosemont only.

L. Pressure Transmitters: Transmitters for water pressure shall provide a 4-20 mA DC signal output directly proportional to pressure. Device shall be constructed with corrosive resistant stainless steel wetted parts and have a die-cast aluminum enclosure specifically designed for NEMA4/IP65 service. Accuracy of ±0.5% of calibrated span. Span not over 200% of sensed pressure. Stability ±0.5% of upper range limit for 6 months. Stainless steel diaphragm, viton 0-rings. Temperature limits: -20°F to 220°F. Rosemount, Setra, or Bristol, only.

M. Fan proof-of-flow switches shall be UL listed adjustable setpoint and differential pressure type. Switches shall be piped to fan inlet and outlet. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inch w.c. All pressure tubing on roof shall be stainless steel. Hawkeye or equivalent.

N. Pump proof-of-flow switches shall be UL listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 150 psi body. Differential pressure switches shall have valved manifold for servicing. Hawkeye or equivalent

O. Current Status Switch: Provide a high performance miniature split-core current status switch with adjustable set point (where indicated). The current status switch shall have an operating range of between 1.25 – 50 amps and be able to detect belt loss and mechanical failure. Shall be Veris Hawkeye H908 or equal.

P. Air flow and static pressure analog sensors shall be ±.5% accuracy, range suitable for the low velocity pressures to be encountered, be selected for approximately 50% over-range, and have an electronic 4 to 20 mA analog output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. Rosemount, Dresser Industries/Ashcroft XLDP or Setra C-264, only.

Q. Electric Low Limit Duct Thermostat: Snap-acting, two pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 15 feet length of bulb. Provide one thermostat for every 20 sq ft of coil surface.

R. Air Flow Control Dampers:

1. Rectangular

   a. Frame: 5 inches x 1 inch x minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
   b. Blades:

      1) Airfoil-shaped, single-piece.

2) All proportional (modulating and mixing) control dampers shall be opposed blade type and all two-position dampers shall be parallel-blade types.
3) Heavy duty 6063-T5 extruded aluminum.
4) Maximum 6 inches (152 mm).

c. Bearings: Molded synthetic sleeve, turning in hole in frame.
d. Seals:

1) Blade: Extruded type for ultra-low leakage from -0 to 2 00 degrees F Mechanically attached to blade edge.
2) Jamb: Flexible metal compression type.

e. Linkage: Concealed in frame.
f. Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade.
g. Finish:

1) Mill aluminum for dampers in exhaust airstreams.

h. Performance Data:

1) Closed Position: Maximum pressure of 13 inches w.g. at a 12 inch blade length.
2) Open Position: Maximum air velocity of 6,000 feet per minute.
3) Leakage: Maximum 5.2 cubic feet per minute per square foot at 4 inches w.g for size 48 x 48 inches.
4) Pressure Drop: Maximum 0.03 inch w.g. at 1,500 feet per minute across 24 inch x 24 inch damper.

i. Similar to Ruskin CD-50

2. Round

a. Frame: Minimum 12 gage x 8 inches deep galvanized steel, 18 inches diameter and above. Flange: Minimum 12 gage x 1-1/2 inches.
b. Blade: Single skin, minimum 16 gage or Double skin, minimum 18 gage. Provide blade stiffeners as required.
c. Blade Stop: Neoprene sponge.
d. Axle: Minimum 1/2 inch diameter continuous plated steel rod to 24 inches diameter, 3/4 inch diameter above 24 inches diameter.
e. Bearings: Flange stainless steel pressed into frame.
f. Blade Seals: Provide seals as required to meet minimum leakage indicated. Mechanically attach blade seals to blade
g. Finish: Mill galvanized.
h. Maximum Static Pressure: 4.0 inches w.g.
i. Performance Data for Damper Diameter of 48 inches, AMCA 500:

1) Maximum System Velocity: 2,500 feet per minute.

2) Leakage with Sponge Seals:

a) Percent of Maximum Flow: 1.40.
b) Total Leakage: 35 cubic feet per minute.

j. Similar to Ruskin CDRS82

S. Air Flow Measurement Station (AFMS):

1. General

a. Each unit shall operate on 24 VAC.
b. A single manufacturer shall provide probe and transmitter.
c. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, RS-485 and BACnet.
d. Sensors shall be UL listed.
e. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer's installation requirements.

2. Duct Mounted

a. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GT. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.
b. Provide one AFMS for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature of each measurement location.
c. Each sensing point shall independently determine the airflow rate and temperature, and shall equally weight and average by the transmitter prior to output. Pitot tube arrays are not acceptable.
d. The operating range shall be from 0 - 5000 fpm with accuracy of ±2% over the entire operating airflow range and be verified against standards that are traceable to NIST.
e. Sensor Probes

1) Sensor probes shall be constructed of anodized, 6063 aluminum alloy tube.
2) Sensor probe mounting brackets shall be constructed of 304 stainless steel.
3) Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.
4) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -10°F to 200 °F and continuous and direct UV exposure.
5) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
6) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene.
7) Each sensing node shall have a temperature accuracy of ±0.15° F over an operating range of -20° F to 160° F and humidity range of 0 to 100% RH

3. Fan/Fan Array

   a. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GTx108-F/AN. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Unit shall be able to monitor up to 8 fans on a single transmitter.
   b. Provide one AFMS for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature of each fan at each measurement location.
   c. Sensor Probes

      1) Sensor probes shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
      2) Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
      3) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -10°F to 200 °F and continuous and direct UV exposure.
      4) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
      5) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene.
      6) Each sensing node shall have a temperature accuracy of ±0.15° F over an operating range of -20° F to 160° F and humidity range of 0 to 100% RH.
      7) The number of independent sensor nodes provided shall be as follows:

         a) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet.
         b) Fan Arrays (1 to 8 fans): 1 probe x 1 sensor node probe in each fan inlet.

2.4 SUPERVISORY CONTROLLERS

A. The Supervisory Controller shall be a fully user-programmable, supervisory controller. The Supervisory Controller shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Supervisory Controllers.

B. Processor – The supervisory controllers shall be microprocessor-based with a minimum word size of 32 bits. It shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. Supervisory Controller size and capability shall be sufficient to fully meet the requirements of this Specification.

C. Memory – Each Supervisory Controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

D. Hardware Real Time Clock – The Supervisory Controller shall include an integrated, hardware-based, real-time clock.

E. The Supervisory Controller shall include troubleshooting LED indicators to identify the following conditions:

1. Power - On/Off
2. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
3. Ethernet Connection Speed – 10 Mbps/100 Mbps/1000 Mbps
4. FC Bus – Normal Communications/No Field Communications
5. Peer Communication – Data Traffic between Supervisory Control Devices
6. Run –Running/in Startup/Shutting Down/Software Not Running
7. Bat Fault – Battery Defective, Data Protection Battery Not Installed
8. 24 VAC – 24 VAC Present/Loss Of 24VAC
9. Fault – General Fault

F. Communications Ports – The Supervisory Controller shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

1. Minimum (1) USB port
2. Minimum (1) URS-232 serial data communication port
3. Minimum (1) RS-485 port
4. One (1) Ethernet port

G. The supervisory controller (FEC, NAE, NCE, NIC, PXC) shall support Hand-Off-Auto (HOA) operations through an HOA switches located within the panel enclosure. No exterior switches or keypads will be allowed. All digital outputs and analog outputs will be able to be manipulated directly from the panel without logging into the front end system (no exceptions).

H. All enclosures for controllers (except those housing terminal unit controllers) shall be provided with a hinged, locking door and 2 sets of keys (no exceptions). All enclosure keys shall be delivered to Utilities & Energy Services upon substantial completion of the project.

I. All supervisory panel wiring inside the enclosure must maintain the protective sheath within 4 inches minimum to the terminal strip. Neatly wire tie all wiring to ensure easy access within the gutter system of the enclosure. Stripping the sheath at wire entry to the enclosure will not be allowed.

J. All wiring using spade connections shall utilize a terminal block.

K. All panels to have conduit penetrations from the bottom only. No top conduit penetrations are allowed. If side penetrations need to be considered, a meeting shall be set up with UES 14 days prior to submittal for review and approval.

2.5 APPLICATION CONTROLLERS

A. Based on the Building Automation System selected for the project, the following products are acceptable. If the project has selected Siemens as the Building Automation System (BAS) then the acceptable application controllers must be the Siemens product, if the project has selected the Johnson Metasys System as the BAS, then the acceptable application controllers must be the Johnson Metasys product. In all cases the acceptable application controllers must use BACnet™ as the native communication protocol between controllers, control panel, and front-end software.

B. Acceptable Products:

1. Siemens Apogee: PXC and programmable TEC/DXR line of controllers.
2. Johnson Metasys: Field Equipment Controllers

2.6 GENERAL - APPLICATION CONTROLLERS

A. Definition: An Application Controller, for this specification, could be an AAC (Advanced Application Controller), an ASC (Application Specific Controller), or and Terminal Equipment Controller (TEC). These would be used on Primary Equipment and Terminal Equipment, respectively.

B. Each Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, minimum 8 bit A to D conversion, and include voltage transient and lightning protection devices. Firmware revisions to the module must be able to be made from the local workstation, portable operator terminals or from remote locations over modems or LANs.

C. The Application Controllers for Primary Equipment shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. The controller, in conjunction with the expansion modules, shall act as one application controller.

D. All point data, algorithms and application software within the controllers shall be custom programmable.

E. Each Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/write-able nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.

F. Each Application Controller shall be configured on the workstation/server software as a BACnet™ device. All of the points shall be configured as BACnet objects. Each controller shall include self-test diagnostics which allow the controller to automatically relay to the system supervisory engine(s) any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.

G. Each Application Controller should be capable of scheduling, either by using an on-board real-time clock or by receiving the time from the system supervisory engine(s).

H. Each Application Controller shall contain both software and firmware to perform full DDC PID control loops.

I. Each Application Controller shall contain a port for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.

J. If being installed outdoors, the Application Controllers shall be capable of being mounted directly in or on the equipment located outdoors. The Application Controllers shall be capable of proper operation in an ambient temperature environment of -20 degrees F to + 150 degrees F.

K. Input-Output Processing:

1. Digital outputs shall be relays or triacs, 24VAC or VDC minimum. Each output shall be configurable as normally open or normally closed.
2. Universal inputs shall be capable of, 0-20mA, dry contact, and 0-5VDC, 2-10VDC or 0-10VDC.
3. Analog output shall be electronic, voltage mode 0-10VDC, 2-10VDC or current mode 4-20mA.
4. Enhanced Zone Sensor Input shall provide one thermistor input, one local set point adjustment, one timed local override switch, and an occupancy indicator.
5. All programming sequences shall be stored in non-volatile memory. All programming tools shall be provided as part of the system. Provide documentation of all programming including configuration files.

L. Each Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the Application Controller. All operating parameters for application programs residing in each Application Controller shall be stored in read/write-able nonvolatile flash memory within the controller. Firmware revisions, application programs and program modifications to the controller shall be capable of being performed over the Wide Area Network (WAN).

M. Each Application Controller shall be able to support various types of zone temperature sensors, such as temperature sensor only, temperature sensor with built-in local override switch, with set point adjustment switch.

N. Each Application Controller for VAV application shall have a built-in air flow transducer for accurate air flow measurement in order to provide the Pressure Independent VAV operation.

O. Each Application Controller for VAV applications shall have an integral direct coupled electronic actuator. If the actuator is not integral to the controller, the controller/actuator assembly shall be factory tested and approved for the intended use. The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque. The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly. The actuator shall not require any limit switches, and shall be electronically protected against overload. When reaching the damper or actuator end position, the actuator shall automatically stop. The gears shall be manually disengaged with a button on the assembly cover. The position of the actuator shall be indicated by a visual pointer. The assembly shall have an anti-rotational strap.

P. Each Application Controller shall have LED indication for visual status of communication and power.

Q. Astronomical Time: Astronomic capability shall allow the system to calculate sunrise and sunset times based on geographical location, and incorporate Daylight Savings Time, for dusk-to-dawn control or dusk-to-time control. This is required in any Application Controller with I/O for the Exterior lighting circuit(s). The Application Controller may receive this value from the Global Building Controller and fail to a "safe" position (ie., lights fail on) upon a loss of communication from the Global Building Controller.

R. In the event of a loss of communication, the Application Controller shall control from a standalone algorithm which maintains the assigned space temperature until communication is restored.

S. UPS: Uninterruptible Power Supply(s) is(are) required for any Application Controller (on primary or terminal equipment) that monitors or serves emergency and/or critical equipment, locations or points.

T. All Application Controller level objects shall be exposed as BACnet Objects.

U. Primary Equipment shall be controlled using one Application Controller when possible. A single controller with adequate Input/Output and resource capacity shall be used for a single piece of equipment as opposed to using two or more smaller controllers to house the programs for one piece of equipment.

V. Each Application Controller for Primary Equipment shall contain the following as Spare I/O:

1. Minimum of: (3) Spare Universal Inputs (or 2-DIs and 1-AI), (1) Spare AO, and (2) Spare DOs.
2. In addition to the Minimum, the Application Controller shall have 10% Spare I/O, of each type; UI (or DI and AI), AO and DO.

2.7 CONTROL VALVES

A. Terminal Unit Control Valves:

1. Characterized Ball, Forged brass/bronze body, Stainless Steel trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
2. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
3. Sizing: 5-psig maximum pressure drop at design flow rate, to close against pump shutoff head. Select control valves for a minimum Cv of 1.0 to reduce the risk of system dirt accumulating in very small orifices in characterizing-discs.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

B. Butterfly Valves:

1. 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
2. Body Style: Lug.
3. Disc Type: Elastomer-coated ductile iron.
4. Sizing: 1-psig maximum pressure drop at design flow rate.

C. Control Valve Sizing

1. The Contractor is responsible for sizing of control valves. Coordinate final equipment water flow rates with approved equipment submittals. Controls contractor to review all valve size sizes and reselect where appropriate.
2. Valves for terminal units, fan coil units and air handling units shall be sized for a maximum pressure drop of 5 psig.
3. Campus butterfly valves shall be sized for a maximum of 2 psig and shall be normally open.

2.8 VALVE AND DAMPER ACTUATORS

A. Electronic direct-coupled actuation shall be provided.

B. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable.

C. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

D. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are acceptable for valves larger than 4”.

E. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation.

F. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA analog control input and provide a 2 to 10VDC or 4 to 20mA operating range.

G. Actuators capable of accepting a pulse width modulating or three-point floating control signal are acceptable for specific uses only, but are generally not preferred. Typically, these uses would be fin tube radiation control valves or small (less than 1 gpm) re-heat control valves..

H. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.

I. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque shall have a manual crank for this purpose.

J. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.

K. Actuators shall be provided with a conduit fitting.

L. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.

M. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of start-up, per Start-up Report or Cx documentation.

N. Manufacturer shall be ISO9001 certified.

O. All actuators located outdoors and exposed to weather shall have a NEMA 4X weathershield. All other control components located outdoors shall be located in NEMA 3R cabinet.

P. All actuators shall have built-in feedback or feedback potentiometer.

Q. Electronic Damper Actuators:

1. Electronic damper actuators shall be equal to Siemens EA or SQ or Johnson Controls M Series actuator.
2. For air handling unit isolation dampers, the actuators shall be electric with spring return. The actuators shall be able to open and close in less than 30 seconds.

R. Butterfly Valve Actuators

1. Bray model CF Series 70 or approved equal.

2.9 COMPRESSED AIR SYSTEM

A. No controls air compressor is required for this project.

PART 3 - EXECUTION

3.1 GENERAL

A. All DDC panels shall be connected to emergency power system.

3.2 LAMINATED SEQUENCE OF OPERATION

A. For each piece of equipment, including, but not limited to pumps, air handling units, fans, fan coil units, etc., provide a laminated sequence of operation, including control schematic, to be mounted on the wall in the mechanical rooms or at location as indicated by Owner.

3.3 INPUT/OUTPUT SUMMARY

A. The I/O Summary on the drawings is provided as a list of the minimum points required by this contract for connection to the Energy Automation system. Furnish all devices, wiring, tubing, etc., necessary to serve and transmit to the DDC panels. Any points not shown on the I/O Summary yet required to accomplish the sequence of operation shall be provided under this contract at no additional cost to the Owner.

3.4 EQUIPMENT, AIR HANDLING UNIT AND FAN START-UP AFTER POWER FAILURE

A. In case of power failure, all AHUs and fans with 7-1/2 HP and larger motor shall be energized as follows upon restoration of normal power: Fifteen seconds (adjustable) after restoration of power, motors shall be started sequentially at 15 second intervals (adjustable) through the DDC system. Initiate start-up with:

1. CHP system and HWP system.
2. AHUs, sequentially starting with AHU-1.
3. PTOA
4. All other equipment to start sequentially after air handling units are verified on.

B. DDC to send alarm if any equipment does not start within 15 minutes and omit that item from remaining starting sequence.

3.5 INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
2. For rooftop mounted equipment, install freezestat controller inside the unit in the airstream.

B. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

C. Contractor shall install labels and nameplates to identify control components according to Section 23 05 53, Identification for HVAC Piping and Equipment.

D. Contractor shall install hydronic instrument wells, valves, and other accessories according to Section 23 21 13, Hydronic Piping.

E. Contractor shall install duct volume-control dampers according to Division 23 Sections specifying air ducts.

F. Install electronic and fiber-optic cables as applicable according to Division 27.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:

a. Verify that DDC controller power supply is from emergency power supply, if applicable.
b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
c. Verify that spare I/O capacity has been provided.
d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section, Demonstration and Training.

B. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 01 91 13, General Commissioning, for contractor training requirements.

3.8 FUNCTIONAL PERFORMANCE TESTING

A. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans.

END OF SECTION

SECTION 23 21 13 - HYDRONIC PIPING AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Condensate-drain piping.
4. Air-vent piping.

B. Related Specifications

1. Section 23 05 19, Meters and Gauges, for HVAC Piping for thermometers and gauges.
2. Section 23 05 23, General Duty Valves for HVAC Piping, for valves
3. Section 23 21 23, Hydronic Pumps, for pumps, motors, and accessories for hydronic piping.
4. Section 23 05 29, Hangers and Supports, for hangers and supports.
5. Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
6. Section 23 21 16, Hydronic Specialties, for hydronic specialties.
7. Section 23 21 13.13, Pre-Insulated Underground Hydronic Water Piping

1.2 SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe
2. Fittings and accessories

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Cleaning/Flushing Plan: This must be submitted and approved prior to any piping being installed. Plan, including all steps to be taken to ensure the piping installation will be cleaned properly prior to: service, circulation through equipment, or connection to another system. This shall include, but not be limited to:

1. A step by step explication of the process.
2. Drawing(s) indicating flow (gpm) values required to meet the minimum velocity in each pipe.
3. Drawing(s) indicating the phase(s) in which the system will be cleaned as required to ensure the minimum velocity will be maintained in each section of piping. It is expected that multiple phases will be required to achieve the minimum velocities in all of the piping safely.

4. Drawing(s) indicating locations of the required temporary connections, valves, strainers, and bypasses.
5. Cutsheet of the temporary pump to be used during flushing.
6. Water treatment and pipe cleaning chemicals.

D. Field quality-control test reports.

E. Submit certification of welder's qualifications to perform the required welding operations.

F. Operation and maintenance data.

G. Victaulic products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.

1.3 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Provide domestic manufactured piping and fittings.

C. Grooved Fittings:

1. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components
2. A Victaulic factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. A Victaulic representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions.

B. Piping shall be shipped from the factory with capped ends and stored on supports off the ground with ends covered at all times to prevent nesting of insects, birds, and other animals. Any pipe found to be without end-caps or not raised off of the ground should be cleaned by the contractor prior to installation.

C. Protect piping from accumulation of dirt and debris in and around piping/components.

1.5 OPERATION AND MAINTENANCE DATA

A. Operation and maintenance manuals shall include the following information:

1. The approved submittal with all approved items present (not a partial resubmittal)
2. Chemicals used in cleaning, flushing, inhibiting, and final water treatment.
3. Water quality test reports from the cleaning process.

PART 2 - PRODUCTS

2.1 STEEL PIPING AND FITTINGS

A. 2 inches and less in diameter. ASTM A 53, Grade B or ASTM A106, Grade B, standard-weight seamless black steel pipe with standard-weight malleable iron threaded fittings, satisfying ASTM B16.3 and ASTM A 197

B. 2-1/2 inches to 10 inches in diameter. ASTM A 53, Grade B or ASTM A106, Grade B, standard-weight seamless black steel pipe with standard-weight seamless steel welded fittings, satisfying ASTM A 234, Grade WPA or WPB, ANSI B16.9.

2.2 COPPER PIPING AND FITTINGS

A. ASTM B88, hard drawn Type L seamless copper tube with wrought copper fittings, ASTM B16.22.

2.3 JOINTS

A. Screwed (Steel Piping, 2” and smaller):

1. Make screwed joints using machine-cut ANSI taper pipe threads.
2. Apply suitable joint compound, such as Teflon tape to the male threads only.
3. Ream pipe to full inside diameter after cutting. All-thread nipples are not permitted.

B. Dissimilar Metals: Make joints between copper and steel pipe and equipment along with steel pipe and ductile iron pipe using insulating unions.

1. Provide insulating unions as manufactured by Crane, EPCO Sales, Inc. or approved equivalent.

C. Solder Joints (Copper Piping):

1. Prior to making joints, cut pipe square and ream to full diameter. Clean exterior of pipe and socket. Apply thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
2. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
3. Utilize lead free solder. Use silver brazing alloy or Sil-Fos on refrigerant piping and on underground piping.

D. Press Fittings

1. At Contractor's option press fittings may be used with copper piping
2. Allowable Manufacturers

    a. Viega (Pro-Press)
    b. Apollo (ApolloXpress)

3. Joints may also be joining method with a non-toxic synthetic rubber elastomer seal (EPDM O-RINGS) with the fitting socket. The fitting shall be pressed under substantial pressure by RIDGID power toll forming a joint rated for 200 psi and tested for 600 psi,
4. For piping 2" and smaller provide wrought-copper fitting with EPDM O-rings with fitting sockets. Fittings shall be pressed under pressure forming a joint rated for 200 psi and tested for 600 psi.
5. Fittings shall have identification to indicate that a fitting is unpressed. Unpressed fittings shall leak under hydrostatic test.

E. Welded (Steel Piping, 2-1/2" and larger):

1. Make welded joints as recommended by the standards of the American Welding Society.
2. Ensure complete penetration of deposited metal with base metal.
3. Provide filler metal suitable for use with base metal.
4. Keep inside of fittings free from globules of weld metal.
5. Do not use mitered joints.
6. Use standard weld elbow fittings for changes of direction or cut a standard elbow for odd angles.

F. Flanged:

1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64 inch per foot inclination of the flange face from true alignment.
2. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
3. Install proper gaskets, suitable for intended service and factory cut to proper dimensions. Red rubber gaskets are not acceptable. Garlock gaskets or EPDM shall be used. Apply non-stick clean surface lubricant coating to both sides of gaskets.
4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use galvanized steel nuts and bolts underground, coated with tow coats of coal tar enamel. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets. Use anti-seize compound on all bolts above and below grade. Bolt threads not to protrude more than 2 threads past nut.
5. Use carbon steel flanges conforming to ANSI B16.5 with materials conforming to ASTM A 105, Grade II or ASTM A 108, Grade II. Use welding neck type flanges at all fittings and on all pipe.
6. Flanges for ductile iron pipe are specified in sections using that pipe.
7. Keep flange covers on equipment and shop-fabricated piping until ready to install in system.

2.4 GROOVED FITTINGS

A. Acceptable Manufacturers: Victaulic Company of America

B. Where allowed in application table in Part 3 of this specification, Victaulic press type fittings are allowed for piping 2 inches and smaller.

C. Where allowed in application table in Part 3 of this specification, Victaulic grooved mechanical couplings are allowed for piping 2-1/2 inches and larger.

D. Grooved Mechanical Couplings:

1. At Contractors option, roll or cut groove couplings, pipe, and fittings may be used in lieu of weld, flange or screwed joints for chill water, hot water and condenser water systems where indicated in the application table in Part 3.
2. All grooved end fittings shall be domestic made ductile iron conforming to ASTM A536; wrought steel conforming to ASTM A234. Grooved ends shall conform with AWWA C606. Adjoining couplings shall consist of two ductile iron housing segments, pressure-responsive gasket, and zinc-electroplated steel bolts and nuts. Factory-fabricated fittings from steel pipe are not allowed. Branch connections must meet the requirements of steel piping called out in this specification, regardless if it is factory-fabricated or field-fabricated.

    a. 2” through 12”: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 deg F

        1) Rigid Type: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style 107.
        2) Flexible Type: For use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration. Victaulic Installation-Ready Style 177. Where Style 177 is not available in the pipe size required, use a Style 77 coupling.

    b. Flange Adapter: Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741 / W741.

3. In applicable locations and applications, Use Victaulic 177 flexible type couplings on expansion loops in accordance with the latest Victaulic recommendations for expansion compensation.

E. Unions are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as unions and disconnect points.)

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8 inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

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

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Unions(for connecting to equipment where OEM connection provided is plastic):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. IPEX Inc.
c. KBi.
d. NIBCO INC.

2. MSS SP-107, CPVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Hart Industries International, Inc.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180°F.

D. Dielectric Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Calpico, Inc.
b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.

2.8 UNIONS

A. Use 150-pound standard (300-pound WOG) malleable iron, ground joint unions with bronze seat. Provide flanged union joints on piping larger than 2-1/2 inches.

2.9 BRANCH CONNECTIONS

A. For Pipe 2 inches and smaller, use threaded fittings for steel pipe. For threaded piping, use straight size of reducing tee.

B. For 2-1/2 Inches through 20 inches. For welded piping, when branch size is the same as and one size smaller than header size, use welding tee. Use Weldolet when branch is two or more sizes smaller than header. For threaded branch connections, use thread-o-let welded to header.

2.10 GASKETS

A. Provide gaskets between flanges of all flanged joints. Inside diameter of gaskets shall conform to nominal pipe size. Gaskets shall be ring type between raised face flanges and full face between flat face flanges with punched bolt holes and pipe opening.

B. Gaskets shall be cut from 1/8 inch thick non-metallic, non-asbestos gasket material suitable for operating temperatures from -150°F to +750°F. Garlock or equal. For pipe smaller than 6 inches, use 1/16 inch thick gasket.

2.11 FLOOR AND CEILING PLATES

A. Provide chrome-plated floor and ceiling plates around pipes exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Size plates to fit pipe or insulation and securely lock in place.

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the top of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

N. Press connections: Copper and copper alloy press connections shall be made in accordance with the manufacturer’s installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer

O. Install valves according to the appropriate section.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 23 05 16, Expansion Fittings and Loops for HVAC Piping.

T. Identify piping as specified in the above referenced specification section.

U. Support piping adequately to maintain line and grade, with due provision for expansion and contraction.

V. Use only long radius elbows on steel and copper piping unless a short radius elbow is specifically shown on the drawings.

W. Slope condensate drain piping at a minimum 1/8 inch per foot in the direction of flow.

3.2 WELDING

A. Weld and fabricate piping in accordance with ANSI Standard B31.9, latest edition, Code for Pressure Piping. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

B. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

C. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.

D. Do not split, bend, flatten or otherwise damage piping before, during or after installation.

E. Remove dirt, scale and other foreign matter from inside piping before tying in sections, fittings, valves or equipment.

3.3 OFFSETS AND FITTINGS

A. Because of the small scale of drawings, the indication of all offsets and fittings is not possible. Carefully investigate the structural and finish conditions affecting the work and take such steps as may be required to meet such conditions.

B. Install all piping close to walls, ceilings and columns so piping will occupy the minimum space. Provide proper space for covering and removal of pipe, special clearances, and for offsets and fittings.

C. Install piping as to not obstruct any equipment or architectural access doors.

3.4 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.

B. At air handling units, where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge and thermometer well and a balancing valve (with memory stop) for balancing, and valves for isolation of each coil. Refer to mechanical details for additional requirements.

3.5 DRAIN VALVES AND VENTS

A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.

B. Install 2 inch drain for 2 -inch pipes and larger.

C. Install a line size drain valve for pipes smaller than 2 inches.

D. Provide hose adapter and cap on all drain lines.

E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.6 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to the above referenced specification section. Refer to drawings for additional requirements.

3.8 CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS

A. Provide service connections to items of equipment furnished by others:

1. Detailed shop drawings of equipment shall be furnished indicated the exact number and location of rough-in points.
2. Such final shop drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions.
3. Making adjustments to field conditions is considered a part of the work required.

B. Roughing-In:

1. When roughing-in, extend service piping to various items of equipment.
2. Temporarily terminate at proper points as indicated on detailed equipment shop drawings or as directed.
3. Do not use contract drawings accompanying specifications for rough-in locations but for pipe sizing and general routing.

C. Stop Valves:

1. Provide stop valves for each service at rough-in locations, except for drains.
2. Stop valve locations are subject to approval, and in all cases must be accessible from the same room in which the furniture or equipment is located.

3.9 CLEANING OF PIPING SYSTEMS

A. Cleaning of piping system must be performed by the mechanical contractor. Cleaning chemical, procedure, water testing, reporting, and consultation must be provided by a qualified water treatment company specializing in this type of work. Qualified water treatment vendor will have the following features:

1. Operating in the business of industrial water treatment for minimum 5 years.
2. Certified to the ISO 9000 quality standard.
3. Manufacture and deliver their own products.
4. Provide technical specialist(s) for onsite water testing, reporting, and consultation.
5. Have the ability to perform offsite analytical laboratory work and reporting if necessary.

B. Acceptable vendors should include, but not be limited to the following companies:

1. ChemCal, Inc.
2. GE Water & Process Technologies
3. Nalco Company

C. Minimum velocity of 10 feet per second for steel piping must be maintained in the pipes during flushing period.

1. Do not use building pumps for circulating water.
2. Provide temporary pumps as required to achieve minimum velocities.
3. Remove flow meters from building piping during flushing operation.
4. Provide means (instrumentation) during flushing period to prove to the Owner that the minimum velocities are maintained in the pipes.
5. For copper piping, maintain the flushing velocity between 3 (min) and 5 (max) feet per second. Limit temperature of water inside piping to a maximum 140°F.

D. Submit a detailed plan for the Engineer's and Owner's review and approval describing in full detail the individual steps associated with this process before any piping is installed.

1. Refer to Submittal section above for further requirements.

E. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide temporary connections and valves as required for cleaning, purging and circulating. Provide temporary relief valves to protect the piping system if recommended by the pipe cleaning subcontractor.

F. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blowoff valve.

G. Provide bypasses at the following equipment as close as feasibly possible to the equipment (no more than 10 feet total of piping at each piece of equipment) and isolate equipment as required (temporary blind flanges or similar):

1. Hydronic coils
2. Flow Meters
3. Control Valves

H. Chemicals shall remove mill scale, oil, and greases as well as passivate surfaces with a protective oxide film. NOTE: All residuals of the cleaning and passivating chemicals must be totally blown-down prior to system startup.

1. Alkaline cleaner/penetrant/dispersant chemical. This product must be in liquid form and capable of removing mill scale, oils, greases, debris, and byproducts of construction. It shall be fed at the vendor's recommended dosage rate based on the volumes of the systems treated.

2. Passivating chemical. This product must be in liquid poly-phosphate form and capable of laying down a protective oxide film on metal surfaces after treatment with the cleaning chemical. It shall be fed at the vendor's recommended dosage rate based on the volumes of the systems treated.
3. Antifoam chemical. This product must be in liquid form and capable of controlling or eliminating foam in water systems.

I. Chemical for inhibiting and controlling corrosion and deposits must be added immediately after the chemical cleaning and passivating procedure.

1. Closed loop corrosion inhibitor chemical. This product must be in liquid form and impart the following active ingredients at the following dosages when fed in the Chilled Water Loop water: 1) nitrite (as NO2) = 400-800 ppm, 2) borate = 200-400 ppm, 3) azole = 20-60 ppm. This product must impart the following active ingredients at the following dosages when fed in Heating Hot Water Loop water: 1) nitrite (as NO2) = 800-1200 ppm, 2) borate = 400-600 ppm, 3) azole = 40-80 ppm.

J. Circulate chemical cleaner and passivator in closed loop water piping systems to remove mill scale, grease, oil, and silt.

K. Flush and drain loops to remove debris prior to using chemicals.

1. Fill loops and add chemical cleaner and passivator at the dosage rates recommended by the water treatment vendor based on system volume.
2. Add antifoam at the dosage rates recommended by the water treatment vendor.
3. Circulate water for 24-72 hours.
4. Drain and flush system.
5. Dispose of circulated water with chemical residuals as per local code requirements.
6. Refill and immediately charge with the proper corrosion inhibitor – based on the type of piping system – to the recommended level.
7. Match chemicals presently used in other systems used by Owner if possible.
8. Submit all chemicals to Owner and Engineer prior to cleaning for approval.
9. Match chemicals presently used in other systems used by Owner.
10. Provide report comparing make-up water quality to the water circulated in the pipe after cleaning chemicals are removed. Report shall include the following at a minimum:

    a. Conductivity
    b. Ph
    c. phosphate
    d. Iron

L. Special requirements, if any, are specified in the appropriate Sections for each type of piping.

M. After systems have been flushed and cleaned; as required by specifications, provide written certification from the cleaning contractor that the systems are clean and ready for use. This shall include the water quality report comparing the make-up water to the water circulated in the piping after removal of chemicals to verify pipe condition.

3.10 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure, minimum 150 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.11 PIPING APPLICATION SCHEDULE

A. Provide piping and fittings meeting the requirements of Part 2 as identified in the table below:

Service	Pipe Sizes	Pipe Material
Chilled Water Piping	2” and smaller	Copper Steel
Chilled Water Piping	2-1/2” and larger	Steel
Heating Hot Water Piping	2” and smaller	Copper Steel
Heating Hot Water Piping	2-1/2” and larger	Steel
Condensate Piping	All	Copper, Galvanized Steel
Condenser Water Piping	All	Steel
Air-vent Piping	All	Copper, Steel
Safety-valve inlet and outlet piping	All	Same as for piping system for which it is installed

3.12 GROOVED END APPLICATION TABLE

A. Grooved end piping and fittings are allowed on this project in the locations identified in the application table below:

Service	Location	Pipe Sizes
Chilled & Heating Hot Water Piping	Mechanical Rooms	All

END OF SECTION

SECTION 23 21 16 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes hydronic specialties, including the following:

1. Air Vents.
2. Air Separator
3. Air/Dirt Separator
4. Dirt Separator
5. Hydraulic Separator
6. Expansion Tank
7. Shot Feeder/Filter
8. Pressure Reducing Valve

B. Related Specifications

1. Section 23 05 19, Meters and Gages for HVAC Piping
2. Section 23 21 13, Hydronic Piping and Fittings.

1.2 SUBMITTALS

A. Product Data:

1. Submit Shop Drawings and product data, including component sizes, rough-in requirements, service sizes, and finishes.
2. Submit manufacturer's installation instructions

1.3 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by the same manufacturer throughout

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment, etc. before installation in accordance with manufacturer’s written instructions.

1.5 OPERATION AND MAINTENANCE DATA

A. Operation and maintenance manuals shall include the following information:

1. The approved submittal with all approved items present (not a partial resubmittal)
2. Shot Feeder/Filter. Include instructions and assembly views for installation of new filter media. Provide minimum two spare sets of filter media for each shot feeder/filter at completion of project (not including the one installed at substantial completion).

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 MANUFACTURERS

A. Expansion Tanks: Bell & Gossett, Taco, C. Adamson, Woods.

B. Automatic Air Vents: Armstrong, APCO, Bell & Gossett,

C. Air Separators: Spirotherm, Thrush

D. Air/Dirt Separators: Spirotherm, Thrush

E. Dirt Separators: Spirotherm, Thrush

F. Water Relief Valves: Keckley, Watts, Bell & Gossett

G. Shot Feeder/Filter: Harmsco, Wingert, Neptune

H. Water Pressure Reducing Valve: Taco, Watts, Zurn

2.3 EXPANSION TANKS (BLADDER TYPE):

A. Construction: Provide captive air expansion tank with a replaceable bladder, flanged connections to replace bladder, steel skirt for vertical mounting, rated at 150 psi working pressure and constructed per ASME Section VIII. Bladder shall be able to accept the full volume of the expansion tank and shall be removable and replaceable.

B. Provide gate valve and pressure gage at remote air connection coupling to register air pressure inside bladder chamber.

C. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valve by-pass.

2.4 AUTOMATIC AIR VENTS

A. Furnish and install cast iron body fixed pivot ball automatic float-type air vents at high points of all hydronic systems and where shown on drawings. Vent body shall be cast iron, with stainless steel float, and stainless steel seat, valve and lever. Vent shall be rated for a minimum of 125 psi, 250 degrees F.

2.5 AIR SEPARATORS

A. Furnish and install as shown on the drawings and schedule a full flow coalescing type air eliminator.

B. Each separator unit shall be fabricated steel rated for 150 psig design pressure and 270 Deg. F. operating temperature. The separator shall provide non-turbulent non-centrifugal flow thru the unit at rated GPM with less than 1 foot of water pressure drop with a velocity not to exceed 4 feet per second through the unit at the specified GPM and CV rating.

C. The air eliminator shall remove 100% of all free and entrained air during system start up and continue to eliminate 99.6% of dissolved air at rated GPM.

D. Unit shall include internal elements filling the entire vessel to suppress turbulence and air elimination efficiency of 100% free air, 100% entrained air, and 99.6% dissolved air at the installed location. The elements must consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed.

E. Each unit is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated air vent that is guaranteed not to leak.

F. The air vent shall have a 2" npt connection for testing and remote venting. Contractor shall pipe to nearest floor drain.

2.6 AIR/DIRT SEPARATORS

A. Furnish and install as shown on the drawings and schedule a full flow coalescing type combination air eliminator and dirt separator, with two equal chambers above and below the inlet/outlet nozzles.

B. Each separator unit shall be fabricated steel rated for 150 psig design pressure and 270 Deg. F. operating temperature. The separator shall provide non-turbulent non-centrifugal flow thru the unit at rated GPM with less than 1 foot of water pressure drop with a velocity not to exceed 4 feet per second through the unit at the specified GPM and CV rating.

C. The air/dirt separator shall remove 100% free air, 100% entrained air, and 99.6% dissolved air at rated GPM. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes.

D. Unit shall include internal elements for removal of air and dirt. The elements must consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed.

E. Each unit is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated air vent that is guaranteed not to leak. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill.

F. The air vent shall have a 2" npt connection for testing and remote venting. Contractor shall pipe to nearest floor drain.

G. Separators to be provided with flanged port on bottom of unit to allow removal of internal components.

2.7 WATER RELIEF VALVES

A. Pressure relief valves installed for the protection of the water circulating circuits shall be single seated diaphragm and spring type valve with screwed connections, similar to Watts No. 174A.

B. 3/4 inch size of bronze construction with bronze seat, composition shut-off disc, and rubber diaphragm.

PART 3 - EXECUTION

3.1 PREPARATION

A. Flush and clean expansion tanks prior to delivery to the Project Site, and keep sealed during construction.

3.2 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

C. Support expansion tanks from building structure in accordance with manufacturer's instructions.

D. Provide manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.

E. Provide valved drain and hose connection on strainer blow down connection.

F. Support pump fittings with floor mounted pipe and flange supports.

G. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.

H. Select system relief valve capacity so that capacity is greater than make up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

I. Pipe relief valve outlet to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

K. Air Vent

1. Provide air vents at the highest points of the hydraulic piping systems and on the uppermost connections to all hydraulic coils. Provide shutoff valves to facilitate maintenance of air vents.

2. Locate all air vents and their discharge lines in accessible locations, preferably clustered.
3. For automatic air vents in above-ceiling spaces or other concealed locations, extend vent tubing to nearest drain
4. Route ½-inch discharge lines to nearest floor drain without air traps.

L. Shot Feeder/Filter

1. Shot feeder/filter shall be installed per manufacturer's instructions and details shown on the construction documents. Provide ball valve at shot feeder/filter drain outlet and pipe to nearest floor drain. Install new filter media in shot feeder/filter at substantial completion of the project.

END OF SECTION

SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides furnishing and installing the following hydronic pumps:

1. Base mounted horizontal split case pumps
2. Base mounted end suction pumps

1.2 RELATED WORK

A. Section 23 00 10, Mechanical General Provisions.

B. Section 23 05 13, Common Motor Requirements for HVAC Equipment.

C. Section 23 05 48, Mechanical Vibration Isolation.

D. Section 23 05 53, Mechanical Identification.

E. Section 23 07 16, Equipment Insulation.

F. Section 23 05 20, Piping Specialties.

G. Section 23 21 00 Heating Water and Chilled Water Piping, Valves and Appurtenances.

H. Section 23 05 15, Variable Frequency Drives.

1.3 REFERENCES

A. ANSI/UL 778 - Motor Operated Water Pumps.

1.4 PUMP SELECTION REQUIREMENTS

A. Select pumps conservatively for scheduled conditions. Furnish pumps which have reasonably high efficiencies, with peak efficiency at or near rated conditions. Select pumps that will operate stably at 15-foot suction lift despite substantial reduction in head or substantial increase in delivery.

B. Provide motor-driven pumps of the type and speed scheduled. Select pumps that are not overloaded throughout the entire range of pump operation. Provide pump connection sizes as scheduled.

C. If the pumps proposed are not considered suitable, submit manufacturer's data on other pumps, for review.

D. Unless otherwise indicated the maximum pump selections shall be limited to 60 HZ.

1.5 SUBMITTALS

A. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Clearly indicate which equipment and options are to be provided

B. Indicate pump's operating point on curves. Include NPSH curve when applicable.

C. Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

D. Submit information on electric motors per requirements and indicating compliance with Section 23 05 13. Motor data must be submitted with pump submittal. No exceptions.

E. Submit manufacturer’s installation instructions under provisions of Section 23 00 10.

F. Provide a letter of certification from pump manufacturer that unit was manufactured and factory assembled by pump manufacturer.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.

C. Include copy of approved submittal, vibration test results and certified pump curve with final balancing point indicated..

D. Include letter of certification stating that pump was factory assembled by pump manufacturer.

1.7 EXTRA PARTS

A. Provide one extra set of mechanical seals for each pump.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Products meeting all requirements of this specification section of the following manufacturers are acceptable

1. Armstrong Pumps
2. Aurora
3. Bell & Gossett
4. Patterson Pumps
5. Taco
6. Grundfos/Paco

2.2 BASE MOUNTED HORIZONTAL SPLIT-CASE CENTRIFUGAL PUMPS

A. General. Provide factory assembled and tested base mounted, single stage double suction split-case pump with double-volute design to allow servicing of impeller and bearing assembly without disturbing piping connections. Pumps shall be rated for a minimum of 175-psi working pressure.

B. Casing. Casing shall be cast iron with suction and discharge flanges and mounting feet cast integral with the lower half casing. Provide tapped openings for vent and drain, and gauge tappings at the suction and discharge nozzles, all equipped with petcocks. Flanges shall be of 125 ANSI Standard. Suction and Discharge shall be on a common centerline in both the horizontal and vertical planes. Casing for pumps 3 inches x 4 inches and larger must accommodate an impeller 5 percent greater in diameter than the impeller actually selected to meet specified performance. Upper half of casing shall be designed to provide for complete removal of bearing, seals and impeller without disturbing connection piping. Upper casing shall be dowel aligned to the lower casing.

C. Impellers. Furnish an enclosed, cast bronze impeller, keyed and locked to the shaft, statically and hydraulically balanced.

D. Wearing Rings. Provide bronze, renewable wearing rings on all pumps 1-1/2 inches and larger. Casing Rings shall be installed with an anti-rotation device.

E. Shaft. Furnish a stainless steel shaft, turned and ground to accurate dimension, of ample size to prevent deflection and key slotted as required.

F. Bearings. Provide antifriction type bearings, grease lubricated, with lubrication fittings, having a 250,000 hour life (AFBMA B_{10}) under maximum condition of load. Bearings shall be protected by separate oil seals and shall be replaceable without disturbing the system piping and regreaseable with removal of the bearings from the bearing housing.

G. Base Plate. Mount the pump assembly and motor on common base plate constructed of structural steel or fabricated steel channel with fully enclosed sides and ends, and securely welded cross members. Base plate shall ensure rigid and true alignment of pump and motor shafts. Grouting area shall be fully opened. As an option, the pump may be install on C-Channel steel base with the open ends temporarily closed for grouting. The base plate shall include a built-in drain pan with tapped drain opening. For chilled water pumps, extend steel base to receive all drip from suction and discharge flanges.

H. Mechanical Seals. The liquid cavity shall be sealed off at the pump shaft by an internally or externally flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225°F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal. Seal boxes shall be equipped with heavy, cast, one-piece, O-ring sealed glands.

I. Couplings. Provide a flexible mechanical coupling rated for the full rated horsepower of the driving motor at motor speed, capable of absorbing torsional vibration. Coupling shall be shielded by an OSHA approved metal or HDPE coupler guard securely fastened to the base. Coupling shall be manufactured by Wood, Sure Flex or equal.

J. Name Plates. Nameplates and other data plates shall be stainless steel, suitably secured to the pump. Provide one spare stainless steel performance nameplate with each pump that is insulated and field install on pump base.

K. Test run VFD pumps with motor at all speeds prior to shipping to ensure that pump assembly will not experience unacceptable levels of vibration during operation.

2.3 BASE MOUNTED END SUCTION PUMPS

A. Description: Pump assembly including motor, coupling, pump and baseplate factory assembled and tested at pump manufacturer's plant.

B. Casing:

1. Cast iron, volute type, centrifugal pump with Class 125 ANSI flanged connection and tapped openings for vent and drain, equipped with petcocks.
2. Casing for pumps 3" x 4" and larger must accommodate an impeller 15 percent greater in diameter than the impeller actually selected to meet specified performance.
3. Design casings to provide for complete removal of bearing, seals and impeller without disturbing piping connections to pumps.

C. Impellers: Furnish enclosed, cast bronze impeller, keyed and locked to the shaft, statically and hydraulically balanced.

D. Wearing Rings: Provide bronze, renewable wearing rings on all pumps 1 1/2" and larger.

E. Shaft: Furnish stainless steel shaft, turned and ground to accurate dimension, of ample size to prevent deflection and key slotted as required. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. In order to improve serviceability and reduce the cost of ownership the shaft sleeve must be slip on (press on not allowable) and must be easily replaced in the field

F. Bearings: The pump bearing frame shall incorporate maintenance free permanently lubricated and sealed bearings with an L10 life of 60,000 hours. Bearing frame shall be equipped with seals to protect bearings from moisture and airborne contaminants.

G. Mechanical Seals: The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250ºF. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity.

H. Pedestals: Furnish cast iron pump and bearing pedestal for pedestal-mounted pumps. Machine the pump bracket for rabbet jointing to pump casing. Precision bore the bearing support to provide accurate alignment between bearings and pump.

I. Couplings: Provide flexible mechanical coupling as manufactured by Woods rated for the full rated horsepower of the driving motor at motor speed.

J. Base Plates: Factory install the pump assembly and the motor on a common rigid hot dipped galvanized steel or cast iron base fabricated and arranged to ensure rigid and true alignment of pump and motor shafts.

1. Furnish base plate with drip rim sloped to tapped drain opening. Base plate to extend beyond full width of pump flanges.
2. Base plate to have openings to facilitate grouting of the base plate to inertia base.

K. Provide manufacturer's factory representative certification for alignment of the pumps. Manufacturer shall inspect pump installation after grouting is complete and certify pump alignment is in accordance with manufacturer's instructions and that the installations comply with the manufacturer's warranty requirements.

L. Motors: Provide motors suitable for VFD (Variable Frequency Drive - pulse width type). Combination of drive and pump shall not produce objectionable noise or vibration throughout operative range of pump.

M. Name Plates. Nameplates and other data plates shall be stainless steel, suitably secured to the pump. Provide one spare stainless steel performance nameplate with each pump that is insulated and field install on pump base.

N. Test run VFD pumps with motor at all speeds prior to shipping to ensure that pump assembly will not experience unacceptable levels of vibration during operation.

2.4 MOTORS

A. Motors for base mounted pumps shall be mounted with pump on baseplate at pump manufacturer's plant and shipped as one unit.

B. Pump and motor shall be factory aligned, and shall be realigned by the Contractor after installation.

C. Motors shall be 1800 rpm except as otherwise scheduled ODP (for indoor application). Equipment manufacturers shall certify in the submittal data that the motors furnished with the pumps are compatible with the variable frequency drives (include manufacturer and Model number) to be installed on this project. If motors are incompatible with VFDs, pump manufacturer shall provide and install new motors at no change in contract price. Refer to Section 23 05 13 for additional motor requirements. Provide Aegis shaft grounding ring for pumps driven by VFDs where required in Specification 23 05 13.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install according to manufacturer's printed recommendations and pipe as shown on drawings. Install pumps with access (minimum 2'-6") for periodic maintenance including removal of motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. The Contractor shall level each pump and grout each pump base.

D. Route drain from drip pan to nearest floor drain.

E. Stored pumps shall have shafts rotated at least once a month.

F. Name Plates: Install spare nameplate as required in Part 2 of this Specification.

3.2 ALIGNMENT

A. Lubricate pumps prior to start-up. Provide manufacturer's factory representative certification for alignment of the pumps. Factory technician shall inspect pump installation after grouting is complete and certify pump alignment is in accordance with manufacturer's instructions and that the installations comply with the manufacturer's warranty requirements.

B. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

C. Comply with pump and coupling manufacturers' written instructions.

D. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install strainer, check valve, isolation valves, pipe supports and other devices as shown on the detail.

F. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

G. Connect wiring according to Section 26 05 19, Insulated Conductors.

3.4 VIBRATION TESTING

A. Vibration velocity readings shall be taken at all bearing locations of all pumps. Pumps driven by variable speed drives shall be tested throughout their range of speeds. Vibration shall not exceed 0.15 inch/second (peak). Record and deliver copies of the test report to the Owner and include report in the O&M Manual

END OF SECTION

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping and accessories used for air-conditioning applications.

1.2 REFERENCES

A. ANSI B16.22 - Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings

B. ASTM B88 - Seamless Copper Water Tube

C. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

D. ASHRAE 15 - Safety Code for Mechanical Refrigeration

E. AHRI 710 – Performance Rating of Liquid Line Dryers.

F. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

G. ANSI/AWS C3.4 - Specification for Torch Brazing

H. AHRI 495 - Performance Rating Of Refrigerant Liquid Receivers

I. ASME B31.5 – Code for Pressure Piping, Section on Refrigeration Piping and Heat Transfer

J. AWS A5.8/A5.8M – Specification for Filler Metals for Brazing and Braze Welding.

1.3 QUALITY ASSURANCE

A. Qualify soldering processes, procedures, and solderers for copper and copper alloy pipe and tube in accordance with ASTM B 828.

B. Qualify brazing processes for copper and copper alloy pipe and tube according to ANSI/AWS C3.4. Qualify brazing procedures and brazer performance in accordance with either Section IX of the ASME Boiler and Pressure Vessel Code, or AWS B2.2.

1.4 SUBMITTALS

A. Product Data:

1. Contractor shall submit schedule indicating the ASTM specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each service.
2. For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Pipe and tube required by the applicable standard to be cleaned and capped shall be delivered to the job site with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipe and tube from moisture and dirt. Elevate above grade. When stored inside, do not exceed the structural capacity of the floor.

C. Protect fittings, flanges, and piping specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements provide products by one of the following manufacturers:

1. Danfoss.
2. Mueller Brass Company.
3. Sherwood

2.2 REFRIGERANT PIPING AND FITTINGS

A. ASTM B88 type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR", with ANSI B16.22 wrought copper or forged brass solder-type fittings

B. Piping shall be shipped pressurized with dry nitrogen gas and sealed under pressure with a positive plug.

C. Solder Filler Metals: ASTM B 32. Use Alloy Sb5 95-5 Tin Antimony or Alloy HB solder to join copper socket fittings on copper pipe.

D. Brazing Filler Metals: AWS A5.8.

2.3 VALVES AND SPECIALTIES

A. General

1. All refrigerant piping specialties shall be suitable for the working refrigerant.

B. Ball Valves

1. Features: Forged brass with full port construction to match line size ID, chrome plated ball, internally equalized ball design, rupture-proof encapsulated stem, access port, brass cap, extended copper flare connection and UL Listed.
2. Working Pressure Rating: 700 psig
3. Working Temperature Range: -40°F to 250°F

C. Check Valves

1. Features: Screw bonnet, forged brass body, Teflon gasket, internal components shall be removable, UL Listed.
2. Working Pressure Rating: 700 psig
3. Working Temperature Range: -40°F to 300°F

D. Y-Type Strainers:

1. Features: Forged brass body with brass clean-out plug, 100-mech monel or stainless steel screen, UL Listed.
2. Working Pressure Rating: 500 psig.
3. Maximum Operating Temperature: 275°F.

E. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture as required for type of refrigerant and temperature. Submit information on color for dry, intermediate and wet indications.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 160°F.

F. Filter Dryers

1. Comply with AHRI 710.
2. Body and Cover: Provide painted-steel shell with zinc-chromated steel top cover with external access connection.
3. Filter Media (Replaceable):

    a. For systems under 15 tons, provide 25 micorn filter media.
    b. For systems 15 tons and above, provide 15 micron filter media.

4. Desiccant Media: 100% molecular sieve solid core suitable for HFC refrigerants or 80% molecular sieve and 20% activated alumina solid core suitable for HCFC refrigerants.
5. Designed for reverse flow (for heat-pump applications).
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 160°F.

G. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275°F.

H. Charging Valves

1. Provide ¼" SAE brass male flare access ports with finger tight, quick seal caps. Provide 2-inch long copper extension sections.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section, Access Doors and Frames, if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

Q. Seal penetrations through fire and smoke barriers according to Division 07 Section, Penetration Firestopping.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

T. Seal pipe penetrations through exterior walls according to Division 07 Section, Joint Sealants, for materials and methods.

U. Identify and label refrigerant piping and valves according to Section 23 05 53, Identification for HVAC Piping and Equipment.

3.2 PIPE JOINT CONSTRUCTION

A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated below:

a. Test Pressures

1) Suction Lines for Air-Conditioning Applications: 185 psig.
2) Suction Lines for Heat-Pump Applications: 325 psig.
3) Hot-Gas and Liquid Lines: 325 psig

b. Fill system with nitrogen to the required test pressure.
c. System shall maintain test pressure at the manifold gage throughout duration of test.
d. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
e. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.4 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers (for ones with replaceable core) after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.5 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 31 13 - DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Perform Work required to provide and install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation

B. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Oval ducts and fittings.
4. Grease-Laden Vapor Exhaust Ductwork
5. Wet Exhaust Ductwork. (Shower, Locker Room, etc)
6. Double-Wall Ductwork
7. Dryer Exhaust Ductwork
8. Sheet metal materials.
9. Sealants and gaskets.
10. Hangers and supports.

C. Related Sections:

1. Division 09 Section, Painting, for interior painting of metal ductwork exposed to view through grilles, registers, and other openings.
2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for testing, adjusting, and balancing requirements for metal ducts.
3. Section 23 07 13, External Ductwork Insulation.
4. Section 23 33 00, Ductwork Accessories, for dampers, spin-in fittings, flexible duct connections.
5. Section 23 34 13, Fans.
6. Section 23 36 00 Air Terminal Units
7. Section 23 37 13, Air Devices.

1.2 DEFINITIONS

A. Low Pressure: Up to 2 inches w.g. positive or negative static pressure and velocity equal to 1500 fpm. Constructed and tested for +2 inches W.G.

B. Medium Pressure: Over 2 inches w.g. through 6 inches w.g. positive or negative static pressure and velocity greater than 1500 fpm. All medium pressure ductwork shall be constructed and tested for +6 inches w.g.

C. High Pressure: Over than 6 inches w.g. positive static pressure and velocity greater than 2500 fpm.

D. Duct Size. The supply, return and exhaust duct sizes shown on drawings are clear inside sheet metal dimensions. Include proper allowances for acoustical lining, where indicated in plans or specifications. For acoustical return air boots, refer to additional information on detail.

1.3 GUARANTEE

A. Guarantee all ductwork for 1 year from the date of final acceptance. The guarantee will cover workmanship, noise, chatter, whistling or vibration. Ductwork shall be free from pulsation under all conditions of operation.

1.4 CONTRACTOR COORDINATION

A. Erect all ducts in the general locations shown on the drawing(s), but conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor to check the physical conditions at the job site and make all necessary changes in cross sections, offsets and similar items, whether they are specifically indicated on drawing(s) or not. Do not obstruct the induced air plenum opening at VAV boxes and service access spaces for VAV boxes and other equipment.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

1.5 STANDARDS AND CODES

A. Except as otherwise indicated, sheet metal ductwork material, fabrication and installation shall comply with second edition of SMACNA HVAC Construction Standards Metal and Flexible, except where indicated otherwise. All air distribution devices (such as dampers) included in this Section shall comply with the second edition of SMACNA HVAC Construction Standards Metal and Flexible.

B. In addition, construct ductwork and all air distribution devices to the following:

1. IMC International Mechanical Code
2. NFPA 90A Installation of Air Conditioning and Ventilating Systems.
3. NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems
4. NFPA 96 Installation of Equipment for the Removal of Smoke and Grease Laden Vapors from Commercial Cooling Equipment.
5. SMACNA Round Industrial Duct Construction Standards
6. SMACNA The Managers' Guide for Welding

1.6 SUBMITTALS

A. Product Data

1. Submit product data for each product. Refer to Section 23 00 10.
2. Provide acoustical data on insulated flexible ductwork as indicated in Part 2.

B. Delegated-Design Submittal. Include the following for each system furnished on the project.

1. System name and type
2. Duct system design pressure.
3. Sheet metal thicknesses and materials.
4. Reinforcement details and spacing.
5. Seam and joint construction and sealing.
6. Fittings, construction and details.
7. Hangers and supports, including materials, fabrication, methods for duct and building attachment.
8. Provide detail of break away connections for fire, fire/smoke and smoke dampers for review.

C. Ductwork shop drawings. Provide CAD-generated shop drawings of mechanical rooms and building ductwork drawn at a minimum scale of ¼ inch per foot. Include the following as a minimum:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory and shop fabricated duct and fittings.
3. Duct layout indicating sizes, configuration and pressure classes.
4. Elevations of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Reinforcement and spacing.
7. Penetrations through fire-rated and other partitions.
8. Equipment installation based on equipment being used on Project.
9. Duct accessories, including access doors and panels, fire dampers and smoke dampers.

D. Samples.

1. Provide a sample of all type of ductwork to Engineer and Owner for approval.
2. Provide a sample of stainless steel welded duct joint to Engineer and Owner for approval. Submit sample prior to duct fabrication. After approval, the sample shall remain at the jobsite for reference.

E. Welding certificates. For duct welders including procedures and standards of acceptance

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Spiral Ductwork. Gowco, McCorvey, United McGill, Lindab (supply duct only).

B. Sheet Metal Products. McCorvey Sheet Metal Works, Gowco, United McGill, Flexmaster

C. Insulated Flexible Duct. Pepertree Air Solutions, Thermaflex, Flexmaster.

D. Double-Wall Flue – Schebler, Selkirk, Metal-Fab, Van Packer

E. Double-Wall Ductwork (supply) - United McGill, Semco

F. Factory Built Insulated Double Wall Grease Exhaust Ductwork – Schebler, Metalfab, Metalbestos, DuraSystems, AMPCO.

2.2 APPLICATION

A. Ductwork shall be constructed in accordance with the following as a minimum. Refer to drawings for any deviations from this table.

SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION (1)
Supply Systems:		
Untreated outside air intake, louver to AHU plenum	Galvanized Steel	Low Pressure
All ductwork downstream of terminal boxes	Galvanized Steel	Low Pressure
All fan coil unit supply ductwork	Galvanized Steel	Low Pressure
Supply ductwork downstream of constant volume single and multi-zone AHUs.	Galvanized Steel	Low Pressure
Supply ductwork downstream of single zone VAV AHUs(2)	Galvanized Steel	Medium Pressure
Mixed air AHU plenum	Galvanized Steel	Medium Pressure
Treated outside air to AHU(3)	Galvanized Steel	Medium Pressure
Inlet connection to terminal box	Flexible Duct	As Specified
Connection to Air Device	Flexible Duct	As Specified
Return Systems:		
Return air boot/transfer duct	Galvanized Steel	Low Pressure
Return air device to return distribution (4)	Galvanized Steel	Low Pressure(5)
Return Air Distribution	Galvanized Steel	Medium Pressure(5)
General Exhaust/Relief Systems:		
Exhaust air device to exhaust distribution(4)	Galvanized Steel	Low Pressure(5)
Exhaust Air Distribution	Galvanized Steel	Medium Pressure(5)
Kitchen Exhaust Systems:		
Kitchen Hood Exhaust	316L Stainless Steel or Factory built double-wall	Medium Pressure(6)
Dishwasher Exhaust	316L Stainless Steel	Medium Pressure(5)
Miscellaneous Exhaust Systems:		
Shower/Locker Room exhaust	316L Stainless Steel	Medium Pressure(5)
Gas-Fired Unit Heaters Flue	Type B Double Wall	Refer to Specs

SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION (1)
Dryer exhaust ductwork	Galvanized Steel	Low Pressure

B. Notes to Table:

1. Positive pressure unless noted otherwise in Table.
2. From air handling unit (AHU) to terminal boxes.
3. From pretreatment AHU to AHU.
4. Runout from air device to return/exhaust air trunk duct
5. Negative pressure SMACNA table.
6. Verify minimum pressure classification per NFPA 96 requirements.

2.3 DUCT MATERIAL AND CONSTRUCTION

A. General. Noncombustible or conforming to requirements for Class I air duct materials or UL 181. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein

B. Galvanized Steel Ducts. Constructed of G-60 coated galvanized steel meeting requirements of ASTM A 653 or ASTM A 527. Stencil coils of sheet steel throughout on 10 foot centers with gage and manufacturer's name. All materials associated with the duct system shall be galvanized steel including stiffeners, fasteners, etc.

C. Stainless Steel Ducts. Type 304 or 316L as indicated in application schedule. For round ductwork, butt-welded (solid welded) longitudinal seam only. Spiral lockseam and Spiral lockseam with standing rib is not acceptable.

D. Fasteners. Rivets, bolts or sheet metal screws.

E. Sealant.

1. Sealant shall be water based, latex UL 181B-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be similar to Foster 32-19, Childers CP-146, Hard Cast Iron Grip 601, Ductmate Pro Seal or Design Polymerics DP 1010.
2. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count.

F. Hangers and Supports.

1. Support ductwork with continuously threaded hanger rods of galvanized steel or 20 gauge straps as indicated in these specifications.

2.4 RECTANGULAR DUCTS AND FITTINGS GENERAL REQUIREMENTS

A. General Fabrication Requirements: Comply with SMACNA based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage for low pressure ductwork, 24 gage for medium pressure ductwork.

B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Snaplock longitudinal seams (L2) are not acceptable.

D. Fittings:

1. Select types and fabricate according to SMACNA Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.
2. Construct bends and elbows per SMACNA Figure 2-2, “Rectangular Elbows”, Type RE1 with radius of not less than 1-1/2 times width of duct on centerline. Where not possible or where indicated on construction documents, construct Type RE2 rectangular elbows with welded-in-place double wall airfoil turning vanes (whether specifically shown on drawings or not), or short radius type RE1 radius elbows.
3. Construct tees per SMACNA Figure 2-5, “Divided Flow Branches”, Type 2, Type 3, Type 4A or 4.
4. Construct branch connections per SMACNA Figure 2-6, “Branch Connection”. Use 45 degree entry, 45 degree lead in, conical or bellmouth connections only.
5. Unless indicated on construction document details, transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence. Divergence upstream of equipment shall not exceed 30 degrees. Convergence downstream of equipment shall not exceed 45 degrees.
6. Bullhead tees are not permitted.

2.5 ROUND AND OVAL DUCTS AND FITTINGS GENERAL REQUIREMENTS

A. General Fabrication Requirements: Comply with SMACNA Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage.

B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Use flanged joints for ducts larger then 48 inches in diameter.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize spiral seam or butt weld seams only. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Fittings:

1. Fittings shall have a wall thickness not less than that specified for longitudinal-seam straight duct or 26 gage, whichever is more stringent.
2. Tees and Laterals: Select types and fabricate according to SMACNA Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize 90 degree tee with oval to round tap, 45 degree lateral tap, or conical fitting only. Wye fittings may be utilized where specifically indicated on drawings and details.
3. Elbows: Construct elbows with radius of not less than 1-1/2 times width of duct on centerline. Provide minimum 5 gore elbows on all 90 deg elbows, 3 gore elbows on 45 degree elbows. Continuously welded stamped long radius elbows may be utilized on ductwork up to and including 12-inches in diameter.
4. Bullhead tees are not permitted.

2.6 LOW PRESSURE DUCTWORK

A. Currently reserved if we need to make a distinction between low pressure and medium pressure construction standards from the general requirements above.

2.7 MEDIUM PRESSURE DUCTWORK

A. Currently reserved if we need to make a distinction between low pressure and medium pressure construction standards from the general requirements above.

2.8 INSULATED FLEXIBLE DUCTWORK

A. Use for connection to diffusers, grilles and terminal boxes as indicated in specifications and details.

B. Construct the inner liner of coated steel helix and a PE or CPE liner substantially bonded together to prevent the duct from collapsing or kinking in short radius bends. Provide fiberglass insulation providing minimum R-4.2 thermal conductance and 3 pound minimum density around inner jacket consisting of fiberglass reinforcement and aluminum foil vapor barrier outer jacket. Use duct rated at minimum working pressure of 10 inches of water positive and 1 inches of water maximum negative pressure (4-12 in I.D.), and 6 inches of water positive and 1/2 inch of water maximum negative pressure (14- 16 I.D.),. Provide duct listed by U.L. at flame spread rate of not over 25 and smoke developed rate of not over 50, and complying with NFPA Standard 90A and 90B. The entire assembly shall be listed by Underwriters Laboratories under U.L. Standard 181 as a Class I flexible air duct. Supplier shall submit laboratory test results indicating acoustical performance comparable to that of "Flexmaster Type 1M-Insulated".

2.9 STAINLESS STEEL DUCTWORK (WET EXHAUST)

A. Applies to Shower/Locker Room and Dishwasher ductwork indicated in specification application table and where indicated on drawings.

B. Provide a welded sample for approval to the engineer and Owner.

C. Provide and construct exhaust ductwork for rectangular ducts and fittings meeting the requirements under Rectangular Ducts and Fittings General Requirements in this specification. Provide and construct exhaust ductwork for round and oval ducts and fittings meeting the requirements under Round and Oval Ducts and Fittings General Requirements in this specification

D. All stainless steel exhaust ductwork shall have welded longitudinal seams and welded transverse joints. Welding procedures shall meet the requirements of SMACNA's The Managers' Guide for Welding. Welds on exposed ductwork inside the building shall be ground and polished. Duct sealant shall not be used to seal ductwork.

E. Provide required transitions from duct to equipment and make equipment connections as indicated on details.

F. Fittings:

1. Refer to Round and Oval Ducts and Fittings General Requirements and Rectangular Ducts and Fittings General Requirements in this specification. Transverse and longitudinal seams shall be butt welded joints.
2. Refer to drawings for additional information.

2.10 DUCTWORK FOR REMOVAL OF GREASE-LADEN VAPORS

A. General.

1. All ductwork removing grease-laden vapors such as those from cooking equipment shall be fabricated in accordance with SMACNA Duct Construction Standards and NFPA 96.
2. Provide access openings for cleaning and inspection of all interior surfaces. Provide sign and gasket per NFPA 96. Provide access openings at all elbows.
3. Use only radius elbows and fittings. No turning vanes, mitered elbows or square elbows are allowed.

B. Field fabricated ductwork.

1. Ductwork shall be constructed of 18 gage stainless steel with liquid-tight continuous external weld on all seams and joints.

C. Factory Built Grease Exhaust Ductwork.

1. All components and ductwork shall be UL listed and approved by the authority having jurisdiction.

2. All components of the grease duct system shall be provided by a single manufacturer to ensure the system meets the requirements of the listing including duct supports, guides, fittings, cleanouts, and expansion joints required to install the duct.
3. The duct sections shall be constructed of an inner wall and an outer wall with ceramic fiber insulation between the walls. The inner wall shall be constructed out of 316 stainless steel. The outer wall shall be constructed out of 316 stainless steel. The duct shall include a 3" thickness of body soluble ceramic fiber insulation between the inner and outer walls. The duct wall assembly shall be tested and Listed at 0 inch clearance to combustibles.

2.11 INTERNAL ACOUSTIC DUCT LINING

A. Internal insulation with JohnsManville Permacote Linacoustic standard fiberglass duct liner with factory-applied edge coating. Insulation shall have a composite, abrasion resistant airstream surface with EPA-registered, anti-microbial coating that will not support microbial growth.

B. Duct Lining used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B.

C. Provide insulation thicknesses as follows:

1. Provide 1/2 inch insulation on all return air transfer ductwork as shown on detail.
2. Additional areas specifically noted on drawings.

2.12 DOUBLE-WALL DUCT AND FITTING (HVAC DUCTWORK)

A. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

B. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct. Ductwork shall be fabricated using a spiral lockseam. Outer surface shall be paintable galvanized steel.

C. Insulation: 2-inch thick fibrous glass. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components, and reduce outer shell diameter to inner duct diameter. Thermal Conductivity (k-Value): 0.26 at 75°F mean temperature. Ductwork shall be tested in accordance with UL-181 for impact and erosion resistance at an internal airflow velocity of 10,000 feet per minute.

D. Perforated Inner Ducts: Fabricate with 0.028-inch thick sheet metal having 3/32-inch diameter perforations, with overall open area of 23 percent.

E. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means. Where spiral duct grilles are indicated, provide a sleeve between the inner and outer wall of the ducts that corresponds to the opening size required by the grille.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Construction Standards. Use construction methods which follow the requirements outlined SMACNA publications, as well as SMACNA Balancing and Adjusting publications, unless indicated otherwise in these specifications or accompanying drawings.

B. Reinforcement. Reinforce ducts having one side equal to 25 inches or more in accordance with recommended construction practice of SMACNA.

C. Plenum Construction. Construct plenum chambers of not less than No. 20 U.S. gage metal reinforced with galvanized structural angles.

D. Cross Breaking or Beading. Cross break or bead sheet metal for rigidity, except ducts which are 12 inches or less in the longest dimension.

E. Wall and Floor Penetrations.

1. Install fire, smoke and combination fire smoke dampers in floor penetrations and in one and two-hour rated walls where indicated in drawings and in accordance with Specification 23 31 33.
2. Where ducts pass through walls in exposed areas, install suitable escutcheons made of galvanized sheet metal angles as closers.
3. At all locations where ductwork passes through floors, provide watertight sleeves projecting 3 inches above finished floor and flush with bottom of floor slab. Fabricate sleeves of 1/8 inch thick steel, galvanized after fabrication. Anchor into adjacent floor slab as required.
4. Sleeves are required inside as well as outside chases.
5. Provide 24 gage sheet metal sleeves for insulated [and non-insulated] ducts penetrating gyp board and CMU walls. Seal openings between ducts and sleeves with fireproofing sealants.

F. Interior Painting. Interior painting of metal ductwork exposed to view through grilles, registers, and other openings is specified in the Section on painting. Do not install grilles, registers, or similar items until painting is complete.

G. Ductwork Openings. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

H. Ductwork Location. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities, including access to electrical and control panels.

I. Instrument Test Hole Fitting. Provide Duro Dyne Model TH-1 instrument test ports with heavy-duty zinc-plated heavy-gage cap, instant-release wing nut, neoprene expansion plug, flat neoprene mounting bracket and mounting holes. Provide fittings to air balance contractor.

J. Provide transitions at equipment and air device connections as per SMACNA standards. Where equipment requires an oval inlet and a round flex duct is routed to the equipment, provide insulated round to oval transition.

K. Install duct mounted electric and hot water coils, provided in other specification sections, if required.

L. Refer to mechanical details for information on terminal box connections, diffuser connections, fume hood connections, lab-trac equipment, etc.

3.2 SEAM AND JOINT SEALING

A. All duct systems (except welded exhaust ductwork and double wall flue) shall be sealed. Duct shall be thoroughly cleaned prior to application of sealant. All transverse joints, longitudinal seams and duct wall penetrations shall be sealed. All ductwork shall be sealed as per seal Class A of SMACNA Standards irrespective of the duct pressure classifications

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports." Unless indicated otherwise in specifications.

B. Hanger Spacing. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing. Install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection. Do not use wire to support ductwork.

C. Horizontal Ducts Up to 40 Inches. Support horizontal ducts up to and including 40 inches in their greater dimension by means of No. 20 U.S. gage band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means. Use clamps to fasten hangers to reinforcing on sealed ducts.

D. Horizontal Ducts Larger Than 40 Inches. Support horizontal ducts larger than 40 inches in their greatest dimension by means of hanger rods bolted to angle iron (or equivalent unistrut) trapeze hangers. Place supports on at least 8'-0" centers according to the following:

Angle Length	**Angle**	**Rod Diameter**
4’-0”	1-1/2” x 1-1/2” x 1/8”	1/4”
6’-0”	1-1/2” x 1-1/2” x 1/8”	1/4”
8’-0”	2” x 2” x 1/8”	5/16”
10’-0”	3” x 3” x 1/8”	3/8”

The trapeze is to be placed on the exterior of non-compressible insulation between hanger and ductwork.

E. Vertical Ducts. Support ducts to ensure rigid installation. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Fig. 4-7, Fig 4-8, Fig 4-9 "Riser Supports – From Floor". Support vertical ducts where they pass through the floor lines with 1-1/2 inches x 1-1/2 inches x 1/4 inch angles for ducts up to 60 inches. Above 60 inches, the angles must be increased in strength and sized on an individual basis considering space requirements. Support vertical duct drops more than 6 feet in length with angle iron frames attached to ducts.

F. Refer to drawings for additional hanger details and requirements. Note that not all hangers are shown on the drawings are in the BIM model. The Contractor shall coordinate all hangers with the structure and other trades.

G. For ductwork insulated with fire rated insulation, coordinate hanger support requirements with manufacturer's installation requirements.

3.4 LOW PRESSURE DUCTWORK

A. Currently reserved if we need to make a distinction between low pressure construction standards from the general requirements above.

3.5 MEDIUM PRESSURE DUCTWORK

A. Currently reserved if we need to make a distinction between medium pressure construction standards from the general requirements above.

3.6 FLEXIBLE DUCTWORK

A. Low Pressure Flexible Ductwork

1. Do not exceed 6 feet in length with any flexible duct.
2. Flexible duct shall be limited to a maximum of a single 90 degree change indirection between the duct and the neck of the air device. This does not include the final turn into the neck of the air device.
3. Support ductwork independently of lights, ceiling and piping. Provide harness at connection to ceiling diffuser as indicated on details.
4. Provide two stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or diffuser. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.

B. Medium Pressure Flexible Ductwork

1. Refer to details for maximum length of flexible ductwork upstream of terminal box.
2. Do not use flexible ductwork for changes in direction of airflow.
3. Provide two stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or terminal box. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.

3.7 KITCHEN (GREASE-LADEN VAPORS) EXHAUST DUCTWORK

A. Provide kitchen, (hoods over steam kettles, etc.) exhaust ductwork as specified in Part 2. Provide clearances around ductwork and install in accordance with NFPA 96 and IMC. Install ductwork without forming dips or traps. Securely fasten and support ducts at every change in direction and in accordance with NFPA96. Supports or fasteners shall not penetrate ductwork.

B. Slope ductwork per IMC. Slope ductwork not less than one-fourth unit in vertical in 12 units horizontal toward the hood for ducts less than 75 feet in length. For ducts 75 feet in length or greater, slope ductwork not less than one unit in vertical in 12 units horizontal toward the hood or approved grease reservoir.

C. Make duct to fan connection in accord with NFPA 96. Provide 1500°F rated gasket between fan and ductwork.

D. Factory Built Grease Exhaust Ductwork

1. Inner pipe joints shall be held together by means of formed vee bands and sealed with manufacturers Grease Duct Sealant.
2. All construction and supporting of the kitchen ventilation system will be in accordance with manufacturers installation instructions.
3. Store grease duct sections inside, or covered adequately to protect from weather or accidental damage.

3.8 DOUBLE-WALL DUCT (HVAC) AND FITTING

A. Paint exterior of ductwork as indicated in Division 9.

B. Provide double wall ductwork in the following locations:

1. Recreation Center, Dining
2. Other areas specifically indicated on drawings.

C. Contractor to coordinate opening locations and sizes in the ductwork for the spiral duct grilles.

3.9 DISHWASHER AND SHOWER ROOM EXHAUST DUCTWORK

A. Provide ductwork as specified in Part 2. Install ductwork without forming dips or traps and slope a minimum of ½-inch per foot towards ceiling grilles or dishwasher. Construction shall be watertight.

B. Terminate ductwork at exhaust fan as recommended by fan manufacturer.

3.10 DRYER EXHAUST DUCTWORK

A. Construct dryer exhaust ductwork in accordance with the International Mechanical Code. Provide sheet metal ductwork fabricated of size as recommended by dryer manufacturer, or as shown on plans. Provide cleanouts in ductwork at all changes of directions.

B. Provide cleanable lint trap as recommended by the dryer manufacturer in the ductwork that is accessible by dryer user.

C. Do not install any screws or other items that may protrude in the ductwork. Joints shall be installed so that male end of slip-fit ductwork shall extend in direction of airflow.

D. Terminate ductwork with rain cap or side wall louver as recommended by dryer manufacturer. Insulate exterior of ductwork with 1-inch insulation to minimize condensation in ductwork.

3.11 FLASHING

A. Where ducts pass through roofs or exterior walls, provide suitable flashing to prevent rain or air currents from entering the building. Provide flashing not less than No. 26 gage stainless steel or 16 ounce copper.

3.12 DUCT LINING

A. Fiberglass acoustical lining is not permitted to be installed on this project except as indicated in this specification or specifically shown on drawings.

B. Install per manufacturer's recommendations. Keep internal lining clean during construction by keeping ends of ductwork sealed during storage and construction.

3.13 TESTS

A. Allowable Leakage. Test ductwork for leaks in accordance with SMACNA before concealing or insulating as indicated below. Arrange for the Owner's Representative to witness the test.

1. Low pressure ductwork. Test low pressure ductwork at +2 inches W.G. Maximum allowable leakage (Lmax) per 100 ft^2 of ductwork shall be equal to $C_L \times P^{0.65}$, where C_L = 6 for rectangular ducts and round flexible ducts, C_L = 3 for round/flat oval ducts, and P = 2" for low pressure ducts.
2. Medium pressure ductwork. Test medium pressure ductwork at +6 inches W.G. Maximum allowable leakage (Lmax) per 100 ft^2 of ductwork shall be equal to $C_L \times P^{0.65}$, where C_L = 6 for rectangular ducts and round flexible ducts, C_L = 3 for round/flat oval ducts, and P = 6" for medium pressure ducts.
3. Lab exhaust ductwork. Test laboratory exhaust ductwork at +6 inches w.g. Maximum allowable leakage is 1/2% of the total system air flow rate. Where partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
4. Test the following ductwork:

    a. Low pressure ductwork:

        1) 25% of ductwork served by terminal boxes.
        2) All ductwork served by fan coil units.
        3) For any low pressure duct that is not tested, close runout connections and place fan in operation. Repair leaks detected by sound or touch.]

b. Medium pressure ductwork:

1) All ductwork served by individual air handling units.
2) All ductwork served pretreatment outside air handling units.
3) All ductwork served by exhaust fans.

c. Other

1) Do not test Double Wall Flue Piping or Dryer Exhaust Ductwork.

B. Equipment. Provide equipment necessary for performing tests, including rotary blower, orifice section and U-tube gage board complete with cocks and rubber tubing.

3.14 CLEANING

A. Protect all ductwork and equipment from dirt during storage, installation and prior to grille, diffuser installation with protective covering at each end. Ductwork exposed to dirt and dust due to inadequate protection will have to be removed, cleaned and reinstalled.

B. Do not operate any air handling units or fan coil units during construction without filters.

C. Provide temporary filters on return air ductwork during construction to protect ductwork from dust.

D. Provide temporary filters on exhaust grilles during construction to protect ductwork from dust.

E. Do not operate kitchen exhaust fans during any drywall operation to protect ductwork.

END OF SECTION

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire dampers.
2. Combination fire and smoke dampers.
3. Smoke dampers.
4. Volume control dampers.
5. Duct access doors.
6. Conical spin-in fittings and taps
7. Duct accessory hardware.
8. Flexible Connection
9. Roof Duct Supports

1.2 RELATED WORK

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

B. Specification 23 31 13, Ductwork

1.3 SUBMITTALS

A. Product Data: Submit product data for each product. Refer to Section 23 00 10.

B. Fire and Combination Fire/Smoke Damper. Include manufacturer's literature to include performance data and installation requirements. Include any wiring diagrams. Installation shall clearly indicate

1. Proposed break-away connections used on the project.
2. Clearance requirements between wall/floor and damper.
3. Mounting/Retaining locations, size, gauge and fastener requirements.

C. Access Doors. Include type of material, installation guidelines, leakage rates and maximum pressure data.

D. Volume Control Dampers. Include type of material, installation guidelines, pressure drop and maximum pressure data.

E. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control damper installations.
d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors. Provide break-away duct/sleeve connection detail.
e. Wiring Diagrams: For power, signal, and control wiring.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Fire dampers, smoke dampers and combination fire/smoke dampers.

1. Include operation and maintenance information, including recommended testing requirements.
2. Assign identification numbers (FD – Fire Damper, FSD – Fire/smoke Damper, SD – Smoke Damper) for each damper. Include table in O&M manual that indicates identification number, room location, duct system and size.

1.5 QUALITY ASSURANCE

A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
2. AMCA 500-D, “Laboratory Method of Testing Dampers for Rating”
3. NFPA 101 - Life Safety Code.
4. SMACNA - HVAC Duct Construction Standards Metal and Flexible – Second Edition
5. UL 555 – Standard for Fire Dampers.
6. UL 555C – Standard for Ceiling Radiation Dampers.
7. UL 555S – Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fire, Smoke and Fire/Smoke Dampers. Greenheck, Pottorff, Ruskin, Nailor.

B. Flexible Connections. Ductmate, Ventfabrics Ventglass.

C. Duct Access Doors. Ductmate, DuraSystems, Flexmaster, Greenheck, Ruskin, United McGill.

D. Roof Duct Supports. Portable Pipe Hangers, MAPA Products.

E. Conical Spin-in Fittings. Flexmaster, Buckley

F. Volume Control Dampers. Flexmaster, Greenheck, Prefco, Ruskin.

2.2 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316L, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

2.3 FIRE DAMPERS (FD)

A. Quality Standards. Furnish and construct fire dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F fusible link.

B. Construct fire dampers such that damper frame material and curtain material are galvanized.

C. Use Curtain Type Fire Dampers for fire dampers where possible. Use Multiple Blade Fire Dampers for fire damper sizes that exceed manufacturer’s allowable Curtain Type Fire Damper sizes, or where velocities or pressures exceed Curtain Type Fire Dampers.

D. Curtain Type Fire Dampers (Type B)

1. Damper shall be classified for dynamic closure to 2000 fpm and 4 inches w.g. static pressure.
2. Damper shall have 5” frame constructed from minimum 20 gage galvanized steel.
3. Blades shall be minimum 24 gage galvanized steel.
4. Closure springs shall be Type 301 stainless steel, constant force or spring clip type.
5. Provide Grille, Grille Access Type or Out of Wall Type of frame where indicated on drawings.

E. Multiple Blade Fire Damper

1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 90”x64” for vertical installation and 60”x48” for horizontal installation.
2. Damper shall have 5” frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
3. Blades shall be 6” wide airfoil type and constructed from minimum 14 gage galvanized steel.
4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
5. Blade seals shall be galvanized steel for flame seal to 1,900 degrees F and mechanically attached to blade edge.
6. Linkage shall be concealed in frame.
7. Provide ½-inch diameter plated steel hex shaped axle attached to blade.
8. Pressure drop shall be a maximum of 0.07 inches w.g. at 1,500 feet per minute through 24 x 24 inch damper.

2.4 COMBINATION FIRE AND SMOKE DAMPERS (FSD)

A. Quality Standards. Furnish and construct combination fire/smoke dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application and a Leakage Class 1 Smoke Rating in accordance with UL 555S. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F. Dampers shall have a minimum 5 year warranty.

1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 120”x96” for vertical installation and 144”x96” for horizontal installation.
2. Damper shall have 5” frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
3. Blades shall be 6” wide airfoil type and constructed from minimum 14 gage (equivalent) galvanized steel.
4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
5. Blade seals shall be inflatable silicone fiberglass material, rated for maintaining smoke leakage at a minimum of 450°F and galvanized steel for flame seal to 1,900 degrees F. Seals shall be mechanically attached to blade edge. Provide stainless steel flexible metal compression jamb.
6. Linkage shall be concealed in frame.
7. Provide ½-inch diameter plated steel hex shaped axle attached to blade.
8. Temperature Release Device. Close in a controlled manner and lock damper during test, smoke detection, power failure, or fire conditions through actuator closure spring. At no time shall actuator disengage from damper blades. Allow damper to be automatically and remotely reset after test or power failure conditions. After exposure to high temperature or fire, inspect damper before reset to ensure proper operation. Controlled closing and locking of damper in 7 to 15 seconds to allow duct pressure to equalize. Instantaneous closure is not acceptable.
9. Actuator. Provide electric 24V, 60 Hz, two-position, fail close actuator. Operators shall be UL listed and labeled.
10. Pressure drop shall be a maximum of 0.07 inches w.g. at 2,000 feet per minute through 24 x 24 inch damper.

2.5 VOLUME CONTROL DAMPERS

A. Provide volume dampers in round and rectangular ductwork where indicated on drawings.

B. General Fabrication Requirements:

1. Comply with SMACNA Chapter 2, "Volume Dampers" unless more stringent requirements are indicated. Provide single blade dampers on round dampers and for rectangular dampers not exceeding 36-inches in width or 12-inches in height. Provide multiblade rectangular dampers for dampers exceeding 36-inches in width or 12-inches in height or where required due to velocity or pressure requirements.
2. Refer to Specification 23 31 13 Ductwork for application table that defines Low and Medium Pressure ductwork.
3. Provide a locking hand quadrant on all dampers. Mount quadrant regulators on stand-off mounting brackets, bases, or adapters on insulated ducts.
4. For stainless steel ductwork, provide stainless steel finish to match ductwork material.
5. Shop fabricated dampers are not acceptable.

C. Round Dampers.

1. Low Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade, continuous 3/8” square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 2”W.G. when closed, and a maximum pressure drop of 0.03”W.G at 1500 feet per minute through a 20-inch damper when tested in accordance with AMCA Fig. 5.3.
2. Medium Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 14 gage (equivalent) galvanized steel blade, continuous 1/2” square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 4”W.G. when closed, and a maximum pressure drop of 0.06”W.G at 2000 feet per minute through a 24-inch damper when tested in accordance with AMCA Fig. 5.3.

D. Rectangular Dampers.

1. Low Pressure Single Blade Damper (Fans systems with less than 1”W.G. Static Pressure). Provide single blade damper with minimum 3-inch x 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade on dampers up to 18-inches wide, 16 gage on dampers over 18-inches wide. Provide a continuous 3/8” square plated steel axle mechanically attached to blade, and synthetic flanged sleeve type bearing. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 1”W.G. when closed.
2. Low Pressure Multi-Blade Damper. Provide opposed multi-blade damper with minimum 5-inch x 16 gage galvanized steel frame, minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2” square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 3”W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1”W.G. at 1500 feet per minute through a 24-inch x 24-inch damper.

3. Medium Pressure Damper. Provide opposed multi-blade damper with minimum 5-inch x 1-inch 16 gage galvanized steel channel frame. Blades shall be minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.16"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.
4. Low Pressure Drop Medium Pressure Damper. Provide opposed multi-blade damper with minimum 4-inch x 1-inch 0.125-inch thick aluminum channel frame. Blades shall be extruded aluminum airfoil type, minimum 0.125-inch thick. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and linkage concealed in jamb. Provide bronze or oilite bearings. Dampers shall be suitable for 5000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.

E. Splitter Dampers. Fabricate splitter dampers of minimum 16 gauge thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/4" diameter rod in self-aligning, universal joint action flanged bushing with set screw. Control splitter with locking quadrants on exposed externally insulated ductwork.

2.6 DUCT ACCESS DOORS

A. Square Frame Access Doors

1. Low Pressure Ductwork

a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 2 manually operated cam locks on access doors 16-inches and under, 4 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.
b. Performance. 24"x24" access door shall be suitable for up to 2"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.

2. Medium Pressure Ductwork

a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 4 manually operated cam locks on access doors 16-inches and under, 8 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.
b. Performance. 24"x24" access door shall be suitable for up to 10"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.

B. Round "Spin" Access Doors

1. Construct outer frame of minimum 22 gage roll formed, double hemmed galvanized steel. Door shall be revovable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 3 manually operated cam locks on access door. Provide continuous foam gasket between door and frame.

C. Grease-Laden Vapor Exhaust Ductwork Access Doors

1. Access door shall be constructed of same material and same thickness as grease exhaust ductwork and be UL Listed.
2. Access panels shall have a gasket or sealant that is rated for 1500ºF and shall be grease tight.
3. Fasteners, such as bolts, weld studs, latches or wing nuts, used to secure the access panels shall be of carbon steel or stainless steel and must not penetrate the duct walls.
4. Access doors shall be suitable for zero clearance fire rated insulation when required. Refer to Specification 23 07 13 External Duct Insulation for coordination.
5. For factory built grease exhaust ductwork, provide access doors manufactured by the ductwork manufacturer.

D. For stainless steel ductwork, provide stainless steel finish to match ductwork material.

E. Where duct size permits, access door size shall be 18-inches in diameter or 18" x 16" for oval and rectangular doors. For duct sizes under 20-inches, provide access door 2-inches smaller than duct size. For ducts 12-inches wide, provide minimum 10" x 12".

2.7 CONICAL SPIN-IN FITTINGS AND TAPS

A. General Construction. For stainless steel ductwork, provide stainless steel finish to match ductwork material.

B. Furnish conical spin-in fittings with quadrant dampers at all round runout ducts serving diffusers and grilles. Fabricate conical fitting of 26-gage galvanized sheet metal with 2-inch build out, continuous 3/8" square shaft, air tight nylon bushings and locking quadrant handle. Connect damper plate to shaft with a minimum 2 u-bolts on dampers 12-inches and greater.

2.8 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Drill temporary test holes for balancing in ducts as required. Cap with neoprene plugs, threaded plugs, or threaded or twist-on metal caps. Provide neat patch on external duct insulation and label as "Test Plug".

C. Provide permanent test holes in ductwork upstream and downstream of all coils, fans, and locations as indicated on drawings. Test holes shall be factory fabricated, airtight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.9 FLEXIBLE CONNECTIONS

A. Provide air-tight flexible connections where ductwork connects to fans, air handling units and fan coil units with fabric as specified below:

Application	Fabric	Coating	Gauge
HVAC (Indoor)	Fiberglass	Neoprene	28
HVAC (Outdoor & Lab)	Fiberglass	Hypalon	28

B. The fabric shall be UL listed, fire retardant, waterproof and mildew resistant, crimped into metal edging strip.

2.10 ROOF DUCT SUPPORTS:

A. Engineered, portable system specifically designed for installation without the need for roof penetrations or flashings, and without causing damage to the roofing membrane. Factory fabricated to support exact duct sizes to be installed.

B. Design system using minimum 14 inch x 16 inch high density polyethylene or 14 gauge stainless steel bases.

C. Provide 1-5/8 inch or 1-7/8 inch 12 gage stainless steel structural steel framing, as required for loading conditions. Framing shall be 3-sided or tubular shape with mill finish.

D. Provide stainless steel clamps, bolts, nuts, washers, and other devices as required for a complete system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

3.2 ACCESS DOORS

A. Install duct access doors on sides or bottom of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. Upstream and downstream of duct mounted duct coils.
2. Downstream from manual volume dampers (not spin-in fittings).
3. Downstream of control dampers.
4. Upstream of airflow measuring stations.
5. Adjacent to and close enough to fire, smoke and combination fire/smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
6. At duct mounted smoke detectors.
7. Upstream or Downstream of turning vanes.
8. In internally lined ductwork, provide access doors for duct liner inspection at 50 foot intervals and downstream of each elbow or branch fitting. Access doors are not required in return air boots.
9. Elsewhere as indicated on drawings, details or specifications.

B. Label access doors according to Section 23 05 53 - Identification for HVAC Piping and Equipment to indicate the purpose of access door.

C. Grease-Laden Vapor Exhaust Ductwork Access Doors. Provide access doors where required per NFPA96 and IMC. This includes:

1. Spaced at not more than 12-foot intervals in horizontal ductwork.
2. Every change in direction of horizontal duct.
3. Openings in vertical ducts at every floor or on the top of the vertical riser if personnel entry is possible.
4. Within 3-feet of exhaust fans with horizontal connected ductwork.

3.3 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

A. Install dampers at locations indicated on the drawings and in accordance with manufacturer's UL approved installation instructions.

B. Install dampers square and free from racking with blades running horizontally.

C. Do not compress or stretch damper frame into duct or opening.

D. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jackshaft.

E. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

F. Provide access doors for all fire, smoke and combination fire/smoke dampers. Refer to details for additional requirements.

3.4 CONICAL SPIN-IN FITTINGS AND TAPS

A. Install conical spin-in fittings with quadrant dampers to serve diffusers as indicated on drawings.

B. After installation of spin-in fitting, seal all around connection to meet leakage class indicated in Specification 23 31 13.

3.5 VOLUME CONTROL DAMPER

A. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

B. Set dampers to fully open position before testing, adjusting, and balancing

3.6 ROOF DUCT SUPPORTS

A. Verify that roofing system is complete and that roof surfaces are smooth, flat, and ready to receive work of this Section. Verify that roof surface temperature is at minimum 60°F for proper adhesive performance.

B. Clean surfaces of roof in areas to receive portable support bases. Remove gravel from gravel surfaced roofs. Remove dirt, dust, oils, and other foreign materials. Prime roofing membrane with a primer compatible with existing components in the roofing system.

C. Locate bases and support framing as indicated on drawings and as specified herein. Provide complete and adequate support of all ducts, whether or not all required devices are shown. Install framing at spacing indicated, but in no case at greater than 15 ft on center. Accurately locate and align bases. Set in adhesive if required by manufacturer's installation instructions. Where applicable, replace gravel around bases. Set framing posts into bases and assemble framing structure as indicated. Use stainless steel fasteners for stainless steel framing. Install ductwork as shown on detail.

3.7 FLEXIBLE CONNECTIONS

A. Install at connections between ductwork and motor driven equipment as shown. Provide a minimum of 1 inch slack in the connections, and a minimum of 2-1/2 inches distance between the edges of the ducts and equipment. Also provide a minimum of 1 inch slack for each inch of static pressure on the fan system. Securely fasten flexible connections to equipment and to adjacent ductwork by means of sealant with sheet metal screws. Where flex ductwork is connected to oval collars in diffusers and plenums, provide a metal transition fitting from oval to round.

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate all volume dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke and combination fire/smoke dampers to verify full range of movement per NFPA and verify that proper heat-response device is installed.

END OF SECTION

SECTION 23 34 13 - FANS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for furnishing and installing fans and supplemental equipment including the following:

1. Centrifugal fans.
2. Propeller Wall Fans
3. Kitchen (grease) Exhaust Fans
4. High Dilution Laboratory Exhaust Fans.

1.2 PERFORMANCE

A. Provide fan type, arrangement, rotation, capacity, size, motor horsepower, and motor voltage as shown. Fan capacities and characteristics are scheduled on the drawings.

B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA), approved test codes and procedures. Supply fans with sound ratings below the maximums permitted by AMCA standards. All fans provided must be licensed to bear the Certified Ratings Seal.

C. Statically and dynamically balance all fans.

D. Fan Efficiency

1. For fans greater than 5 HP, the fans shall have a fan efficiency grade (FEG) of 67 or higher based on manufacturers' certified data, as defined by AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

1.3 SUBMITTALS

A. General:

1. Submit shop drawings and product data.
2. Shop drawings shall indicate assembly, unit dimensions, weight, required clearances, construction details and field connection details.
3. Product data shall indicate capacities, ratings, fan performance, motor electrical characteristics, and gages and finishes of materials.
4. Provide fan curves with specified operating point clearly plotted.
5. Provide the fan's fan efficiency grade, peak total efficiency and operating efficiency as defined by AMCA 205.
6. Include backdraft damper information for each fan, including the size of the backdraft damper.
7. Submit sound power levels.
8. Submittals shall show compliance with Section 23 05 13, Common Motor Requirements for HVAC Equipment.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. Kitchen (Grease) exhaust fans shall comply with NFPA-96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations and UL 762 Power Ventilator for Restaurant Exhaust Appliances.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.

C. Include copy of approved submittals (with all comments corrected).

D. Include copy of vibration test reports.

E. Include copy of airflow measuring station calibration curves.

1.6 AIR FLOW MEASURING STATION

A. Fans with Air Flow Monitoring selected shall include the following.

1. Flow monitoring station shall monitor the pressure difference between the fan inlet and the smallest diameter of the inlet cone.
2. Volumetric flow to be calculated from empirically derived formulas based on testing by the fan manufacturer.
3. Flow monitoring station shall not use air restricting probes that reduce fan performance or create additional fan sound.
4. Four equidistantly spaced sensor orifices to be drilled in the smallest diameter of the inlet cone venturi. Flow tubes from each venturi sensor to extend to a termination plate mounted on the fan housing.
5. High-pressure flow probe(s) to be mounted in low velocity fan inlet. Flow probes from the high-pressure sensor shall extend to a termination plate mounted on the fan housing.
6. Termination plate shall include a low-pressure connection, a high-pressure connection, and a listing of the empirically determined flow rate coefficient.
7. Flow monitoring station shall accurately measure the pressure differential to within ±3%.
8. Flow monitoring station to be installed by the fan manufacturer as part of the standard fan assembly.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fans:

a. Acme Engineering & Mfg. Corp.
b. Greenheck.
c. Loren Cook Company.
d. Twin City Fan & Blower

2. High Dilution Lab Exhaust Fans:

a. Loren Cook Variplume.
b. Greenheck Vektor
c. Twin City Fan & Blower

2.2 PROTECTIVE COATINGS

A. Manufacturer's Standard: Apply manufacturer's standard prime coat and finish to fans, motors and accessories, except on aluminum surfaces or where special coatings are required.

B. Galvanizing:

1. After fabrication of the parts, hot-dip coat all surfaces which require galvanizing.
2. Where galvanizing is specified, a zinc coating may be used.
3. After fabrication, apply the zinc coating and air-dry the coating to 95 percent pure zinc.
4. Acceptable zinc coatings include Zincilate, Sealube, Amercoat, Diametcoat, or an approved equal.

C. Fasteners for all fans and relief hoods mounted outside of building and in crawl space shall be stainless steel.

2.3 SUPPLEMENTAL EQUIPMENT

A. Motor Covers: Provide weatherproof motor covers for installations out of doors. Apply the same finish as used on the fan.

B. Belt Drives:

1. Unless otherwise specified for belt-driven fans, equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20 percent speed variation from full open to full closed. Size drives for 150 percent of rated horsepower. Key the fan sheave to the fan shaft.
2. Nonadjustable motor sheaves may be used for motor sizes over 15 horsepower, at the Contractor's option. However, if changing a nonadjustable sheave becomes necessary to produce the specified capacity, the change must be made at no additional cost.

3. Provide belt guards and apply the same finish as used for the fan.

C. Safety Disconnect Switch: Provide a factory-wired, safety disconnect switch on each unit equipped with a 115/1/60 motor. Division 26 will provide safety disconnect switches for all motors that are not 115/1/60, such as three phase motors, unless noted otherwise in specifications or fan schedule.

D. Relief Vents and Air Inlets: Provide vents and inlets with aluminum frames and 1/2-inch mesh, galvanized bird screens. Include dampers, motorized dampers on inlets and adjustable counter balanced dampers for relief vents as indicated on fan schedule and in specifications.

E. Prefabricated Roof Curbs: Furnish prefabricated roof curbs with built-in cant strips and lined with glass fiber insulation. Curbs may be made of No. 18 U.S. standard gage galvanized steel or 0.063 inch aluminum. The minimum height is 8 inches. Include on each roof curb a resilient pad for equipment mounting on the top flange. Include damper tray where indicated on schedule or specifications. Refer to Kitchen Exhaust Fan specification for additional requirements roof curbs serving grease exhaust fans.

F. Motors. All 115/1/60 motors shall be provided with thermal overload protection.

G. Nameplates. Provide an aluminum or stainless steel nameplate secured with screws to the equipment in a location that is readable when the equipment is installed and in operation. The following information shall be included on the nameplate: manufacturer, model number, serial number, date of manufacture, Motor HP, Motor enclosure, motor volts/ph/hz and rpm, design CFM, design SP, Fan Class, Fan RPM, Max RPM.

H. Sound Attenuating Base: Construct sound attenuating bases of No. 18 U.S. standard gage galvanized steel or 0.063 inch aluminum. Include a built-in cant strip for curb mounting and a resilient pad for equipment mounting on the top flange. Line the base with 2 inches of glass fiber insulation and fit internally with glass fiber acoustical baffles.

I. Fan Isolation Base. Provide fan manufacturer's factory isolation base to provide support for fan and motor. The base shall be constructed of structural steel C4x4.5 channel (minimum) and coated same as specified for lab exhaust fans. All connections shall be welded. The base shall have mounting holes at each of the four corners for installation of vibration isolators.

2.4 ROOF-MOUNTED DOWNBLAST EXHAUST FANS (EF-??)

A. General. Fan shall be a spun aluminum, roof mounted, belt or direct driven as indicated on schedule, downblast centrifugal exhaust ventilator.

B. Construction. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have a rolled bead for added strength. A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Unit shall have integral conduit chase provide through curb cap and into the motor compartment.

C. Wheel. Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05.

D. Fan Motor, Bearings and Drives. Motor shall be NEMA design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

E. Supply a disconnect switch on all 120V/1ph and 277/1ph fans and have the switch and motor factory wired to the junction box.

F. Options.

1. Dampers.

    a. Motorized Dampers. Provide 120V motorized backdraft dampers with curb flanges where indicated on schedule. Damper size shall be full size of duct connection or full size of curb opening if curb opening is smaller than the ductwork.
    b. Gravity Dampers. Provide gravity backdraft dampers with curb flanges where indicated on schedule. Damper size shall be full size of duct connection or full size of curb opening if curb opening is smaller than the ductwork

2. Provide speed controllers on all direct drive fans.
3. Auto Belt Tensioner. Provide an automatic tensioning device that adjusts for the correct belt tension, only for single belt drives.
4. Pressure Probe: Provide a ¼ inch diameter tube in the fan venturi that allows hook up to manometer

2.5 ROOF MOUNTED UPBLAST EXHAUST FANS (EF-??)

A. General. Fan shall be a spun aluminum, roof mounted, belt driven, upblast centrifugal exhaust ventilator.

B. Construction. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have a one piece inlet spinning and continuously welded curb cap corners for maximum leak protection. The windband shall have a rolled bead for added strength. A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.

C. Wheel. Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05.

D. Fan Motor, Bearings and Drives. Motor shall be Nema design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

2.6 GRAVITY RELIEF HOOD AND AIR INTAKES

A. Reference Supplemental Equipment above for additional information.

B. Shall be constructed of heavy gauge aluminum, with precision formed, arched panels with interlocking seams. The hood shall be bolted to a minimum 8 gauge aluminum or 12 gauge galvanized steel support structure. A radius throat must be provided for optimum performance. Lifting lugs shall be provided to help prevent damage from improper lifting. The base shall have continuously welded curb cap corners for maximum leak protection.

2.7 ROOF MOUNTED KITCHEN EXHAUST FAN (KEF)

A. General. Fan shall be a spun aluminum roof mounted, belt driven centrifugal exhaust fan meeting the requirements of UL762.

B. Construction: The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The windband shall have a rolled bead for added strength. A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An external wiring compartment with integral conduit chase shall be provided into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. A one inch thick, three pound density foil back heat shield shall be utilized to protect the motor and drive components from excessive heat. Lifting lugs shall be provided to help prevent damage from improper lifting.

C. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. The wheel shall be coated with non-stick coating (Teflon) to prevent grease from sticking to the wheel. Wheel shall be balanced in accordance with AMCA Standard 204.

D. Fan Motor, Bearing and Drives. Motor shall be NEMA design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM. Provide automatic belt tensioner.

E. Miscellaneous:

1. Provide NEMA 3R pre-wired disconnect switch for fans as indicated on fan schedule.
2. Provide roof curb meeting requirements of NFPA-96, including a vented extension. Provide a hinged base to allow fan to tilt away for access to wheel and ductwork for inspection and cleaning.
3. Provide grease trough and extended lube lines.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans level and plumb.

B. Support floor-mounting units using spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section, Cast-in-Place Concrete.

D. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 23 05 53, Identification for HVAC Piping and Equipment.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00, Air Duct Accessories.

B. Ground equipment according to Division 26 requirements.

C. Connect wiring according to Section 26 05 19, Insulated Conductors.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes air distribution devices including the following:

1. Single Duct Terminal Units.

1.2 COOPERATION WITH OTHER TRADES

A. Coordinate work with Division 26 Electrical Sections to ensure intended functions of lighting and air systems are achieved.

1.3 SUBMITTALS

A. Product Data: Submit schedule for each box indicating size, capacity, sound data and other data to show compliance with the specifications and schedule on drawings. Submit product data indicating materials, finishes and options provided that clearly indicate compliance with Part 2 of this Section. For all types of terminal boxes, provide documents proving that the box performance as submitted has been certified by an independent laboratory

B. Samples: At the request of the Owner and/or A/E team, submit one terminal unit of each specified for review.

1.4 TERMINAL UNIT TESTING:

A. Two terminal units of each type will be selected by the Owner for testing by the TAB firm. After the terminal units have been shipped to the job site, the Owner and TAB firm will select which terminal units will be tested. The Contractor will then ship the terminal units from the job site to the TAB firm's testing facility.

B. The boxes will be tested for casing and damper leakage at the TAB firm's testing facility. The TAB firm will ship the terminal units back to the job site at Contractor's expense for installation after testing is complete.

C. If a terminal box fails testing, the manufacturer shall visit the TAB firm's testing facility and modify the terminal unit to meet the leakage requirements. The TAB firm will then retest the terminal unit to verify it meets the leakage requirements. If the terminal unit passes the test, the manufacturer shall provide a written procedure for repair and modifications of the terminal units for review and approval by the Owner. If approved by the Owner, the manufacturer shall implement the repairs and modifications to all the terminal units at the job site. If the required repairs and modifications can not be made at the job site, the contractor shall ship all of the applicable terminal units back to the factory for repair and modifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANURACTURERS

A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:

1. Price
2. Krueger
3. Metalaire

2.2 TERMINAL BOX CROSS-FLOW AVERAGING SENSOR (APPLIES TO ALL TYPES OF TERMINAL BOXES)

A. Units shall be provided with a grid of multipoint velocity sensors. Each flow cross shall include a minimum of 8 pickup points of amplified sensing for each 16 inches of duct diameter. The pickup points shall be divided evenly in each of the four quadrants of the duct. Ducts larger than 16 inches in diameter shall be divided into sections which are each averaged to its respective center and then cascaded so that the entire cross-sectional area is traversed.

B. Center tapped averaging sensors shall provide a differential pressure signal that represents actual airflow within an accuracy of +5 percent of maximum rated flow. This accuracy shall be maintained when inlet duct varies from straight to 90 degrees entrance approach angle.

2.3 SINGLE DUCT TERMINAL BOXES (TYPE VV AND VE)

A. Furnish boxes with performance certified as per ARI Standard 880, for installation above the ceiling with capacities as scheduled. Boxes shall be listed in the latest ARI directory. Provide boxes supplied by the manufacturer fully assembled with air dampers, heating coil, self-contained volume regulator, and disconnect switch. Select boxes with maximum scheduled CFM within mid to 80 percent of box listed capacity range. All controls components including HVAC controller shall be supplied by the ATC Contractor to the box manufacturer for factory installation. Controls shall be electronic for DDC application.

B. The damper actuator must be factory installed by box manufacturer. All required linkages must be furnished and factory-installed and performance tested by the box manufacturer. Provide control transformer, disconnect switch, etc., as required.

C. Box maximum volumes shall be adjustable through DDC over the entire range of operation. Contractor shall verify all maximum and minimum volumes in the field.

D. Provide a self-contained, pressure-independent volume regulator to vary discharge CFM up to 3 inches W.G. duct static pressure. The box controls will be factory installed to satisfy specified control sequence.

E. Set the damper linkages so that primary air delivered to the box varies from 100 percent to scheduled minimum, depending upon the cooling load.

F. Casing shall be single wall 20-gage galvanized steel, internally lined with at least 1 inch thick, 1-1/2 lb dual density insulation of fiberglass complying with NFPA 90A and UL 181. All exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibers in the air stream. Leakage not to exceed the following at 1 inch water gage. Tapes and sealants on the exterior of the casing are not acceptable. Provide gasketed access door with ¼ turn metal cam lock in bottom of terminal box.

Box Inlet Size (in)	Casing Leakage CFM
4 - 14	10
16	14

G. Limit installed unit discharge sound levels to NC-30 and radiated to NC-30, based upon 1”W.G. static pressure drop across the unit. NC shall be reported calculated using the acoustical reductions indicated in latest version of AHRI 885, appendix E.

H. Heating Water Coil (where scheduled). Provide one or two row coils as indicated on schedule. The heating coil shall be on the discharge of the terminal box. Coils shall be constructed of minimum 0.016 inch thick copper tubes with aluminum fins, installed in 22 gauge galvanized steel casing. All coils shall be leak tested to a minimum of 200 psi. Electronic control valve shall be provided by ATC Contractor for field installation. Field insulate hot water coil casing as indicated in duct insulation specification. Seal all exposed edges of insulation. The air pressure drop across the coil shall not exceed scheduled values. Provide a separate coil for duct mounting if necessary to meet this requirement. Air pressure drop across the heating coil shall not exceed 0.15” and the water pressure drop through the coil shall not exceed 10 feet of head.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Seal connection at box, as required, to comply with system maximum leakage. Install ductwork at inlet of boxes so that the maximum straight run of duct is achieved at the box inlet. Install boxes so that minimum 3'-0" clearance is maintained in front of box-mounted control and electrical panels. Refer to detail for additional requirements.

B. For fan powered terminal box, install filter during construction phase. Change out filter just before final field observation by the Engineer. Provide one set of spare filters per terminal to the Owner.

C. Store units under protective tarps and in accordance with manufacturer’s installation instructions.

D. Provide clear access to unit mounted access doors on bottom of units.

E. Field insulate all exposed heating coil ubends, headers and coil casing with specified duct insulation.

F. Seal the connection between the hot water coil and the terminal box with duct sealant.

END OF SECTION

SECTION 23 37 13 – AIR DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes air distribution devices including the following:

1. Diffusers.
2. Grilles.
3. Registers.
4. Sound attenuators.

1.2 COOPERATION WITH OTHER TRADES

A. Coordinate work with Division 26 Electrical Sections to ensure intended functions of lighting and air systems are achieved.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: At the request of the Owner and/or A/E team, submit each exposed product for each color and texture specified.

C. Sound Attenuators. Submit schedule for each sound attenuator indicating size, airflow and static pressure. Submit product data indicating materials, acoustical performance and options provided that clearly indicate compliance with Part 2 of this Section. For all sound attenuators, provide documents proving that the acoustical performance as submitted has been certified by an independent laboratory in accordance with ASTM Specification E477-2013.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:

1. Diffusers, Grilles and Registers. Krueger, Price, Metalaire.
2. Sound Attenuators. Commercial Acoustics, Transonics, United McGill, Price, Vibroacoustics.

2.2 DIFFUSERS

A. Square Plaque Diffuser (MARK A – E):

1. Provide aluminum plaque diffuser, precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct. An inner plaque assembly shall be incorporated that drops no more than 1/4 inch below the ceiling plane to assure proper air distribution performance. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck.
2. Finish shall be White Powder Coat.
3. Provide transitions for rectangular duct connections if required.

B. Perforated (MARK F – K):

1. Provide steel frame construction with aluminum perforated face and white factory finish. Frame the diffuser face with a mitered and welded frame.
2. Face shall have no less than 51% free area.

2.3 DIFFUSERS - PART OF A RATED CEILING ASSEMBLY

A. Provide UL fire rated ceiling diffuser with louver face, radiation fire damper and thermal blank radiation barrier.

2.4 GRILLES

A. Supply (MARK L):

1. Use double-deflection supply grilles made of aluminum.
2. Install vertical face blades and horizontal rear blades. Provide solid, extruded aluminum blades which are individually adjustable. Space at not more than 3/4 inch centers for rear blades and 1/2 inch centers for face blades and not less than 5/8 inch deep.
3. Employ grille frames of extruded aluminum with welded and mitered corners and mounting gaskets.
4. Provide white finish on all grilles unless indicated otherwise on drawings.
5. Provide integral aluminum opposed blade damper with mill finish.

B. Return and Exhaust (MARK M):

1. For ceiling return, provide scheduled diffuser with white factory finish. Use construction and frame styles as specified for ceiling diffusers, but without pattern controllers. Use neck sizes as shown.
2. For wall return and exhaust, provide a 45 degree fixed-blade aluminum grille. Provide 3/4 inch blade spacing as scheduled, with front blades parallel to long dimension. Provide solid, extruded frames and aluminum blades which are individually adjustable on sizes larger than 24 inches x 24 inches, roll-formed aluminum blades for smaller grilles. Include mounting gaskets. Provide white finish unless noted otherwise on drawings.
3. Provide aluminum opposed blade damper with mill finish for all air devices used for exhaust.

C. Spiral Duct Grille (MARK Q):

1. Shall be a double deflection type with two sets of fully adjustable deflection blades, spaced ¾" on center. Grille shall be mounted on spiral ductwork without use of transitions. Grille shall be curved to match the radius of the duct.
2. Front blades shall run parallel to the short dimension.
3. Provide air-scoop adjusted via operator on the side frame for balancing.
4. Provide finish that can be painted in field.
5. Provide closed cell foam gasket attached to the border to provide a tight seal around opening of the ductwork.

D. Heavy Duty Return (MARK W):

1. Provide a 0 degree fixed-blade 14 gauge steel grille. Provide 3/8 inch blade spacing as scheduled, with front blades parallel to long dimension. Include mounting gaskets. Provide white finish unless noted otherwise on drawings. Provide key operated opposed blade damper for all air devices.

2.5 SLOT DIFFUSERS

A. Supply (MARK S – U):

1. The linear slot diffuser shall utilize heavy wall extruded aluminum air deflector frames. These frames shall be designed to accommodate notched compressible space bars, complete with integral hanger, spaced approximately 24 inches on center. The steel air pattern controllers are fully adjustable and can be moved from side to side to create various air pattern configurations. These dual pattern controllers shall be fully adjustable to allow shut-off without adding any blank-off devices. The spacer bars and pattern controllers shall be removable for on-site modification and trimming.
2. Provide minimum 10 inch high plenum with 1/4 inch thick. 2lb density insulation. Plenum shall have tabs for supporting from structure. Provide hard ceiling clips for installing unit in gypboard, end caps and other accessories required for complete installation. Confirm border type with Architect prior to submittal.

B. Return (MARK V – X):

1. Similar in construction to supply slot diffuser but without plenum. Provide perforated black galvanized steel light shield. Where installed in a vertical wall (sidewall installation), do not provide light shield where light shield would conflict with studs.

C. Provide blank-off plates on unused sections of slot diffusers where indicated on the drawings.

D. Provide end caps at ends of slot diffusers.

2.6 ACCESSORIES

A. Supply Grille Extractors. Provide each supply grille with an air control device capable of positively regulating the volume of air extracted from the supply duct.

1. Select extractors similar to Price Model AE1, tight-closing in the minimum position. Include a key-operated or worm-gear adjusting mechanism to facilitate positioning from the grille opening. Where adjustment is not accessible at the grille opening, provide a control rod equipped with a locking quadrant.
2. For ductwork control, use Young regulators. Provide extractors 30 inches and longer with a support rail inside of the duct at the outboard quarter point of the extractor. Construct the support rail of angle or channel members formed of sheet metal fastened securely to the duct. Make the rails 18 inches long, except where duct width prevents the extractor from sagging when moved toward its maximum position.
3. Check extractors thoroughly for freedom of operation. If necessary, oil bearing points before installing.

B. Mounting Frames. Provide each grille or register not equipped with a removable core with a companion, all-purpose mounting frame constructed like a grille frame to facilitate installation and removal of the grille or register without marring adjacent mounting surfaces.

1. Furnish frames with 1/2 inch thick sponge rubber gasket to prevent air leakage.
2. Provide a frame that neatly fits the grille. Mounting frames will not be required for grilles or registers mounted directly on exposed ductwork.

C. Return Air Canopy

1. Furnish and install a Return Air Canopy (RAC) on all perforated return air diffusers where shown on the drawings. The RAC shall be constructed of 24-gauge solid steel casing with absorptive acoustic fiberglass media. Acoustic media shall be shot-free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin. The glass fiber shall be in accordance with erosion requirements of UL 181, and shall conform to the physical properties and requirements of ASTM C1071. The entire assemble shall meet the 25/50 flame/smoke requirements of ASTM E84

2.7 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

2.8 SOUND ATTENUATORS

A. Construct casings of not less than 22-gage galvanized steel for diameters up to 36 inches, and 18 gage for diameters up to 48 inches. Furnish perforated face sheets over acoustical material of not less than 5.0 pounds per cubic foot of compressed density glass fiber or mineral wool.

B. Airtight construction shall be provided by use of a duct sealing compound on the job site by the Contractor. Silencers shall not fail structurally when subjected to a differential air pressure of 8 inches w.c. inside to outside of casing.

C. Refer to schedule for performance requirements. Lower performance will not be accepted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install ceilings adjacent to fixtures until installation of fixtures, air supply assemblies, return-air blank-off strips and flexible duct have been properly approved. Remove and reinstall any part of the installation found incorrect.

B. Diffusers. Louvered diffuser outlets mount tight against the ceiling. Fasten outlets securely to ductwork with sheet metal screws. For perforated diffusers, attach the frame assembly by a concealed hinge assembly to an outer frame compatible with the type of ceiling on which the diffuser is installed.

3.2 SOUND ATTENUATORS.

A. Install sound attenuators per manufacturer's recommendations. Support sound attenuator from structure, independent of ductwork. On attenuators installed in vertical ductwork, support from structure above using threaded rod or support from floor below using minimum 3/8 inch threaded rod. Prior to connection of adjacent ductwork, the silencer should be vacuum-cleaned or wiped clean with a cloth to remove all debris.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.2 RELATED WORK

A. Section 23 31 13, Ductwork

B. Section 23 73 13, Air Handling Units

1.3 REFERENCES

A. AMCA 99 – Standards Handbook.

B. ARI 850 – Commercial and Industrial Air Filter Equipment.

C. ASHRAE 52.1 – Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.

D. ASHRAE 52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.

E. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality.

F. IEST RP-CC—1 – HEPA Filters.

G. NFPA 70 – National Electrical Code.

H. SMACNA – HVAC Duct Construction Standards – Metal and Flexible.

I. UL 586 – High Efficiency, Particulate Air Filter Units.

J. UL 900 – Test Performance of Air Filter Units.

1.4 DEFINITIONS

A. IEST – Institute of Environmental Sciences and Technology.

B. HEPA – High Efficiency Particulate Air.

C. MERV – Minimum Efficiency Reporting Value.

1.5 SUBMITTALS

A. Product Data: Include dimensions; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; MERV rating, efficiency and test method; fire classification; furnished specialties; and accessories for each unit indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Include wiring diagrams.

C. Operation and Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the specified products with minimum three years documented experience, who issues complete catalog data on total product.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 90A and NFPA 90B.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site in accordance with Section 23 00 10, Mechanical General Provisions.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean, dry space and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Ship equipment to jobsite with not less than a prime coat of paint or as specified.

1.8 PROJECT CONDITIONS

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

1.9 SCHEDULING

A. Capacities and characteristics are generally shown on schedules on Drawings. Reference shall be made to schedules for such information.

B. Capacities shown are minimum capacities. Variations in capacities of scheduled equipment supplied under contract will be permitted only with written direction from Owner.

1.10 MAINTENANCE

A. Extra Materials: Provide two complete sets of filters for each unit. Tag to identify associated unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AAF International/Flanders
2. Cambridge.
3. Camfil
4. Koch
5. Dwyer Instruments, Inc.

2.2 FILTERS

A. Filters shall be listed in accordance with UL 900 and shall be tested and reported in accordance with ASHRAE Test Standards 52.1 and 52.2. Dust spot efficiencies listed are results when tested by ASHRAE Standard 52.1. MERV and MERV-A values listed are results when tested by ASHRAE Standard 52.2. and ASHRAE Standard 52.2 Appendix J.

B. Medium Efficiency Panel Filter (Disposable, Dry Type)

1. MERV 8 Filters:

a. Media: 0.18-inch nonwoven cotton and synthetic blend media, formed into a uniform radial pleat. Provide industry standard sizes as required for installation. The minimum media area shall be 17.3 square feet for a 24X24 filter.
b. Frame: Provide filter media in permanent removable frames with corrosion resistant welded wire grid bonded to the downstream side of the media. Media shall be fully bonded to frame to prevent air leakage.

c. Rating: Initial resistance no greater than 0.31-inches w.g. at 500 FPM face velocity. Minimum Efficiency Reporting Value shall be MERV 8, dust spot efficiency of 25-30 percent.
d. Thickness: 2-inches or 4-inches. Pre-filters shall be 2-inches unless otherwise noted on the Drawings or Specifications.

C. High Efficiency Filter V-Bank Filter (Disposable, Dry Type)

1. MERV 11 Filters

a. Media: Media: Microfine glass laminated to a reinforcing backing formed into a lofted media blanket with a uniform radial pleat. Pleats media packs shall be assembled into a V-bank configuration with sufficient total media area to meet airflow requirements. Provide industry standard sizes as required for installation. The filter minimum media area shall be 194 square feet for a 24X24X12 size filter.
b. Frame: Frame: The media packs shall be bonded to the inside periphery of an ABS enclosing frame with a polyurethane sealant. The enclosing frame shall include top and bottom molded tracks as in integral part of the frame to ensure a proper seal. Rigid plastic end caps shall be mechanically fastened to the top and bottom of the media pack enclosing structure to ensure a rigid and durable filter.
c. Rating: Initial resistance no greater than 0.29 inch w.g. at 500 FPM face velocity. Minimum Efficiency Reporting Value shall be MERV 11, dust spot efficiency of 60-65 percent. Thickness: 12 inch thick (nominal) frame.

2. MERV 13 Filters

a. Media: Microfine glass laminated to a reinforcing backing formed into a lofted media blanket with a uniform radial pleat. Pleats media packs shall be assembled into a V-bank configuration with sufficient total media area to meet airflow requirements. Provide industry standard sizes as required for installation. The filter minimum media area shall be 194 square feet for a 24X24X12 size filter.
b. Frame: The media packs shall be bonded to the inside periphery of an ABS enclosing frame with a polyurethane sealant. The enclosing frame shall include top and bottom molded tracks as in integral part of the frame to ensure a proper seal. Rigid plastic end caps shall be mechanically fastened to the top and bottom of the media pack enclosing structure to ensure a rigid and durable filter.
c. Rating: Initial resistance no greater than 0.28-inches w.g. at 500 FPM face velocity. Minimum Efficiency Reporting Value shall be MERV 13, dust spot efficiency of 80-85 percent. Thickness: 12-inch thick (nominal) frame.

2.3 FILTER GAUGES

A. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case. Provide vent valves, black figures on white background, front calibration adjustment. The range of the scale shall be no greater than 1" w.g. above the filter manufacturer’s recommended final resistance for the type of filter to which the gauge is being applied, 2 percent of full-scale accuracy. Provide with adjustable signal flag.

B. Accessories: Static pressure tips with integral compression fittings, 1/4-inch aluminum or polymer tubing.

2.4 PARTICULATE AND GAS-PHASE FILTERS

A. MERV 15 & CARBON FILTER

1. Media: Synthetic filter media with rapid absorption carbon embedded within the media. Media shall be capable of absorbing volatile organic compounds (VOCs), SOx, NOx, and Ozone. Carbon media shall be non-dusting
2. Frame: Filter shall be in a V-bank configuration and be mounted on a 12” filter rack. The media packs shall be bonded to the inside periphery of an ABS enclosing frame with a polyurethane sealant. The enclosing frame shall include top and bottom molded tracks as in integral part of the frame to ensure a proper seal. Rigid plastic end caps shall be mechanically fastened to the top and bottom of the media pack enclosing structure to ensure a rigid and durable filter.
3. Rating: Initial resistance shall be 0.48”WG at 2,000 fpm face velocity. Minimum efficiency rating shall be MERV 15.
4. Acceptable manufacturers: AFF Varisorb XL15, Camfil Farr CityCarb, approved equal.

2.5 BI-POLAR IONIZATION FILTER

A. Description: Provide cold plasma filtration device made out of extruded aluminum and stainless steel. The filtration device shall require no maintenance or replacement parts. The filter shall have the ability to remove odors, kill mold bacteria, and viruses

B. Filter shall utilize 120 power and be turned on/off by the building automation system.

C. Acceptable manufacturers: Global Plasma Solutions, Approved Equal.

2.6 V-BANK FILTER DUCT MOUNTED FILTER HOUSING

A. Acceptable manufacturer:

1. American Air Filters
2. Camfil Farr
3. Koch

B. Construction:

1. Unit shall be constructed out of 16 gauge galvanized steel with predrilled standing flanges, hinged access doors, and filter sealing gasketing.
2. Provide intermediate support channels spaced at 2’ increments.
3. Unit shall be rated for maximum 0.5% airflow leakage at 6”WG.
4. Acceptable filter sizes are 24x24 and 24x12 at 2” of depth.
5. Provide fully gasketed doors.
6. Provide double walled insulated housing and doors with a minimum of 2” of fiberglass insulation.

PART 3 - INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Coordinate filter installations with duct and air-handling unit installations.

D. Electrical wiring and connections are specified in Division 26 Electrical Sections.

END OF SECTION

SECTION 23 62 00 - AIR-COOLED DX CONDENSING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:

1. Unitary small air cooled condensing units (5 tons and smaller).

1.2 PERFORMANCE REQUIREMENTS

A. Provide performance as scheduled on Drawings.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, sound data and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and maintenance data.

D. Warranty Information.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE/IESNA 90.1-2013 Compliance:

C. Energy efficiency and performance shall be certified as follows:

1. Unitary Small AC to ANSI/AHRI Standard 210/240.

D. Sound data shall be certified to ANSI/AHRI Standard 270.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer’s installation instructions for rigging, unloading, and transporting units.

1.6 WARRANTY

A. Unitary small AC units.

1. Provide 5-year compressor warranty.
2. Provide 5-year parts warranty.

PART 2 - PRODUCTS

2.1 UNITARY SMALL AC UNITS (5 TONS AND LESS)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. York
2. Trane
3. Carrier
4. Daiken
5. LG
6.

B. REFRIGERANT

1. Without exception, the refrigerant for the units shall be R-410A.

C. MANUFACTURED UNITS

1. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
2. Condenser Coil: Seamless copper or aluminum tube, aluminum finned coil; factory leak tested to 150 psig and pressure tested to 425 psig. Circuit to match compressors.
3. Condenser Fans and Drives: Propeller fans for vertical air discharge; directly driven with permanently lubricated ball-bearing motors with integral current- and thermal-overload protection; and anti-short cycle timer control circuit to prevent the compressor from restarting for five (5) minutes after stopping.
4. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors; and high and low pressure switches.
5. Unit Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating, designed for outdoor installation with weather protection for components and controls, and with removable panels for access to controls, condenser fans, motors, and drives; fan guards, lifting eyes, and removable legs.
6. Accessories: Provide the following accessories with each unit:

a. Low-Ambient Kit for temperatures down to 0ºF.
b. Crankcase Heater.
c. Thermal Expansion Valve (TXV).
d. Hard Start Kit.
e. Filter drier.
f. Field installed disconnect switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances for service and maintenance.

B. Install air-cooled condensers on concrete base. Concrete bases are specified in Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.

C. Install roof-mounting units on equipment Thy-curb roof supports.

D. Vibration Isolation: Mount air-cooled condensers on rubber pads with a minimum deflection of 1/4 inch.

E. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Section 23 23 00, Refrigerant Piping.

F. Furnish charge of refrigerant and oil.

G. Furnish and install all low voltage control wires as required.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Contractor shall perform the following field tests and inspections and prepare test reports:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Non-precharged refrigerant piping:

    a. After all refrigeration equipment and piping is installed, charge the system with the proper refrigerant and dry nitrogen to 300 psig. Test all joints for leaks with electronic leak detector. Repair any leaks and recharge and retest. .
    b. After refrigerant system has been pressure tested, connect a suitable vacuum pump and evacuate the piping system and equipment. Operate the vacuum pump as long as required to evaporate all moisture in the system. Check the humidity within the system with a wet bulb indicator until the wet bulb temperature is reduced to minus 40°F. After the system has been evacuated, break the vacuum by charging the proper refrigerant into the system.

4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

6. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Remove and replace malfunctioning air-cooled condensers and retest as specified above.

3.3 ADJUSTING

A. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.

B. Shut down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.

C. Provide cooling season start-up and winter season shutdown for first year of operation.

END OF SECTION

SECTION 23 73 13 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.

B. Section 23 05 53, Identification for HVAC Piping and Equipment.

C. Section 23 05 93, Testing, Adjusting and Balancing for HVAC.

D. Section 23 31 13, Ductwork.

E. Section 23 05 13, Common Motor Requirements for HVAC Equipment.

F. Section 23 41 00, Particulate Filtration

G. Section 26 29 13, Motor Starters - 600V and Below.

H. Section 23 05 50, Noise Control for Mechanical system

1.2 PERFORMANCE

A. Unit capacities and characteristics are scheduled on drawings. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit, with clearances as required for maintenance, access and coil pull.

B. The fan filter unit shall be constructed to the same requirements as the air handling units.

1.3 QUALITY ASSURANCE

A. Fan Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal for air foil wheels.

B. Sound Ratings: AMCA 301; tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

D. Filter Media: ANSI/UL 900 listed, Class I or Class II.

E. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410.

F. Unit Performance Rating. ARI 430.

1.4 STRUCTURAL REQUIREMENTS

A. Provide factory assembled units. Large units may be shipped in assembled sections. Provide rigging hooks for the non modular units. Provide additional bracing for large unit casing as required for structural integrity.

B. Furnish units with sealing and fastening hardware supplied by the manufacturer. Include written instructions needed to complete field assembly of the components.

C. Provide units designed and constructed so that coils, panels, fan housing and fans can be removed without affecting the structural integrity of the unit.

D. Provide continuous structural base rail channels beneath unit assembly for structural rigidity of assembly. Provide 6 inch (minimum) C-welded Structural steel channel (formed or mechanically fastened bases are not acceptable). Vertical and horizontal unit sections supporting fan sections, coil sections or other unit components shall be designed to support loads without deflecting the perimeter base or sections. The manufacturer shall submit data in accord with paragraph 1.6 B indicating support points of unit assembly.

1.5 PRESSURE RANGES DEFINED

A. Low Pressure Units: Total static pressures up to 2 inches w.g.

B. Medium Pressure Units: Total static pressures above 2 and up to 6.0 inches w.g.

C. High Pressure Units: Total static pressure above 6.0 inches w.g.

1.6 SUBMITTALS

A. Submit shop drawings and product data. Product data shall include complete description of air handling unit construction, including materials of construction, material thicknesses, insulation thickness and “K” valves, fan curves and coil performance data.

B. Provide shop drawings indicating complete unit assembly, dimensions, weight loading at support points, required clearances, construction details, access door dimensions, and field connection locations and sizes for both coil, condensate and duct connections. Separate section drawings are not acceptable. Indicate locations of factory mounted electrical junction boxes.

C. Show compliance in submittal with Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment, and Section 23 05 13, Common Motor Requirements for HVAC Equipment.

D. Provide product data including dimensions, weights (dry and wet), capacities, ratings, fan performance, motor electrical characteristics, gages and finishes of materials. Individual component computer type drawings are not acceptable. Provide complete assembly drawings.

E. Submit fan curves with specified operating point clearly plotted and at scheduled RPM. Fan performance shall include the effects of inlet screens, safety screens and other system effects. Fan curbs shall include the stall (do not select) line, multiple RPM lines and full characteristic for the fan. The fan curb submittal on fan array units shall include the unit performance in fan array characteristics.

F. Submit sound power levels for fan outlet, inlet and casing radiation at rated capacity.

G. Submit product data of filter media, filter performance data, filter assembly and filter frames.

H. Provide statement of compliance for leakage and deflection requirements.

I. Provide information on fan airflow monitoring stations. Submit calibration curves prior to unit shipment.

J. Contractor shall submit 1/4 inch scale drawing of each mechanical room for review by owner and engineer. Drawing shall show coil pull spaces and coordination of all ductwork, all chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room. Provide plan and elevation views detailing installation.

K. Contractor shall submit plan indicating methods for Delivery, Storage and Handling of Air Handling Units prior to shipping of units.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 05.

B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.

C. Provide tab for each air handling unit provided.

1. Include copy of approved submittals (with all comments corrected).
2. Include factory vibration test results for fans, and files vibration test for fans bearings and motors per Section 23 05 93.
3. Provide copy of calibration curve for all fan airflow monitoring station.

1.8 EXTRA FILTERS

A. Provide two sets of spare MERV8 disposable panel (3 sets total) filters and one spare set of MERV13 filters at project completion.(2 total sets) for each unit

1.9 DELIVERY, STORAGE AND HANDLING

A. During shipment, it’s the responsibility of the Contractor to ensure AHUs are wrapped with a tight sealing membrane, including electrical components. Wrapping membrane shall cover entire AHU during shipping regardless of size or shape. Units shall be protected against rain, snow, wind, dirt, road salt/chemicals, rust and corrosion.

B. All handling and storage procedures shall be per manufacturer's recommendations and these specifications. Refer to Paragraph 3.1 for additional information.

C. Coordinate delivery of units with project schedule, units may not be stored outside and exposed to elements (even if under protective tarps). Store units protected from weather under protective tarps, inside building or a warehouse. Units shall be protected from rain and other sorts of moisture while in transit and on-site. Provide protective covering over equipment.

D. Storage procedures and protection shall be approved by Owner and Engineer as indicated under Submittals..

PART 2 - PRODUCTS

2.1 PRODUCTS OF MANUFACTURERS

A. Products of Manufacturers listed below complying with each of the requirements of the specifications are acceptable:

1. Haakon
2. Temtrol.
3. Energy Labs
4. Daiken
5. Climate Craft
6. Trane

2.2 FABRICATION AND DESIGN

A. Fabricate units with fan and coil sections plus accessories, including heating coil sections, filter section, cooling coil section as scheduled.

B. Factory fabricate air handling units of sizes, capacities and configuration as indicated and specified. See drawings for additional information on component layouts.

C. Base performance on sea level altitude and design conditions as scheduled.

2.3 CASING

A. Construction: Casing shall be constructed of double wall, side, roof and floor panels, 22-gage inner panel and 24 gauge outer panels with foam insulation, galvanized steel and protected with the manufacturer's standard finish. Provide an additional 0.125 inch aluminum diamond tread plated liner walk-on surface in unit access areas (sections with access doors) for all units. Exterior panels must removable from the outside of the unit without affecting the structural integrity of the unit. Exterior panels shall be painted with minimum 1,000 hour salt spray and humidity test according to ASTM B-1117 and ASTM D2247.

B. Access: Provide access to entry for sections of the unit by minimum 68" tall hinged access doors big enough to permit access to and removal of internal parts and entry for cleaning. Access door insulation shall be same thickness as that of air handling unit walls. Provide full perimeter gasketing on the door or casing to seal access panels. Provide fan, filter and coil section with access doors with Ventlock latches and hinges or Allegis or Southco Series 300. Minimum width of door shall be 18 inches at coil sections (upstream and downstream of cooling and heating coils) and 24 inches at fan sections. Provide an access sections as indicated on AHU Component Diagrams on the Construction Documents. Provide an access section with a door on left and right side of each coil or as indicated on the component diagram. Minimum length for cooling coil section shall be 36 inches and for heating section 24 inches including access sections. Refer to drawings for additional information on access locations. Provide viewing window in access doors in the fan and coil sections. Windows shall be double-pane tempered glass at a height between 4.5 to 5.5' above mechanical room elevation. All doors shall open against pressure.

C. Coil Connections Panels: Provide removable panels through which piping may pass. Use rubber grommets to seal airtight around pipes on insider and outside of units. Grommets shall completely pass from outside of unit to inside of unit, and seal all insulation inside casing from airstream.

D. Finish: G90 Galvanize all parts of the unit, both inside and out, including supports. Insulation: Provide foam insulation as indicated below. All panels (roof, walls, floor) and access doors shall have a minimum thermal conductivity R of 12.5 (Hr-ft2-F/BTU).:

1. Foam Insulation: Unit shall be completely insulated throughout the entire unit, with all panels and structural frame members insulated with a minimum 2 inches of foam insulation. Panels shall have a minimum thermal conductivity R of 12 (Hr-ft2-F/BTU).

E. Drain Pans: Provide a minimum 16 gauge, Type 304 stainless steel double-bottom IAQ type drain pan with minimum 2 inch thick uncompressed insulation in the sealed space between two pans. Extend the drain pan a minimum of 12 inches from the downstream of each coil face. Provide coil section access door to drain pan for inspection and cleaning.

1. Inside chilled water coil section pan shall be all-welded stainless steel construction, with slopes and connections adequate for complete drainage of condensate. IAQ drain pan is required. Hot water coil section pan liner may be galvanized steel.
2. Provide a stainless steel large threaded drain connection on side at the low point of the chilled water pan. Provide galvanized steel connection on hot water pan. Coordinate the condensate drain location with project drawings.
3. When two or more cooling coils are used, with one stacked above the other, individual drain pans of stainless steel, with copper drains piped to the main drain pan shall be provided beneath each of the coils.

F. Air handler support base shall elevate condensate drain connection not less than 10 inches above finished floor. Submittal shall include dimensional drawing of insulated condensate drain piping including cleanable trap for each air unit. Install unit on 4-inch concrete housekeeping pad with drains piped to floor drain.

G. Leakage and Deflection Requirements:

1. Leakage requirements: The unit shall be constructed to for an allowable leakage of 1% of the rated unit airflow at a total static pressure of ±8 inch w.g. Provide statement of compliance with submittal that unit is constructed to meet this requirement.
2. Deflection requirements: The unit shall be constructed so the maximum panel deflection shall not exceed an L/240 ratio when tested at a total static pressure of ±8 inch w.g. 'L' is defined as the height of the unit on the sides, width of the unit on top panels and the smaller of width or height for the ends. Provide statement of compliance with submittal that unit is constructed to meet this requirement.

H. Test and Balancing Ports

1. Provide a permanent factory-installed sealable port on each section of unit to allow for testing and balancing of system, except where port would be blocked by filters or coils. TAB ports may be located in the access doors of the unit.

2.4 FAN SECTION

A. Fans should be designed for quiet, slow-speed operation under specified rating conditions. Provide minimum Class II construction. Fan speed shall be able to be increased 10% without exceeding maximum fan RPM.

B. Wheels. Provide single width single inlet (SWSI) plenum fans.

1. All SWSI plenum fans shall have airfoil blades, flat blades are not acceptable. Fan blades shall be continuously welded to the backplate and inlet shroud, and securely keyed to the fan shaft.
2. Coat all non-aluminum fan parts with enamel paint; all fan wheel hardware and fasteners shall be cadmium plated or stainless steel.

C. Scrolls: Provide fan scrolls of galvanized steel or air dried phenolic painted construction. Housing shall be of heavy gauge and continuously welded. Rigidly secure the scrolls in the casing to prevent vibration.

D. Shafts: Provide tubular or solid hot rolled steel, ground and polished, with keyway and protectively coated with lubricating oil.

E. Blower wheels cantilevered on the ends of the shafts are not acceptable.

F. Statically and dynamically balance fan, motor and drive assembly over entire speed range. Air handling units, fans, bearings and fan sheaves shall be balanced to ISO-1940 G6.3 standards or to a maximum of 7 mil peak to the horizontal and vertical plane as measured at the fan mounting leg. Filter out measurements shall be taken in the horizontal and vertical and axial planes. Measurements shall not exceed 9.5 mils horizontally, vertical planes and axial planes. Submit factory balance data with O&M Manuals for each air handling unit assembly.

G. Drive: Provide direct drive air handlers only.

H. Motors:

1. Provide motors rated for "inverter ready" and per Section 23 05 13, Common Motor Requirements for HVAC Equipment.
2. Provide fan motors that will not overload when scheduled fan rpm is increased 10 percent. Submit a fan curve for each scheduled unit showing operating points at scheduled conditions and at scheduled rpm increased 10 percent. Minimum motor sizes as scheduled must be provided without exception. Where larger than scheduled motor sizes are provided, the mechanical contractor shall provide motor VFD or Starter, conduit, wiring, disconnect, etc. suitable in accord with NEC as required for increase in motor nameplate horse power.
3. Submit data on motors in accord with Section 23 05 13, Common Motor Requirements for HVAC Equipment.
4. Air Handler Fan Section shall include a factory mounted external mounted electrical junction box for single point electrical connection (for each motor). The air-handling unit manufacturer shall provide wiring between the motor and the junction box, so that field penetrations are not required for powering the motor. All wiring shall be done in accordance with the latest NEC guidelines. All wiring (for motors) shall be 600v rated type MTW/THWN stranded copper in EMT or metallic (galvanized) flexible conduit (max 3 feet). The junction box shall be at least 6 inches x 6 inches, and be located at least 5 inches above the unit baserail on the drive side of the unit. For all electrical penetrations, seal conduit and wiring connections at motor and junction box air tight to prevent condensation within motor and junction box and conduit. Isolate junction box as required to prevent sweating.

I. Vibration Isolation: Provide internal vibration isolators as specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment. Completely isolate entire fan and motor assembly.

J. SWSI Plenum Fans:

1. Inlet panels shall be of heavy-gauge reinforced steel construction. The inlet panel incorporates a removable spun inlet cone designed for smooth airflow into the accompanying inlet retaining ring of the fan wheel.
2. Plug fans (supply and relief/exhaust) shall be provided with a fan shut down switch in the access doors to the fan and on access door in the section upstream of the fan or provide fans with fan safety cage and inlet screen. Cage shall be large enough to allow working room for wheel and bearing service and shall have removable sections to allow wheel removal. If safety cage is provided, include the pressure losses due to the cage in the internal static pressure calculation.

K. Airflow Monitoring (Measuring) Station:

1. For each air handling unit fan (supply fan, exhaust fan, etc), provided a piezometer ring airflow measuring system. The system shall consist of a piezometer ring mounted on the throat (inlet venturi) and a static pressure tap mounted on the face of the inlet cone. The piezometer ring shall consist of multiple pressure taps on the inlet venturi and piped to a termination plate inside the air handling unit for field supplied differential pressure transducer by Division 23 09 00, Instrumentation and Control for HVAC.

2. The airflow monitoring station shall have an accuracy of 5% of actual flow. If accuracy of airflow measuring station is not within 5% of field measured flow, a duct mounted airflow measuring station shall be provided. The duct mounted airflow measuring station shall be equivalent to Ebtron Gold series or approved equal.
3. The airflow monitoring station shall provide no resistance to airflow. Probes installed in the fan inlet venturi which restrict airflow are not allowed.
4. Probes shall be constructed of aluminum, with 1/4 inch nylon tubing utilized between taps and termination plate.
5. Termination plate shall utilize 1/8-27 NPTF connections and mounted on fan structure.
6. Manufacturer shall provide all calibration curves for airflow monitoring stations prior to unit shipment.

2.5 COILS

A. Provide each coil section with 18” inch wide hinged access doors (refer to AHU component drawing for additional details on access door locations) with alleges or ventlock latches to both sides (upstream and downstream) of coils. Enclose coils with headers and return bends fully contained within casing. Each coil shall be individually removable from stainless steel tracks. Where coils are “multiple stack”, each coil shall be able to be removed without removing other coil. Provide access panels for coil section to allow removal of coil.

B. Standards: Supply products of leading manufacturers with dependable published ratings, or equal. Certify performance in accordance with latest edition ARI Standard 410. Submit coil descriptive literature and rating information for review.

C. Fabrication: . Air Handling Units shall have copper tubes with aluminum fins.

1. Mount in a stainless steel casing permitting removal of coil from unit.
2. Fins may be either plate type, with tubes mechanically bonded into the fins, or ribbon type, helically wound on individual tubes. Provide a tight, mechanical bond between fins and tubes. Use a minimum of six and a maximum of ten fins per linear inch of tube.
3. Design coil section to prevent condensate carryover at face velocities of 500 FPM. Provide minimum coil face area or maximum face velocity as scheduled.
4. Each coil may only have a single supply and return connection. The maximum height of a single coil is 60-inches. Any unit requiring a cooling coil greater than 60-inches tall shall utilize a stacked coil, with each coil having a supply and return connection. Each coil shall be removable as indicated above.
5. Chilled water coil bulkhead shall be stainless steel.

D. Water Coils, Chilled Water: Balance the circuits for equal pressure drop of no more than 15 feet total on coils of piped in series. Maximum of 8 row per coil section. Refer to AHU component drawings for number of coil sections.

1. Arrange each circuit for counter flow cooling with bottom supply connections. Provide drain and vent connections at bottoms and top. Locate coil headers at the same end of the coil.

2. Select water coil for approximately 3 to 4 feet per second velocity (2 fps minimum, 5 fps maximum). Provide 1/2 inch or 5/8 inch diameter tubes with minimum .025 inch tube wall and .008 inch aluminum or copper fins. Each coil shall be tested at the factory under water at not less than 250 psi air pressure and shall be suitable for 200 psi working pressure. Submit data indicating tube wall thickness at straight and all U-bends.
3. Supply and return connections shall be clearly and permanently identified.

E. Heating Coils, Hot Water: Provide hot water coils one or two rows deep, except where noted otherwise. Design and construct heating water coils and heating coil sections the same as cooling coils.

2.6 FILTER SECTION

A. Provide front loaded filter racks.

B. Filters. Refer to 23 41 00

C. Make frames of heavy gauge G-90 galvanized channel construction, rigid and square with a nominal 2-inch or 4-inch thickness as required.

D. Provide commonly stocked filters only. No special filter dimensions will be allowed.

E. Fabricate filters using dimensions to suit the arrangement and size of filter slides or racks in which filters are installed.

F. Replacement Filters. Furnish spare sets of all air conditioning system filters as indicated in this Section.

G. Provide magnehelic gauge with dry set of contacts for each filter bank in filter Section.

2.7 CONTROLS

A. The air handling units shall be provided with field mounted controls per the requirements of Sections 23 09 00.

B. The AHU manufacturer shall provide a ½” electrical conduit stub-ins and j-box at each section of the air handling units. The j-box shall be mounted on the exterior of the unit. The j-box and conduit shall be used by the controls contractor as a path for control wiring into unit.

2.8 LIGHTS

A. Vapor proof fluorescent or LED lights (ceiling or wall mounted) shall be provided in each compartment with access doors (except in filter section). Lights shall be controlled by one light switch located at the supply air fan access door. Wire lights to junction box for 120v connection by Division 26. All wiring shall be in EMT conduit or galvanized flexible metal conduit for units using pretreated outside air.

2.9 SINGLE-ZONE UNITS

A. Low Velocity Single Zone Air Handling Units: Provide draw-through type units. Provide filter sections, preheat coil (where scheduled), access sections, cooling coil and fan sections as scheduled and shown on drawings. Include internal fan and motor vibration isolation. Refer to drawings for additional requirements.

2.10 DAMPERS

A. Where indicated, provide damper at outside air inlet, outlet or relief/exhaust air outlet. Dampers shall be of low leak design having stamped 16 gage stainless steel blades, and stainless steel frame, suitable for gulf coast application. The damper blades shall be provided with a PVC coated polyester fabric mechanically locked into the blade edge. The jamb is a flexible metal, compression type. Leakage shall not exceed 4 CFM/square foot at 1" w.g. The blades shall be parallel acting. Interlock dampers to remain open while AHU is in operation and close when AHU is shutdown. Size dampers for a maximum velocity of 1000 feet per minute.

B. Dampers shall be opposed blade type.

2.11 ENTHALPY PLATE EXCHANGER

A. The ERV core shall transfer both sensible and latent energy between the incoming fresh air stream and the exhaust stale air stream.

B. The ERV core shall be in either a cross-flow or counter cross-flow orientation and have no moving parts.

C. The ERV core shall be certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. Products not currently AHRI certified will not be accepted.

D. The ERV core shall achieve the minimum effectiveness value as indicated in the schedule.

E. The fresh air stream must have complete separation from the stale air stream to prevent cross contamination.

F. The ERV core shall have Exhaust Air Transport Ratio of less than 1% as tested to AHRI 1060 (EATR) to prevent cross-over of gases, contaminants or odors.

G. The ERV core’s Outdoor Air Correction Factor (OACF) shall not exceed 1.0 as tested to AHRI 1060 (OACF) Standard.

H. The ERV core shall not be degraded or promote the growth of mold and bacteria with a rating of zero in testing according to ISO846 A and C.

I. The ERV core must be able to tolerate freezing temperatures of -30°C (-22°F and not have an increase in EATR or decrease in performance after being frozen.

J. The ERV core must be able to tolerate high temperatures of +60°C and not have an increase in EATR or decrease in performance at these elevated temperatures.

K. The ERV core must be freeze tolerant tested to 40 freeze thaw cycles from -20o C to +20o C while maintaining the energy recovery effectiveness and EATR rating of less than 1%.

L. The ERV core must be water washable to remove dust and contaminants.

M. The ERV core must be flame proof and comply with UL 723 with a flame spread index that shall not be over 25 and a smoke index that shall not be over 50.

N. The ERV cores should have particulate filters positioned before the incoming air streams.

O. Accepted manufacturer: Core Technologies, Innergytech, or approved equal, subject to compliance with requirements.

2.12 OUTDOOR ROOF MOUNTED UNITS

A. Outdoor air handling units shall meet all the requirements of Specification 23 73 13, with exception of revisions and additions indicated below. Unit shall be an outdoor rooftop unit.

B. Revision to Paragraph 2.3.

1. Unit shall have foam insulation meeting the requirements of Paragraph 2.3, E, 2. Use of fiberglass insulation is not an option.
2. Finish (2.3D). The exterior of the unit shall be completely cleaned prior to application of finished coats. A prime coat shall be applied prior to painting. A finish coat of acrylic polyurethane shall then be applied. Unit finish shall exceed 500-hour salt spray test, with (5%) solution without any sign of red rust in accordance with ASTM B-117.
3. Roof seams shall be continuously caulked and covered with formed 20 gauge galvanized seam caps. All panel fasteners shall be secured in such a manner as to prevent fastener penetrations that are exposed to the airstream. The unit shall have a sloped roof to promote drainage of precipitation and prevent standing water. The roof shall have a minimum pitch of 1/4 inch per foot. The roof shall overhang the side panels by a minimum of 1-1/2 inches to prevent precipitation drainage from streaming down the unit side panels. Units with flat roofs are not acceptable
4. Exterior casing screws shall be zinc chromate coated.
5. Provide ¾” openings with grommets between interior wall sections. The openings will be used to run control wiring interiorly for the unit.

C. Roof Curb.

1. Provide a full-perimeter, gasketed and insulated roof curb. Roof curb shall ship loose for field installation prior to unit placement.
2. The roof curb shall be prefabricated of minimum 18 gage galvanized steel or aluminum, sloped to accommodate roof pitch.
3. The roof curb shall be insulated with 1-1/2”, 3 pound fiberglass insulation and include a wood nailor,
4. Isolation rail:

a. Spring components shall be 2" deflection, free-standing, unhoused, laterally stable steel springs. Springs shall have a lateral stiffness greater than 1.0 times the rated vertical stiffness and shall be designed for 50% overload to solid.
b. Springs shall be color coded to indicate load capacity.
c. Rails shall provide continuous support for the rooftop equipment and shall be designed to provide isolation against casing-radiated vibration in the rooftop equipment housing and structure borne vibration from rotating and mechanical equipment in the rooftop package.
d. Rail assembly shall consist of extruded aluminum top and bottom members connected by spring isolators and a continuous air- and water-tight seal. The seal shall be a beaded elastomeric material retained in a keyway along the top extrusion. The weather strip shall be sealed along the bottom with an aluminum fascia strip.
e. Rail assemblies shall incorporate means for attachment to the building and the supported equipment and shall incorporate additional stiffening members if necessary to assure stability.
f. Vibration isolator shall be selected by the manufacturer for each specific application to comply with deflection requirements as shown on the Vibration Isolation Schedule or as indicated on the project documents.

5. Acoustic barrier panels Price QLP4 model:

a. Acoustic barrier panels shall be tongue and groove construction, four-inch depth, and shall consist of:

1) 18 gauge solid steel skin
2) 18 gauge solid steel liner
3) 18 gauge full depth splitters spaced a maximum of 16 inches apart

6. Absorptive acoustic mineral wool media

a. Acoustic media:

1) Acoustic media shall be stone wool-based mineral wool insulation.
2) Media shall be packed with a minimum of 10% compression to eliminate voids and settling.

7. Electrical:

a. Provide unit mounted NEMA 3R fused disconnect

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate delivery of units with project schedule, indoor AHU units may not be stored outside and exposed to elements. Store units protected from weather under protective tarps, inside, rotate fans periodically as recommended by manufacturer. Units that exhibit signs of water damaged will not be accepted. Provide owner a monthly report indicating date fan rotated for each air unit.

B. Install in conformance with ARI 435.

C. Assemble units in accordance with manufacturer's installation instructions. Isolate all ducts connected to the air handling unit with flexible duct connections. Units shall be protected from dust, dirt, water, and debris during construction.

D. Chilled and heating water piping to coil connections shall be installed to permit operation and maintenance of all valves and pumps from mechanical room floor. Valves shall not be installed at heights greater than seven feet above finished floor. Where multi-coil (stacked) arrangement is used, provide each supply and return line to and from each coil section with a union, thermometer well, plug valve for balancing and isolation valves as indicated on details.

E. Any openings made in the units for addition of controls components shall be sealed air tight, both inside and out. No insulation shall be exposed to the airstream.

F. Do not operate units for any purpose, temporary or permanent, until interior of ductwork and air handling unit is clean, filters are in place, bearings lubricated, fan has been test run under observation and Owner's permission is received.

G. Route condensate drains from chilled water coil drain pans and moisture eliminator sections of the filter rack to the nearest floor drain.

3.2 START-UP AND TESTING

A. AHU Inspection:

1. A manufacturer's factory-trained and factory-employed service technician shall perform an inspection of each unit and installation prior to startup. The technician shall inspect and verify the following as a minimum:

    a. Damage of any kind.
    b. Installation in accordance of the manufacturer's requirements.
    c. Proper reassembly and sealing of unit segments at shipping splits.
    d. Removal of shipping bolts and restraints.
    e. Sealing of piping and electrical penetrations.

2. The manufacturer's technician shall provide a report to the A/E and Owner summarizing any problems found and correction recommendations.

B. Deflection and Leakage Testing:

1. Two units shall be selected at random by the owner to be tested for leakage and deflection after assembly.
2. Testing shall be conducted by the manufacturer on site with the aid of the Contractor. The testing shall be witnessed by the owner's representative and TAB Contractor. Test shall be conducted before duct installation but after all components have been installed.
3. Testing Procedure

a. AHU Preparation

1) Assemble and seal AHU sections per manufacturer's installation manual.
2) Close and latch access doors. No additional sealing is permitted.
3) Seal duct and damper openings.
4) Blank off and seal supply fan openings.
5) Blank off and seal supply fan bulkhead to isolate positive and negative pressure sections.

b. Pressurization procedure

1) Pressurize positive pressure side to specified static pressures using a pressure blower. Measure and monitor differential pressure exerted on the cabinet with a pressure gage and measure the leakage.
2) Pressurize negative pressure side to specified static pressures using a pressure blower. Measure and monitor differential pressure exerted on the cabinet with a pressure gage and measure the leakage.
3) Measure the panel deflections at the centers (length and width) of four panels chosen by the owner.

c. If any of the tested unit does not pass the leakage and deflection requirements outline in Part 2 of this specification section:

1) The manufacturer shall provide written instructions to the owner on how to address the issues. The procedure shall be approved to the owner and the unit shall be repaired and retested at the Contractor's expense.
2) Two additional AHUs on the project shall be tested at contractor's expense.

C. Controls:

1. All controls wiring shall be routed into the unit through the conduit penetration provided the AHU manufacturer. Once all wiring has been routed tested and commissioned, the mechanical contractor shall caulk the penetration for an air tight seal.

D. AHU Safety Door Safety Switches:

1. AHU door safety switches shall be hard wired to the VFD safety interlocks.

END OF SECTION

SECTION 23 82 19 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies horizontal fan coil units for concealed overhead or exposed installation.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Units shall be ARI 440 certified and labeled.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2013, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1-2013 Compliance: Applicable requirements in ASHRAE/ IESNA 90.1-2013, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

A. Provide one (1) year manufacturer’s warranty. Include coverage of fan-coil unit and motors.

1.5 DEFINITION

A. Exposed cabinet is defined as a unit that does not have supply or return duct connections, but has integral supply and return registers.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Coil-Unit Filters: Install new filters at substantial completion per Part 3 of this specification. Furnish one additional spare filters for each filter installed to be used by Owner after substantial completion.
2. Fan Belts: Furnish one spare fan belt for each unit installed

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide scheduled products by one of the following:

1. Daikin
2. Enviro-Tec, Inc.
3. Greenheck
4. International Environmental Corporation.
5. Johnson Controls
6. Temtrol
7. Zehnder Rittling
8. LG

2.2 DIRECT DRIVE FAN-COIL UNITS

A. Cabinet. Construct of heavy gauge galvanized steel panels. Exposed units shall be shall be finished with a heat cured anodic acrylic powder paint of the standard factory color. All units shall be insulated with 1/2-inch, 1-1/2 pound foil faced fiberglass insulation meeting NFPA 90A requirements. Insulate coil and fan sections. Seal insulation edges.

B. Access. Exposed units shall have fan and filter bottom access panel attached with quarter turn quick open fasteners for access to service.

C. Fan. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. Plenum unit fan assemblies shall be easily serviced through an access panel provided.

D. Motor. Motors shall be high efficiency, permanently lubricated sleeve bearing, permanent split-capacitor type with UL and CSA listed automatic reset thermal overload protection and three separate horsepower taps. Single speed motors are not acceptable.

E. Hydronic Coil. 1/2 inch copper tube, 0.016 or 0.025-inch tube wall thickness, with mechanically bonded aluminum fins spaced no closer than 12 fins/inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220°F. Include manual air vent and drain valve.

F. Drain Pan. Primary condensate drain pans shall be single wall, heavy gauge stainless steel for corrosion resistance, and extend under the entire cooling coil. Drain pans shall be of one-piece construction and be positively sloped for condensate removal. Drain pans on concealed models shall be field reversible for right or left hand connections. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21

G. Filters. All plenum and exposed units shall be furnished with a minimum 1" pleated MERV 6 filter. Filters shall be tight fitting to prevent air bypass. Plenum unit filters shall be easily removable from the bottom of the unit without the need for tools.

H. Electrical. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations. The factory mounted terminal wiring strip consists of a multiple position screw terminal block to facilitate wiring terminations for the electric control valves and thermostats. Provide unit mounted three speed fan and disconnect switch.

I. Controls: All controls, including terminal equipment controller for fan coil unit shall be supplied by Temperature Controls Contractor to fan coil unit manufacturer for factory installation.

J. Options: Refer to FCU Schedule

1. Provide double deflection discharge grille where indicated on fan coil unit schedule.
2. Provide insulated mixing box with return and outside air connections.

K. [DX Coil. Furnish a DX coil, tested to 450 PSIG pressure and factory sealed and charged with a minimum of 5 PSIG nitrogen or refrigerated dry air. DX coils shall be provided with a fixed orifice refrigerant distributor.]

2.3 BELT DRIVE FAN COIL UNITS

A. General. Provide horizontal or vertical fan coil units as indicated on schedule. All units shall be of “draw-thru” design with coils, fans, motor/ drive and drain pan completely contained within the unit cabinet.

B. Cabinet. Construct of 18-gage galvanized steel panels. Exposed units shall be shall be finished with a heat cured anodic acrylic powder paint of the standard factory color. Units shall be insulated with 1-inch, 1-1/2 pound foil faced fiberglass insulation meeting NFPA 90A requirements. Insulate coil and fan sections. Seal insulation edges.

C. Access. All access panels shall be fully insulated and attached with standard fasteners on at least two opposite sides. No coil or drain piping or electrical connections shall pass through any access panel.

D. Fan. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. Fan shall have permanently lubricated ball bearings with a minimum design average life (L50) of 100,000 hours.

E. Motor. Motors shall be high efficiency, standard NEMA design motors of the horsepower listed in the equipment schedule. All motors shall be 1750 RPM, 60 hertz single speed motors rated for continuous duty. All motors shall be reversible rotation type. Three phase motors shall be "across-the-line" start type. All motors shall be mounted on an adjustable base. All motor wiring is to be terminated in a junction box, external to the unit casing. All fan drive assemblies shall include an adjustable pitch motor pulley, a fixed pitch blower pulley and a standard cross section "V-belt". All fan drives shall be selected at a minimum service factor of 1.2.

F. Hydronic Coil. 1/2 inch copper tube, 0.016-inch or 0.025- inch tube wall thickness, with mechanically bonded aluminum fins spaced no closer than 12 fins/inch, rated for a maximum working pressure of 300 psig and a maximum entering-water temperature of 200°F. Include manual air vent and drain valve. Provide stainless steel coil casing.

G. Drain Pan. Primary condensate drain pans shall be single wall, heavy gauge IAQ stainless steel for corrosion resistance, and extend under the entire cooling coil. Drain pans shall be of one-piece construction and be positively sloped for condensate removal.. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21

H. Filters. All units shall be furnished with flat filter rack with hinged access on both sides, designed to accept a 2" MERV 6 pleated filter. Filters shall be tight fitting to prevent air bypass.

I. Electrical. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations. The factory mounted terminal wiring strip consists of a multiple position screw terminal block to facilitate wiring terminations for the electric control valves and thermostats

J. Controls: All controls, including terminal equipment controller for fan coil unit shall be supplied by Temperature Controls Contractor to fan coil unit manufacturer for factory installation.

K. Options:

1. Provide mixing box where shown on schedule or drawings. Mixing box shall be fully insulated and constructed the same as cabinet.
2. A main incoming power non-fused disconnect switch shall be factory furnished and wired by the unit manufacturer for single point power connection where indicated on schedule.
3. Unit shall have a 12 gauge galvanized steel base rail for ceiling or floor mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fan-coil units to comply with NFPA 90A.

B. Suspend fan-coil units from structure with vibration isolators as specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.

C. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation.

D. Install new filters in each fan-coil unit at Substantial Completion.

E. For units located above ceilings, provide a 22 gage galvanized steel auxiliary drain pan mounted below the entire unit and primary drain pan. Temperature Controls Contractor to install a float switch to alarm and shut-down fan coil unit upon sensing of water.

F. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

G. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 23 33 00, Air Duct Accessories. Comply with safety requirements in UL 1995 for duct connections.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION