SECTION 23 00 00 - MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section applies to all Division 23 (mechanical) work.

B. Related Documents: The general provisions of the Contract, including General and Supplementary Conditions and General Requirements applies to all Division 23 work.

1.2 COORDINATION BETWEEN SPECIFICATION SECTIONS

A. Each specification section within their respective division shall be coordinated with all other sections in that division for related work.

1.3 COORDINATION OF WORK

A. General:

1. Refer to the Division 1 sections for general coordination requirements applicable to the entire work. The contractor shall recognize that the contract documents are diagrammatic in showing certain physical relationships which must be established within the plumbing, mechanical and electrical work, and in its interface with other work including utilities and that such establishment is the exclusive responsibility of the Contractor. Because the drawings are diagrammatic and on a small scale, all rises, drops, offsets, etc., have not been shown. The Contractor shall agree to provide and install the necessary conduit, piping, fittings, valves, ducts, and other specialties to suit such conditions without additional cost to the Owner.
2. Piping and conduits, except electrical conduits run in floor construction, suspended ceiling space, or roof space shall be run parallel with lines of the building unless otherwise noted on drawings. Water supply pipes, where practicable, shall be placed at same elevation and hung on multiple hangers. Electric conduits shall not be hung on hangers with any other service, unless approved by the Engineer and shall be hung above all other service pipes. The different service pipes, valves, fittings, and similar items, shall be so installed that after the covering is applied there will be not less than 1/2" clear space between the finished covering and other work and between the finished covering of parallel adjacent pipes. Hangers on different service lines running close to and parallel with each other shall be in line with each other and parallel to the lines of the building. Exact location of electric outlets, piping, ducts, and the like shall be coordinated to avoid interferences between lighting fixtures, piping, ducts, and similar items.
3. Locate operating and control equipment properly to provide easy access, and arrange entire mechanical and electrical work with adequate access for operation and maintenance.
4. Give right-of-way to piping which must slope for drainage.
5. Advise other trades of openings required in their work for the subsequent move-in of large units of plumbing, mechanical and electrical work (equipment).
6. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

This page left blank for double-sided format printing

SECTION 26 64 20 – MODULAR WATER CHILLERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of chillers specified in this section include the following:

1. Modular water-cooled water chillers.

C. Refer to other Division 23 sections for concrete pads, piping, specialties, pumps, valves, etc., required external to chillers for installation.

D. Refer to other Division 23 sections for vibration isolation work required in conjunction with modular chillers.

E. Refer to other Division 23 sections for field-installed insulation on modular chiller evaporator and other machine surfaces subject to sweating.

F. Refer to Section 23 00 00 for equipment certification requirements.

G. Refer to Division 26 sections for the following work:

1. Power supply wiring from power source to power connection to chiller power connections as applicable.

H. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control and interlock wiring between operating controls, indicating devices, and control panels.

1.2 SUBMITTALS

A. Product Data: Submit product data, including rated capacities, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.

D. Maintenance Data: Submit maintenance and operating data. Include this data in maintenance manual in accordance with requirements of Division-1 and Section 23 00 00.

E. Quality Control Submittals:

1. Submit certification of compliance with ARI, ASME, UL and ASHRAE fabrication requirements specified in Quality Assurance below.
2. Submit certification of compliance with performance verification requirements specified in PART 2 of this Section.
3. Submit quality control reports specified in PART 3 of this Section.
4. Submit AHRI Certification according to AHRI 590 or applicable certification program.
5. Run Test Report: Submit copy of manufacturer's run test report.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. ASHRAE Compliance: Fabricate and install chillers to comply with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
2. Chiller is required to be factory run tested at manufacturer's facility to job specific requirements, prior to shipment. Provide a copy of the report to engineer for review.
3. Modules shall be ETL listed in accordance with UL standard 1995 and shall be CSA certified per standard C22.2 #236 on all heat exchangers.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver chiller modules as a complete factory-assembled unit with full refrigerant charge and oil. Provide protective crating and covering.

B. Coordinate the delivery of the chiller modules in sufficient time to allow movement into the building.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, provide chillers from one of the following:

1. Basis of Design: Multistack
2. Other manufacturers (Owner pre-approval required)

2.2 OPERATING CONDITIONS

A. Chiller shall be designed for parallel evaporator water flow.

B. Each refrigerant circuit shall consist of an individual compressor, common dual circuited condenser, dual circuited evaporator, thermal expansion valve, and control system.

C. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit chiller must be able to produce chilled water even in the event of a failure of one or more refrigerant circuits.

D. Circuits shall not contain more than capacity of R-410A refrigerant indicated on drawings.

E. General:

1. Chiller Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
2. Chiller modules shall be AHRI certified.
3. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3rd party verified test stand.
4. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.

F. The liquid to be chilled will be water containing corrosion inhibitors.

2.3 PERFORMANCE REQUIREMENTS

A. Chiller Performance: Refer to the Chiller Schedule on the drawings.

B. Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

C. Electrical: Chiller shall feature single-point power connection and shall not utilizing adjoining power cabinets as pull boxes.

D. Operation Following Loss of Normal Power: chiller shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored.

E. Acoustics: provide optional sound package to reduce sound pressure levels measured at 1 meter at a minimum of 12 dBA.

2.4 COMPONENTS

A. Modules shall ship wired and charged with refrigerant.

B. Each module shall be supplied with a lightweight aluminum frame with sound reduction panels. Panels are powder coated 20 gauge steel with 1” of fiberglass insulation to reduce sound levels.

C. Compressors:

1. Each module shall contain two hermetic scroll compressors independently circuited and mounted to the module with rubber-in-shear isolators.
2. Each system also includes high discharge pressure and low suction pressure manual reset safety cut-outs.
3. All compressors shall be mechanically and electrically isolated to facilitate proper maintenance, service, and or removal.
4. Provide with (2) Copeland variable speed compressors.

D. Evaporators and Condensers:

1. Each evaporator and condenser brazed plate heat exchangers and headers shall be constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig refrigerant side working pressure and 360 psig water side working pressure.
2. Both the condenser and evaporator heat exchanger shall be mounted below the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.
3. Isolation valves shall be installed between the heat exchangers and water supply mains for heat exchanger isolation and removal without the requirement to remove a module or shut down the entire chiller allowing for total access to all serviceable components.

E. Controls:

1. Scheduling of the various compressors shall be performed by a microprocessor based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time.
2. The Master Controller shall monitor and report the following on each refrigeration system:
    a. Discharge Pressure Fault
    b. Suction Pressure Fault
    c. Compressor Winding Temperature
    d. Suction Temperature
    e. Evaporator Leaving Chilled Water Temperature
3. The Master Controller shall be powered by the chillers single point power connection and shall monitor and report the following system parameters:
    a. Chilled Water Entering and Leaving Temperature
    b. Condenser Water Entering and Leaving Temperature
    c. Chilled Water and Condenser Water Flow
4. An out of tolerance indication from these controls or sensors shall cause a “fault” indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire chiller will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller’s 2 line by 40 character back-lit LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
5. Individual monitoring of leaving chilled water temperatures from each refrigeration system shall be programmed to protect against freeze-up.
6. The control system shall monitor entering and leaving chilled water temperatures to determine system load and select the number of compressor circuits required to operate. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, to fine tune the chiller to different existing building conditions.
7. The Chiller shall be capable of interfacing to a building automation system. Interface shall be accomplished using an Interoperability Web Portal and shall be capable of communication over BACNet, MS/TP - TCP/IP.

F. Chiller shall have a single point power connection and external inputs and outputs to be compatible with the building management system. Inputs/Outputs include:

1. Remote Start/Stop
2. Customer Alarm Relay
3. Customer Chilled/Load Limit Reset Signal
4. ECW to Mechanical Cooling Module

5. LCW from Mechanical Cooling Module
6. ECHW to Mechanical Cooling Module
7. LCHW from Mechanical Cooling Module
8. Power Phase Monitor
9. Chilled Water Flow Switch Input
10. Condenser Water Flow Switch Input
11. Full Load Indicator Relay
12. Condenser Pump Relay
13. DDRS Condenser Multiflush Relay
14. Chilled Water Pump Relay

G. Each inlet water header shall incorporate a built in 30-mesh (maximum) in-line strainer system to prevent heat exchanger fouling and accommodate 100% flow filtration with a minimum surface area of 475 sq. inches per module. Condenser-side strainer system shall incorporate an automatic debris blow-down system for self-cleaning of the strainer system that is controlled and powered by the chiller.

H. Provide single point power connection. Chiller shall be equipped with a pre-engineered genuine bus bar electrical system for single point power at a 22,000 amp SCCR. Where the equipment size exceeds the amp rating of the electrical system, multiple power connections may be applied. Pre-engineered system shall also incorporate individual module isolation circuit breakers for full redundancy and ability of a module to be taken off-line for repair while the rest of the modules continue to operate. Individual power feeds to each module shall be unacceptable.

I. Modules shall mount on 6” I-beam (W6x15) painted steel frame.

2.5 SAFETIES, CONTROLS, AND OPERATION

A. Chiller safety controls system shall be provided with the unit (minimum) as follows:

1. Low evaporator refrigerant pressure
2. Loss of flow through the evaporator
3. Loss of flow through the condenser
4. High condenser refrigerant pressure
5. High compressor motor temperature
6. Low suction gas temperature
7. Low leaving evaporator water temperature

B. Failure of chiller to start or chiller shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.

C. The chiller shall be furnished with a Master Controller as an integral portion of the chiller control circuitry to provide the following functions:

1. Provide automatic chiller shutdown during periods when the load level decreases below the normal operating requirements of the chiller. Upon an increase in load, the chiller shall automatically restart.

2. Provisions for connection to automatically enable the chiller from a remote energy management system.
3. The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.
4. Each module shall contain a slave controller that will allow any module to run in the event of a master controller failure or loss of communication with the master controller via an on/off/manual toggle switch.

D. Normal Chiller Operation

1. When chiller is enabled, the factory supplied Master Controller stages the chiller capacity from minimum to maximum as required by building load.
2. The Chiller control system shall respond to Entering Water Temperature (constant primary flow) or to Leaving Water Temperature (variable primary flow) and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.

E. Power Phase Monitor (PPM)

1. Provide a Power Phase Monitor on the incoming power supply to the chiller. This device shall prevent the chiller from operating during periods when the incoming power is unsuitable for proper operation.

2. The Power Phase Monitor shall provide protection against the following conditions:
   a. Low Voltage (Brown-Out)
   b. Phase Rotation
   c. Loss of Phase
   d. Phase Imbalance

2.6 FACTORY FINISH

A. Provide manufacturer's standard factory-finish.

2.7 SOURCE QUALITY CONTROL

A. Performance Verification:

1. All modules shall be factory run tested prior to shipment on an AHRI certified or 3rd party verified test stand. Provide test results of factory at full load and 3 part load points performance testing. Engineer to confirm part load points during submittal process and format for utility rebate if pursued.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide and install as shown on the plans a factory assembled, charged, and run tested, water-cooled packaged modular chiller.

B. Coordinate the size and location of concrete equipment pads.

C. Install chillers in accordance with manufacturers installation instructions.

D. Install chillers plumb and level, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.

E. Install vibration isolators to concrete pad with anchor bolts and secure chiller to vibration isolators.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 23. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping in manner to allow servicing and maintenance.
2. Chilled Water Piping: Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, flow switch, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, thermometer, pressure gage, and flange.
3. Condenser Water Piping: Provide flanged connections to condenser, arranged piping to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with thermometer, drain line and shutoff valve, and plugged tee. Provide easily accessible basket strainer filtration before the module.
4. Install (4) temperature sensors and sensor wells are furnished by the manufacturer:
    a. entering chilled water,
    b. leaving chilled water,
    c. entering condenser water, and
    d. leaving condenser water.
5. Vent Piping: Provide drain piping as indicated from rupture disc to suitable drain.

3.3 PIPING SYSTEM FLUSHING PROCEDURE

A. Prior to connecting the chiller to the condenser and chilled water loop, the piping loops shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organics. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.

B. During the flushing, a 30 mesh (max.) Y-strainers (or acceptable Equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on board chiller strainers shall not be acceptable.

C. Existing piping systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer’s instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

D. Prior to supplying water to the chiller the Water Treatment Specification shall be consulted for requirements regarding the water quality during chiller operation. The appropriate chiller manufacturer’s service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

3.4 WATER TREATMENT REQUIREMENT

A. Supply water for both the chilled water and condenser water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the chiller's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular chillers using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

1.	pH	Greater than 7 and less than 9
2.	Total Dissolved Solids (TDS)	Less than 1000 ppm
3.	Hardness as $CaCO_3$	30 to 500 ppm
4.	Alkalinity as Ca CO_3	30 to 500 ppm
5.	Chlorides	Less than 200 ppm
6.	Sulfates	Less than 200 ppm

3.5 FIELD QUALITY CONTROL

A. Provide the services, to include a written report, of a factory authorized service representative to supervise the field assembly of the components, installation, and piping and electrical connections.

3.6 DEMONSTRATION

A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.

B. Start-up Service:

1. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions if not factory charged. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.
3. Do not place chillers in sustained operation prior to initial balancing of mechanical systems for interface with chillers.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the data contained in the Operating and Maintenance Manuals specified in this Section and in Division 1.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

3.7 WARRANTY

A. General: Provide written special project warranty on chiller work, agreeing to replace/repair inadequate and defective materials and workmanship, including leakage, breakage, improper assembly and failure to perform as required. Include separate product warranties as indicated (if

any) for specific parts or products in the work. Provide warranty signed by both the Installer and Contractor.

B. Manufacturer's Warranty: Manufacturer shall provide full parts and labor warranty coverage for entire chiller for a period of one year. All parts shall be warranted against defects in material and workmanship. Similar parts-only coverage shall be provided for the chiller compressors for a period of five years. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.

C. Under add alternate bid, provide extended 5 year comprehensive chiller parts and labor.

END OF SECTION 23 64 20

This page is intentionally left blank for printing purposes

SECTION 23 64 90 - REFRIGERANT MONITORING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant monitors, alarms, and audio/visual signaling devices.

1.3 DEFINITIONS

A. CMOS: Ceramic metal-oxide semiconductor.

B. HFC: Hydrofluorocarbon.

C. HCFC: Hydrochlorofluorocarbon.

D. IR: Infrared.

E. LED: Light-emitting diode.

F. ppm: Parts per million.

1.4 SUBMITTALS

A. Product Data: For SCBA; include mounting details and service requirements and compliance with authorized Federal agency.

B. Shop Drawings: For each type of refrigerant monitor; include refrigerant ppm range, temperature range, alarm outputs, readout range, furnished specialties, installation requirements, and power consumption.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Include machinery room layout showing location of monitoring devices in relation to refrigerant equipment.

D. Product Certificates: For monitoring devices and SCBA, signed by product manufacturer.

E. Operation and Maintenance Data: For refrigerant monitoring equipment and SCBA to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. ASHRAE: Monitoring system shall comply with ASHRAE 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Refrigerant Monitoring Equipment:

a. Bacharach HGM-MZ.
b. Mine Safety Appliance Company (MSA).
c. Trane RMWG.

2.2 FUNCTIONAL DESCRIPTION OF REFRIGERANT MONITORING SYSTEM

A. On leak detection by refrigerant sensor(s), the system shall perform the following:

1. Activate machinery room ventilation.
2. Activate audio and visual alarm inside and outside machinery room.
3. Notify Building Automation System of alarm condition.

2.3 REFRIGERANT MONITOR

A. Description: Photoacoustic Infrared sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and automatically activating ventilation system.

B. Performance Requirements:

1. Refrigerant to Be Monitored: HFC-134a and R-410A as required for new chillers.
2. Refrigerant Concentration: 0 to 1000 ppm.
3. Accuracy: 0 to 50 ppm; 1 ppm, 50 to 1000 ppm; plus or minus 10 percent of reading.
4. Linearity: 0 to 50 ppm; 1ppm, 50 to 1000 ppm; plus or minus 10 percent of reading.
5. Sensitivity: 1 ppm.
6. Resolution: 1 ppm.
7. Operating Temperature: 32 to 122 deg F.
8. Temperature Effect: ±.3% per ˚C of reading.
9. Response Time: 50 percent of a step change in 1 minute.
10. Relatively Humidity: 0 to 95 percent, non-condensing over the operating temperature range.
11. Sample Flow Rate: .75 liters/Minute.
12. Maximum Tubing Length: 150ft.

C. Operating Requirements:

1. Maximum Power Input: 120-V ac; 60 Hz, .56A.
2. Alarm Relays: SPDT alarm contacts rated at 2A at 250VAC inductive or 5A at 250VAC resistive:

a. Three (3) assigned to PPM level alarms.
b. One (1) assigned to system faults.

3. Alarm Set Points: Displayed on front of meter.
4. Audible Output: Sonic alert at 75 dB at.
5. Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing.
6. Serial Output Type: RS 232.
7. Building Automation System (BAS) Communications Interface: provide BACnet® Protocol Converter Kit to convert Modbus RTU via RS 485 signaling.

D. Sensor Configuration: Photoacoustic IR sensor.

1. Four (4) sensing channels.
2. Expandable to eight channels.

E. User interface: Large Graphics LCD, vacuum-fluorescent indicating lights for each alarm set point; standard alarm; acknowledge switch and test switch mounted on front panel; and alarm status LEDs and service fault LEDs.

1. Enclosure: NEMA 4, type as required for ambient condition.
2. Remote Display

F. Alarm Output: Indicating light flashes and siren sounds.

1. Unit-mounted audio/visual signal devices and alarm silence pushbutton. Alarm silence pushbutton shall silence both local and remote audio signal devices.
2. Field-adjustable alarm set points.

G. Calibration: Factory calibrated.

2.4 REMOTE AUDIO/VISUAL SIGNAL DEVICES

A. Non-Hazardous Locations: Audio/visual devices shall be designed for general duty type applications. The following audio/visual signal devices shall be provided in the maintenance offices, and the west entrance to the chiller plant:

1. Audio Devices: NEMA 3R, IP54 enclosure molded from impact resistant acrylic-styrene-acrylonitrile plastic. Unit shall have internal amplifier, swivel mounting and 4” electrical wall mounting box. Multi-tone device shall produce a wail, yelp, or horn tone that is user selectable by reconfiguring the internal jumpers and shall produce a sound level of 108dB at 10 feet.

a. Power Requirements: 120V @ 0.21A.
b. Basis of Design: Federal Signal model SST-MV.

2. Visual: NEMA 3R, IP41 enclosure with. Device shall have a base for wall mounting or ½ inch pipe mount, removable strobe mechanism, outer dome, and strobe tube rated for 4,000 hours of operation. Provide amber lens for warning and red lens for alarm signaling. Device shall provide a 100,000 candlepower strobe light effect with a flash rate of 80 flashes/minute.

a. Power Requirements: 120V @ 0.06A.
b. Basis of Design: Federal Signal model 141ST.

B. Hazardous Locations: Audio/visual indicating devices shall be explosion-proof when mounted in a refrigeration machinery room or in a room with chillers. The following audio/visual signal devices shall be provided:

1. Audio Devices: NEMA 3R, IP44 enclosure listed for Class 1, Division 1, Groups B, C, & D constructed of die-cast aluminum with internal amplifier, spun aluminum projector, and adjustable mounting bracket. Multi-tone device shall produce a wail, yelp, or horn tone that is user selectable by reconfiguring the internal jumpers and shall produce a sound level of 108dB at 10 feet.

   a. Power Requirements: 120V @ 0.21A.
   b. Basis of Design: Federal Signal model SSTX-MV.

2. Visual: NEMA 4X, IP66 enclosure listed for Class 1, Division 1, Groups C & D with self-contained power supply. Device shall have an aluminum finned base for wall mounting, tempered glass outer dome, polycarbonate inner lens and strobe tube rated for 10,000 hours of operation. Provide amber lens for warning and red lens for alarm signaling. Device shall provide a lightning bolt flash of light with a flash rate of 80 flashes/minute.

   a. Power Requirements: 120V @ 0.25A.
   b. Basis of Design: Federal Signal model FB2PSTX.

2.5 CONTROL CABLE

A. Electronic and fiber-optic cable for control wiring shall be as specified in Division 26.

2.6 SOURCE QUALITY CONTROL

A. Refrigerant Monitor: Factory tested and certified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chiller layout for proper location of monitoring device.

B. Verify refrigerant contained in chiller(s) to ensure compatibility of refrigerant monitor.

C. Examine machinery room ventilation system to verify its operation with refrigerant monitor(s).

3.2 INSTALLATION

A. Install refrigerant monitoring equipment level and plumb.

B. Install labels and nameplates to identify monitoring devices and SCBA components according to Division 23 Section "Mechanical Identification."

C. Install building wire and cable according to Division 26.

D. Install signal and communication cable according to Division 26 Section.

E. Provide two (2) sampling points per chiller between 6” and 16” above floor.

F. Install tubing with line end filters in accordance with manufacturer’s instructions.

G. Install purge line to provide clean air for resetting the infrared zero baseline.

H. Install an exhaust line to vent gas samples away from the instrument.

I. Install charcoal purge filter in accordance with manufacturer’s instructions.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Program unit.
3. Connect to the Building Management System via optional BACnet® Protocol Converter.
4. Test and adjust controls and safeties.
5. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust alarm set points.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant monitoring devices.

B. Include training materials and test results in O & M Manual.

END OF SECTION 23 64 90

This page is intentionally left blank for printing purposes

SECTION 23 65 50 – CLOSED CIRCUIT FLUID COOLERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. New FC-2 under Add Alternate Bid.

B. Extent of factory-fabricated closed circuit fluid cooler work required by this section is indicated on drawings and schedules and by requirements of this section.

C. Types of factory-fabricated closed circuit fluid coolers specified in this section include the following:

1. Induced-draft, counter-flow closed circuit fluid cooler.

1.2 RELATED SECTIONS

A. Refer to other Division 23 sections for remote closed circuit fluid cooler sump, not work of this section.

B. Refer to other Division-23 sections for automatic temperature controls required in conjunction with factory-fabricated closed circuit fluid coolers.

C. Refer to Division-23 section "Water Treatment System" for water treatment system.

D. Refer to Division-23 section “Hydronic Piping” for water piping to factory-fabricated closed circuit fluid coolers.

E. Refer to Division-23 section "Vibration Isolation" for vibration control work required in conjunction with factory-fabricated closed circuit fluid coolers.

F. Refer to Division-26 sections for the following work:

1. Power supply wiring from power source to power connection on closed circuit fluid cooler. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

G. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:

1. Control and interlock wiring between operating controls, indicating devices, and closed circuit fluid cooler temperature control panels.
2. Provide variable frequency drives for closed circuit fluid cooler motors in accordance with Division 23 “Variable Frequency Drives”.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of factory-fabricated closed circuit fluid coolers, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Provide manufacturer's certification of closed circuit fluid cooler cooling capacity, based on factory performance tests, and provide performance curve plotting Leaving-Water Temperature (LWT) against Wet-Bulb Temperature (WBT).

C. Certify closed circuit fluid cooler wind resistance to withstand pressure indicated, in any direction.

D. Certify earthquake resistance against loading as indicated.

E. Codes and Standards:

1. UL and NEMA Compliance: Provide electric motors and electrical components required as part of factory-fabricated closed circuit fluid cooler, which have been listed and labeled by UL and comply with NEMA Standards.
2. NEC Compliance: Install closed circuit fluid coolers in accordance with NFPA 70 "National Electrical Code".

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including rated capacities, pressure drop, fan performance data, weights (shipping, installed, and operating), installation and start-up instructions, and rating curves with selected points clearly indicated.

B. Shop Drawings: Submit assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of all components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to closed circuit fluid coolers. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory- installed and portions to be field-installed.

D. Maintenance Data: Submit maintenance data and parts list for each closed circuit fluid cooler, control, and accessory; including "trouble- shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams, in maintenance manual; in accordance with requirements of Section 23 00 00.

E. Certifications: Submit required certifications and written tests results for required testing.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handle closed circuit fluid coolers and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged closed circuit fluid cooler or components; replace with new.

B. Store closed circuit fluid coolers and components in clean place. Protect from dirt, fumes, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading closed circuit fluid coolers and moving them to final location.

PART 2 - PRODUCTS

2.1 FACTORY-FABRICATED CLOSED CIRCUIT FLUID COOLER CONSTRUCTION

A. General: Fabricate closed circuit fluid coolers using manufacturer's standard design, materials, and construction in accordance with published product information, except as otherwise indicated.

B. Design structural system for the following live loading in addition to closed circuit fluid cooler dead-loads and operating-loads:

1. Wind Loading: 30 psf on exposed vertical surfaces.
2. Earthquake Resistance: Acceleration of 1.0 G horizontally through center of gravity.

C. Fabricate structural system including assembly of collecting basin and steel casings by the following methods:

1. Bolt connections with fasteners having equal or better corrosion-resistance than materials fastened; seal joints to make watertight enclosure.
2. Weld connections and weld metal seams continuously to make watertight.
3. Provide rigging supports on structure for final rigging.

D. Provide stainless steel casings, fabricated and installed by manufacturer to make cooler watertight.

E. Collecting Basin and Sump: Designed and installed to support water and to ensure water tightness:

1. Provide stainless steel.
2. Provide integral type collecting basin and sump with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow and water make-up.

F. Drift Eliminators: Fabricated by manufacturer into three-pass configuration to limit drift-loss to .001 percent of the maximum circulating-water flow-rate:

1. Provide inert polyvinyl chloride plastic, having flame spread rating of 5 per ASTM E 84.

G. Louvers: Designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging:

1. Provide stainless steel.

H. Water Distribution System: Distribution system shall consist of schedule 40 PVC pipe and precision molded ABS spray nozzles. All spray branches shall be removable for cleaning. Nozzles shall be threaded into the header for easy removal and shall have internal sludge ring to eliminate clogging. System shall provide a water flow rate of 6 GPM over each square foot of unit face area to ensure proper flooding of the coil.

I. Heat Transfer Coil: The coil shall be all prime surface steel, encased in a steel framework and hot-dip galvanized after fabrication as a complete assembly. The tubes shall be arranged in a self-spacing, staggered pattern in the direction of air-flow for maximum heat transfer efficiency and minimum pressure drop, without the use of additional spacers between the coil tubes. The coil shall be designed with sloping tubes for free drainage of liquid and shall be pneumatically tested at 350 P.S.I.G., under water.

J. Water Recirculation Pump: The pump shall be a close - coupled, centrifugal type with mechanical seals, installed vertically at the factory to allow free drainage on shut down. Pump motor shall be totally enclosed fan cooled (T.E.F.C.) suitable for outdoor service. Pump shall be selected by the manufacturer to provide the required flow based on the system pressure drop including the pressure drop of the centrifugal separator.

1. The centrifugal separator shall be sized for 50% of the distribution system flow.

K. Discharge Dampers: Provide airfoil capacity control dampers and linkage for cells as indicated, formed of galvanized steel sheets, designed and installed by manufacturer to control air flow and to provide linear control of fluid cooler capacity.

L. Discharge Hoods: One of the following materials, including access doors, fabricated and installed by manufacturer to prevent recirculation of discharge air:

1. Provide galvanized steel.

M. Basin Heaters: Provide electric immersion heaters including thermostat and low-water cutout, in weatherproof enclosure, for field wiring. Provide basin heaters sized by manufacturer to maintain basin water at 40°F at an ambient temperature of -20°F and wind velocity of 15 mph.

N. Water Level Control: Provide electric float switch and solenoid makeup valve.

O. Flow Control Valves: Provide one of the following flow control valves for balancing flow to the distribution system, and for shut-off during servicing:

1. Provide butterfly valves.

2.2 FACTORY FABRICATED CLOSED CIRCUIT FLUID COOLER FANS, MOTORS, AND DRIVES

A. Fans: Aluminum alloy axial propeller-fan of fixed-pitch type statically balanced.

1. Fan shall be fitted in a cowl with a venturi air inlet and galvanized steel mesh screen bolted to the outlet.
2. Fan Bearings: One of the following types installed by manufacturer.

a. Provide self-aligning ball bearings rated for and L-10 life of 75,000 hours; include external extended grease lines, and fittings.

B. Drive: Provide direct driven type.

C. Motor Type: Provide totally enclosed, air over, (TEAO) energy efficient type motor. Motors shall be suitable for outdoor service and shall have a 1.25 service factor.

2.3 FACTORY FABRICATED COOLING TOWER ACCESSORIES

A. Vibration Cutout Switch: Provide switch to de-energize fan motors if excessive vibration occurs due to fan imbalance.

B. Discharge Damper Controls: Provide electric damper operator, with end switches.

C. Assemble Components by one of the following methods:

1. Use galvanized or stainless fasteners and accessories to assemble components.

D. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline- soluble rust preventative compound on ferrous parts which cannot be galvanized, including shafts and machined parts.

1. Finish components with zinc-coated metal surfaces by one of the following methods:

a. Coat abraded areas and welded areas with 95% pure zinc rich compound.

E. Maximum Permissable Sound Pressure Level: Use 0.0002 microbar as reference. Measure at 50’ in several directions, uniformly covering 360 deg. Do not exceed maximum permissible dB level in each of the following octave bands:

1. 63 HZ - dB
2. 125 HZ - dB
3. 250 HZ - dB
4. 500 HZ - dB
5. 1000 HZ - dB
6. 2000 HZ - dB
7. 4000 HZ - dB
8. 8000 HZ - dB

F. Vibration Control: Provide as scheduled, one of the following types of vibration isolators, with number and size of isolators selected by manufacturer.

1. Isolator Type 2: Rubber floor isolator.

G. WATER FILTRATION SYSTEM (CENTRIFUGAL SEPARATOR):

1. The centrifugal vortex separator shall be furnished for installation in the liquid supply/circulation system to remove separable solids from the system. The Separator shall remove 98% by weight, or separable solids 200 mesh (74 microns) and larger.
2. A centrifugal vortex separator shall be furnished for installation in the liquid supply/circulation system to remove separable solids from the system. The Separator shall remove 98%, by weight, of separable solids 200 mesh (74 microns) and larger.
3. The separator shall be designed with tangential entry into the acceptance chamber. Upon tangential slots and accelerated into the reduced diameter separation cylinder. The solids heaver than the carrying liquid are centrifugally spiralled down the perimeter of the separation cylinder past the deflector stool and allowed to accumulate in the separator's collection chamber. The liquid (free of separable solids) will follow the vortex created and entered on the deflector stool up through the interior of the separation cylinder and into the vortex finder which becomes the separator outlet.
4. Quiescent solids accumulation shall be facilitated by the baffle spin arrestor below the deflector stool in the collection chamber. Separation and collection of solids shall not promote excessive wear nor require a continuous "involuntary" underflow.
5. Separator Construction:

a. The separator shall be fabricated of carbon steel (or stainless steel) with shell material and head material equivalent to schedule 40 thickness or better.
b. Paint coating shall be Mactek M-Line Enamel (Stainless steel shall be unpainted).

6. Separated Solids Purging Operation:

a. Automatic: A full port, straight-through motorized ball valve may be installed on the standard purge opening and operated as determined by the building automation system.

7. Manufacturer: Subject to compliance with requirements, provide condenser water filtration system of one of the following:

a. Lakos Separators, A Claude Laval Corporation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which factory-fabricated closed circuit fluid coolers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

A. General: Install closed circuit fluid coolers where indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, to ensure that closed circuit fluid coolers comply with requirements and serve intended purposes.

B. Access: Provide access and service space around and over closed circuit fluid cooler as indicated, but in no case less than that recommended by manufacturer.

C. Support: Install floor-mounted units on 8" high reinforced concrete pad, 4" larger on each side than closed circuit fluid cooler base. Cast anchor bolt inserts into pad.

D. Placement: Mount unit on vibration isolators. Level units to tolerance of 1/8" in 10'-0", in both directions.

E. Water Piping: Refer to Division-23 section "Hydronic Piping". Provide flanged or union connections to closed circuit fluid cooler, with flexible pipe connections if equipment is mounted on vibration isolators. Pitch lines so water will drain into sump. Connect inlets to closed circuit fluid cooler with shutoff valve, and balancing valve. Connect outlets with shutoff valves.

F. Make-up and Water Piping: Refer to Division-23 section "Water Distribution Piping". Provide flanged or union connections to closed circuit fluid coolers, with flexible pipe connections if cooler is mounted on vibration isolators. Pitch lines so water will drain into sump. Connect to automatic fill valve with 3-valve bypass, and backflow preventer.

G. Drain Piping: Refer to Division-23 section "Storm Water Systems". Connect drain, overflow, and bleed lines to closed circuit fluid cooler as indicated, full size of connection on cooler.

H. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.3 ADJUSTING AND CLEANING

A. Cleaning: Clean inside of closed circuit fluid cooler thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

B. Start-up: Comply with manufacturer's instructions for filling and start-up of operation, but not less than the following:

1. Verify lubrication of rotating parts; lubricate as needed.
2. Verify fan rotation direction.
3. Verify that motor amperage is in accordance with manufacturer's data.
4. Adjust water level control for proper operating level.
5. Adjust bleed valve for indicated percentage of circulated water volume.
6. Adjust temperature controls and verify operation.

C. Operation Test: Test each closed circuit fluid cooler to show that it will operate in accordance with indicated requirements.

3.4 CLOSEOUT PROCEDURES

A. Provide services of manufacturer's technical representative for one 8-hour day to instruct Owner's personnel in operation and maintenance of factory-fabricated closed circuit fluid coolers.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 23 65 50

B. Coordination Drawings:

1. For locations where several elements of mechanical (or combined plumbing, mechanical and electrical) work must be sequenced and positioned with precision in order to fit into the available space, prepare coordination drawings (shop drawings) showing the actual physical dimensions (at accurate scale) required for the installation. Prepare and submit coordination drawings prior to purchase-fabrication-installation of any of the elements involved in the coordination.
2. Install equipment and materials to provide required access for servicing and maintenance.

C. Contract Document Discrepancies:

1. If work is required in manner to make it impossible to produce first class work, or should discrepancies appear among contract documents, request interpretation before proceeding with work. If Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out work in satisfactory manner. Should conflict occur in or between drawings, and specifications, Contractor is deemed to have estimated on more expensive way of doing work unless he shall have asked for and obtained written decision before submission of proposal as to method or materials required.

1.4 FEES, PERMITS, LICENSES, UTILITY CONNECTION CHARGES, AND UTILITY COST.

A. The Contractor shall obtain and pay for all fees, permits, licenses, utility connection charges (water, sanitary sewer, storm sewer and gas) and utility cost for services to the building required.

B. The Contractor shall maintain all necessary signal lights, guard against danger and use all proper means for the safety of the public.

C. The Contractor shall pay for opening and repairing all pavement cuts.

D. The Contractor shall furnish to the Architect copies of all fees, permits and licenses required for all mechanical work herein specified before any mechanical work is started.

1.5 CONTRACTORS RESPONSIBILITY FOR CONSULTANTS ADDITIONAL SERVICES

A. The Consultant is entitled to compensation for additional services not included in their contract but provided on this project. Since our contract is with the Owner or Architect, the Owner or Architect has the responsibility to compensate us for these additional services. The Consultant will provide, without advance authorization from the Client, the Additional Services listed below. These services will be tracked in our office and billed to the Client upon completion of the project. The client will in turn deduct the sum of these additional services from the contractors final payment. The following is a list of services that have been included in our contract with the client along with a description of services that will be charged against the contractors final payment due to services brought about due to the contractors actions:

1. Re-submittals: The consultant has included in their contract with our Client, one (1) review for each submittal item. The contractor is required to carefully review each submittal from their suppliers and subcontractors for compliance with the contract documents along with a written notice of deviations of any type prior to submitting them to the Engineer for review. The Contractor shall be responsible to the Client for all

reasonable costs charged by the Consultant to the Client for the Additional Services required for re-submittals.

2. Substitutions: The Consultant has included in their contract with our Client, incorporation of minor changes to the contract documents to develop record documents in electronic format. These changes are limited to unforeseen site conditions and clarifications to the contract documents. Review of substitutions for compliance with the contract documents, and services required to modify and coordinate changes required due to contractor substitutions or deviations from the contract documents are not included in our contract with the Client. The Contractor shall be responsible to the Client for all reasonable costs charged by the Consultant to the Client for the Additional Services required to modify and coordinate documents or provide field coordination due to contractor substitutions or deviations from the contract documents.
3. Requests For clarification or Interpretation (RFI): The Contractor may, after exercising due diligence to locate required information, request from the Consultant clarification or interpretation of the requirements of the Contract Documents. The Consultant shall, with reasonable promptness, respond to such Contractor's request for clarification or interpretation. However, if the information requested by the Contractor is apparent from field observations, is contained in the Contract Documents or is reasonably inferable from them, the Contractor shall be responsible to the Client for all reasonable costs charged by the Consultant to the Client for the Additional Services required to provide such information.
4. Construction Meetings & Site Observations: The consultant has included a predetermined number of construction meetings and site observations in their contract with the owner based on the anticipated construction period specified. However if additional construction meetings and site observations are required due to the contractors delay in completion of the project, the Contractor shall be responsible to the Client for all reasonable costs charged by the Consultant to the Client for the Additional Services required to attend additional construction meetings or provide additional site observations.
5. Re-inspections: The contractor is responsible to prepare a final punch list for the project and to correct all items prior to calling for a final inspection from the consultant. Upon being notified, the consultant will then visit the site and prepare a final punch list. The contractor is then required to correct all items on the consultant's final punch list and call for a re-inspection of the project. If all items have not been corrected, the final punch list will be updated and additional re-inspections will be required. However, if additional re-inspections are required, the Contractor shall be responsible to the Client for all reasonable costs charged by the Consultant to the Client for the Additional Services required for the additional re-inspections.

1.6 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number (such as "the pump"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.7 CLEANING AND PROTECTION

A. General: During handling and installation of work at project site, each contractor shall clean and protect work in progress and adjoining work on a basis of perpetual maintenance. Apply suitable protective covering on newly installed work where reasonably required to ensure freedom from damage or deterioration at time of substantial completion; otherwise, clean and perform maintenance on newly installed work as frequently as necessary through remainder of

construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

1.8 MAINTENANCE AND OPERATION MANUALS

A. Prepare and submit two (2) copies of maintenance and operation instructions for all Division 23 and Division 26 equipment furnished. Organize maintenance and operating manual information into suitable sets of manageable size and bind into individual binders properly identified and indexed (thumb-tabbed). Include emergency instructions, spare parts listing, copies of warranties, wiring diagrams, recommended "turn-around" cycles, inspection procedures, shop drawings, product data, and similar application information. Bind each manual of each set in a heavy-duty 2", 3-ring vinyl-covered binder, and include pocket folders for folded sheet information. Mark identification on both front and spine of each binder.

1.9 PROJECT CLOSE OUT

A. General: Refer to the Division 1 sections for general closeout requirements. Maintain a daily log of operational data on mechanical equipment and systems through the closeout period; record hours of operation, assigned personnel, fuel consumption and similar information; submit copy to Owner.

B. Record Drawings: For Division 23 and Division 26 work, give special attention to the complete and accurate recording of underground conduit, piping and ductwork, other concealed and non-accessible work, branching arrangement and valve location for piping systems, locations of dampers and coils in duct systems, locations of control system sensors and other control devices, and work of change orders where not shown accurately by contract documents.

C. Closeout Equipment/Systems Operations: Sequence operations properly so that work of project will not be damaged or endangered. Coordinate with seasonal requirements. Operate each item of equipment and each system in a test run of appropriate duration with the Owner's operating personnel present, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance. Clean and lubricate each system, and replace dirty filters, excessively worn parts and similar expendable items of the work.

D. Operating Instructions: Conduct a full-day walk-through instruction seminar for the Owner's personnel to be involved in the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, efficiency and similar features of the systems.

E. Turn-Over of Operation: At the time of substantial completion, turn over the prime responsibility for operation of the mechanical equipment and systems to the Owner's operating personnel.

1.10 FINAL COMPLETION

A. The following special requirements shall be provided in addition to these specifications elsewhere in these specifications:

1. The Division 23 Contractors shall not call for a final completion check until the entire Mechanical and Electrical Equipment and Systems have been installed, adjusted, balanced and in full and complete satisfactory operation and the following certifications of

inspection from equipment suppliers have been completed and submitted to the Architect/Engineer. Certifications of Inspections for Division 23 Equipment are required on the following items of equipment:

a. Chillers (Factory Representative)
b. Pumps (Local Rep)
c. Air control devices (Local Rep)
d. Glycol feeders (Local Rep)
e. Fans (Local Rep)
f. Temperature control equipment (Manufacturer's rep)

B. The Certifications shall consist of letters signed by Factory Trained and Authorized Service Engineers stating the following:

1. They have inspected all of their equipment on the project.
2. They approve the condition of the equipment and its installation.
3. They have fully checked its operation and certify that it is operating properly.
4. They will note any problems, conditions or objections that could lead to future operating problems.
5. Log Sheets shall be provided on start-up of all chillers. Factory trained representative shall certify log sheets.
6. Units shall be inspected by all concerned and certify the installation and operation of the units and associated heating and cooling equipment. Certification to come from the local rep and the factory.

C. Exceptions may be permitted upon written request from the Contractor listing any minor items that are uncompleted and beyond his reasonable control. The full guarantee that they will be completed at a named later date and the guarantee extended as required to provide a full warranty.

1.11 FINAL PAYMENT

A. Final Payment will not be made until the Contractor has satisfactorily completed all final inspection items.

1.12 GUARANTEE

A. The one-year guarantee period shall not start until the project is fully completed and the Contractor has received the Final Payment and Certification of Completion.

B. All equipment and all work shall be fully guaranteed, parts, and labor, for one full year from the date of the Certificate of Completion. Repairs made during this period must be fully guaranteed for an additional one year period from the date of repairs.

C. The Division 23 Contractor has the full responsibility to guarantee all equipment and work and shall assume full responsibility to repair any equipment at his cost that the manufacturer refuses to guarantee.

D. The Owner has the right to order repairs to any equipment or work provided hereon and to charge the Contractor for same if repairs are not made by the Contractor within a reasonable period of time not to exceed 24 hours during an emergency or 72 hours on a non-critical item.

E. Where equipment is furnished by the owner and installed by the contractor, the contractors responsibilities shall remain as indicated above except that the owner will assist in enforcing the stipulated manufacturer's warranty.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 00 00

SECTION 23 01 00 – MECHANICAL SUBMITTALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 GENERAL

A. Shop drawing Submittals shall comply with the requirements of Division 1, Section 01300, and with the requirements of this Section. Shop Drawing Submittals shall include specially-prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to a range of similar projects. Performance curves shall show the full operating range of the proposed equipment

B. Shop Drawing Submittals shall also include product data which includes standard printed information on materials, products and systems; not specially-prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

1.3 SUBMITTAL REQUIREMENTS

A. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.

B. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, contractor, subcontractor, submittal name and similar information to distinguish it from other submittals. Show Contractor's executed review and approval marking and provide space for Architect's/Engineer's "Action" marking. Package each submittal appropriately for transmittal and handling. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "without action".

C. Provide Contractor's certification on form, ready for execution, stating that information submitted complies with requirements of contract documents. Failure to fully review submittals for compliance with contract documents may result in rejection by the Architect/Engineer requiring re-submittal by the contractor. Contractor shall pay the Architect/Engineer for review of all re-submittals in accordance with Section 15000 “Mechanical General Provisions”.

1.4 SUBMITTAL LIST

A. Shop drawings shall be submitted for, but not limited to, the items listed in each section of the specifications. Submittals, in addition to those listed, may be required by the Architect/Engineer. The following is a summary list of submittals required for the project.

SECTION	ITEM	DATE RECEIVED BY A/E	TRANSMITTAL NO.	DATE RETURNED
23 00 00	Record Drawings			
23 00 00	Maintenance & Operations Manuals			
23 05 00	Access Panels			
23 05 00	Concrete Work			
23 05 00	Joint Sealers			
23 05 53	Mechanical Identification			
23 05 29	Equipment Supports			
23 05 93	Testing, Adjusting & Balancing Certifications			
23 05 93	Testing, Adjusting & Balancing Plan			
23 05 93	Testing, Adjusting & Balancing Report			
23 07 00	Mechanical Insulation Materials			
23 08 00	Commissioning Equipment Checklists			
23 09 00	Temperature Control System Product Data			
23 09 00	Temperature Control System Shop Drawings			
23 09 00	Performance Verification Tests			
23 10 00	Variable Frequency Drives			
23 21 13	Hydronic Piping Product Data			
23 21 13	Hydronic Piping Layout Shop Drawings			
23 21 13	Maintenance & Operations Manuals			
23 21 13	Welders' Qualifications			
23 21 13	Test Reports			
23 21 13	Hydronic Piping (Layout Drawings)			
23 21 23	Pumps			
23 25 00	Water Treatment Systems			
23 64 17	Centrifugal Water Chillers			
23 64 20	Modular Water Chillers			
M6.01	Temporary Air-Cooled Chiller Package			
23 64 90	Refrigerant Monitoring System			
23 65 20	Closed Circuit Fluid Cooler			

END OF SECTION 23 01 00

SECTION 23 03 00 – ELECTRICAL PROVISIONS OF MECHANICAL WORK AND MECHANICAL PROVISIONS OF ELECTRICAL WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of electrical provisions to be provided as mechanical work and the requirements for piping and duct work connections to equipment furnished under Division 26 is indicated in other Division-23 sections, on drawings, and as further specified in this section.

B. Types of work, normally recognized as electrical but provided as mechanical, specified or partially specified in this section, include but are not necessarily limited to the following:

1. Motors for mechanical equipment.
2. Starters for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment and for all 2-speed motors.
3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
4. Furnish and install all electrical control circuit conduits and wiring and control devices required to perform the equipment control functions as specified in Division 23, including float control switches, flow control switches, and similar mechanical-electrical devices provided for mechanical systems.
5. Electrical heating coils and similar elements in mechanical equipment.
6. Furnish and install capacitors for power factor correction on all mechanical equipment as specified in other sections of this Division.
7. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of this Section and Division 26.

C. The mechanical work required for equipment furnished under Division 26 specified or partially specified in this section include, but are not necessarily limited to, the following:

1. Piping and ductwork connections for Engine driven electrical generator.

D. Refer to Division-23 Controls sections for control system wiring.

E. Refer to other Division-23 sections for specific individual mechanical equipment electrical requirements.

F. Refer to Division-26 sections for motor starters and controls not furnished integrally with mechanical equipment.

G. Refer to Division-26 sections for junction boxes and disconnect switches required for motors and other electrical units of mechanical equipment.

1.2 QUALITY ASSURANCE

A. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division-26 sections.

Comply with applicable requirements of Division-26 sections for electrical work of this section which is not otherwise specified.

B. Standards: For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology herein. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

C. Electrical components and materials shall be UL labeled.

1.3 SUBMITTALS

A. Listing, Motors of Mechanical Work:

1. Concurrently with submittal of mechanical products listing (Division 23 Section “Shop Drawings” and Division-1 requirements), submit separate listing showing rating, power characteristics, application (connected equipment), and general location of every motor to be provided with mechanical work.
2. Submit updated information promptly when and if initial data is revised.
3. Include in listing of motors, notation of whether motor starter is furnished or installed integrally with motor or equipment containing motor.
4. Submit thermal overload selection calculations including required selection parameters.

PART 2 - PRODUCTS

2.1 MOTORS

A. Manufacturer: Except where item of mechanical equipment (which otherwise complies with requirements) must be integrally equipped with motor produced by another manufacturer, provide motors for mechanical equipment manufactured by single one of the following:

1. ABB Industrial Systems
2. Baldor Electric Co.
3. General Electric Co.
4. Louis Allis Div.; Litton Industrial Products, Inc.
5. Marathon Electric Mfg. Corp.
6. Magne Tek Inc.
7. US Electric Motors.

B. Motor Characteristics: Except where more stringent requirements are indicated, comply with the following requirements for motors of mechanical work:

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
2. Service Factor:

a. Minimum 1.15 for polyphase motors and 1.35 for single-phase motors.
b. For installation altitudes greater than 3,300 feet the effective service factor shall be reduced to 1.0 on motors with nameplate service factors of 1.15 and greater.
c. Motors with nameplate Service Factors of 1.0 shall not be used for installation altitudes greater than 3,300 feet.

3. Irrespective of the schedule, installed motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range, but not less than 75% of the nameplate; if a standard size does not fall within this range the next larger NEMA standard motor size shall be used.
4. Temperature Rating: Rated for 40 deg C environment with maximum 50 deg C temperature rise for continuous duty at full load (Class A Insulation). Provide Class B Insulation for motor ambient conditions in excess of 40 deg. C.
5. Starting Capability: Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
6. Motors 1/2 horsepower and larger shall have bearings with pressure grease lubrication.
7. Motors connected to drive equipment by belt shall be furnished with adjustable slide rail bases except for fractional horsepower motors which shall have slotted bases. Motor leads shall be permanently identified and supplied with connectors.
8. Phases and Current Characteristics:

    a. Provide squirrel-cage induction polyphase motors for 1 hp and larger.
    b. Provide capacitor-start single-phase motors for 3/4 hp and smaller, except 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type.
    c. Coordinate current characteristics with power specified in Division-26 sections, and with individual equipment requirements specified in other Division-23 sections.
    d. For 2-speed motors provide 2 separate windings on polyphase motors and equipment starter with decelerating relay.
    e. Do not purchase motors until power characteristics available at locations of motors, ambient conditions, and altitude have been confirmed, and until rotation directions have been confirmed and the motor selected accordingly.

9. Motor Construction: Provide general purpose, continuous duty, premium efficiency motors, Design "B" except "C" where required for high starting torque.

    a. Bearings: Ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is normally inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual sections of Division 23 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
    b. Enclosure Type: Except as otherwise indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather- protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division 23 for other enclosure requirements. Provide motors with steel housings and bases for motors less than 5HP in size and cast iron housings and bases for motors larger than 5HP. Aluminum housings and bases will not be permitted.
    c. Overload Protection: Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
    d. Each motor shall be free from magnetic hum, designed for quiet operation.

10. Efficiency:

    a. Provide motors with efficiency in accordance with IEEE Standard 112, test Method B.
    b. Minimum efficiencies and power factors shall not be less than listed in the table below for 460V, 3 phase, 1,800 rpm motors:

MOTOR SIZE (HP)	1,200 RPM PREMIUM EFFICIENCY		1,800 RPM PREMIUM EFFICIENCY	
	EFFICIENCY (%)	POWER FACTOR (%)	EFFICIENCY (%)	POWER FACTOR (%)
1	82.5	64	85.5	74.5
1.5	87.5	65.5	86.5	76.5
2	88.5	68.5	86.5	75.5
3	89.5	71	89.5	78.5
5	89.5	73	89.5	81.5
7.5	91	78	91	83.5
10	91	78.5	91.7	83.5
15	91.7	78	93	83
20	91.7	78.5	93	86
25	93	78.5	93.6	83
30	93	79	94.1	83.5
40	94.1	79	94.1	78
50	94.1	79	94.5	79
60	94.5	80.5	95	84
75	94.5	81.5	95	85.5
100	95	83	94.4	85.5
125	95	83.5	95.4	86.5
150	958	84	95.8	85.5
200	95.8	82	95.8	86.5

c. Minimum efficiencies and power factors for motors at other voltages and speeds for smaller than 1 HP in size shall be from the same “Energy Efficient” product line that conforms to the above table.

11. Variable Speed Motors: Variable speed motors used in conjunction with variable frequency drives shall be inverter duty type and rated for across the line starting. Variable speed motors 5HP and larger shall have shaft grounding kits. Variable speed motors serving direct driven fans and pumps shall be rated for a minimum of 120Hz operation (200% speed) by the manufacturer.

C. Name Plate: Provide metal nameplate on each motor, indicating full identification of manufacturer, ratings, characteristics, power factor, construction, special features and similar information.

2.2 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor Starter Characteristics:

1. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
2. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

B. Manual Switches:

1. Provide manual switch and pilot light for motors 1/3 hp and smaller, except where interlock or automatic operation is indicated.
2. Provide extra switch positions and pilot lights for multi-speed motors.

3. Overload Protection: Provide melting alloy type thermal overload relays.

C. Magnetic Starters: Provide magnetic starters for motors 1 hp and larger, and for smaller motors where interlock or automatic operation is indicted. Include the following:

1. Hand-Off-Auto selector switch and pilot lights, properly arranged for single-speed or multi-speed operation as indicated.
2. Trip-free thermal overload relays, each phase.
3. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-23 Controls sections.
4. Built-in 120-volt control circuit transformer, fused from line side, where service exceeds 240 volts.
5. Externally operated manual reset.
6. Undervoltage release or protection.
7. Monitors for phase loss or reversal: Solid-state voltage and phase-angle sensing device which drives a SPDT electromechanical output relay.

D. Electrical Heating Elements: Where electric resistance coils and other heating elements are included in mechanical equipment or otherwise indicated as mechanical work, and except as otherwise indicated, provide 120-volt units where rating is less than 2 KW, higher-voltage single-phase units where rating is 2 KW but less than 5 KW, and higher-voltage 3-phase units where rating is 5 KW and greater.

E. Motor Connections: Provide flexible conduit, except where plug-in electrical cords are specifically indicated.

2.3 CAPACITORS

A. Capacitors shall be installed on all motors 1 horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.

B. Features:

1. Individual unit cells.
2. All welded steel housing.
3. Each capacitor internally fused.
4. Non-flammable synthetic liquid impregnant.
5. Craft tissue insulation.
6. Aluminum foil electrodes.
7. KVAR size shall be as required to correct motor power factor to 90 percent or better.
8. Provide disconnect switches for each capacitor.

2.4 DISCONNECT SWITCHES

A. Fusible switches: fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics as indicated.

B. Non-fusible switches: for equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than 2 horsepower, switches shall be the same as fusible type.

C. Manual Starters: for equipment 1/3 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated equipped with thermal overloads.

2.5 EQUIPMENT FABRICATION

A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, gear drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

2.6 CONTRACTOR COORDINATION

A. The following information is provided as an aid to interdisciplinary coordination. It is the general contractors responsibility to assure that full and complete coordination of the subcontractors is achieved to provide complete and fully operational systems.

B. Unless otherwise indicated, all motors, equipment, controls, etc. shall be furnished, set in place and wired in accordance with the following schedule.

ITEM	FURNISHED BY	SET BY	POWER WIRING BY	CONTROL WIRING BY
Equipment Motors	MC	MC	EC	--
Motor Control Centers	EC	EC	EC	MC*
Unit Mounted Motor Starters, Contactors, and Overload Heaters	MC	MC	EC	MC
Loose Motor Starters, Contactors and Overload Heaters	EC	EC	EC	MC
Fused and Unfused Disconnect Switches, Thermal Overload and Heaters	EC	EC	EC	--
Manual Operating Multi-speed Switches	MC	EC	EC	EC
Control Relays and Transformers	MC	MC	EC	MC
Thermostats and Time Switches	MC	MC	EC	MC
Temperature Control Panels	MC	MC	EC	MC
Variable Speed Drives	MC	EC	EC	MC
Electrically Operated Terminal Air Boxes	MC	MC	EC	MC
Electric actuators and Solenoid Valves, Damper Motors, PE and EP Switches	MC	MC	MC	MC
Combination Smoke and Fire Dampers	MC	MC	EC	EC
Duct Smoke Detectors	EC	MC	EC	EC

ITEM	FURNISHED BY	SET BY	POWER WIRING BY	CONTROL WIRING BY
Refrigeration Equipment, Cooling Tower, and Controls	MC	MC	EC	MC
Pushbutton Stations	MC	MC	EC	EC
Temporary Heating Connections	MC	MC	EC	MC
MC = Mechanical Contractor EC = Electrical Contractor * Temperature Control Wiring Only By Mechanical Contractor				

C. All starters shall be furnished by the Mechanical Contractor unless otherwise indicated on the preceding schedule. All starters shall be provided with three O.L. heaters, one normally-open and one normally-closed auxiliary contact and shall conform to NEC and NEMA requirements.

D. Immersion thermostats, remote bulb thermostats, motorized valves, controls, etc., which are an integral part of the mechanical equipment or directly attached to ducts, piping, equipment, etc., shall be set in place under mechanical contract. Motor driven units which are controlled from line voltage manual operating or start-stop switches or automatic controls such as line voltage thermostats, float switches or time switches which operate at line voltage shall be wired for both power and control circuit under the electrical contract. This description shall apply to equipment not covered by 23 09 00 (Electric Control System)

E. Factory prewired control panels and packaged HVAC units shall be provided with one power source connection point unless noted otherwise.

F. For split HVAC systems (systems with remote condensers or condensing unit), the Electrical Contractor shall provide 3/4" conduit with six #14 THW between units for control wiring connections by the Mechanical Contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Deliver starters and wiring devices which have not been factory- installed on equipment unit to electrical Installer for installation.

END OF SECTION 23 03 00

This page is intentionally left blank for printing purposes

SECTION 23 05 00 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of basic mechanical materials and methods work required by this section is indicated on drawings and schedules, and/or specified in other Division-23 sections.

B. Types of basic mechanical materials and methods specified in this section include the following:

1. Mechanical equipment nameplate data.
2. Selective demolition including:
    a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
    b. Dismantling mechanical materials and equipment made obsolete by these installations.
3. Excavation for underground utilities and services, including underground piping (under the building and from building to utility connection), tanks, basins, and equipment.
4. Miscellaneous metals for support of mechanical materials and equipment.
5. Joint sealers for sealing around mechanical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
6. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.
7. Mechanical Identification of mechanical materials and equipment.
8. Concrete for floor patching, equipment bases, etc.
9. Painting of mechanical materials and equipment.

1.2 DEFINITIONS

A. The following definitions apply to excavation operations:

1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
2. Subbase: as used in this Section refers to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
3. Subgrade: as used in this Section refers to the compacted soil immediately below the slab or pavement system.
4. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Architect/Engineer.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 1 Specification Sections, and Section 23 01 00.

B. Product data for the following products:

1. Access panels and doors.
2. Joint sealers.

C. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for mechanical materials and equipment.

D. Coordination drawings for access panel and door locations.

E. Samples of joint sealer, consisting of strips of actual products showing full range of colors available for each product.

F. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.

G. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.

1. Coordinate sequencing with construction phasing and Owner occupancy specified in Division 1 Section "Summary of Work."

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer for the installation and application of joint sealers, access panels, and doors.

B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

C. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

1. Provide UL Label on each fire-rated access door.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.6 PROJECT CONDITIONS

A. Conditions Affecting Selective Demolition: The following project conditions apply:

1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

B. Conditions Affecting Excavations: The following project conditions apply:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The owner will not be responsible for interpretations or conclusions drawn from this information.
4. Existing Utilities: Locate existing underground utilities in excavation areas in accordance with Colorado State Law. If utilities are indicated to remain, support and protect services during excavation operations.
5. Remove existing underground utilities indicated to be removed.

    a. Uncharted or Incorrectly Charted Utilities: Contact utility owner immediately for instructions.
    b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Engineer prior to utility interruption.

6. Use of explosives is not permitted.

C. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

1.7 SEQUENCE AND SCHEDULING

A. Coordinate the shut-off and disconnection of utility services with the Owner and the utility company.

B. Notify the Architect/Engineer and Owner at least 5 days prior to commencing demolition operations.

C. Perform demolition in phases as indicated.

PART 2 - PRODUCTS

2.1 MECHANICAL EQUIPMENT NAMEPLATE DATA

A. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

2.2 SOIL MATERIALS

A. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, or natural or crushed sand.

B. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100 percent passing a 1-1/2 inch sieve, and not more than 5 percent passing a No. 4 sieve.

C. Backfill and Fill Materials: Materials complying with ASTM D2487 soil classification groups GW, GP, GM, SM, SW, and SP; free of clay, rock, or gravel larger than 2 inches in any dimension; debris; waste; frozen materials; and vegetable and other deleterious matter.

2.3 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.

F. Fasteners: Zinc-coated, type, grade, and class as required.

2.4 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less than 15/32 inches.

2.5 JOINT SEALERS

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Elastomeric Joint Sealers: Provide the following types:

1. One-part, nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.
3. Products: Subject to compliance with requirements, provide one of the following:

a. One-Part, Nonacid-Curing, Silicone Sealant:

1) "Chem-Calk N-Cure 2000," Bostic Construction Products Div.
2) "Dow Corning 790," Dow Corning Corp.
3) "Silglaze N SCS 2501," General Electric Co.
4) "Silpruf SCS 2000," General Electric Co.
5) "864," Pecora Corp.
6) "Rhodorsil 5C," Rhone-Poulenc, Inc.
7) "Spectrum 1," Tremco, Inc.
8) "Spectrum 2," Tremco, Inc.
9) "Dow Corning 795," Dow Corning Corp.
10) "Rhodorsil 6B," Rhone-Poulenc, Inc.
11) "Rhodorsil 70," Rhone-Poulenc, Inc.
12) "Omnisea," Sonneborn Building Products Div.
13) "Chem-Calk 100," Bostic Construction Products Div.
14) "Gesil N SCS 2600," General Electric Co.

b. One-Part, Mildew-Resistant, Silicone Sealant:

1) "Dow Corning 786," Dow Corning Corp.
2) "SCS 1702 Sanitary," General Electric Co.
3) "863 #345 White," Pecora Corp.
4) "Rhodorsil 6B," Rhone-Poulenc, Inc.
5) "Proglaze White," Tremco, Inc.
6) "OmniPlus," Sonneborn Building Products Div.

D. Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.

1. Products: Subject to compliance with requirements, provide one of the following:

a. "Chem-Calk 600," Bostic Construction Products Div.
b. "AC-2-," Pecora Corp.
c. "Sonolac," Sonneborn Building Products Div.
d. "Tremco Acrylic Latex 834," Tremco, Inc.

2.6 FIRE BARRIER PENETRATIONS

A. General: All cracks, voids, or holes for the passing of mechanical and electrical items through fire rated floors, walls and ceilings and having a fire rating of 1 hour or more shall be sealed with a fire barrier caulk, putty, or sealant. Caulk, putty, and sealant systems shall be installed in

accordance with the manufacturers recommendations to maintain a fire rating of 3 hours minimum.

B. Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors. Sealants and accessories shall have fire-resistant ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

C. Fire-Resistant Caulk:

1. Products: Subject to compliance with requirements, provide one of the following:

a. "Dow Corning Fire Stop Foam," Dow Corning Corp.
b. "Pensil 851," General Electric Co.
c. “3M” CP 25 Caulk or 303 Putty

2.7 ACCESS DOORS

A. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.

B. Frames: 16-gauge steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.

1. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.
2. For gypsum wallboard or plaster: perforated flanges with wallboard bead.
3. For full-bed plaster applications: galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.

C. Flush Panel Doors: 14-gage sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.

1. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.

D. Locking Devices: Where indicated, provide 5-pin or 5-disc type cylinder locks, individually keyed; provide 2 keys.

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

1. Bar-Co., Inc.
2. J.L. Industries.
3. Karp Associates, Inc.
4. Milcor Div. Inryco, Inc.
5. Nystrom, Inc.

2.8 PAINTING, FINISHING

A. Painting of mechanical and electrical work exposed in occupied spaces, except mechanical and electrical machine rooms and maintenance/service space; and work exposed on the exterior is specified and performed under other divisions of these specifications.

B. Factory finishes, shop painting, and special protective coatings are specified in the individual equipment specification sections.

C. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.

D. Paint inside of ductwork black, where it can be seen from occupied spaces through diffusers, grilles or louvers (under any lighting condition).

2.9 CONCRETE AND REINFORCEMENT

A. Concrete mixes shall be designed by the Contractor to produce the classes of concrete specified below. Concrete shall be Class A for reinforced concrete and shall be designed for a maximum compressive strength of 3000 psi at 28 days. Concrete shall be class B for nonreinforced work unless otherwise shown or specified and shall be designed for a minimum compressive strength of 2500 psi at 28 days. Design mix computations and test data shall be submitted for approval. Maximum size aggregate shall be 3/4 inch. Exterior concrete shall have air entrainment of 5 to 7 percent. Concrete quality, mixing, placing, of reinforcement shall conform to American Concrete Institute Publications ACI 318 and 347. Maximum dimension of slab between construction joints shall be 25 feet. All exposed construction joints shall be sealed with approved joint sealant.

B. Reinforcement: Bars shall be deformed, grade 40 billet or axle steel, or grade 50 rail steel. Mesh shall be welded steel wire fabric with wires at right angles to each other.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION FOR JOINT SEALERS

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.3 SELECTIVE DEMOLITION

A. General: Demolish, remove, demount, and disconnect abandoned mechanical materials and equipment indicated to be removed and not indicated to be salvaged or saved.

B. Materials and Equipment to be Salvaged: Remove, demount, and disconnect existing mechanical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage by Owner.

C. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

D. Mechanical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, fixtures, and insulation.

    a. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping and ducts allowed to remain.

2. Perform cutting and patching required for demolition in accordance with Division 1 Section "Cutting and Patching."

3.4 EXCAVATION

A. Slope sides of excavations to comply with OSHA, local codes and ordinances. Shore and brace as required for stability of excavation.

B. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.

C. Install sediment and erosion control measures in accordance with local codes and ordinances.

D. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

F. Excavation for Underground Tanks, Basins, and Mechanical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

1. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.
2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

G. Trenching: Excavate trenches for mechanical installations as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of pipe and equipment.
2. Excavate trenches to depth indicated or required for piping to establish indicated slope and invert elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.
3. Limit the length of open trench to that in which pipe can be installed, tested, and the trench backfilled within the same day.
4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of pipe. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and pipe.
5. Excavate trenches for piping and equipment with bottoms of trench to accurate elevations for support of pipe and equipment on undisturbed soil.

    a. For pipes or equipment 6 inches or larger in nominal size, shape bottom of trench to fit bottom 1/4 of the circumference. Fill unevenness with tampered sand backfill. At each pipe joint over-excavate to relieve the bell or pipe joint of the pipe of loads, and to ensure continuous bearing of the pipe barrel on the bearing surface.

H. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F (2 degrees C).

I. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
2. Under building slabs, use drainage fill materials.
3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
4. For piping less than 30 inches below surface of roadways, provide 4-inch thick concrete base slab support. After installation and testing of piping, provide a 4-inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
5. Other areas, use excavated or borrowed materials.

J. Backfill excavation as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

K. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

L. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

M. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. prevent displacement of piping and equipment by carrying material uniformly around them to approximately same elevation in each lift.

N. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

    a. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
    b. Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
    c. Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.

O. Subsidence: Where subsidence occurs at mechanical installation excavations during the period 12 months after Substantial completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.6 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around mechanical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.7 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

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

3.8 INSTALLATION OF CONCRETE AND REINFORCEMENT

A. Reinforcement: Reinforcement shall be supported off the floor or ground during placement of concrete. Exposed ends of bars shall be protected with plastic caps when not working immediately in or around the site if exposed to the public

B. Testing: The Contractor shall make for test purposes one set of three cylinders taken for each day's pour. The test cylinders shall be made and cured in accordance with ASTM Standard C 31. Two cylinders shall be tested by the Contractor in accordance with ASTM Standard C 39. The test result shall be the average of the strengths of the two cylinders. If the average strength of the cylinders falls below the minimum allowable strength, such changes may be required in the proportions of the concrete mix as will be necessary to obtain the required strength. One cylinder shall be stored by the Contractor for future testing for check tests.

C. Finishing: Finishes shall be as specified below. The dusting of surfaces with cement will not be permitted.

1. Monolithic Finish: Surfaces of interior floor slabs shall be finished by tamping the concrete with suitable tools to force coarse aggregate down from the surface, screeded with straightedges, and floated to the required finish level to within a tolerance of 1/8 inch in 10 feet. While the concrete is still green, but sufficiently hardened to bear a man's weight without imprint, the surface shall be steel troweled smooth and left free from tool

makers. Exposed finished floors shall be given a second steel troweling to produce a burnished appearance.

2. Rough Slab Finish: Slabs to receive fill and mortar setting beds shall be finished by screeding with straightedges to bring the surface to the required finish with no coarse aggregate visible. In addition, roof slabs and slabs to receive membrane waterproofing shall be floated to produce a reasonably true and uniform surface and shall be slightly steel troweled.
3. Broomed Finish: Exterior concrete slabs shall be screeded and floated to bring the surface to the required finish level with no coarse aggregate visible, steel-troweling to an even smooth surface, and brooming with a fiber-bristle brush in a direction transverse to that of the main traffic.

D. Curing: Immediately after placing or finishing, concrete surfaces not covered by forms shall be protected against moisture loss for not less than seven days. Curing shall be accomplished by moist curing, waterproof paper or polyethylene sheet curing or membrane curing. Membrane curing compound shall be applied as recommended by the manufacturer. Compound shall not be used on surfaces that are to receive any subsequent treatment that depends upon adhesion or bonding to the concrete.

END OF SECTION 23 05 00

SECTION 23 05 19 – METERS AND GAUGES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-23 sections.

B. Types of meters and gauges specific in this section include the following:

1. Temperature Gauges and Fittings.

   a. Glass Thermometers.
   b. Remote Reading Dial Thermometers.
   c. Dial Type Insertion Thermometers.
   d. Thermometer Wells.
   e. Temperature Gauge Connector Plugs.

2. Pressure Gauges and Fittings.

   a. Pressure Gauges.
   b. Pressure Gauge Cocks.
   c. Pressure Gauge Connector Plugs.

3. Flow Measuring Gauges.

   a. Calibrated Balance Valves.
   b. Electromagnetic Flow Meters.
   c. BTU (Energy) Meters.

C. Meters and Gauges furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

A. Manufacturers Qualifications: Firms regularly engaged in manufacturer of meters and Gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. UL Compliance: Comply with applicable UL standards pertaining to meters and Gauges.
2. ANSI and ISA Compliance's: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Section 23 00 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Glass Thermometers:

a. Ernst Gage Co.
b. Marshalltown Instruments, Inc.
c. Trend Instruments, Inc.
d. Trerice (H.O.) Co.
e. Weiss Instruments, Inc.

2. Pressure Gauges:

a. Ametek/U.S. Gauge
b. Marsh Instrument Co., Unit of General Signal.
c. Marshalltown Instruments, Inc.
d. Trerice (H.O.) Co.
e. Weiss Instruments, Inc.

3. Temperature and Pressure Gauge Connector Plugs:

a. Peterson Engineering Co.

2.2 GLASS THERMOMETERS

A. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9" long.

C. Adjustable Joint: Die cast aluminum, finished to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.

D. Tube and Capillary: Organic liquid filled, magnifying lens, 1% scale range accuracy, shock mounted.

E. Scale: Satin faced, non-reflective aluminum, permanently etched markings.

F. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.

G. Range: Conform to the following:

1. Hot Water: 30°F - 240°F with 2°F scale divisions.
2. Chilled Water: 30°F - 130°F with 1°F scale divisions.
3. Condenser Water: 30°F - 130°F with 1°F scale divisions.
4. High Temperature Hot Water: 50°F – 500°F with 5°F scale divisions.

2.3 THERMOMETER WELLS

A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

B. Manufacturer: Same as thermometers.

2.4 TEMPERATURE GAUGE CONNECTOR PLUGS

A. General: Provide temperature gauge connector plugs pressure rated for 500 psi and 200°F. Construct of brass and finish in nickel-plate, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

2.5 PRESSURE GAUGES

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Type: General use, 1% accuracy, ANSI B 40.1 grade A, phospher bronze bourdon type, bottom connection.

C. Case: 4-1/2” diameter black glass reinforced thermo plastic (PBTP), solid front construction, blowout back safety design, weatherproof.

D. Connector: Brass with 1/4" male NPT. Provide protective syphon when used for steam service.

E. Scale: White coated aluminum, with permanently etched markings.

F. Range: Conform to the following:

1. Vacuum: 30" Hg - 15 PSI.
2. Water: 0 - 100 PSI.
3. Steam: 0 - 200 PSI.

2.6 PRESSURE GAUGE ISOLATION VALVES

A. General: Provide ball valves on low pressure systems and barstock or forged steel valves on high temperature water systems. Refer to Division 23 Sections “General Duty Valves” and “Industrial Valves”.

B. Syphon: 1/4" straight coil constructed of brass tubing with 1/4" male NPT on each end.

C. Snubber: 1/4" brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

D. Manufacturer: Same as for pressure gauges.

2.7 PRESSURE GAUGE CONNECTOR PLUGS

A. General: Provide pressure gauge connector plugs pressure rated for 500 psi and 200°F. Construct of brass and finish in nickel-plate, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

2.8 CALIBRATED BALANCE VALVES

A. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT o-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.

B. Manufacturer: Subject to compliance with requirements, provide calibrated balance valves of one of the following:

1. Bell & Gossett ITT; Fluid Handling Div.
2. Flow Design Inc.
3. Thrush Products, Inc.

2.9 ELECTROMAGNETIC FLOW METERS

A. General: Provide a bi-directional insertion-type electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, integral transmitter, installation valves, installation depth gauge and calibration certificate. Flowmeter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown. Wetted components shall be constructed of 316L stainless steel with attached tag indicating calibration information. Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.

B. Maximum Pressure/Temperature Rating: 400 psig / 200 deg F.

C. Accuracy: Flowmeter shall provide calibrated outputs directly from the integral transmitter, throughout the operating range with the accuracy stated as follows:

1. Plus or minus 1.0% of rate from 2.0 to 20.0 ft/sec velocity (10:1 turndown).
2. Plus or minus 0.02 ft/sec below 2 ft / sec

D. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard that is traceable to NIST.

E. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

F. Manufacturer: Subject to compliance with requirements, provide electromagnetic flow meters of one of the following:

1. Basis of Design: ONICON Model F-3500 Series Insertion Electromagnetic Flowmeter
2. Approved equal.

2.10 BTU METERS

A. General: The entire Energy Measurement System shall be built and calibrated by a single manufacturer, and shall consist of a flow meter, two temperature sensors, a BTU meter, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST* traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer's two year warranty.

B. BTU Meter: The BTU meter shall provide the following points both at the integral LCD and as outputs to the building control system: Energy Total, Energy Rate, Flow Rate, Supply Temperature and Return Temperature. Output signals shall be either serial network (protocol conforming to BACnet® MS/TP, BACnet/IP,) and/or via individual analog and pulse outputs. Each BTU meter shall be factory programmed for its specific application and shall be re-programmable using the front panel keypad (no special interface device or computer required).

C. Temperature sensors: Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within +0.15°F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).

D. Liquid Temperature Range: -4°F - 212°F.

E. Power Input: 120 VAC, 60 Hz.

F. Data Output: 6-digit electromechanical counter with readout in kwh or btu.

G. Accuracy: ±0.4% over range of 3.3 to 33 ft/sec; ±0.8% over range of 1.0 to 3.3 ft/sec; ±0.0075% at flows less than 1 ft/sec.

H. Memory: Nonvolatile memory retains all program parameters and totalized values in the event of power loss.

I. Connection Type: ANSI 150 class flange.

J. Manufacturer: Subject to compliance with requirements, provide products of one of the following:

1. ONICON Incorporated System 10.
2. Approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF TEMPERATURE GAUGES

A. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.

B. Locations: As applicable to this project, install in the following locations, and elsewhere as indicated:

1. At inlet and outlet of each hydronic zone.
2. At inlet and outlet of each hydronic boiler and chiller.
3. At inlet and outlet of each hydronic coil in air handling units, and built-up central systems.
4. At inlet and outlet of each hydronic heat exchanger.
5. At inlet and outlet of each hydronic heat recovery unit.
6. At inlet and outlet of each thermal storage tank.

C. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

D. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.3 INSTALLATION OF PRESSURE GAUGES

A. General: Install pressure gauges in piping tee with pressure Gauge cock, located on pipe at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated:

1. At suction and discharge of each hydronic pump.
2. At discharge of each pressure reducing valve.
3. At water service outlet.
4. At inlet and outlet of water cooled condensers and refrigerant cooled chillers.

C. Pressure Gauge Cocks: Install in piping tee with snubber. Install syphon for steam pressure gauges.

D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 INSTALLATION OF FLOW MEASURING GAUGES

A. General: Install flow measuring gauges on piping systems located in accessible locations at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated.

1. At discharge of each pump.
2. At inlet of each hydronic coil in built-up central systems.

C. Wafer-Type Flow Meters: Install between 2 Class 125 pipe flanges, ANSI B16.1 (cast-iron) or ANSI B16.24 (cast-bronze). Provide minimum straight lengths of pipe upstream and downstream from meter in accordance with Manufacturer's installation instructions.

D. Calibrated Balance Valves: Install on piping with readout valves in vertical upright position. Maintain minimum length of straight unrestricted piping equivalent to 3 pipe diameters upstream of valve.

E. Flow Meters: Install in horizontal or vertical pipe with 10 pipe diameters upstream and 10 pipe diameters downstream of straight unrestricted piping. Provide minimum 40” of vertical clearance. Calibrate meter after installation in accordance with manufacturer's installation instructions.

F. BTU Meters: Install in piping where indicated, in hydronic supply line. Provide thermal well in return line for remote sensor. Mount meter on wall if accessible, if not provide bracket to support meter.

3.5 ADJUSTING AND CLEANING

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

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 23 05 19

SECTION 23 05 21 – PIPING SPECIALTIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Types of piping specialties specified in this section include the following:

1. Pipe Escutcheons.
2. Pipeline Strainers.
3. Dielectric Unions.
4. Mechanical Sleeve Seals.
5. Water Hammer Arresters.
6. Drip Pans.
7. Pipe Sleeves.
8. Sleeve Seals.

C. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

A. Manufacturers Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for 'Y' Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than 'Y' Type".

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Section 23 00 00.

PART 2 - PRODUCTS

2.1 PIPING SPECIALTIES

A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

2.2 PIPE ESCUTCHEONS

A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

D. Manufacturer: Subject to compliance with requirements, provide pipe escutcheons of one of the following:

1. Chicago Specialty Mfg. Co.
2. Producers Specialty & Mfg. Corp.
3. Sanitary-Dash Mfg. Co.

2.3 LOW PRESSURE Y-TYPE PIPELINE STRAINERS

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 PSI working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in.

B. Threaded Ends, 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2" and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

F. Grooved Ends, 2-1/2" and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

G. Manufacturer: Subject to compliance with requirements, provide low pressure Y-type strainers of one of the following:

1. Armstrong Machine Works.
2. Hoffman Specialty ITT; Fluid Handling Div.
3. Metraflex Co.
4. R-Pve; Div. White Consolidated Industries, Inc.
5. Spirax Sarco.
6. Victaulic Co. of America.
7. Watts Regulator Co.

2.4 HIGH PRESSURE Y-TYPE PIPELINE STRAINERS:

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 250 psi working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in.

B. Threaded Ends, 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2" and Larger: Cast-iron body, bolted steel retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2" and Larger: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

F. Manufacturer: Subject to compliance with requirements, provide high pressure Y-type strainers of one of the following:

1. Armstrong Machine Works.
2. Hoffman Specialty ITT; Fluid Handling Div.
3. Metraflex Co.
4. R-Pve; Div. White Consolidated Industries, Inc.
5. Spirax Sarco.
6. Watts Regulator Co.

2.5 DIELECTRIC UNIONS

A. General: Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.

B. Manufacturer: Subject to compliance with requirements, provide dielectric unions of one of the following:

1. B & K Industries, Inc.

2. Capital Mfg. Co., Div. of Harsco Corp.
3. Eclipse, Inc.
4. Epco Sales, Inc.
5. Perfection Corp.
6. Rockford-Eclipse Div.

2.6 MECHANICAL SLEEVE SEALS

A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

B. Manufacturer: Subject to compliance with requirements, provide mechanical sleeve seals of one of the following:

1. Thunderline Corp.

2.7 WATER HAMMER ARRESTERS

A. General: Provide bellows type water hammer arresters, stainless steel casing and bellows, pressure rated for 250 PSI, tested and certified in accordance with PDI Standard WH-201.

B. Provide water hammer arresters at the following locations:

1. Upstream of quick closing make-up water valves such as solenoid valves for cooling towers.

C. Manufacturer: Subject to compliance with requirements, provide water hammer arresters of one of the following:

1. Amtrol, Inc.
2. Smith (Jay R.) Mfg. Co.
3. Tyler Pipe; Sub. of Tyler Corp.
4. Zurn Industries, Inc.; Hydromechanics Div.

2.8 FABRICATED PIPING SPECIALTIES

A. Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2". Reinforce top, either by structural angles or by rolling top over 1/4" steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" drain line connection.

B. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closing with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gages: 3" and smaller, 20 gage; 4" to 6", 16 gage; over 6", 14 gage.
2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.
4. PVC Plastic-Pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.

5. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

C. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.

B. Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff valve in strainer blow down connection, full size of connection, except for strainers 2" and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:

a. Pumps.
b. Temperature control valves.
c. Pressure reducing valves.
d. Temperature or pressure regulating valves.
e. Steam traps serving steam main drops.

C. Dielectric Unions: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.

D. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

E. Fire Barrier Penetration Seals: Where pipes pass through fire rated walls, floors, or ceilings, fill all cracks, voids, or holes with fire rated joint sealer. Refer to Division 23 Section “Basic Mechanical Materials and Methods”.

F. Water Hammer Arresters: Install in upright position, in locations and of sizes in accordance with PDI Standard WH-201, and elsewhere as indicated.

3.2 INSTALLATION OF FABRICATED PIPING SPECIALTIES

A. Drip Pans: Locate drip pans under piping passing over or within 3' horizontally of electrical equipment, and elsewhere as indicated. Hang from structure with rods and building

attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.

B. Pipe Sleeves: Install pipe sleeves of types indicated where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect/Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation (if any) will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Where insulation includes vapor-barrier jacket, provide sleeve with sufficient clearance for installation. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves. Extend floor sleeves 1/4" above level floor finish, and 3/4" above floor finish sloped to drain. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.

1. Install sheet metal sleeves at interior partitions and ceilings other than suspended ceilings.
2. Install steel-pipe or plastic-pipe sleeves except as otherwise indicated.
3. Install iron-pipe sleeves at exterior penetrations, both above and below grade.
4. Install PVC pipe sleeves at exterior penetrations below grade.
5. Install Reusable Molded PE sleeves at exterior penetrations below grade. Set in cast-in-place concrete and remove with formwork.

END OF SECTION 23 05 21

SECTION 23 05 23 – GENERAL DUTY VALVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes general duty valves common to most mechanical piping systems.

B. Types of valves specified in this section include the following:

1. Gate
2. Ball
3. Plug
4. Globe
5. Butterfly
6. Check

C. Special purpose valves are specified in individual piping system specifications.

D. Valves tags and charts are specified in Division-23 Section "[Mechanical Identification] [Basic Mechanical Materials and Methods]."

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 1 Specifications Sections and Section 23 01 00.

B. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.3 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliances: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.4 DELIVERY, STORAGE AND HANDLING

A. Preparation for Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.
2. Protect valve ends against damage to threads, flange faces, and weld-end preps.
3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set

butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
2. Protect valves from weather. Store valves indoor. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valve off the ground or pavement in watertight enclosures.

C. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to the compliance with requirements, provide valves from one of the manufacturers listed in valve schedule.

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising steam or rising outside screw and yoke stems.

1. Non-rising stem valves may be used where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.
2. Lever Handles, on quarter-turn valves 6 inches and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves.
3. Chain-wheel operators for valves 2-1/2 inches and larger, installed 72 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.
4. Gear drive operators on quarter-turn valves 8 inches and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stem arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.
2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
3. Solder-Joint: Comply with ANSI B16.18.

    a. Caution: Where soldered end connections are used, use solder having a melting point below 840°F for gate, globe, and check valves; below 421°F for ball valves.

2.3 GATE VALVES

A. Gate Valves - 2 Inches and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze, with threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Gate Valves - 2-1/2 Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, with flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

2.4 BALL VALVES

A. Ball valves - 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof steam, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water and low pressure steam.

B. Ball Valves - 1-1/4 Inch to 2 Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water and low pressure steam.

2.5 PLUG VALVES

A. Hydronic System Plug Valves: Valves shall be of the non-lubricated eccentric type with the plug completely resilient rubber covered. Flanged valves shall fully comply with ANSI 125/150 standards. Ports shall be round, and with minimum solids passage equal to 81% of the corresponding pipe area on sizes 2" through 12" to facilitate "plugging". Valve bodies shall be ASTM A126 Class B with 90% nickel welded seats. No other seats will be allowed. Plugs shall be Ductile Iron to ASTM A536. Plugs shall be of one piece construction with PTFE thrust washers on the top and bottom journals. Valves shall be furnished with self-adjusting "U" cup packing and shall have bearings top and bottom of sintered oil impregnated 316 stainless steel. Each valve shall be given hydrostatic and seat tests and be rated at 175 PSI per ANSI 125 unless specified otherwise.

2.6 GLOBE VALVES

A. Globe Valves - 2 Inch and Smaller: MSS SP-80; Class 125, body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where pressure requires

B. Globe Valves - 2-1/2 Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

2.7 BUTTERFLY VALVES

A. Butterfly Valves - 2-1/2 Inches and Larger: MSS SP-67; rated at 250 psi, cast iron body conforming to ASTM A 126, Class B. Provide valves with aluminum bronze disc, stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with adjustable index plate for sizes 2 through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. Provide lug type valves, wafer type valves will not be permitted. Drill and tap valves on dead-end service or requiring additional body strength.

2.8 CHECK VALVES

A. Swing Check Valves - 2 Inches and Smaller: MSS SP-80; Class 125, cast bronze body and cap conforming to ASTM B 62, with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or Class 125 valves are not available.

B. Swing Check Valves - 2-1/2 Inches and Larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing and bronze disc or cast iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

C. Silent Check Valves: Class [125][250], cast iron body; [globe style][wafer style] with replaceable bronze seat, and non-slam design lapped and balanced twin bronze flappers and stainless steel trim and torsion spring. Provide valves designed to open and close at approximately one foot differential pressure.

D. Lift Check Valves 2 Inches and Smaller: Class 125, cast-bronze body and cap conforming to ASTM B 62, horizontal or angle pattern, lift-type valve, with stainless steel spring, bronze disc holder with renewable "Teflon" disc, and threaded ends. Provide valves capable of being refitted and ground while the valve remains in the line.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such action. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and for freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.2 VALVE SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size 2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water and low pressure steam service.
2. Steel Pipe Sizes 2 Inches and Smaller: Threaded or grooved-end.
3. Steel Pipe Sizes 2-1/2 Inches and Larger: Grooved-end or flanged.

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves for shut-off duty; globe, ball, plug, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.

B. Use gate valves only where required to make hot-taps into existing piping system or as indicated.

C. Provide memory stops for all valves used for throttling service.

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

E. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shut-down. Unions are not required on flanged devices.

F. Install three-valve bypass around each pressure reducing valve using throttling type valves.

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

H. Install valves in a position to allow full stem movement.

I. Check valves at pump discharge shall be non-slam silent check valves.

J. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal or vertical position with hinge pin level.

2. Silent Check Valves: Horizontal or vertical position, between flanges.
3. Life Check Valve: With stem upright and plumb.

3.4 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket, using steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside or tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to insure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating the valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FLANGED CONNECTIONS

A. Align flanges surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

C. For dead end service, butterfly valves required flanges both upstream and downstream for proper shutoff and retention.

3.7 FIELD QUALITY CONTROL

A. Tests: After piping system have been tested and put into service, but before final adjusting and balancing, inspect valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

3.8 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive finish painting or insulation.

3.9 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES - 2 INCHES AND SMALLER				
SERVICE	GATE	GLOBE	BALL	CHECK
Condenser Water	125	125	150	125
Chilled Water	125	125	150	125
Domestic Hot and Cold Water	125	125	150	125
Heating Hot Water	150	150	150	150
Low Pressure Steam (0-15 PSIG)	150	150	150	150

VALVES - 2-1/2 INCHES AND LARGER				
SERVICE	GATE	GLOBE	BALL	CHECK
Condenser Water	125	125	200	125
Chilled Water	125	125	200	125
Domestic Hot and Cold Water	125	125	200	125
Heating Hot Water	125	125	200	125
Low Pressure Steam (0-15 PSIG)	125	125	200	125

3.10 VALVE SCHEDULE

A.

GATE VALVES - 2 INCH AND SMALLER (Class 125 - Bronze Body)				
	THREADED		SOLDERED	
MANUFACTURER	NRS	RS	NRS	RS
Crane	438	428	1324	1334
Grinnell	3000	3010	3000SJ	3010SJ
Hammond	IB645	IB640	IB647	IB635
Jenkins	370	47	1240	1242
Lukenheimer	2129	2127	2133	2132
Milwaukee	105	148	115	1149
Nibco	T113	T111	S113	S111
Powell	507	500	1822	1821
Stockham	B103	B-100	B-104	B-108

B.

GATE VALVES - 2 INCH AND SMALLER (Class 150 - Bronze Body)				
	THREADED		SOLDERED	
MANUFACTURER	NRS	RS	NRS	RS

Crane	437	431UB	X	X
Grinnell	3050	3060	X	X
Hammond	IB637	IB629	X	IB648
Jenkins	X	47U	X	X
Lukenheimer	3153	3151	3154	3155
Milwaukee	X	1151	X	1169
Nibco	T-136	T-135	S-136	X
Powell	2712	2714	X	1842
Stockham	B-130	B-120	X	B-124
REMARKS: X – Means not available.				

C.

GATE VALVES - 2-1/2 INCH AND LARGER (Class 125 – Iron Body)		
MANUFACTURER	RS, OS&Y	NRS
Crane	465-1/2	461
Grinnell	6020A	6060A
Hammond	IR1140	IR1138
Jenkins	651A	326
Lukenheimer	1430	1428
Milwaukee	F2885	F-2882
Nibco	617-0	F-619
Powell	G623	G-612
Stockham	1793	1787
REMARKS: X – Means not available.		

D.

BALL VALVES - 1 INCH AND SMALLER		
MANUFACTURER	THREADED ENDS	SOLDER ENDS
Conbraco (Apollo)	77-100	77-200
Jomar	T-100N	S-100N
Nibco	T-585-70-66	S-585-70-66
Watts	B-6080	B-6081
REMARKS: X – Means not available.		

E.

BALL VALVES – 1-1/4 INCH AND LARGER		
MANUFACTURER	THREADED ENDS	SOLDER ENDS
Conbraco (Apollo)	82-100	82-200
Jomar	T-600-4B	S-600-4B
Nibco	T-590-Y	S-590-Y
Watts	B-6800	B-6801
REMARKS: X – Means not available. For grooved end connections, use Victaulic Style 721.		

F.

GLOBE VALVES - 2 INCH AND SMALLER		
	CLASS 125	CLASS 150

MANUFACTURER	THREADED	SOLDER	THREADED	SOLDER
Crane	1	1310	17TF	X
Grinnell	3210	3210SJ	3240	X
Hammond	IB440	IB423	IB413T	X
Jenkins	746	1200	106-A-2	X
Lunkenheimer	2140	2146	407	X
Milwaukee	502	1502	590	X
Nibco	T-211-B T-211-Y	S-211-B S-211-Y	B-22	X
Powell	650	1823	150	X
Stockham	B-16	B-14T	B-22	X
REMARKS: X – Means not available.				

G.

GLOBE VALVES – 2-1/2 INCH AND LARGER		
MANUFACTURER	STRAIGHT BODY	ANGLE BODY
Crane	351	353
Grinnell	6200A	X
Hammond	IR116	IR118
Jenkins	613	X
Lunkenheimer	1123	1124
Milwaukee	F2981	F2986
Nibco	F-718-B	F-818-B
Powell	241	243
Stockham	G-512	G-515
REMARKS: X – Means not available.		

H.

BUTTERFLY VALVES – 2-1/2 INCH AND LARGER			
MANUFACTURER	DISC. MATERIAL	LEVER	GEAR
Centerline	Aluminum Bronze	Series 225	Series 225
Grinnell	Aluminum Bronze	Or Equal	Or Equal
Keystone	Aluminum Bronze	222	222
Nibco	Aluminum Bronze	Or Equal	Or Equal
REMARKS: X – Means not available. For grooved connections use Victaulic Series 300A,700A, and 703A for Aluminum Bronze Disc.			

SWING CHECK VALVES - 2 INCH AND SMALLER				
	CLASS 125		CLASS 150	
MANUFACTURER	THREADED	SOLDER	THREADED	SOLDER
Crane	37	1342	137	X
Grinnell	3300	3300SJ	3320	X
Hammond	IB940	IB941	IB946	X
Jenkins	92-A	1222	92-A	X
Lunkenheimer	2144	2145	230-70	X
Milwaukee	509	1509	510	X
Nibco	T-413	S-413	T-433	X

Powell	578	1825	596	X
Stockham	B-319	B-309	B-321	X

REMARKS:
X – Means not available.
For grooved connections, use Victaulic Series 712.

SWING CHECK VALVES – 2-1/2 INCH AND LARGER		
MANUFACTURER	CLASS 125	CLASS 175
Crane	373	X
Grinnell	6300A	X
Hammond	IR1124	X
Jenkins	X	729
Kennedy	X	FIG. 126
Lunkenheimer	1790 IBBM	X
Milwaukee	F2974	X
Nibco	F-918	X
Powell	559	X
Stockham	G-931	G-940

REMARKS:
X – Means not available.
For grooved connections, use Victaulic Series 712.

SILENT CHECK VALVES – 2-1/2 INCH AND LARGER				
MANUFACTURER	WAFER STYLE		GLOBE STYLE	
	CLASS 125	CLASS 250	CLASS 125	CLASS 250
Metraflex	#900			
Milwaukee	1800			
Mueller	101MAP	103MAP	105MAP	107MAP
Nibco	W-910	W-960	F-910	F-960

REMARKS:
X – Means not available.

LIFT CHECK VALVES – 2 INCH AND SMALLER		
MANUFACTURER	HORIZONTAL	ANGLE
Hammond	X	IB954
Jenkins	655-A	X
Lunkenheimer	233	X

REMARKS:
X – Means not available.

Plug Valves - 2 Inch and Smaller: Lunkenheimer: 454.
Plug Valves - 2-1/2 Inch and Larger: Powell: 2201.

END OF SECTION 23 05 23

SECTION 23 05 29 – HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of supports and anchors required by this section is indicated on drawings and/or specified in other Division-23 sections.

B. Types of supports and anchors specified in this section include the following:

1. Horizontal-Piping Hangers and Supports.
2. Vertical-Piping Clamps.
3. Hanger-Rod Attachments.
4. Building Attachments.
5. Pipe Covering Protection Saddles and Shields.
6. Spring Hangers and Supports.
7. Pipe Anchors.
8. Pipe Alignment Guides
9. Miscellaneous Materials.
10. Equipment Supports.
11. Roof Equipment Supports.

C. Supports and anchors furnished as part of factory-fabricated equipment, are specified as part of the equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

A. Manufacturers Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Code Compliance: Comply with 2012 IPC Section 308.5 and other applicable codes pertaining to product materials and installation of supports and anchors.
2. ANSI/ASME B31.1 – Power Piping.
3. UL and FM Compliance: Provide products which are UL-listed and FM approved.
4. MSS Standard Compliance:

a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
b. Select and apply pipe hangers and supports, complying with MSS SP-69.
c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
d. Terminology used in this section is defined in MSS SP-90.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly or components.

C. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Section 23 00 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers and Supports

    a. Anvil.
    b. B-Line Systems, Inc.
    c. Carpenter and Patterson, Inc.
    d. Corner & Lada Co., Inc.
    e. Elcen Metal Products Co.
    f. Fee & Mason Mfg. Co., Div. Figgie International.
    g. PHD Manufacturing, Inc.
    h. Piping Technology & Products, Inc.
    i. Unistrut.

2. Pipe Covering Protection Saddles and Shields

    a. Anvil.
    b. Elcen Metal Products Co.
    c. PHD Manufacturing, Inc.
    d. Pipe Shields, Inc.
    e. Piping Technology & Products, Inc.

3. Pipe Alignment Guides

    a. Adsco.
    b. Anvil.
    c. Heppan Precision Products, Inc.
    d. Metraflex (The) Co.
    e. PHD Manufacturing, Inc.
    f. Piping Technology and Products.

4. Roof Equipment Supports

    a. Custom Curb, Inc.

b. Pate Co.
c. Thycurb Div.; Thycurb Corp.

2.2 HORIZONTAL-PIPING HANGERS AND SUPPORTS

A. General: Except as otherwise indicated, provide factory- fabricated horizontal-piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems. Provide hot dipped galvanized steel hangers and supports in tunnels, shallow concrete trenches, and valve vaults.

B. Adjustable Steel Clevis Hangers: MSS Type 1.

C. Yoke Type Alloy Steel Pipe Clamps: MSS Type 2.

D. Steel Double Bolt Pipe Clamps: MSS Type 3.

E. Steel Pipe Clamps: MSS Type 4.

F. Pipe Hangers: MSS Type 5.

G. Adjustable Swivel Pipe Rings: MSS Type 6.

H. Adjustable Steel Band Hangers: MSS Type 7.

I. Adjustable Band Hangers: MSS Type 9.

J. Adjustable Swivel Rings, Band Type: MSS Type 10.

K. Split Pipe Rings: MSS Type 11.

L. Extension Split Pipe Clamps: MSS Type 12.

M. U-Bolt: MSS Type 24.

N. Clips: MSS Type 26.

O. Pipe Slides and Slide Plates: MSS Type 35, Structural tee slide assembly with PTFE slide bearings, including one of the following plate types:

1. Plate: Unguided type.
2. Plate: Guided type.
3. Plate: Hold-down clamp type.

P. Pipe Saddle Supports: MSS Type 36, including steel pipe base- support and cast-iron floor flange.

Q. Pipe Stanchion Saddles: MSS Type 37, including steel pipe base support and cast-iron floor flange.

R. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast-iron floor flange.

2.3 VERTICAL-PIPING CLAMPS

A. General: Except as otherwise indicated, provide factory- fabricated vertical-piping clamps complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper piping systems. Provide hot dipped galvanized steel clamps in tunnels, shallow concrete trenches, and valve vaults.

B. Two-Bolt Riser Clamps: MSS Type 8.

C. Four-Bolt Riser Clamps: MSS Type 42.

2.4 HANGER-ROD ATTACHMENTS

A. General: Except as otherwise indicated, provide factory- fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems. Provide hot dipped galvanized steel hanger rod attachments in tunnels, shallow concrete trenches, and valve vaults.

B. Steel Turnbuckles: MSS Type 13.

C. Steel Clevises: MSS Type 14.

D. Swivel Turnbuckles: MSS Type 15.

E. Malleable Iron Sockets: MSS Type 16.

F. Steel Weldless Eye Nuts: MSS Type 17.

2.5 BUILDING ATTACHMENTS

A. General: Except as otherwise indicated, provide factory- fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper piping systems. Provide hot dipped galvanized steel building attachments in tunnels, shallow concrete trenches, and valve vaults.

B. Concrete Inserts: MSS Type 18.

C. Top Beam C-Clamps: MSS Type 19.

D. Side Beam or Channel Clamps: MSS Type 20.

E. Center Beam Clamps: MSS Type 21.

F. Welded Beam Attachments: MSS Type 22.

G. C-Clamps: MSS Type 23.

H. Side Beam Clamps: MSS Type 25.

I. Adjustable Beam Clamps: MSS Type 27.

J. Steel Beam Clamps W/Eye Nut: MSS Type 28.

K. Linked Steel Clamps W/Eye Nut: MSS Type 29.

L. Malleable Beam Clamps: MSS Type 30.

M. Steel Brackets: One of the following for indicated loading:

1. Light Duty: MSS Type 31.
2. Medium Duty: MSS Type 32.
3. Heavy Duty: MSS Type 33.

N. Side Beam Brackets: MSS Type 34.

O. Plate Lugs: MSS Type 57.

P. Horizontal Travelers: MSS Type 58.

2.6 PIPE COVERING PROTECTION SADDLES AND SHIELDS

A. General: Except as otherwise indicated, provide pipe covering protection saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size pipe covering protection saddles and shields for exact fit to mate with pipe insulation.

B. Pipe Covering Protection Saddles: MSS Type 39; steel saddle welded to pipe, fill interior voids with segments of insulation matching adjoining insulation.

C. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.

D. Thermal Hanger Shields: Constructed of 360 degree insert of high density, 100 PSI, water-proofed calcium silicate, encased in 360 degree sheet metal shield. Provide assembly of same thickness as adjoining insulation.

2.7 SPRING HANGERS AND SUPPORTS

A. General: Except as otherwise indicated, provide factory- fabricated spring hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type of one manufacturer for each piping service. Select spring hangers and supports to suit pipe size and loading.

B. Restraint Control Devices: MSS Type 47.

C. Spring Cushion Hangers: MSS Type 48.

D. Spring Cushion Roll Hangers: MSS Type 49.

E. Spring Sway Braces: MSS Type 50.

F. Variable Spring Hangers: MSS Type 51; preset to indicated load and limit variability factor to 25%.

G. Variable Spring Base Supports: MSS Type 52; preset to indicated load and limit variability factor to 25%; include load flange.

H. Variable Spring Trapeze Hangers: MSS Type 53; present to indicated load and limit variability factor to 25%.

I. Constant Supports: Provide one of the following types, selected to suit piping system. Include auxiliary stops for erection and hydrostatic test, and field load-adjustment capability.

1. Horizontal Type: MSS Type 54.
2. Vertical Type: MSS Type 55.
3. Trapeze Type: MSS Type 56.

2.8 PIPE ALIGNMENT GUIDES

A. Spider Guides: Provide factory-fabricated guides, of heavy fabricated steel, consisting of a bolted two- section outer cylinder and base with a two-section guiding 4-finger spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel. Provide hot dipped galvanized steel pipe alignment guides in tunnels, shallow concrete trenches, and valve vaults.

B. Pipe Slide and Slide Plate Guides: MSS Type 35, structural tee slide assembly, PTFE slide bearing, and guided hold-down type plate. Order structural tee for specified insulation thickness or cut vertical leg in field as required due to space constraints.

C. Pipe Roller Guides: MSS Type 41, pipe rollers above and below pipe with MSS type 39 pipe covering protection saddles welded to pipe.

2.9 MISCELLANEOUS MATERIALS

A. General: Provide hot dipped galvanized steel materials in tunnels, shallow concrete trenches, and valve vaults.

B. Structural Steel: ASTM A 36/A36M, steel Plates, Shapes and Bars, black and galvanized.

C. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex-head, track bolts and nuts.

D. Washers: ASTM F844, steel, plain, flat washers.

E. Grout: ASTM C1107, Grade B, non-shrink, nonmetallic.

1. Characteristics include post-hardening, volume-adjusting, drying, hydraulic-cement-type grout that is non-staining, non-corrosive, nongaseous and is recommended for both interior and exterior applications.
2. Design Mix: 5,000-psi (34.5Mpa), 28-day compressive strength.
3. Water: Potable.
4. Packaging: Premixed and factory-packaged.

F. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and sheer capacities appropriate for supported loads and construction materials where used. Fasteners for fire protection systems include UL listing and FM approval.

G. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval.

2.10 ROOF EQUIPMENT SUPPORTS

A. General: Construct roof equipment supports using minimum 18-ga galvanized steel with fully mitered and welded corners, 3" cant, internal bulkhead reinforcing, integral base plates, pressure treated wood nailer, and 18-ga galvanized steel counter flashing.

B. Configuration: Construct to sizes as indicated, compensate for slope in roof so top of support is dead level.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.3 INSTALLATION OF BUILDING ATTACHMENTS

A. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS

SP-69. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Install reinforcing bars through openings at top of inserts.

B. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches (100mm) thick.

C. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer's written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches (100mm) thick.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Comply with MSS SP-69 and SP-89. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on field-fabricated, heavy-duty trapeze type hangers where possible. Install supports with maximum interval spacing complying with both MSS SP-69 and 2012 IPC Table 308.5 Hanger Spacing. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

C. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Support fire protection systems piping independently of other piping.

E. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

F. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

G. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.1 are not exceeded.

I. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.1.
2. Saddles: Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated.

3. Shields: Install MSS Type 40, protective shields on cold piping with vapor barrier. Shields span an arc of 180 degrees and have dimensions in inches not less than the following:

NPS (Inches	LENGTH (Inches)	THICKNESS (Inches)
1/4 to 3-1/2	12	0.048
4	12	0.060
5 and 6	18	0.060
8 to 14	24	0.075
16 to 24	24	0.105

4. Pipes 8 Inches (200mm) and Larger: Include wood inserts.
5. Insert Material: Length at least as long as the protective shield.
6. Thermal-Hanger Shields: Install with insulation of same thickness as piping.

3.5 INSTALLATION OF ALIGNMENT GUIDES

A. Install guides in locations as recommended by the expansion joint manufacturer but in no case shall the first guide be located less than 10 pipe diameters from the end of the expansion joint.

B. Install guides at locations indicated and at intervals required to maintain alignment of the pipe as indicated below:

PIPE SIZE	MAXIMUM GUIDE SPACING (FT)
1-1/2”	10’
2”	12’
2-1/2”	15’
3”	20’
4”	25’
5”	30’
6”	35’
8”	45’
10”	60’

3.6 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.1, and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ASME B31.1 and with AWS standards.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe- runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.7 EQUIPMENT SUPPORTS

A. Provide concrete housekeeping bases for all floors mounted equipment furnished as part of the work of Division-23. Size bases to extend minimum of 4" beyond equipment base in any direction; and 3-1/2" above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.

B. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

C. Furnish roof equipment supports to Contractor for installation as part of work of Division 7.

3.8 ADJUSTING AND CLEANING

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

B. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.

3.9 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erection of 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 by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal is specified in Division 9 Section “Painting.”

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

END OF SECTION 23 05 29

SECTION 23 05 48 – MECHANICAL VIBRATION AND SEISMIC CONTROLS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of vibration control work required by this section is indicated on drawings and schedules, and/or specified in other Division-23 sections.

B. Types of vibration control products specified in this section include the following:

1. Fiberglass Pads and Shapes.
2. Neoprene Pads.
3. Vibration Isolation Springs.
4. Pad-Type Isolators.
5. Plate-Type Isolators.
6. Double-Plate-Type Isolators.
7. Threaded Double-Plate-Type Isolators.
8. All Directional Anchors.
9. Neoprene Mountings.
10. Spring Isolators, Free-Standing.
11. Spring Isolators, Housed.
12. Spring Isolators, Vertically-Restrained.
13. Thrust Restraints.
14. Equipment Rails.
15. Fabricated Equipment Bases.
16. Inertia Base Frames.
17. Roof-Curb Isolators.
18. Isolation Hangers.
19. Riser Isolators.
20. Flexible Pipe Connectors.

C. Vibration control products furnished as integral part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

D. Refer to other Division-23 sections for equipment foundations, hangers, sealants, gaskets, and other work related to vibration control work.

E. Refer to other Division-23 sections for requirements of electrical connections to equipment isolated on vibration control products.

F. Refer to other Division-23 sections for requirements of duct connections to air handling equipment isolated on vibration control products.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Except as otherwise indicated, obtain vibration control products from single manufacturer.

C. Engage manufacturer to provide technical supervision of installation of vibration control products.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration control product. Submit schedule showing size, type, deflection, and location for each product furnished.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components. Detail bases, and show location of equipment anchoring points, coordinated with equipment manufacturer's shop drawings.

C. Maintenance Data: Submit maintenance data for each type of vibration control product. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Section 23 00 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide vibration control products of one of the following:

1. Amber/Booth Co.
2. Korfund Dynamics Corp.
3. Mason Industries, Inc.
4. Peabody Noise Control, Inc.
5. Vibration Eliminator Co., Inc.
6. Vibration Mountings and Controls, Inc.

2.2 VIBRATION CONTROL MATERIALS AND SUPPORT UNITS

A. Fiberglass Pads and Shapes: Glass fiber of not more than 0.18 mil diameter, produced by multiple-flame attenuation process, molded with manufacturer's standard fillers and binders through 10 compression cycles at 3 times rated load bearing capacity, to achieve natural frequency of not more than 12 Hertz, in thicknesses and shapes required for use in vibration isolation units.

B. Neoprene Pads: Oil-resistant neoprene sheets, of manufacturer's standard hardness and cross-ribbed or waffled pattern.

C. Vibration Isolation Springs: Wound-steel compression springs, of high-strength spring alloy steel; with spring diameter not less than 0.8 of compressed height of spring at rated loads. Provide minimum additional travel to solid, equal to 50% of rated deflection. Provide spring wire with elastic limit stress exceeding stress at solid deflection.

D. Pad-Type Isolators: Except as otherwise indicated, provide manufacturer's standard pad-type isolation unit, fiberglass pads or shapes, or neoprene pads.

E. Plate-Type Isolators: Laminate pad-type isolator to steel plate.

F. Double-Plate-Type Isolators: Cement pad-type isolator to either side of 16-ga shim and cement assembly to load distribution steel plate.

1. Where required for anchorage of equipment, include threaded anchor bolt secured to plate and extending through unit, distance sufficient for anchorage of equipment as indicated.
2. Include 2 holes in plate for bolting unit to substrate.

G. Threaded Double-Plate-Type Isolators: Provide double-plate-type isolator, with threaded connection centered in one plate and oversized hole in other plate.

1. Except as otherwise indicated, included threaded insert extending through entire thickness of unit.
2. Include 2 bolts in plate opposite threaded plate, for bolting unit to substrate.

H. All-Directional Anchors: Provide all-directional acoustical pipe anchor consisting of telescopic arrangement of 2 sizes of steel tubing separated by minimum 1/2" thickness of heavy-duty neoprene and duck, or neoprene isolation material. Provide vertical restrains by similar material arranged to prevent vertical travel in either direction. Design for maximum 500 PSI load on isolation materials and provide for equal resistance in any direction. Equip anchor with threaded hole on top and 2 holes in base plate for bolting down; or provide welding provisions top and bottom, if indicated.

I. Neoprene Mountings: Provide neoprene mountings consisting of neoprene element bonded between 2 steel plates that are neoprene-covered to prevent corrosion. Provide minimum rated deflection of 0.35". Provide threaded hole in upper plate and 2 holes in base plate for securing to equipment and to substrate.

J. Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.

1. Include holes in bottom plate for bolting unit to substrate as indicated.

K. Spring Isolators, Housed: Except as otherwise indicated, provide vibration isolation spring between telescoping steel housings with top and bottom loading plates, and with pad-type isolator bonded to bottom of loading plate. Include resilient inserts to separate and guide telescoping housings.

1. Equip top loading plate with equipment anchorages as indicated or as required for support and attachment.
2. Include pad-type isolator bonded to top of top loading plate, except on units with leveling bolts.
3. Include holes in bottom plate for bolting unit to substrate.

L. Spring Isolators, Vertically-Restrained: Provide spring isolators in housing that includes vertical limit stops. Design housing to act as blocking during erection, and with installed height and

operating height being equal. maintain 1/2" minimum clearance around restraining bolts, and between housing and springs. Design so limit stops are out of contact during normal operation.

M. Thrust Restraints: Provide horizontal thrust restraints consisting of spring element in series with neoprene pad. Select spring deflection same as for equipment loading. Design so thrust restraints can be pre-set and adjusted in field. Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit.

N. Equipment Rails: Where rails or beams are indicated for use with isolator units to support equipment, provide steel beams complying with ASTM A36, with minimum depth of 6" or 0.10 x span of beam between isolators (whichever is greater). Provide welded bracket at each end of beams, and anchor each end to spring isolator unit. Provide bolt holes in beams matching anchor bolt holes in equipment. provide beams of section modules indicated or, if not indicated, selected for normal-weight equipment loading to limit static load stress to 16,000 PSI.

O. Fabricated Equipment Bases: Where supplementary bases are indicated for use with isolator units to support equipment (base not integral with equipment), provide welded rectangular unit, fabricated of structural steel shapes, plates and bars complying with ASTM A36, as shown. provide welded support brackets at points indicated, and anchor base to spring isolator units. Except as otherwise indicated arrange brackets to result in lowest possible mounting height for equipment, but provide minimum of 1". Provide bolt holes in base matching anchor bolt holes in equipment.

1. Where indicated, provide for auxiliary motor slide base under motor or motor slide rails for adjusting belt tension. Design primary base for bolting of rails or slide base in position.
2. Where sizes of base framing members are not indicated, fabricate base with depth of structure not less than 0.10 x longest span of base, rigidly braced to support equipment without deflections or distortions which would be detrimental to equipment or equipment performance.

P. Inertia Base Frames: Where inertia bases are indicated for use with isolation units to support equipment, provide rectangular structural beam channel, or complete sheet metal box concrete forms for floating foundations, with materials complying with ASTM A36. Frame unit as shown or, if not shown, with minimum depth of 0.08 x longest dimension of base, but not less than 6" deep. Size frame as shown or, if not shown, so that weight of frame plus concrete fill will be greater than operating weight of equipment supported. Provide steel reinforcing both ways with both ends of reinforcing butt welded to base framing.

1. Provide welded support brackets at points indicated, and anchor base frame to spring isolator units.
2. Provide anchor bolts, located as required for equipment anchorage and supported for casting of concrete. Locate bolts as indicated.
3. Provide adjustable bolts in pipe sleeves; for minimum of 1/2" adjustment around anchor bolts.

Q. Roof-Curb Isolators: Fabricated frame units sized to match roof curbs as shown, formed with isolation springs between extruded aluminum upper and lower sections, which are shaped and positioned to prevent metal-to-metal contact. provide continuous airtight and waterproof seal between upper and lower extrusions. Include provisions for anchor of frame unit to roof curb, and for anchorage of equipment to unit.

R. Isolation Hangers: Hanger units formed with brackets and including manufacturers' standard compression isolators of type indicated. Design brackets for 3 times rated loading of units. Fabricate units to accept misalignment of 15° off center in any direction before contacting hanger

box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.

1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
2. Provide neoprene element, with minimum deflection of 0.35", securely retained in hanger box.
3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
4. Provide hangers, pre-compressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.

S. Riser Isolators: Suspend risers from, or support risers by, spring hangers or spring isolators. Wherever possible, anchor risers at central point with resilient anchors. Provide hanger or mounting deflection of 0.75" except in those expansion locations where additional deflection is required to limit deflection or load changes to ±25% of initial deflection. Provide sliding guides held in position by resilient anchors, located between anchor points and end of piping, spaced as indicated.

T. Flexible Pipe Connectors:

1. For non-ferrous piping, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. For ferrous piping, provide stainless steel hose covered with stainless steel wire braid for NPT steel nipples or 150 PSI ANSI flanges, welded to hose.

U. Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 PSI at 220°F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PERFORMANCE OF ISOLATORS

A. General: Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

3.3 APPLICATIONS

A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 1980 Systems Volume, Chapter 35 "Sound and Vibration Control", Table 27. Where more than one type of product is offered, selection is Installer's option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers as indicated, and for first 3 points of support for pipe sizes 4" and less, for first 4 points of support for pipe sizes 5" through 8", and for first 6 points of support for pipe sizes 10" and over.

3.4 INSTALLATION

A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contracts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

D. Install inertia base frames on isolator units as indicated, so that minimum of 1" clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.

E. For air handling equipment, install thrust restraints as indicated, and also wherever thrust exceeds 10% of equipment weight.

F. Locate isolation hangers as near overhead support structure as possible.

G. Weld riser isolator units in place as required to prevent displacement from loading and operations.

H. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

3.5 ADJUSTING AND CLEANING

A. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated.

B. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

END OF SECTION 23 05 48

SECTION 23 05 53 – MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of mechanical identification work required by this section is indicated on drawings and/or specified in other Division-23 sections.

B. Types of identification devices specified in this section include the following:

1. Painted Identification Materials.
2. Plastic Pipe Markers.
3. Plastic Tape.
4. Underground-Type Plastic Line Marker.
5. Plastic Duct Markers.
6. Valve Tags.
7. Valve Schedule Frames.
8. Engraved Plastic-Laminate Signs.
9. Plastic Equipment Markers.
10. Plasticized Tags.

C. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of the equipment assembly in other Division-23 sections.

D. Refer to other Division-23 sections for identification requirements at central-station mechanical control center; not work of this section.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin

of schedule. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Section 23 00 00.

C. Maintenance Data: Include product data and schedules in maintenance manuals; in accordance with requirements of Section 23 00 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide mechanical identification materials of one of the following:

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

2.2 MECHANICAL IDENTIFICATION MATERIALS

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PLASTIC PIPE MARKERS

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

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

C. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125^{o}F or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

D. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Laminated or bonded application of pipe marker to pipe (or insulation).
4. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

E. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:

1. Laminated or bonded application of pipe marker to pipe (or insulation).
2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide, full circle at both ends of pipe marker, tape lapped 3".
3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

F. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.

1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.4 PLASTIC DUCT MARKERS

A. General: Provide manufacturer's standard laminated plastic, color coded duct markers. Conform to the following color code:

1. Green: Cold air.
2. Yellow: Hot air.
3. Yellow/Green: Supply air.
4. Blue: Exhaust, outside, return, and mixed air.
5. For hazardous exhausts, use colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following:

1. Direction of air flow.
2. Duct service (supply, return, exhaust, etc.).
3. Duct origin (from).
4. Duct destination (to).
5. Design cfm.

2.5 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure- sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2- 1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.6 VALVE TAGS

A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener.
1. Provide size and shape as specified or scheduled for each piping system.
2. Fill tag engraving with black enamel.

B. Valve Tag Fasteners: Manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

C. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hole to allow attachment.

2.7 VALVE SCHEDULE FRAMES

A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

C. Fasteners: Self-tapping stainless steel screws, except contact- type permanent adhesive where screws cannot or should not penetrate the substrate.

2.9 PLASTIC EQUIPMENT MARKERS

A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers. Conform to the following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Brown: Energy reclamation equipment and components.
5. Blue: Equipment and components that do not meet any of the above criteria.
6. For hazardous equipment, use colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible.

1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2" x 4" markers for control devices, dampers, and valves; and 4-1/2" x 6" for equipment.

2.10 PLASTICIZED TAGS

A. General: Manufacturer's standard pre-printed or partially pre- printed accident-prevent tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with approximate pre- printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.11 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.

1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. General Installation Requirements:

1. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

A. General: Identify air supply, return, exhaust, intake and relief ductwork with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color).

B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacings along exposed runs.

C. Access Doors: Provide stenciled or plastic-laminate type signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:

1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.
2. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non- concealed locations.

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
3. Near locations where pipes pass through walls or floors/ ceilings, or enter non-accessible enclosures.
4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.4 VALVE IDENTIFICATION

A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.

1. Tagging Schedule: Comply with requirements of "Valve Tagging Schedule" at end of this section.

B. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

1. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices.

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Meters, gages, thermometers and similar units.
3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
4. Pumps, compressors, chillers, condensers and similar motor- driven units.
5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
6. Fans, blowers, primary balancing dampers and mixing boxes.
7. Packaged HVAC central-station and zone-type units.
8. Tanks and pressure vessels.
9. Strainers, filters, humidifiers, water treatment systems and similar equipment.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 1'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 the size of principal lettering.

D. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

E. Optional Use of Plasticized Tags: At Installer's option, where equipment to be identified is concealed above acoustical ceiling or similar concealment, plasticized tags may be installed within concealed space to reduce amount of text in exposed sign (outside concealment).

1. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at Installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

3.6 ADJUSTING AND CLEANING

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.7 EXTRA STOCK

A. Furnish minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

END OF SECTION 23 05 53

SECTION 23 05 93 – TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of testing, adjusting, and balancing work required by this section is indicated on drawings and schedules, and by requirements of this section; and is defined to include, but is not necessarily limited to, air distribution systems, hydronic distribution systems, and associated equipment and apparatus of mechanical work. The work consists of setting speed and volume (flow) adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to work as required by contract documents.

B. Component types of testing, adjusting, and balancing specified in this section includes the following as applied to mechanical equipment:

1. Pumps.
2. Chillers.
3. Cooling towers / fluid coolers
4. Flow meter calibration
5. Fans.

C. Refer to Division-23 sections for installation and start-up of equipment to be tested, adjusted, and balanced.

D. Refer to Division-23 sections for pressure testing of piping and/or ductwork systems.

E. Refer to Division-26 sections for electrical hook-up and wiring of equipment to be tested, adjusted, and balanced.

1.2 QUALITY ASSURANCE

A. Tester's Qualifications: Firm with at least 3 years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project, who is not Installer of system to be tested, and is otherwise independent of project.

B. Tester's Qualifications: Firm certified by National Environmental Balancing Bureau (NEBB) in those testing and balancing disciplines similar to those required for this project, who is not Installer of system to be tested and is otherwise independent of project.

C. Tester's Qualifications: Firm certified by Associated Air Balance council (AABC) in those testing and balancing disciplines similar to those required for this project.

D. Codes and Standards:

1. NEBB Compliance: Comply with NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" as applicable to mechanical air hydronic distribution systems, and associated equipment and apparatus.

2. AABC Compliance: Comply with AABC's Manual MN-1 "AABC National Standards", as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.
3. Industry Standards: Comply with ASHRAE recommendations pertaining to measurements, instruments, and testing, adjusting, and balancing, except as otherwise indicated.

1.3 SUBMITTALS

A. Submit certified test reports signed by Test and Balance Supervisor who performed TAB work. In addition, have report certified by Professional Engineer who is familiar with TAB work and also with project, and who is registered in jurisdiction where testing is being conducted.

B. Include identification and types of instruments used, and their most recent calibration date with submission of final test report.

C. Submit biographical data on Engineer who is to directly supervise testing, adjusting, and balancing work.

D. Maintenance Data: Include in maintenance manuals, copies of certified test reports, and identification of instruments; in accordance with requirements of Division 1.

1.4 JOB CONDITIONS

A. Do not proceed with testing, adjusting, and balancing work until work has been completed and is operable. **Ensure that there is not latent residual work still to be completed.**

B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

1. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.2 TEST INSTRUMENTS

A. Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in the following TAB standards:

1. NEBB's Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
2. AABC's Manual MN-1 "AABC National Standards".

PART 3 - EXECUTION

3.1 INSPECTION

A. At time of bid take-off, review drawings for completeness in regards to balancing operations. Notify prospective contractors of discrepancies such as missing balancing dampers, balancing valves, etc. upon submittal of proposal to insure that these items are covered in his bid.

B. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable. Before any air balance work is done, the system shall be checked for:

1. Excessive duct leakage.
2. Filters are installed (and changed if they are dirty).
3. Correct motor rotation.
4. Equipment lubrication and vibration.
5. Proper operation of automatic control dampers and valves.
6. Manual control dampers and air outlet dampers are wide open at this time.
7. Coil fins are cleaned and combed where needed.
8. Steam, condensate, and hydronic systems have been flushed and cleaned.

C. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.

3.2 TOLERANCES

A. Adjust air systems to the following tolerances:

1. Supply systems shall be balanced so that:

a. the total quantity to each space is within -5% to +10% of design values;
b. if two outlets in space, each outlet is within -10% to +10% of design value;
c. if three or more outlets in space, each outlet is within -10% to +10% of design value.

2. Exhaust and return systems shall be balanced so the total quantity from each space is -10% to +10% of design values.

B. Adjust hydronic systems to the following tolerances:

1. Heating System:

a. Supply water temperature 80°F to 120°F: 0% to +10% of design value.
b. Supply water temperature 120°F to 160°F: -5% to +10% of design value.
c. Supply water temperature above 160°F: -5% to +10% of design value.

2. Cooling System:

a. Supply water temperature above 55°F: 0% to +10% of design value.
b. Supply water temperature 45°F to 55°F: -5% to +10% of design value.
c. Supply water temperature below 45°F: -5% to +10% of design value.

3.3 AIR SYSTEM TESTING, ADJUSTING AND BALANCING

A. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards, with the following minimum requirements.

B. The system shall be tested in all operating modes (full return air, full outside air, and full cooling).

C. System static pressure profiles which identify pressure differences across all components of air handling units and built-up systems shall be provided. Pressure drops shall be individually measured and recorded for intake and exhaust vents, hoods, louvers, manual and auto control dampers, filters, coils, air washers, fans, terminal units, etc. System static pressure profiles and fan motor amperages shall be recorded in all modes.

D. Make the following test, adjustments and recordings:

1. Test and adjust exhaust fans. Rotation and RPM to design requirements.
2. Test and record fan motor full load amperes after above adjustments.
3. Make Pitot Tube Traverse at main supply, return and exhaust ducts. Obtain design CFM at fans. Design cfm is based on filters being approximately 50% loaded with dirt. Pressure drop across filters during balancing shall be simulated to that condition. After balancing is completed, check fan motor amperage with the filters clean.
4. Test and adjust system static pressures; suction, and discharge.
5. The duct statics shall be confirmed both through the instrumentation installed on the job and by the balancing contractor.
6. Test and adjust system design recirculation air CFM.
7. Test and adjust system design outside air CFM (maximum and minimum).
8. Test and record entering air dry bulb temperatures for heating and cooling.
9. Test and record entering air wet bulb temperatures for cooling.
10. Test and record leaving air dry bulb temperatures for heating and cooling.
11. Test and record leaving air wet bulb temperatures for cooling.
12. Adjust exhaust air ducts to proper design CFM.
13. Adjust zones to proper design CFM, supply, return, and exhaust.
14. Adjust automatically operated dampers to operate as specified, indicated, and/or noted. The testing agency shall check controls for proper calibrations and list the controls requiring adjustments by control installers.
15. Change pulleys, belts, and dampers, or add dampers as required for correct balance, as recommended by the air balancing agency, at no additional cost to the Owner.
16. Test and adjust exhaust fans for required CFM. Installed range hood fans shall be adjusted to CFM requirements as shown on the drawings.
17. Record static pressures immediately upstream of volume dampers.
18. Where tenant work has not been completed at the time of balancing the air system, adjust the volume control damper at each floor takeoff from the main risers to approximate the design air flow on that floor as indicated on the drawings.

E. The balancing contractor shall provide fixed pitch pulleys for all fans. Adjustable pitch pulleys may be provided by the equipment manufacturer to determine the final balanced position. The adjustable pitch pulleys shall be replaced with fixed pitch pulleys that shall be selected at the fan final design conditions. Coordinate/confirm with the mechanical contractor.

F. For direct drive fans controlled by variable frequency drives or electrically commutated motors, minimum and maximum fan speed shall be set by the balancing contractor to achieve final balanced flows. Note that motor speed may be significantly above 60Hz.

G. When air balancing is done and manual dampers are set, all test holes shall be plugged and all manual damper positions shall be marked. The following information shall be recorded in the final report: Design inlet or outlet size, actual inlet or outlet size, and design CFM (velocity) for each terminal in the system. The pitot tube traverse method for determining main duct CFM shall be used and recorded wherever possible; flow hood measurements at registers and diffusers may be totalized for branch duct quantities.

3.4 WATER SYSTEM TESTING, ADJUSTING AND BALANCING

A. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards, with the following minimum requirements.

B. Preliminary checks, settings and adjustments shall be as follows:

1. Open valves to full open position. Close coil bypass stop valves. Set mixing valve to full coil flow.
2. Remove and clean strainers.
3. Examine the water in the system and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Check expansion tanks to determine that they are not air bound and the system is completely full of water.
6. Check air vents at high points of water systems and determine that all are installed and operating freely.
7. Set temperature controls so coils are calling for full flow.
8. Check operation of automatic bypass valves.
9. Check and set operating temperatures of heat exchangers, boilers and chillers to design requirements.

C. Phase I - Water systems testing and balancing procedures shall be as follows:

1. Set chilled water, hot water, and condenser water pumps to the proper gallon per minute delivery.
2. Adjust water flows through heat exchangers, boilers and chillers to design requirements.
3. Check leaving water temperatures and return water temperatures through heat exchangers, boilers and chillers. Reset to correct design temperature.
4. Check water temperatures at inlet side of cooling and heating coils. Note rise or drop of temperatures from source.
5. Proceed to balance each chilled water coil and hot water coil.
6. Mark settings on valves and record data upon the completion of flow readings and adjustments at coils.

D. Phase II - Water systems testing and balancing procedures shall be as follows:

1. Recheck settings at the pumps, heat exchangers, boilers and chillers and re-adjust, if required, after adjustments are made to coils.
2. Install pressure gauges on coils, and read pressure drop through coil at set flow rate on demand for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop.
3. Check and record the following items at each cooling and heating element:

    a. Inlet water temperatures.
    b. Leaving water temperatures.
    c. Pressure drop of each coil, heat exchanger, boiler and chiller.
    d. GPM at each pump, coil, heat exchanger, boiler and chiller.

e. GPM at each heating and cooling coil.
f. Pump operating suction and discharge pressure and final total dynamic head.
g. List mechanical specifications of pumps.
h. Rated and actual running amperage of pump motor.
i. Check control valves for operation from full open to full closed, and record pressures.
j. Check humidifier valves for operation from full open to full closed, and record humidity.

4. Constant volume hydronic systems with flow measuring devices: Systems/ devices shall be balanced proportionally using the flow measuring devices. On completion of the balance, the following information shall be recorded in the report: Flow meter size and brand, measuring device orifice size, required flow rate and pressure drop, valve settings on balancing valves with a readable scale, flow rate in both full coil flow and full bypass modes.
5. Variable flow hydronic systems with flow measuring devices: With all system balancing devices, manual shut-offs, and control valves in full open position, check main flow and pump motor amperage(s) to verify that full load motor current ratings are not exceeded. If excessive flow at main pumps results in motor overload, reduce main system flow as necessary so that motor FLA is not exceeded and recheck main flow. Using local FMS devices, verify and record full open flow rates at terminal devices. (Balancing of individual FMS devices is not required.) Close at least 50% of the system control valves and verify that system differential pressure controls are functional and set point is proper to obtain full flow at furthest terminal unit. With most (98%) of main flow shut off by local control valves, verify that close-off rating of control valves is not exceeded.
6. When all hydronic balancing is done, all balancing valve positions shall be marked and the locking devices set. Control valve bypass loops (where used) shall be set with the balancing valve to provide equal flow in either mode. Confirm in report.

3.5 SEASONAL CONSIDERATIONS

A. Test, adjust and balance system during summer season for air conditioning systems and during winter season for heating systems, including at least period of operation at outside conditions within 5°F wet bulb temperature of maximum summer design condition, and within 10°F dry bulb temperature of minimum winter design condition. When seasonal operation does not permit measuring final temperatures, then take final temperature readings when seasonal operation does permit.

3.6 CLOSEOUT PROCEDURES

A. Prepare report of test results, including instrumentation calibration reports, in format recommended by applicable standards.

B. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

C. Mark equipment settings, including damper control positions, valve indicators, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.

D. Prepare a report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced; including, where necessary, modifications which exceed requirements of contract documents for mechanical work.

E. Retest, adjust and balance systems subsequent to significant system modifications, and resubmit test results.

END OF SECTION 23 05 93

This page is intentionally left blank for printing purposes

SECTION 23 07 00 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.

B. This section includes pipe, duct, and equipment insulation.

1.2 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 degree F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 degree F.

D. Thermal Resistivity: "r-values" represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.

E. Density: Is expressed in lb/sq.ft.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation.

B. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

1.4 QUALITY ASSURANCE

A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E 84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.

1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.6 SEQUENCING AND SCHEDULING

A. Schedule insulation application after testing of piping and duct systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Glass Fiber:

a. CertainTeed Corporation.
b. Knauf Fiberglass GmbH.
c. Manville.
d. Owens-Corning Fiberglas Corporation.
e. USG Interiors, Inc. - Thermafiber Division.

2. Mineral Wool:

a. Owens Corning® Thermafiber® Pro Section WR
b. Manville MinWool-1200® Pipe Insulation
c. Rock Wool Manufacturing Company.
d. Mineral Products of Texas, Inc.

3. Flexible Elastomeric Cellular:

a. Aerocel by Aeroflex
b. Armstrong World Industries, Inc.
c. Halstead Industrial Products.
d. IMCOA.
e. Rubatex Corporation.

4. Calcium Silicate:

a. Manville.
b. Owens-Corning Corporation.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.

B. Jacket: All-purpose, factory-applied, laminated glass-fiber- reinforced, flame-retardant kraft paper and aluminum foil having self-sealing lap.

C. Board: ASTM C 612, Class 2, semi-rigid jacketed board.

1. Thermal Conductivity: 0.23 average maximum, at 75 degree F mean temperature.
2. Density: 12 pcf average maximum.
3. Maximum Temperature Use: 400°F.

D. Blanket: ASTM C 553, Type II, Class F-1, jacketed flexible blankets.

1. Thermal Conductivity: 0.24 average maximum, at 75 degree F mean temperature.
2. Maximum Temperature Use: 400°F.

E. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, jacketed.

1. Thermal Conductivity: 0.23 average maximum at 75 degree F mean temperature.
2. Density: 10 average maximum.

F. Adhesive: Produced under the UL Classification and Follow-up service.

1. Type: Non-flammable, solvent-based.
2. Service Temperature Range: Minus 20 to 180 degree F.

G. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.

2.3 MINERAL WOOL

A. Material: Felted mineral wool bonded together with a high temperature binder. Mineral wool insulation shall incorporate a water repellant additive.

B. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation.

1. Thermal Conductivity: 0.23 average maximum at 75 degrees F mean temperature.
2. Density: Nominal 8 pcf.
3. Maximum Temperature Use: 1,200°F.

C. Board: ASTM C 612, Class 2, semi-rigid jacketed board.

1. Thermal Conductivity: 0.23 average maximum, at 75 degree F mean temperature.
2. Density: Nominal 8 pcf.
3. Maximum Temperature Use: 1,200°F.

2.4 FLEXIBLE ELASTOMERIC CELLULAR

A. Material: EPDM rubber based with flexible expanded closed-cell structure with smooth skin on both sides.

1. Tubular Materials: ASTM C 534, Type I.
2. Sheet Materials: ASTM C 534, Type II.

B. Thermal Conductivity: 0.245 average maximum at 75 degree F.

C. Vapor Transmission Rate: 0.03 Perms.

D. Sealing System: Self-sealing with protape.

E. Temperature Use Range: -250°F to +250°F.

F. Flame Spread/Smoke Developed Rating: 25/50 up to 2-inches in thickness.

2.5 CALCIUM SILICATE

A. Material: ASTM C 533, Type I; inorganic, hydrous calcium silicate, non-asbestos fibrous reinforcement; incombustible.

B. Form: Molded flat block, curved block, grooved block, and preformed pipe sections as appropriate for surface.

C. Thermal Conductivity: 0.60 at 500 degree F.

D. Dry Density: 15.0 pcf maximum.

E. Compressive Strength: 60 psi minimum at 5 percent deformation.

F. Maximum Temperature Use: 1600°F.

G. Fire Performance Characteristics: Provide materials identical to those whose fire performance characteristics have been determined, per test method indicated below, by UL or other testing and inspecting organization acceptable to authorities having jurisdiction.

1. Test Method: ASTM E 84.
2. Flame Spread: 0.
3. Smoke Developed: 0.

2.6 INSULATING CEMENTS

A. Mineral Fiber: ASTM C 195.

1. Thermal Conductivity: 1.0 average maximum at 500 degree F mean temperature.
2. Compressive Strength: 10 psi at 5 percent deformation.
3. Temperature Use Range: 100°F to 1600°F.

B. Expanded or Exfoliated Vermiculite: ASTM C 196.

1. Thermal Conductivity: 1.10 average maximum at 500 degree F mean temperature.
2. Compressive Strength: 5 psi at 5 percent deformation.
3. Temperature Use Range: 100°F to 1800°F.

C. Mineral Fiber, Hydraulic-Setting Insulating and Finishing Cement: ASTM C 449.

1. Thermal Conductivity: 1.2 average maximum at 400 degree F mean temperature.
2. Compressive Strength: 100 psi at 5 percent deformation.

3. Temperature Use Range: 100°F to 1200°F.

2.7 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer.

B. Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:

1. Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
2. Class 2, Grade A for bonding glass fiber insulation to metal surfaces.

2.8 FIELD APPLIED JACKETS

A. General: ASTM C 921, Type 1, except as otherwise indicated for field applied jackets.

B. Foil and Paper Jacket: Laminated glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

1. Water Vapor Permeance: 0.02 perm maximum, when tested according to ASTM E 96.
2. Puncture Resistance: 50 beach units minimum, when tested according to ASTM D 781.

C. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 20-mils thick, roll stock ready for shop or field cutting and forming to indicated sizes.

1. Adhesive: As recommended by insulation manufacturer.

D. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultra-violet-resistant PVC.

1. Adhesive: As recommended by insulation manufacturer.

E. Aluminum Jacket: ASTM B 209, 3003 Alloy, H-14 temper, factory cut and rolled to indicated sizes.

F. Aluminum Jacket: ASTM B 209, 3003 Alloy, H-14 temper, roll stock ready for shop or field cutting and forming to indicated sizes.

1. Finish and Thickness: Stucco embossed finish, 0.016 inch thick.
2. Moisture Barrier: 1-mil, heat-bonded polyethylene and kraft paper.
3. Elbows: Preformed 45-degree and 90-degree, short- and long-radius elbows, same material, finish, and thickness as jacket.

G. Stainless-Steel Jacket: ASTM A 167, Type 304 or 316, 0.10-inch thick, No. 2B finish, and factory cut and rolled to indicated sizes.

H. Stainless-Steel Jacket: ASTM A 167, Type 304 or 316, 0.10-inch thick, No. 2B finish, and roll stock ready for shop or field cutting and forming to indicated sizes.

1. Moisture Barrier: 1-mil, heat-bonded polyethylene and craft paper.
2. Elbows: Gore type, for 45-degree and 90-degree elbows in same material, thickness, finish as jackets.
3. Jacket Bands: Stainless steel, Type 304, 3/4-inch wide.

I. Shrink Wrap Polyurethane: 20 mil polyurethane tube.

2.9 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Woven glass fiber fabrics, plain weave, presized a minimum of 8 ounces per sq. yd.

1. Tape Width: 4 inches.
2. Cloth Standard: MIL-C-20079H, Type I.
3. Tape Standard: MIL-C-20079H, Type II.

B. Bands: 3/4-inch wide, in one of the following materials compatible with jacket:

1. Stainless Steel: Type 304, 0.020 inch thick.
2. Galvanized Steel: 0.005 inch thick.
3. Aluminum: 0.007 inch thick.
4. Brass: 0.01 inch thick.
5. Nickel-Copper Alloy: 0.005 inch thick.

C. Wire: 14-gage nickel copper alloy, 16-gage, soft-annealed stainless steel, or 16-gage, soft-annealed galvanized steel.

D. Corner Angles: 28-gage, 1-inch by 1-inch aluminum, adhered to 2-inch by 2-inch kraft paper.

E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

2.10 REMOVABLE INSULATION COVERING

A. General: Provide factory fabricated flexible field applied insulation covering at expansion joints, pressure reducing valves, valves, and condensate pumps. Insulation covering shall be as follows:

1. Design: Provide custom designed reusable insulation covers to conform to the shape of the equipment, fitting, or device to be insulated. Covers that encapsulate the equipment, fitting or device and conceal its type are not acceptable.
2. Identification: Each cover shall have a permanently attached stainless steel tag secured to the outer surface of the cover for the purpose of identifying the manufacturer and source to reorder.
3. Construction: Insulation covers shall be sewn with two parallel rows of lock stitching (approximately 10 to 14 stitches per inch) approximately 1/4 to 1/2 inches apart. “Hog Ringed” seams are not acceptable. Insulation covers 2 inches thick and above shall be gusseted to insure full insulation thickness throughout.
4. Thermal Requirements: Insulation thickness shall be sufficient to provide a cold face temperature at or below 140ºF regardless of the thickness of the adjacent pipe insulation.
5. Jacketing: Jacketing shall be silicone impregnated fiberglass fabric minimum 16 ounces per square yard containing a minimum of 25 percent silicone by weight. Fabric shall be

suitable for use with steam to 500ºF. Insulation shall be asbestos-free constructed of glass fiber insulating material composed of 100 percent Type E fiberglass, density of 11.5 pounds per cubic foot, alkalinity shall be 0.15 percent or less, conductivity “k” value no more than .38 at a mean temperature of 400ºF when measured in accordance with ASTM C177.

6. Sewing Thread: Kevlar or Teflon coated fiberglass suitable for the purpose intended.
7. Accessories: Type 304 stainless steel quilting and lacing pins shall be used to secure the insulation with the jacket. Drawcord shall be suitable for 600F service minimum diameter of 0.125 inch. Tie wire for securing covers shall be minimum No. 16 B&S (0.051 inch diameter) gauge soft annealed Type 302 or 304 stainless steel.

2.11 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.

1. Water Vapor Permeance: 0.08 perm maximum.
2. Temperature Range: Minus 20 to 180 degree F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.

1. Water Vapor Permeance: 0.02 perm maximum.
2. Temperature Range: Minus 50 to 250 degree F.
3. Color: Aluminum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.

B. Mix insulating cements with clean potable water. Mix insulating cements contacting stainless-steel surfaces with demineralized water.

1. Follow cement manufacturer's printed instructions for mixing and portions.

3.2 INSTALLATION, GENERAL

A. Refer to schedules [on the drawings][at the end of this Section] for materials, forms, jackets, and thicknesses required for each mechanical system.

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

C. Install vapor barriers on insulated pipes, ducts, and equipment having surface operating temperatures below 60 degree F.

D. Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions.

E. Install insulation with smooth, straight, and even surfaces.

F. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

G. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

H. Seal Ends: Except for flexible elastomeric insulation, taper ends at 45 degree angle and seal with lagging adhesive. Cut ends of flexible elastomeric cellular insulation square and seal with adhesive.

I. Apply adhesives and coatings at manufacturer's recommended coverage-per-gallon rate.

J. Keep insulation materials dry during application and finishing.

K. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:

1. Fibrous glass ducts.
2. Metal ducts with duct liner.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
5. Flexible connectors for ducts and pipes.
6. Vibration control devices.
7. Testing laboratory labels and stamps.
8. Nameplates and data plates.
9. Access panels and doors in air distribution systems.
10. Below grade piping.
11. Piping specialties including air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.

B. Stagger joints on double layers of insulation.

C. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.

D. Apply insulation with a minimum number of joints.

E. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Cover circumferential joints with butt strips, at least 3-inches wide, and of same material as insulation jacket. Secure with adhesive and outward clinching staples along both edges of butt strip and space 4 inches on center.
3. Longitudinal Seams: Overlap seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches on center.

a. Exception: Do not staple longitudinal laps on insulation applied to piping systems with surface temperatures at or below 35 degree F.

4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints, over staples, and at ends butt to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.
6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere, staple, and seal. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

F. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

G. Exterior Wall Penetrations: For penetrations of below grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor barrier coating.

H. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer. Refer to Division [7 Section "Joint Sealants"] [23 Section “Basic Mechanical Materials and Methods”].

I. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer. Refer to Division [7 Section “Joint Sealants”][23 Section “Basic Mechanical Materials and Methods] for firestopping and fire-resistant joint sealers.

J. Floor Penetrations: Terminate insulation underside of floor assembly and at floor support at top of floor.

K. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight. Bond with adhesive.

1. Use same material and thickness as adjacent pipe insulation.
2. Overlap nesting insulation by 2 inches or 1-pipe diameter, which ever is greater.
3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.
4. Insulate elbows and tees smaller than 3-inches pipe size with premolded insulation.
5. Insulate elbows and tees 3 inches and larger with premolded insulation or insulation material segments. Use at least 3 segments for each elbow.
6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

L. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install saddles, shields, and inserts as specified in Division 23 Section "Hangers and Supports." For cold surface piping, extend insulation on anchor legs a minimum of 12 inches and taper and seal insulation ends.

1. Inserts and Shields: Cover hanger inserts and shields with jacket material matching adjacent pipe insulation.

3.4 GLASS FIBER AND MINERAL WOOL PIPE INSULATION INSTALLATION

A. Bond insulation to pipe with lagging adhesive.

B. Seal exposed ends with lagging adhesive.

C. Seal seams and joints with vapor barrier compound.

3.5 FLEXIBLE ELASTOMERIC CELLULAR PIPE INSULATION INSTALLATION

A. Slip insulation on the pipe before making connections wherever possible. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.

B. Valves, Fittings, and Flanges: Cut insulation segments from pipe or sheet insulation. Bond to valve, fitting, and flange and seal joints with adhesive.

1. Miter cut materials to cover soldered elbows and tees.
2. Fabricate sleeve fitting covers from flexible elastomeric cellular insulation for screwed valves, fittings, and specialties. Miter cut materials. Overlap adjoining pipe insulation.

3.6 CALCIUM SILICATE PIPE INSULATION INSTALLATION

A. Secure insulation with stainless-steel bands spaced at 12-inch intervals.

B. Apply 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 16-gage soft-annealed stainless-steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

C. Finishing: Apply a skim coat of mineral fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on 1 layer of glass cloth or glass tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth finish.

D. Metal Jacket: Where indicated, apply metal jacket over finished insulation as specified in this Section for installation of metal jackets.

3.7 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Install board and block materials with a minimum dimension of 12 inches and a maximum dimension of 48 inches.

B. Groove and score insulation materials as required to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

C. Insulation Thicknesses Greater than 2 Inches: Install insulation in multiple layers with staggered joints.

D. Bevel insulation edges for cylindrical surfaces for tight joint.

E. Secure sections of insulation in place with wire or bands spaced at 9-inch centers, except for flexible elastomeric cellular insulation.

F. Protect exposed corners with corner angles under wires and bands.

G. Manholes, Handholes, and Information Plates: Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

H. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

I. Finishing: Except for flexible elastomeric cellular insulation, apply 2 coats of vapor barrier compound to a minimum thickness of 1/16 inch. Install a layer of glass cloth embedded between layers.

3.8 GLASS FIBER AND MINERAL WOOL EQUIPMENT INSULATION INSTALLATION

A. Secure insulation with anchor pins and speed washers.

B. Space anchors at maximum intervals of [12][18] inches in both directions and not more than [2][3] inches from edges and joints.

C. Apply a smoothing coat of insulating and finishing cement to finished insulation.

3.9 FLEXIBLE ELASTOMERIC CELLULAR EQUIPMENT INSULATION INSTALLATION

A. Install sheets of the largest manageable size.

B. Apply full coverage of adhesive to the surfaces of the equipment and to the insulation.

C. Butt insulation joints firmly together and apply adhesive to insulation edges at joints.

3.10 DUCT INSULATION

A. Blanket Insulation: Install tight and smooth. Secure to ducts having long sides or diameters as follows:

1. Smaller Than 24 Inches: Bonding adhesive applied in 6-inch-wide transverse strips on 12-inch centers.
2. 24 Inches and Larger: Anchor pins spaced 12 inches apart each way. Apply bonding adhesive to prevent sagging of the insulation.
3. Overlap joints 3 inches.
4. Seal joints, breaks, and punctures with vapor barrier compound.

3.11 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Install fire-rated insulation systems in accordance with manufacturers listing and requirements.

B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

C. Insulate duct access panels and doors to achieve same fire rating as duct.

D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 23 Section "Basic Mechanical Materials and Methods."

3.12 FIELD APPLIED JACKETS

A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 1-1/2-inch laps at longitudinal joints and 3-inch-wide butt strips at end joints.

1. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.

B. Interior Exposed Insulation: Install continuous PVC jackets.

C. Exterior Exposed Insulation: Install continuous aluminum jackets and seal all joints and seams with waterproof sealant.

D. Install metal jacket with 2-inch overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 12 inches on center and at butt joints.

E. Install the PVC jacket with 1-inch overlap at longitudinal and butt joints and seal with adhesive.

F. Install glass cloth jacket directly over insulation. On insulation with a factory applied jacket, install the glass cloth jacket over the factory applied jacket. Install jacket drawn smooth and tight with a 2-inch overlap at joints. Embed glass cloth between (2) 1/16-inch-thick coats of lagging adhesive. Completely encapsulate the insulation with the jacket, leaving no exposed raw insulation.

3.13 FINISHES

A. Paint finished insulation as specified in Division 9 Section "Painting."

B. Flexible Elastomeric Cellular Insulation: After adhesive has fully cured, apply 2 coats of protective coating to exposed insulation.

3.14 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules on the drawings.

B. Interior, Exposed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Refrigerant suction.
2. Hydronic piping (100 to 250 degree F).

C. Interior, Concealed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Refrigerant suction.
2. Hydronic piping (100 to 250 degree F).

D. Exterior, Exposed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Refrigerant suction.

E. Exterior, Concealed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Refrigerant suction.

F. Duct Systems: Unless otherwise indicated, insulate the following duct systems:

1. Interior concealed supply, return and outside air ductwork.
2. Interior exposed supply, return and outside air ductwork.

3.15 PIPE INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:

1. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, S - Stainless Steel, C - Canvas, SWP - Shrink Wrap Polyurethane.
2. Pipe Sizes: NPS - Nominal Pipe Size.

3.16 EXISTING INSULATION REPAIR

A. Repair damaged sections of existing mechanical insulation, where damaged or removed for new connections. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

3.17 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 23 07 00

This page is intentionally left blank for printing purposes

SECTION 23 08 00 - MECHANICAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General Commissioning Requirements 01 91 00
B. Commissioning Checklists 23 08 00.01
C. All applicable provisions of the divisions 23, 26 and 28 also apply to this section.

1.2 SUMMARY

A. This section includes general requirements that apply to the implementation of the commissioning process in addition to section 01 91 00.

1.3 EQUIPMENT/SYSTEMS TO BE COMMISSIONED

A. The following equipment/systems will be commissioned in this project:

1. Chiller CH-1, pumps, and CT-1.
2. Chiller CH-2, pumps, and FC-2.
3. Air Control.
4. Glycol Feeders.
5. Existing Fan EF1 and new EF-2.
6. Building Automated Control System (BAS)

1.4 RESPONSIBILITIES

A. The general responsibilities of various parties in the commissioning process are provided in section 01 91 00. The specific responsibilities may also be identified in the Technical Specifications.

B. Mechanical Contractor, their subcontractors, and vendors shall assign representatives with expertise and authority to act on their behalf and schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

1. Provide detailed startup procedures
2. Include the cost of commissioning in the total contract price.
3. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents.
4. Attend and participate in commissioning team meetings. No later than 60 days prior to startup of the first piece of major equipment, meet with the CxA, CM, A/E, and PM and Owner to finalize the detailed commissioning procedures and schedule.
5. Review and accept construction checklists provided by the commissioning authority.
6. Complete construction checklists as work is completed and provide to CxA.
7. Accomplish commissioning process test procedures.
8. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
9. Cooperate with the CxA for resolution of issues recorded in the “Issues Log”.
10. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.
11. Provide the training of Owner personnel.
12. Ensure that subcontractors and vendors provide assistance for seasonal or deferred performance testing, performed by the CxA, according to the specifications.
13. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
14. Perform all warranty work for materials furnished under the contract for the time specified in the contract, including all warranties and curing all latent defects within the time period

provided in the contract.

C. TAB Contractor Responsibilities:

1. Contract Documents Review: With the CxA, review the Contract Documents before developing TAB procedures. Identify possible balancing device accessibility, effectiveness, and discontinuities in the Contract Documents (this TAB Subcontractor review of the Contract Documents may satisfy requirements specified in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" item 3.1.A).

2. In conjunction with CxA, TAB Contractor shall verify the following:
   a. Accessibility of equipment and components required for TAB Work.
   b. Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
   c. Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
   d. Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.
   e. Air and water flow rates have been specified and compared to rated equipment output capacities.
3. TAB contractor shall participate in 10% TAB airside and 5% waterside verification with CxA and Cx Team (this may satisfy requirements specified in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" Inspections item 3.23). TAB contractor shall provide final report for review to CxA prior TAB Verification.
4. TAB Contractor shall participate in tests as typically specified in sections "HVAC Instrumentation and Controls" and "Sequence of Operation."

D. HVAC Instrumentation and Control Contractor Responsibilities:

1. Assist CxA with review control designs for design compliance, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.
2. Assist CxA in preparation of BAS control tests.
3. Perform BAS control tests and complete prepared test forms for CxA review prior to CxA testing.
5. Attend TAB verification testing.
6. Contractor shall assist CxA to obtain trends of the system operating parameters to evaluate acceptable system functionality. The requirements of trending shall be specified with FPT procedures. Contractor shall establish these trends, ensure they are being stored properly, provide CxA web-based remote access, and forward the data in electronic format to the CxA.
7. Contractor shall assign adequate personnel and tools for FPT tests, and as required for scheduled retests.

E. Vendors

1. Provide all requested submittal data, including detailed startup procedures and specific responsibilities of the Owner to keep warranties in force.
2. Assist in equipment testing per agreements with subcontractors and/or contractor.
3. Include cost of all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing, operating, and maintaining equipment according to these contract documents in the base bid price to the contractor.
4. Analyze specified products and verify that the A/E has specified the newest, most current

equipment reasonable for this project's scope and budget.
5. Provide requested information regarding equipment sequence of operation and testing procedures.
6. Review construction checklists and test procedures for equipment installed by factory representatives.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to General Commissioning Requirements 01 91 00.

PART 3 - EXECUTION

3.1 COMMISSIONING MEETINGS

A. Refer to General Commissioning Requirements 01 91 00.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT

A. Refer to General Commissioning Requirements 01 91 00.
B. Refer to Commissioning Checklists 23 08 00.01.

3.3 OPERATIONS AND MAINTENANCE MANUALS / DATA

A. Refer to General Commissioning Requirements 01 91 00.

3.4 FUNCTIONAL PERFORMANCE TESTING

A. Refer to General Commissioning Requirements 01 91 00.

3.5 TRAINING OF OWNER PERSONNEL

A. Refer to General Commissioning Requirements 01 91 00.

3.6 DEFERRED TESTING

A. Refer to General Commissioning Requirements 01 91 00.

3.7 COMMISSIONING DOCUMENTS

A. Refer to General Commissioning Requirements 01 91 00.

END OF SECTION 23 08 00

This page is intentionally left blank for printing purposes

SECTION 23 08 00.01 - COMMISSIONING CHECKLISTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. General Commissioning Requirements 01 91 00

B. Mechanical Commissioning Requirements 23 08 00

C. All applicable provisions of the divisions 23, 26 and 28 also apply to this section.

1.2 SUMMARY

A. This section includes general requirements that apply to the implementation of the commissioning process in addition to section 01 91 00.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to General Commissioning Requirements 01 91 00.

PART 3 - EXECUTION

1.1 CHECKLISTS

A. Complete following installation checklists as work is completed and provide to CxA:

1. CHILLER CH-1
2. CHILLER CH-2
3. FLUID COOLER FC-2
4. GLYCOL FEEDERS
5. PUMPS

END OF SECTION 23 08 00

This page is intentionally left blank for printing purposes

SECTION 23 09 10 - BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Provide engineering, documentation, materials, equipment, components, installation, supervision, calibration, software programming, and checkout for a complete and operational Building Automation System (BAS).

1.2 PRODUCTS FURNISHED UNDER THIS SECTION AND INSTALLED BY OTHER TRADES

A. Supply the following to the Division 23 contractor to install in accordance with instructions from, and under the supervision of, the trade installing the BAS.

1. Automatic control valves.
2. Pipe or tank mounted switches.

1.3 WORK NOT INCLUDED IN THIS SECTION

A. The following equipment will be furnished and installed by other trades:

1. Power wiring including power to the Building Automation System DDC controllers to the extent it is shown under Division 26.
2. Fire alarm devices, fire alarm wiring, and fire alarm control panels.

1.4 RELATED SECTIONS

A. Division 23: Mechanical.

B. Division 26: Electrical.

1.5 REFERENCES

A. ANSI: American National Standards Institute, 1430 Broadway, New York, New York 10018.

1. ANSI 70-2 - Control Valve Seat Leakage.
2. ANSI B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.
3. ANSI B16.5 - Pipe Flanges and Flanged Fittings.
4. ANSI B16.34 - Valves Flanged and Butt Welded End.
5. ANSI C2 - National Electric Safety Code.

B. API: American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

1. RP 550 - Manual on Installation of Instruments and Control Systems.

C. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, Georgia 30329.

1. 135-2001 - BACnet - A Data Communication Protocol for Building Automation and Control Networks.

D. ASTM: American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

1. ASTM A 216 - Steel Castings, Carbon, Suitable for Fusion Welding for High Temperature Service.
2. ASTM A 269 - Seamless and Welded Austenitic Stainless Steel Tubing.
3. ASTM A 53 - Pipe Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless.
4. ASTM B 61 - Steam or Valve Bronze Castings.
5. ASTM B 62 - Composition Bronze or Ounce Metal Castings.
6. ASTM B 75 - Seamless Copper Tube.
7. ASTM B 280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
8. ASTM D 1248 - Polyethylene Plastics Molding and Extrusion Materials.
9. ASTM D 1693 - Environmental Stress Cracking of Ethylene Plastics.

E. IEEE: Institute of Electrical and Electronics Engineers, 445 Hose Lane, P.O. Box 1331, Piscataway, New Jersey 08855-1331.

1. 802 - Local and Metropolitan Area Networks: Overview and Architecture.
2. C62.41 - Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.

F. ISA: Instrument Society of America, P.O. Box 12277, Research Triangle Park, North Carolina 27709.

1. S75.01 - Flow Equations for Sizing Valves.
2. S75.03 - Face to Face Dimensions for Flanged Globe Style Control Valve Bodies (ANSI Classes 125, 150, 250, 300 and 600).
3. S75.04 - Face to Face Dimensions for Flangeless Control Valves (ANSI Classes 150, 300 and 600).
4. S75.11 - Inherent Flow Characteristics and Rangeability of Control Valves.

G. MSS: Manufacturer's Standardization Society, 127 Park Street, N.E., Vienna, Virginia 22180.

1. SP-69 - Pipe Hangers and Supports, Selection and Application.

H. NEMA: National Electrical Manufacturers Association, 2101 L. Street N.W., Washington, D.C. 20037.

1. ICS-1 - General Standards for Industrial Control and Systems.
2. ICS-2 - Standards for Industrial Control Devices, Controllers and Assemblies.
3. 250 - Enclosures for Electrical Equipment, 1000 Volts Maximum.

I. NFPA: National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.

1. NFPA 70 - National Electrical Code (NEC).

J. UL: Underwriters Laboratories, 333 Pfingsten Road, Northbrook, Illinois 60062.

K. Local building codes.

1.6 DEFINITIONS

A. BAS: Building Automation System.

B. DDC: Direct digital control:

1. Has digital input and output capability.
2. Has programmable proportional-integral-derivation (PID) control capability and combinations of these control capabilities.
3. Provide control loops with PID control algorithm.
4. Able to control equipment locally, independently of the front end hardware, using a dedicated microprocessor.
5. A designated and dedicated controller within the BAS system, thereby participating in global control of the building (ie., load shed, peak loading, etc.).
6. Enables the system sequences of operation, input/output summaries, and system operating descriptions.

C. I/O: Input and output points.

D. LAN: Local Area Network.

E. Power wiring: Wire or cable carrying nominal 120 volts and higher.

F. Instrumentation cable: Wire or cable carrying less than nominal 120 volts.

G. Control wiring: Wire or cable carrying nominal 120 volts or less.

1.7 SYSTEM DESCRIPTION AND DESIGN CRITERIA

A. Control Objectives and Concepts:

1. The BAS is a major element in providing effective management of the facility and its activities.
2. The BAS is required to strike a balanced function between economics, operating costs, energy, safety, and comfort.
3. Design the BAS for availability under equipment and power failures and adverse and emergency conditions possible within the building.
4. The BAS shall be able to run unattended. It shall provide manual interaction capability.
5. The BAS shall provide transaction histories of key events and produce hard copies of information on energy, occupancies, equipment data, etc., from the available data.
6. Items and details that are specified and shown on the drawings indicate the minimum elements and characteristics that shall be supplied. Furnish and install other products that are not mentioned, but are required to accomplish the control objectives and concepts.
7. The building has distributed mechanical systems and an energy plant which must automatically balance available energy with large variations in loads, occupancies, schedules and weather changes. Design the BAS to accomplish these objectives.

B. General:

1. The BAS is a software-based system providing both overall and local supervision, coordination and control of HVAC equipment, lighting, energy metering and points to provide a fully operational Building Automation System.
2. The BAS shall use DDC for control of equipment and devices.
3. The BAS shall be fully integrated and installed as a single complete package.
4. The BAS shall utilize standard products kept in inventory.
5. Provide, as a minimum, the number of DDC controllers indicated with location as shown on the drawings.
6. I/O summaries reflect an estimate of the BAS points required. Furnish and install additional points to accomplish the control sequences of operation and the control objectives and concepts defined.
7. Ensure the operation of motor driven equipment functions according to the sequence of operations. Where modifications are required, implement the modifications at no additional cost to the Owner. Do not implement the modifications until submitting to the Architect/Engineer a written description of the modification(s) and why the modifications are necessary.

C. System Speed:

1. System communication speed and response time at the time of BAS acceptance:

   a. Values of analog and digital points connected to the BAS shall be updated at least every 2 seconds for use by the DDC controllers. Points used globally shall comply with this requirement.
   b. Values of analog and digital points connected to the BAS shall be updated and displayed at least every 10 seconds for use by a BAS operator.
   c. Alarms of analog and digital points connected to the BAS shall be displayed within 2 seconds of activation or change of state.

D. Control Accuracy:

1. Accuracy shall meet the following end to end overall system accuracy, including errors associated with the sensor, transmitter, lead wire, and analog to digital converter. If the specified products cannot meet the accuracies indicated below, notify the Architect/Engineer and propose alternatives that will meet the accuracy.
2. Temperature:

   a. Air system temperatures: Within 0.5 degree F.
   b. Space temperatures: Within 1.0 degree F.
   c. Others not identified above: Within 1.0 degree F.

3. Relative Humidity:

   a. All: Within 5 percent RH over a range from 0 to 100 percent.

4. Pressure:

   a. Air Systems: Within 1 percent of design setpoint.

E. BAS Reliability:

1. Design, install and configure the BAS DDC controllers (both standalone and unitary) to yield a mean time between failure (MTBF) of at least 40,000 hours based on a

confidence level of at least 90 percent. The MTBF value shall include any failure for any reason to any part of a DDC controller.

F. Power:

1. Power Line Surges:

a. Protect equipment connected to AC circuits from power-line surges to meet the requirements of IEEE C62.41. Do not use fuses for surge protection.
b. Test the equipment protection in the normal mode and in the common mode, using the following two waveforms:

1) A 10 microsecond by 1,000 microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.
2) An 8 microsecond by 20 microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

c. Provide a power line conditioner for each control power circuit to provide both voltage regulation and noise rejection. The power line conditioner shall be of the ferro-resonant design, with no moving parts and no tap switching while electrically isolating the secondary from the power line side. Size for 125 percent of the actual connected KVA load. Characteristics of the power line conditioner shall be as follows:

1) At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal. Accomplish full correction of load switching disturbances within 5 cycles, and 95 percent correction within two cycles of the onset of the disturbance.
3) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

2. Ground Fault:

a. Protect the BAS equipment and products from ground fault by providing grounding. Equipment shall not fail under ground fault.

3. Emergency Power Source:

a. When controlling systems and equipment that are fed from an emergency power source, also feed the associated controls for the systems and equipment from an emergency power source.

G. Ambient Temperature and Humidity:

1. BAS (except the BAS workstation) shall be capable of operating under ambient environmental conditions of 32 to 100 degrees F dry bulb and 10 to 90 percent relative humidity, non-condensing. Field instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or encountered for the installed location.
2. Provide electrical, and electronic products that are not installed in a control panel with a NEMA 250 Type enclosure that is suitable for the installed location. Comply with the following unless a more stringent enclosure is specified:

a. Within ductwork and air-handling equipment: Type 4.
b. Unheated and non-heated areas: Type 12.
c. Heated and ventilated areas:

1) Filtered Ventilation: Type 1.
2) Non-filtered ventilation: Type 12.

d. Heated and air-conditioned areas: Type 1.
e. Mechanical Equipment Rooms:

1) Air-handling unit rooms: Type 1.

H. Software:

1. Provide software to support the functions specified as standard off-the-shelf software that is fully supported. No special "patches" or first-time software will be accepted. Provide the latest version of software available at the time of final acceptance.
2. Generate a data base and colorgraphic displays from the sequences of operation, input/output summaries, control schematics, logs and additional spare points to meet the BAS functions drawn and specified. Make additions and changes to databases and color graphic displays as a result of detailed design and review by the Owner and Architect/Engineer.
3. Provide, without additional cost to the Owner, software to implement the functions and achieve the overall BAS control objectives specified and clarified at the coordination meetings.
4. The BAS shall be programmable by the Owner.
5. Execute control functions within the DDC controller. Loop control shall be executed using direct digital control algorithms. The Owner shall be able to customize control strategies and sequences of control, and shall be able to define control loop algorithms and choose the optimum loop parameters for loop control.
6. Provide a PID loop for each analog output.
7. The BAS software shall incorporate an adjustable delayed starting sequence to prevent the instantaneous starting of motors. The software sequence shall function under normal and abnormal start conditions such as a power failure.
8. Create database and display I/O values with at least the following precision:

a. Relative Humidity:

1) All: x % RH.

b. Pressure:

1) Air Systems: x.x in. WC.

c. Temperature:

1) Air Systems: x.x deg. F.
2) Space: x.x deg. F.

d. Speed:

1) Fan: x %.

e. Position:

1) Valve: x % open.
2) Damper: x % open.

f. Voltage:

1) All: x.x volts.

g. Amps:

1) All: x.x milliamps.
2) All: x.x amps.

I. BAS Interfaces:

1. Provide a system control panel for, and located adjacent to each DDC Controller. Do not install products in the DDC controller enclosure, unless they are an integral part of the DDC controller.
2. Provide devices and wiring as indicated in the sequences of operation. Provide wiring between the field devices and the wiring terminals. Provide control devices and control wiring necessary to implement the sequences of operation which is not provided under Division 26.
3. Provide the hardware, software and installation to interface with equipment and systems, which are being controlled and monitored by the BAS. Refer to the sequences of operation, schematics, input/output summaries and to the individual Division 23 and 26 Sections for specific interface requirements. Integration options shall include:

a. Direct Protocol

1) The BAS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BAS system and 3rd party manufacturers' control panels. The BAS shall receive, react to, and return information from multiple building systems, including but not limited to the computer room air conditioners (CRAC's), variable frequency drives, and power monitoring system.
2) All data required by the application shall be mapped into the Network Controller's database, and shall be transparent to the operator.
3) Point inputs and outputs from the third-party controllers shall have real-time interoperability with BAS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Dial-Up and Local Area Network Communications.
4) The Facility Management System shall provide any combination of third-party controllers on a single network. A minimum of 100 third-party controllers shall be supported on a single network. Integration shall be via RS-232 or RS-485 technologies.
5) The system operator shall have the ability to verify, and diagnose communication messages and point information between third-party controllers and the BAS.

b. Neutral Protocol Integration - BACNet

1) The neutral protocol used between systems will be BACNet over Ethernet and comply with the ASHRAE BACNet standard 135-2001.
2) The BACNet System Integrator (BSI) will allow bi-directional communications between the host system and a BACNet system over an

Ethernet data link. Supported media shall include fiber, 10base2, and 10baseT.

3) A complete Protocol Implementation Conformance Statement (PICS) shall be provided for the Integrator and all BACNet system devices.
4) The BSI shall conform to BACNet conformance class 4, and provide the ability to monitor and control BACNet system points from the host system and host system points from the BACNet system.
5) The ability to share data and change of state (COS) between the host and BACNet systems shall be provided.

4. The fire alarm and detection system as specified under Division 26 shall have top priority in controlling systems and equipment. The fire alarm and detection system shall override BAS safeties including but not limited to:

a. Low limit temperature switches.
b. Pressure differential switches.
c. Software safeties.

5. Interface the BAS with the existing BAS:

a. The BAS operator for the existing BAS shall be able to monitor and control every input and output point in the new BAS from the existing BAS system, using the existing BAS system software.
b. The new BAS must maintain, as a minimum, the functionality of the existing BAS, and access to all existing points. Vendor to provide training on operation of the new BAS, and to include details of existing BAS interface.
c. The system performance requirements specified, shall be satisfied when monitoring and controlling the system from the existing BAS system.
d. Provide the software and hardware necessary to achieve the requirements specified.
e. Visit the site and become familiar with the existing system and the interface requirements necessary to achieve the requirements specified.

1.8 BAS NETWORKS

A. Wide Area Network:
1. The Building Automation System (BAS) hardware and software for this project must communicate with the existing Delta BAS throughout the campus, including Legacy Delta Controllers. Communication shall include exchanging full data between all schools on the network. Alarms, historical trending, and changes of value shall be e-mailed via the campus Intranet/Internet. Historical trending and changes of value shall display 1-8 points on a single graph.
2. The new system naming schemes for this project shall be consistent with current naming schemes throughout the campus.
3. The Intranet connection at this project must be Ethernet with TCP/IP Addresses for each panel (controller). Interface existing Delta products via BACnet and provide gateway to Legacy Delta controllers. The BAS for This project through the wide area network shall display, monitor, edit, modify and command all points/objects on all Delta controllers in all buildings on the network. The BAS at this project shall provide immediate access to all points/objects. The new BAS must facilitate a graphical interface.
4. The new BAS shall provide password protection consistent with the campus wide area network.
5. The new graphics must be compatible with and able to transfer to the Delta Controls Web Browser Software.

6. Modems or telephone connections shall not be permitted.

B. Architecture:

1. The network architecture shall consist of no more than 2 levels. A high level local area network (LAN) shall support Supervisory DDC controllers and BAS operator workstations and a low level LAN shall support unitary DDC controllers.
2. The network shall be modular and have the inherent ability to be expanded and modified without having to remove and replace existing equipment.
3. The high level LAN and low level LAN communication shall be transparent to the BAS operator. All I/O points residing on either LAN shall be global and be shared between both LANs.
4. Design the BAS to eliminate dependence upon any single device for alarm reporting and control execution. Each controller shall operate independently by performing it's own control alarm management and historical data collection.

C. General:

1. Provide separate and dedicated networks for BAS use only. Do not use a network that shares or serves other building systems.
2. Communication between the high level and low level LANs shall be through DDC controllers that are connected to both LANs.
3. Communication throughout the BAS shall use an open protocol. Provide protocol(s) and associated documentation to the Owner for future use by competitors to develop a communication interface with the BAS.

    a. If the BAS trade will not disclose information, all networks, controllers and communication within the BAS, shall support and comply with ASHRAE 135 (BACnet) to provide interoperability with a multiple vendor and multiple protocol system(s). Demonstrate compliance of this requirement.
    b. The Building Automation System (BAS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall not be limited to only use of open communication protocol standards, but be able to also integrate a wide variety of third-party devices and applications via existing vendor protocols and through the latest software standards.

4. Avoid the use of repeaters to amplify electronic signals. With Architect/Engineer approval, limited use is acceptable only on the high level LANs, and only if there is no other options.

D. High Level LAN:

1. Use an industry standard IEEE 802 protocol with commonly available, multiple source network equipment and products.
2. Data transfer and communication shall operate at a speed of at least 2.5 mega bits per second.
3. Ethernet is the preferred network, however, other technologies will be considered. If the Owner has standardized on another type of LAN for office automation, use that type for the BAS.
4. Provide for a combined total of at least 50 Supervisory DDC controllers and BAS operator workstations.
5. Provide for multiple user communications and multiple session activity.
6. BAS operator workstations and Supervisory DDC controllers shall reside on the high level LAN, with communications directly between controllers, directly between workstations, and between controllers and workstations, on a peer to peer basis.

7. Use supervisory DDC controllers, for control of primary systems and equipment, such as chillers, boilers, cooling towers, pumps, fans, air-handling units and roof-top units over 20 tons

E. Low Level LAN:

1. Limit the use of the low level LAN to data transfer and communication between unitary DDC controllers.
2. Data transfer and communication shall operate at a speed of at least 76,000 bits per second.
3. Limit the use of unitary DDC controllers to the following HVAC equipment:

   a. Variable Air Volume Units.
   b. Power Ventilators.
   c. Booster Coils.
   d. Unit Heaters.
   e. Fan Coil Units.
   f. Baseboard Radiation.

4. Connect VAV unit DDC controllers to the same DDC controller serving the VAV units' respective air-handling system.

F. BAS Operator Interfaces:

1. Access:

   a. Access to the BAS networks, through a computer workstation, notebook computer or dial-up communications shall not limit the BAS operator to availability of data.

   b. The hardware configuration of the BAS networks shall be transparent to the BAS operator when accessing data.
   c. If not already provided as a part of the BAS design, provide an easily accessible, properly protected and labeled high level LAN communication port in each mechanical equipment room. The communication port shall provide for connection of either a computer workstation or a notebook computer.

2. Computer Workstations: (Existing)

   a. Connect workstations to the high level LAN through a communications port directly on the LAN or through a communications port on a DDC Controller.
   b. Workstations shall be able to communicate with any device connected to either the high level or low level LANs.
   c. Workstations, with modems, shall be able to communicate remotely with any device connected to either the high level or low level LANs. Communication via a modem shall not interfere with LAN activity, nor shall LAN activity prevent the workstation from handling incoming calls.

3. Notebook Computers:

   a. Connect notebook computers to the high level LAN through a communications port directly on the LAN or through a communication port on a DDC Controller.
   b. Connect notebook computers to the low level LAN through a communication port on a unitary DDC Controller.

c. Notebook computers shall be able to communicate with any device connected to either the high level or low level LANs, regardless of the location of the physical connection to the BAS.
d. The notebook computer shall provide monitoring, programming, scheduling, setpoint adjustments and reporting capabilities of I/O connected anywhere in the BAS. Provide dynamic graphic displays on notebook computers that are identical to the workstations.

4. Dial-up Communications:

a. Through the use of a standard modem, the BAS operator shall be able to communicate with any device connected to either the high level or low level LANs.
b. Provide auto-dial and auto-answer communications to allow workstations, notebook computers and Supervisory DDC Controllers to communicate with remote workstations, remote notebook computers and remote Supervisory DDC controllers, via telephone lines.

1) Workstations and Notebook computers with modems:

a) BAS operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected via the local area network. Provide routines to automatically answer calls, and either file or display information sent remotely. Communications taking place over telephone lines shall be completely transparent to the BAS operator.
b) The Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers, so it is not required to remember or manually dial telephone numbers.

2) Remote Supervisory DDC Controllers:

a) Unless specifically indicated, DDC Controllers are not to be furnished with modems.
b) DDC Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
c) DDC Controllers shall analyze and prioritize alarms to minimize the initiation of calls. Buffer non-critical alarms in memory and report them as a group of alarms, or until a BAS operator manually requests an upload.
d) Make provisions for handling busy signals, no-answers, and incomplete data transfers. Call default devices when communications cannot be established with primary devices.

5. Internet Access: Provide remote access to the high level LAN and low level LAN through the internet to access the campus-wide intranet. Internet access shall include the capability of accessing all controllers along with their associated input/output devices. This access shall provide all monitoring, alarm reporting, and access to the entire system database.

G. Failures:

1. Provide detection and correction of single and multiple failures of either BAS operator workstations, notebook computers, supervisory DDC Controllers, unitary DDC Controllers and the network media itself. In the event of failure(s), provide automatic reconfiguration

of the network to allow all operational equipment to perform their designated functions. The automatic reconfiguration shall maximize the availability of data for global purposes.

2. Provide message and alarm buffering to prevent data from being lost. Use error detection, correction and retransmission to guarantee data integrity.
3. Ensure alarms, including no-signal response, are reported within 2 seconds of failure.
4. Failure of a supervisory DDC Controller that connects the low level LAN to the high level LAN shall not impair the operation of the low level LAN or the high level LAN.
5. In the event of LAN communications loss, a supervisory DDC controller and unitary DDC controller shall continue to monitor and control points reporting to it.
6. A computer workstation, notebook computer, DDC controller, and unitary DDC controller shall have the capability to lock out communication with discrete I/O point(s) anywhere in the BAS.

1.9 SUBMITTALS

A. General:

1. Submit shop drawings, product data and samples in accordance with the Section 01300.
2. Submit first a coordinated schedule for Architect/Engineer reviews and approval:

   a. List each proposed submittal. Designate by item, name and specification.
   b. Date of submission.
   c. Dates that reviewed submittal will be needed.
   d. Schedule of coordination meetings. Schedule shall include for each meeting: topics, date, time, duration, and location.
   e. Submission shall not begin until coordination schedule has been approved.

3. Before shop drawings and brochures are submitted for approval, certify that each separate drawing or each item of equipment complies with the drawings and specifications. Certification shall be in the form of a stamp which states:

   "This shop drawing or brochure has been checked prior to submittal to the Architect/Engineer and it complies in all respects, except as noted, with the requirements of the drawings and specifications.

   Signed _____

   Dated _____

4. Submit brochures that contain only information relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.
5. Obtain written approval from the Architect/Engineer for each sequence, schematic, and input/output summary before proceeding with implementation.
6. Shop drawings shall contain complete wiring, routing, and schematic diagrams, software descriptions, calculations, and details required to demonstrate that the system has been coordinated and will function as a system.
7. Keep shop drawings updated throughout the course of the work. Show field changes as well as contract modifications as they occur. At completion, provide 3 sets of as-built drawings and one set of 3 mil mylar (double matte) drawings to the Owner for final approval.
8. Submittals shall show sufficient data to indicate compliance with the contract documents.

a. Proper sizes and capacities.
b. The item will fit the available space and provide proper service.
c. Construction methods, materials and finishes.
d. Manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions for each product in the system.

9. Responsibility for errors and omissions in submittals is not relieved by the Architect/Engineer review and approval of submittals.
10. Responsibility for deviations from the requirements of the contract documents is not relieved by the Architect/Engineer, unless the Architect/Engineer gives written acceptance for each specific deviation.
11. Submittal sheets shall be sequentially numbered with the format sheet number of number. For example, 1 of 3.

B. The submittal shall be submitted in phases. Submittal phases shall consist of:

1. Phase I Documentation:

a. Submittals on products furnished by the BAS trade but installed by other trades.
b. Damper actuator sizing calculations.
c. Recommended installation details for products furnished to others for installation. Installation details shall include a bill of materials.
d. Electrical power requirements for each location.
e. DDC controller and control panel locations.
f. "Response to the specifications."
g. Installation instructions for products furnished.
h. Samples (if requested).
i. Control valve and actuator sizing calculations. Include the valve schedule.

2. Phase 2 Documentation:

a. Sequences of operation.
b. Schematics (with instrument operating ranges).
c. Input/output summaries.
d. Installation details for each type of field mounted device installed under this section. The installation detail shall include a bill of materials.
e. Submittal on products installed under this section.
f. Ladder type schematic wiring diagrams for each piece of controlled equipment. Include unique wiring and terminal designations. Typical diagrams are not acceptable.
g. Installation instructions for the products furnished.
h. Samples (if requested).
i. Software documentation.

3. Phase 3 Documentation:

a. Field wiring diagrams.
b. Provide control panel drawings which show main dimensions, materials of construction and interior equipment. Drawings shall include front and rear elevations and nameplate legend. Provide a unique drawing for each panel.
c. Provide field tubing diagrams and plan drawings showing instrument air connections and pneumatic accessories (valves, pressure gauges, etc.) at each pneumatic instrument located remotely from the control panel.
d. Provide a copy of each proposed final colorgraphic display to be installed on system panels for approval.

4. Phase 4 Documentation:

    a. As-built shop drawings.
    b. Drawings indicating detailed input/output connections. Include the terminal identification.
    c. Input/output lists describing the function of each input and output and associated addresses.
    d. Complete software documentation including analog input/output registers, timer/counter registers, internal coils used and other information required to allow future software addition without disturbing resident programs.
    e. Interconnection diagrams showing internal wiring connections between field mounted components and terminal boards within the panels.
    f. Instrument index and calibration schedule.

C. Response to Specifications:

1. The manufacturer shall submit a point by point statement of compliance with this specification Section.
2. The statement of compliance shall consist of a list of all numbered paragraphs. Each specification paragraph shall be cross referenced to the page/drawing in the submittal on which the compliance is confirmed; the confirming data on the page/drawing shall be highlighted.
3. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the paragraph number.
4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
6. Submissions which do not include a point by point statement of compliance as specified shall be rejected.

D. Documentation Requirements:

1. Provide technical specification data sheets for proposed products. Data sheets shall be referenced to products by specification Section, page number, paragraph, subparagraph.
2. The submittal shall contain a complete functional work statement which addresses aspects of the implementation of the BAS including, but not be limited to, the following:

    a. BAS central system configuration complete with peripheral devices, batteries, power supplies, diagrams, with interconnection diagrams.
    b. Complete detail on hard copy reports, summaries, and logs with respect to format and timing of events which cause their generation.
    c. Complete definition of system operation under failure conditions. Define other failure conditions not covered in this specification which are unique to the proposed system.
    d. Complete bibliography of documentation and media to be delivered to the Owner.
    e. Definition of factory, installation and acceptance test and plans and procedures to be generated in support of the test.
    f. Definition of training of operating personnel.

3. The application software submittal shall consist of a flow diagram and an outline of the subroutines that indicate each program variable name and the units of the variable.

    a. This document shall indicate the origin of constants that are used in the engineering equations and a reference source for the equations.

b. The software submittal shall include but not be limited to the following:

1) Complete and detailed operator interface definition for operator alphanumeric and graphic devices.
2) Complete network communications description for message handling, diagnostic and handshaking protocols.
3) Complete operation system description, including architectural aspects which affect the implementation of this particular system.
4) Complete definition of system data base file architecture, including capacities and limitations thereto.
5) Complete detail on hard copy reports, summaries, and alarm logs, both with respect to format and to timing of events which cause their generation.
6) Complete definition of system operation under failure conditions. Also, define any other failure conditions which are peculiar to the proposed system.
7) Complete definition of application programs and device drivers to be generated. Specific information on data acquisition and control strategies shall be included, showing their relationship to system timing, processing burden and system throughout.

4. Submittal Drawings:

a. General:

1) Floor plans shall be drawn to a scale of at least 1/8 inch equals 1 foot.
2) Identify and indicate location, layout and arrangement of equipment, components, materials and accessories.
3) Drawings shall be prepared on the same size sheets used by the Architect/Engineer (i.e. 24”x36” Full Scale or 12”x18” half scale).
4) Floor plan backgrounds shall show as a minimum walls, structural grid lines, and room names, room numbers, piping and ductwork. Screen backgrounds.
5) Title block requirements shall be established by Owner.
6) Provide a Symbol and Abbreviation Sheet with each drawing package.

b. Wiring Drawings:

1) Riser diagram of trunk wiring:

a) Conduit size.
b) Number, size and type of conductors.

2) Plan Drawings Showing:

a) DDC controller location.
b) Equipment, instruments, components, materials, and accessory locations.
c) Conduit size for field devices connecting to a DDC controller.
d) Number, size, and type of conductors for field devices connecting to a DDC controller.

3) Control Wiring Diagrams:

a) Control wiring diagram of motor controller circuits, interlocks, operating switches, relays, and interface to the BAS.

b) Point to point schematic wiring diagrams for each piece of equipment component, and accessory.
c) Wiring diagrams submitted shall be in accordance with NEMA Standards No. ICS-1 and No. ICS-2.

c. Include the following control valve information as a minimum. Set up the schedule on an Windows compatible computer in a data base format (dbf). In addition to the schedule, submit 2 copies of the data files. Follow the format example below using one page per valve.

1)	Item Number:	Example
2)	Tag:	AHU-1
3)	Equipment/Service:	
4)	Fluid:	Chilled Water
5)	Temperature (degrees F):	44
6)	Design Flow (GPM):	90
7)	Design (PSID):	7.0
8)	Valve Manufacturer:	Belimo
9)	Valve Model:	ET
10)	Valve Size (Inches):	2
11)	Body Type:	Globe
12)	Connection (Screwed/Flanged):	Screwed
13)	Valve Pressure Rating (PSIG):	400
14)	CV Design:	59.34
15)	CV Minimum:	1. 07
16)	Valve CV @ 10% Stem Travel:	1 .66
17)	Valve CV @ 20% Stem Travel:	2.93
18)	Valve CV @ 30% Stem Travel:	4.66
19)	Valve CV @ 40% Stem Travel:	6.98
20)	Valve CV @ 50% Stem Travel:	0.8
21)	Valve CV @ 60% Stem Travel:	16.5
22)	Valve CV @ 70% Stem Travel:	25.4
23)	Valve CV @ 80% Stem Travel:	37.3
24)	Valve CV @ 90% Stem Travel:	50.7
25)	Valve CV @ 100% Stem Travel:	59. 7
26)	Specified Valve Shutoff Pressure	200 (Ft of Water):
27)	Actual Valve Shutoff Pressure	60 (Ft. of Water):
28)	Actuator Manufacturer:	Belimo
29)	Actuator Model:	B6300
30)	Actuator Size:	40
31)	Actuator Fail Position:	Close
32)	Remarks:	

5. Provide an instrument index and calibration schedule for each of the following products: Actuators, positioners, sensors, switches, transducers, transmitters, valves and venturis. The schedule shall be set-up on an IBM compatible personal computer in a database format (dbf). In addition to the schedule, submit 2 copies of the diskettes. The instrument index and calibration schedule shall include the following information as a minimum. Follow the format example below using one page per instrument.

a.	Tag Number:	TE/TT 010012
b.	Instrument Description:	100 ohm platinum RTD spring loaded temperature element with thermowell and a 4-20 ma temperature

		transmitter
c.	Manufacturer and Model Number:	Rosemount Model 0078S-11N-0600, Rosemount Model 00444-RL1-N-1-A-2
d.	Location:	Building One, Level Zero, Room 000
e.	Service:	Chilled water supply
f.	Specification Reference:	Section 230910, page 000, paragraph x
g.	Electronic/Electric:	Electronic
h.	DDC Controller Reference:	DDC-0.01
i.	DDC Controller Location:	Building 1, Level Zero, Room 000
j.	DDC Controller Terminal Connections:	15,16
k.	Input/Output Type:	Analog input (AI) 4-20millamp
l.	Software Default Status:	42 degrees F (setpoint)
m.	DDC Controller "Power Off" Point Status:	
n.	DDC Controller "Power Return" Point Status:	
o.	Data Before Calibration:	
p.	Calibration:	32 degrees F at 4 millamps to 105 degrees F at 20 millamps
q.	Date of calibration:	
r.	Person Responsible for Calibration:	
s.	Temperature of Surrounding During Calibration:	
t.	Spare Parts Inventory:	
u.	Remarks:	

6. Submit data on the mean time before failure and the mean time to repair for each product.
7. Manufacturer's instructions:

    a. Comply with instructions in full detail, including each step in the sequence.
    b. Should the instruction conflict with the contract documents, request clarification from the Architect/Engineer before proceeding.

E. Product samples:

1. Provide to Architect/Engineer upon request (one) of each of the following, if requested:

    a. DDC controller.
    b. Temperature transmitter.
    c. Single point temperature sensor.
    d. Averaging temperature sensor.
    e. Inside air static pressure sensor.
    f. Differential air pressure transmitter.
    g. Space mounted temperature sensor/transmitter.
    h. Outside air static pressure sensor.
    i. Differential liquid pressure transmitter.
    j. Automatic control valve (complete with actuator and positioner).

2. Upon review, the products will be returned C.O.D. to the address defined by the party submitting the samples.

F. Resubmittals shall:

1. Respond to each of the Architect/Engineer's previous submittal review comments.
2. Clearly identify each change that differs from the previous submittal. Cloud changes made to drawings. Changes that are made and not identified, will not be considered.

1.10 BID SUBMITTAL

A. Provide with the bid, an original and four copies of, technical documentation describing elements of the system.

B. The following are guidelines for the desired technical and management details to be included with the bid. It is mandatory that the Architect/Engineer's specifications not be repeated back to the Architect/Engineer, but rather that the bidder give full exhibition to equipment, software and procedures which they intend to employ. The required submission will be used for technical review and evaluation and used to determine that the bid provides the minimum acceptable performance characteristic of equipment and design.

1. Equipment:

a. Utilize the bidder's most advanced equipment to provide a complete BAS. Where newly designed "one of a kind" items are required, make specific mention of this fact.
b. Where major components or subsystems are the products of different manufacturers, submit full and complete manufacturer's data.
c. When alternate software is bid, proof of existence of the software, similar to the required software, is required. Submit names, addresses, and telephone numbers of users of these software packages.

2. Future growth must be anticipated in the initial installation. Furnish specific information in the bid submission indicating the bidder's competence to perform this system expansion.
3. The technical documentation shall contain information to demonstrate the bidder's technical, design, managerial, planning, fabrication, and quality assurance capabilities.
4. The technical documentation shall demonstrate that the bidder has developed a sound technical approach to the design and fabrication of the BAS.
5. Demonstrate design capability by presenting a conceptual design of the BAS. This shall include descriptions of the procedures or computations used to generate the design.
6. Understand that the evaluation of the bid is based on compliance with the specification.

C. Information to be Submitted and Format:

1. Include a written detailed description of the intended system design. Pay particular attention to all points of equipment interface for compatibility.
2. Include manufacturers standard literature for items of equipment proposed. Review standard literature included to ensure information contained conforms to the specification requirements. Manufacturer's literature shall include, but not be limited to, the BAS computer with disk drives, color graphic CRT operator station, printers, modem, software package, DDC controller, temperature sensors, pressure sensors, thermostats, switches, transducers, relays, valves with operators and pilot positioners, dampers with operators and pilot positioners, communication wiring both standard and shielded, etc. Where the data is not available or sufficiently detailed, a written description may be given to ensure coverage of all pertinent technical aspects.

3. Submit a description of the planned communication links, engineering approach and justification, in sufficient detail for a clear understanding of the proposed lay out and future expansion, complete with schedules.
4. Specific items to be included in the submittal are described below. This basic presentation sequence shall be used to aid in evaluation. Format details are left to the discretion of the bidder.
5. Response to Specifications:

    a. Submit a point by point statement of compliance with the specifications as part of the technical documentation.
    b. The statement of compliance shall consist of a list of numbered paragraphs in the specification.
    c. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the paragraph number.
    d. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
    e. Where a full description of a deviation is not provided, it is assumed that the proposed system does not comply with the paragraph in question.
    f. Any bid submission which does not include a point by point statement of compliance may be disqualified.
    g. Provide with bid a listing of all test equipment required to service the BAS including cost associated with purchasing the equipment directly from the original manufacturer.

D. Description and Sequence of Information Required:

1. Statement of how the proposed effort will result in a BAS which meets the contract documents.
2. Description of the bidder including:

    a. Engineering design capabilities in mechanical engineering, control engineering, electrical engineering, and computer sciences, etc, as applicable.
    b. Description of management, planning, and quality control capabilities of a BAS, as applicable.
    c. Description of fabrication and on-site installation capabilities.
    d. Submit qualifications and experience resumes for management and engineering personnel to be used on this project.

3. Discussion of the engineering disciplines which are critical to the BAS design and the specific design aspects which are critical to a successful design. Sufficient detail shall be included to present the depth and breadth of the bidder's understanding of the BAS requirements and the design problems.
4. Description of the bidder's technical approach to the design and fabrication of the BAS including a listing of the proposed design and fabrication steps. A flow chart with appropriate narrative may be utilized. Detail shall be included to show clearly the technical and managerial rationale for the technical approach.
5. A conceptual design for the overall system described in detail and providing information as to the types, sizes, rating or capabilities, materials, characteristics and features of the components used in the system. Furnish manufacturer's standard literature on equipment in schedule form, with technical information. Major elements to be included are:

    a. Communication trunk lines.

b. System hardware including BAS computer, CRT operator stations, printers, modem, DDC controller, portable operator's terminal.
c. Software.
d. Sensing components and interface including temperature sensors, pressure sensors, thermostats, switches, transducers, relays, etc.
e. Products including valves, dampers, actuators, etc.

6. Submit drawings, specifications and calculations that clearly depict the descriptions of the technical approach, including but not limited to, functional block diagrams, communications layout, interfaces, control sequence schematics and response to specification. Show all signal flow between the BAS computer and DDC controllers.
7. Define the operational safety aspects of the system. Describe safety features and controls of the BAS and its major elements analyze system failure and detail emergency procedures for each failure. The analysis shall include, but not be limited to the following:

a. Loss of electric power.
b. Failure of computer.
c. Failure of individual DDC controllers.
d. Fire alarm condition.
e. Activation of a safety device, such as a low limit stat, or pressure switch.

8. Describe the system integrity including, but not be limited to the following:

a. Submit a reliability analysis including the mean time between failure of DDC Controllers. The analysis shall be based on the maximum use of standard commercial components and designs of proven performance and reliability. Average life and mean time between failure value documentation shall be a part of this evaluation.
b. Provide a bill of materials for major system components indicating whether parts are off the shelf or require special order. The list shall include other information necessary to answer the following questions:

1) Are components and component parts known brands which may be purchased from local suppliers?
2) If special order is required, what is estimated lead time for procurement?
3) Is a large inventory of components or component parts necessary to keep system operational?

9. Discuss the maintenance requirements of each major system component (include BAS computer, operator stations, printers, DDC controller with field terminal as a minimum) indicating whether routine maintenance may be accomplished with the system in operation, in place or off the site. Indicate also the length of time between routine maintenance and mean down-time of the system necessary to perform periodic maintenance.
10. Provide a written narrative describing the design procedure and computations which were used to produce the conceptual design. The conceptual design will be considered on technical merit, in addition to the bidder's demonstration and acknowledgment that the fixed requirements of the specification are met.
11. To aid the Architect/Engineer in the evaluation process, bidders are to present information in a single bound, loose leaf volume. Drawings may be submitted in a separate packet.

E. Bid Submittal Evaluation Procedure:

1. Technical documentation will be evaluated on, but not limited to the following criteria:

a. Overall system capabilities: System capabilities are dependent on compatibility between components and the use of the manufacturer or industry standards in the interaction between components. The use of known standard components and interaction methods must be demonstrated to ensure compatibility between the system and future additions to the system.
b. Provision of complete utility software: Provision of applicable utility software required due to special system configuration of equipment and as specified.
c. Address failure mode of BAS computer and DDC controller: Include failure of any given component for the equipment. Failure mode possibilities must be considered in providing a system which ensures continuous operation of building even if the BAS computer is down. Equipment failure caused by BAS computer failure will not be considered acceptable.
d. Effects of the system on controlled environments and equipment: Blind application without consideration of the personnel and equipment affected is not acceptable. Submit system designs which clearly consider the environmental effects on personnel and equipment and have provisions implemented to handle special cases of conflict between environmental control and energy control.
e. Maintainability of hardware: Discuss warranty period maintenance. Use comprehensive methods to enable fast and easy fault identification and subsequent quick and noncomplicated repair. Include adequate documentation of bidder's maintenance capabilities.
f. Flexibility and ease of system operation, programming and expansion: Demonstrate that flexibility for growth, programming and ease of operation are provided and that changes can be made by in-house personnel.
g. Full application of distributed processing: Only the centrally coordinated processes shall be lost when the BAS computer is down, with the use of intelligent DDC controllers in the field. The DDC controllers shall continue to operate and control the building and processes, with limited energy savings .
h. Correlation of software packages: Discuss interrelation of the system software as a factor in the event oriented processing system. Total correlation between the BAS computer and the DDC controllers is necessary to establish effectiveness and avoid failure either within the system or equipment connected to the system.
i. Effective utilization of memory: The effective and efficient handling of real-time data and the processing of that data into useful information and positive control action shall be dependent upon both main and auxiliary memory. Ensure and demonstrate that effective use of memory and adequate memory is provided to allow for future expansion.
j. Ease of operator interface from any of the operating stations. Integration of operator interface into system architecture.

2. Provide sufficient information to show that the bidder possesses the capability to conceive, engineer, and produce the BAS. Evaluation will include:

a. Project management capabilities such as years of experience and similar projects designed, installed and functioning.
b. Design engineering capabilities in the disciplines critical to the BAS.
c. Hardware capabilities.
d. Software capabilities.

3. Demonstrate that the bidder fully understands the requirements of the BAS, the technical disciplines involved, the specific considerations involved in the design, and the fabrication problems involved. Evaluation will include:

a. Bidder's general understanding of the BAS requirements.

b. Bidder's recognition of the general and specific design problems involved in the BAS.
c. Bidder's in-depth understanding of the design solutions to be achieved and how to achieve them, as evidenced by the submittal.

4. Confirm that the technical approach the bidder will use to design the BAS represents sound engineering practice.
5. The conceptual design is feasible in terms of current engineering, and manufacturing is sufficiently detailed to so demonstrate. Evaluation will include:

a. Does the concept item meet applicable industry standards and other specification requirements?
b. Bidder recognition of any special tolerance of fabrication aspect of his concept.

6. Maintenance program.

1.11 QUALITY ASSURANCE

A. Requirements Included:

1. Quality control of products and workmanship.
2. Manufacturer's instruction.
3. Manufacturer's certificates and field services.

B. Description:

1. Maintain quality control over:

a. Supervision.
b. Subcontractors.
c. Suppliers.
d. Manufacturers.
e. Products.
f. Services.
g. Workmanship.
h. Site conditions.

2. Produce work in accordance with contract documents.

C. Quality Control Program:

1. Provide and maintain an effective quality control program and inspection system to ensure that supplies and services required under the contract conform to the specifications. Maintain and make available to the Owner and Architect/Engineer adequate records of the inspections.

D. Workmanship:

1. Comply with industry standards except when more restrictive tolerances are specified requirements indicate more rigid standards or more precise workmanship.
2. Provide qualified personnel to produce work of specified quality.
3. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and cracking.

4. Provide finishes to match approved samples.

1.12 COORDINATION MEETINGS

A. Demonstrate and review the progress of the BAS installation with the Owner and the Architect/Engineer.

B. Meeting schedule shall be determined following the awarding of the contract. Refer to submittal paragraph for coordination meeting schedule submittal procedure.

C. Exact locations, dates and times will be determined following the awarding of the contract. Location of meetings shall be at project site unless otherwise approved by Owner.

D. Design meetings to involve the Owner and the Architect/Engineer with the design and implementation of the BAS.

E. Meeting topics: System architecture, BAS hardware including BAS computer, operator stations, printers, DDC controllers, software, interfaces to other systems, installation schedule, coordination with other trades, system documentation, color graphics, alarms, and other topics.

1.13 WARRANTY

A. General:

1. The guarantee and warranty period shall be as specified under the General Conditions. Begin the warranty period at the successful completion of the endurances test specified under BAS acceptance.
2. The Owner will notify the BAS trade of failure and observed defects in the system during this period.
3. Corrections to the work during this period, shall be at no cost to the Owner.

    a. Guarantee response time to the site shall be no longer than 12 hours following the call from the Owner.

4. Emergency service shall be available to the Owner on a 24-hour a day basis during this period. No overtime premium shall be charged during the warranty period.
5. Furnish new and install or repair and replace products to specified quality.

B. Procedures:

1. Before starting corrections during the warranty period, conform to the Owner's established policy for work on his premises.
2. Before service arrives at the project site to perform the corrective work, notify the Owner.
3. Upon completion of the corrective work, file a signed copy of the service report with the Owner. Acceptance of corrective work must be acknowledged by the Owner.
4. If the corrective work requires more than 24 hours to complete, notify the Owner and give an estimate of the completion date.
5. Modification, alteration, addition or removal of hardware or software from the BAS shall be performed off-line.
6. Maintain at the site a written maintenance, modification, and repair log:

    a. Record in the Log:

1) Each incident of equipment malfunction.
2) Date, time and duration of all maintenance and repair work performed on the equipment.
3) A description of the cause for the work.
4) Diagnostic report of corrections or adjustments.
5) Parts repaired and parts replaced.
6) A narrative of all special events.

b. The information in the log shall be aggregated into a management report, delivered on a monthly basis to the Owner.

C. Routine Maintenance During the Warranty Period:

1. During the warranty period, provide normal maintenance service as recommended by the manufacturer.
2. Maintenance shall include but is not limited to:

a. Equipment.
b. Components/Instruments.
c. Accessories.
d. Materials.
e. Hardware.
f. Software maintenance and updates.

D. Scheduled Maintenance:

1. Provide a computer program to schedule preventive maintenance activities.
2. During the inspection of each element in the BAS, make instrumented tests and adjustments. Repair faulty equipment and replace worn parts.
3. Schedule at least two minor inspections and one major inspections during the warranty period.
4. Minor inspections: Schedule minor inspections with the owner 3 & 7 months after BAS Acceptance. Minor inspections shall include the following tasks:

a. Visual checks of the BAS.
b. Adjustments.

5. Major inspections: Major inspections shall occur prior to the end of the warranty period or the warranty period shall be extended until such inspection has been completed at the contractors expense. Scheduled major inspections with the owner 11 months after BAS acceptance. Include all minor inspection work plus the following:

a. Exercise scan and command functions.
b. Verify displays, printouts and logs.
c. Demand each point in system and check display.
d. Test start, stop and auto functions.
e. Cause alarms and check displays.
f. Verify alarm return-to-normal.
g. Clean and vacuum equipment.
h. Field check and calibrate equipment, components and accessories.
i. System software diagnostics and correction.
j. Resolution of Owner's problems.

6. Provide additional routine preventive maintenance on the BAS computer and peripherals as recommended by the equipment manufacturer.

7. Maintenance shall be scheduled prior to implementation and Contractor shall submit a report of the visit to the Owner.

E. Seasonal Test:

1. During the warranty period, not later than 6 months from completion of the endurance test, conduct a 10-day seasonal test to demonstrate that the BAS functions properly during the opposite climatic season.
2. Provide printed logs of the test results.

F. Damages:

1. Repair damages resulting from repair work.

1.14 SPARE PARTS

A. Supply recommended spare parts lists and the actual spare parts to accomplish the system's operation during the warranty period. These parts must be delivered with the system itself and be continually stocked on the Owner's premises.

B. Provide a spare parts list and price list for the recommended spare parts to maintain the BAS after the warranty. Submit these lists with the as-built shop drawings.

1.15 OPERATION AND MAINTENANCE MANUAL

A. General: Provide 3 copies of an operation and maintenance manual bound in a hardback, loose-leaf binder, to the Owner after BAS acceptance. The manual shall include the names, addresses and telephone numbers of each trade installing products, and of the nearest service representative for each product. The manual shall have a Table of Contents and tab sheets. Update manuals to include modifications made during installation, checkout and acceptance. The manual shall include as a minimum the Sections described in the following paragraphs.

B. Functional design section: The functional design section shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. Hardware and software functions, interfaces, and requirements shall be provided for all system operating modes.

C. Hardware section: The hardware section shall describe equipment provided, including general description and specifications, installation and checkout procedure, electrical schematics and layout drawings, alignment and calibration procedures, manufacturer's repair parts list indicating supply sources, interface definition, signal identification and timing diagrams.

D. Software section: The software section shall describe programming and testing, starting with a system overview and proceeding to a detailed description of each software module, instruct the user on programming or reprogramming any portion of the BAS and other information necessary to enable proper integration, loading, testing, and program execution.

1. Complete electronic schematic wiring diagrams for printed circuit boards, and all peripheral devices included in these specifications.
2. Complete software program flow charts for system indicating interactions of all software.
3. Complete software listing including parameter listing in the computer language being provided.

4. An operator's reference table listing the addresses of all connected input points, output points and unguarded software parameters. Settings shall be shown where applicable.

E. Operation section: The operation section shall provide instructions for operation of the system including as a minimum; operator instruction on man-machine interface, system startup procedures, use of system and applications software, alarm presentation (where applicable), failure and recovery procedures, preventative maintenance schedule, parameter schedules and sequence definition, and system access requirements. Include computer programs and data files into the related computers including all control programs, initial approved parameters and settings, English descriptors, and color graphics complete with dynamic dispersed data. In addition, the following, to be user implemented, shall have samples installed for training and validation:

1. Bar chart (four different bars on one chart).
2. Curve plot (five curves on one plot).
3. Trend log.
4. Alarm message (action taking message).
5. Run time maintenance message.
6. Trouble action message.

F. Maintenance section: The maintenance section shall provide descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair of replacement of defective components.

G. Maintain flash-drive or CD copies of data file and application software for reload use in the event of a system crash or memory failure, including DDC controller programs. Deliver one copy to the Owner during training session, and archive one copy in the BAS trades local software vault.

1.16 DELIVERY, STORAGE AND HANDLING

A. Handle products carefully to prevent damage, breaking, denting and scoring. Do not install damaged products.

B. Deliver and store products in a clean and dry place. Protect products from the weather, dirt, dust, water, construction debris and physical damage.

C. Comply with the manufacturer’s rigging and installation instructions for unloading and moving to the final installed location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers’ acceptable contingent upon strict compliance with the specification. Manufacturers’ shall provide products and installation.

1. Delta Controls.
2. Trane Controls.

B. The BAS shall be supplied and installed by a trade specializing in such work for at least 10 years.

C. The BAS trade shall have a local office staffed with factory trained engineers and system technicians fully capable of providing instruction, routine maintenance, and emergency service on all system components.

D. The BAS manufacturer shall have documented proof, for Architect Engineer review, that the BAS trade has resident factory trained personnel and all areas and scope of the BAS. Manufacturers who do not have a BAS trade, with factory trained staff, are not acceptable.

2.2 MATERIALS

A. General:

1. Use materials in the system that are:

a. In compliance with applicable codes.
b. Selected to prevent corrosion and galvanic action.
c. New, never used.

2.3 PIPING AND TUBING

A. Pneumatic Tubing and Piping:

1. Copper Tubing:

a. Copper tubing shall be seamless phosphor deoxidized copper, soft annealed of drawn tempered with chemical and physical properties in accordance with ASTM B-75. Dimensions weights and tolerances shall be in accordance with ASTM B-280. Minimum tube wall thickness shall be 0.030 inches.
b. Fittings for copper tube shall be brass compression type fittings similar to Parker CPI or brass solder joint type similar to Mueller Brass type “Streamline.”

2. Polyethylene Tubing:

a. Polyethylene tubing shall be fire-resistant, plenum rated black virgin polyethylene ASTM D 1248 type 1 class C grade 5. Tubing shall meet stress crack test ASTM D 1693.
b. Fittings for polyethylene tubing shall be compression type similar Parker “Poly-Tite”.

2.4 WIRE, CABLE, CONDUIT

A. Wire:

1. Single Conductor Control Wiring above 24 volts:

a. Wire size shall be at least No. 16 AWG.
b. Conductor shall be 7/24 soft annealed copper stranding with a 2 inch to 2-1/2 inch lay.

c. Conductor insulation shall be 600 volt, type THWN or THHN, 90 degrees Celsius per UL 83.
d. Conductor colors shall be black (hot), white (neutral), green (ground).
e. Furnish wire on spools.
f. Basis of design: Okonite Okoseal N-Type.

B. Cable:

1. Single Twisted Shielded Instrumentation Cable above 24 volts:

a. Wire size shall be minimum No. 18 AWG.
b. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2 inch to 2-1/2 inch lay.
c. Conductor insulation shall have a type THHN/THWN or TFN rating.
d. Shielding shall be 100 percent type .35/.5 mil aluminum/mylar tape, helically applied with 25 percent overlap, aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.
e. Outer jacket insulation shall have a 600 volt, 90 degrees Celsius rating and shall be type "TC" cable.
f. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
g. Furnish wire on spools.
h. Basis of design: Dekoron IC52-67000.

2. Single Twisted Shielded Instrumentation Cable 24 volts and lower:

a. Wire size shall be minimum No. 18 AWG.
b. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2 inch to 2-1/2 inch lay.
c. Conductor insulation shall have a nominal 15 mil thickness, constructed from flame retardant PVC..
d. Shielding shall be 100 percent type 1.35 mil aluminum/polymer tape, helically applied with 25 percent overlap, aluminum side in with a No. 20-22 AWG tinned copper drain wire.
e. Outer jacket insulation shall have a 300 volt, 105 degrees Celsius rating and shall be type PLTC cable.
f. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
g. Furnish wire on spools.
h. Basis of design: Okonite Type P-OS .

3. LAN Cable:

a. Comply with the requirements dictated by the BAS manufacturer, contingent upon compliance with the following:

1) The cable is plenum rated.
2) The cable complies with NFPA 70.

C. Power Wiring:

1. General:

a. All power wiring, class 1, 2 or 3 wiring required for satisfactory installation and operations of all equipment required on this project for the section of work

specified under temperature control shall be supplied and installed by the Temperature Control Contractor (TCC).

b. All wiring shall be installed in accordance with all applicable electrical codes and shall comply with equipment manufacturer's recommendations.

c. The TCC shall be responsible for all required permits for his work.

2. Wire and Cable

a. All wire shall be copper THHN and meet the minimum wire size and insulation class listed.

Wire Class	Min. Wire Size	Min. Insulation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge	600 Volt
Class Two	18 Gauge	300 Volt

3. Power wiring shall be in accordance with Division 26 specifications.

D. Conduit:

1. Conduit shall be EMT type, minimum 1/2” for control and communications and minimum 3/4” for power.

2.5 DDC CONTROLLERS AND CONTROL PANELS

A. Stand-alone direct digital supervisory DDC control units (Supervisory controllers):

1. General:

a. Each Supervisory DDC controller shall perform both control functions and energy management routines as defined by the operator.

b. Each supervisory DDC controller shall employ a microprocessor based, multi-tasking, multi-user, real time digital control processor featuring:

1) Distributed database, and distributed intelligence on the network.

c. Each supervisory DDC controller shall be capable of full operation:

1) As a completely independent unit.
2) As a part of a system wide distributed BAS network.

d. Equip each supervisory DDC controller for interface to the I/O connected to it.

e. Construct each supervisory DDC controller so that all functions are implemented on replaceable circuit boards to permit field maintenance.

1) The number of input/output spares per DDC controller shall be equal to 20 percent of each type (analog input, analog output, digital input, digital output) of the tatal implemented input/outputs with a minimum of 3 points for each, analog inputs, analog outputs, digital inputs, digital outputs.

f. Provide the supervisory DDC controller with:

1) Main power switch.
2) On-off line switch: Enables and disables communications with BAS network.

3) Reset button: Initializes BAS operation.
4) DDC controller outputs disable switch: Forces data environment (point definition, operating parameters, control loops, etc.) to failure mode.
5) Power on LED indication: Includes one for each power supply voltage.
6) On line (network communication), LED indication.
7) LED indication self test of DDC controller for communications functions.
8) DDC controller outputs disabled, LED indication.
9) LED status indication for each digital input and output.

g. Provide a real time clock maintaining hours; minutes, seconds, day of the week; accurate to plus or minus 1 second per day.
h. Provide for each supervisory DDC controller the RAM and or PROM that is required to implement the specified functions for a fully loaded DDC controller. At BAS acceptance, each DDC controller shall not use more than 80 percent of its installed RAM and or PROM. Provide sufficient memory to support the DDC controller's operating system and data bases, including;

1) Control Processes.
2) Energy Management Applications.
3) Alarm Management.
4) Historical Trend Data for all I/O Points.
5) Maintenance Support Applications.
6) BAS Operator Interfaces.
7) Monitoring of Manual Override.

i. Provide a communications interface and associated drivers for communications between the DDC controller and the BAS computer, laptop computer, and bulk loading device.
j. Provide battery back-up for all volatile memory required for DDC controller operation in the stand alone (noncommunicating) mode and for operation in the startup mode.

1) Provide a sealed battery backup capable of supporting memory within the DDC controller for a period of 72 hours.
2) Provide circuitry to eliminate erratic operation due to low battery charge, sensing battery performance to execute an orderly shut down before the electronic minimum operating point is reached.
3) Provide automatic charging of batteries and an operating alarm point indication that the DDC controller is under battery power.

k. Upon restoration of power, the DDC controller shall automatically begin program execution, based on a Architect/Engineer and Owner approved starting sequence.
l. Where internal air circulation is required for reliable operation, install fans with finger guards. Monitor the internal enclosure temperature and alarm at the BAS computer workstation if high limits are exceeded.

2. Enclosure:

a. Provide NEMA 250 Type 1 enclosure in mechanical equipment rooms. Enclosure shall be Underwriter's Laboratories listed for line voltage applications.
b. Construction shall be of minimum 18 gauge steel. Support the front door using a non-removable piano type hinge which runs the entire height of the enclosure. Fit the door with a key locking latch. The enclosure shall not exceed 36 inches wide by 48 inches high. Locks shall be common keyed. Provide one pair of keys per DDC controller.

c. Finish the enclosure exterior with baked enamel at least 5 mils thick. The color to be manufacturers standards. Finish panel interiors white.
d. Size the enclosure to provide a minimum of 25 percent spare area on the enclosure sub-panel.
e. Arrange the enclosure so similar type equipment is grouped together.
f. Interior ambient temperature shall not rise above the manufacturer's recommended maximum operating temperature for products installed within. Provide filtered louvers and circulating fans, when necessary, to meet this criteria.
g. Mount equipment within the control enclosure on an internal panel(s). Equipment shall have nameplates. Provide engraved, laminated phenolic nameplates (white letters on a black background). Nameplates shall have a at least 1/4 inch high lettering.
h. Provide brackets to mount the enclosure on a wall or a floor supported structural channel frame.

3. Communication:

a. Each Supervisory DDC controller in the network shall share point information such that control routines executed at one Supervisory DDC controller may receive inputs from any other controller within the network.

1) If the network communication trunk line fails or other DDC controllers malfunction, the control loop shall continue to function using the last value received.
2) If the network communication trunk line fails, send a message to alarm the BAS of a failure.

b. Provide communication between the BAS network and all controllers (both supervisory DDC and unitary DDC) including:

1) Download transmission of system and application software, operating parameters and constraints.
2) Upload transmission of data, including parameters of the data environment (point definitions, operating parameter, control loops, etc.) and constraints.

c. Initial controller parameters shall be downloaded from the BAS workstation or notebook computer. Enter changes to RAM resident controller parameters using BAS computer. Software from the BAS computer shall be downloaded to the proper controller for execution. Perform controller parameter changes with any controller on-line.

1) The operator shall be able to initiate a download of the disk file containing a copy of the DDC controller data base from the BAS computer to the DDC controller. After downline loading, the operator shall be able to initialize and start full operation of the DDC controller from the BAS computer.

d. A DDC controller return from power failure shall result in a request for initialization, if required, and shall be reported to the BAS network.
e. A DDC controller initialization request shall result in the downloading from the BAS computer RAM based system and application software, operating parameters, and constraints.
f. Provide error checking techniques of field communications.

4. Maintenance and support:

a. Provide the following minimum features to facilitate maintenance and support.

1) Mount circuit components on circuit cards for ease of removal and replacement.
2) Disconnect mechanism to allow for disconnect from the communications trunk. Additionally, provide a quick access connector so that, when the DDC controller is isolated from the trunk, it may be connected to field test equipment.
3) Primary power, logic power, and excitation power on indicator lights along with indicator lights that demonstrate that the DDC controller is receiving and sending transmissions on the communications trunk.

b. Provide an auxiliary 110 volt AC duplex power outlet at the DDC controller to connect test equipment.

B. Unitary DDC Controllers:

1. General:

a. Temperature operating limits shall be as least 32 to 110 degrees F.
b. Humidity operating limits shall be at least 5 to 90 percent relative humidity, non-condensing.
c. The DDC controller, laptop computer, and BAS computer shall be capable through the unitary DDC controller of monitoring the following:

1) System status (heat, cool, out of range).
2) VAV unit primary airflow (cfm).
3) Space temperature (degrees F).
4) Space temperature setpoint for heating and space temperature setpoint for cooling during both occupied and unoccupied modes of operation.
5) Maximum and minimum VAV unit primary air flow limits (cfm).
6) VAV unit primary air damper position (percent open).
7) Fan status (on/off).
8) Heating energized (on/off) for each stage.

d. The DDC controller, laptop computer, and BAS computer shall be capable through the unitary DDC controller of controlling the following:

1) Space temperature setpoint for heating and cooling during both occupied and unoccupied modes of operation.
2) VAV unit primary air damper position.
3) Heating energized and de-energized setpoints for each stage of heat.

e. Provide PID control algorithm.

2. Controller:

a. The controller shall consist of a microprocessor on a single board. The controller shall accept inputs and provide multiple control strategies in software to control outputs as defined in the sequences of operations.

3. Laptop Computer:

a. Connections for the laptop computer shall be provided directly at the unitary DDC controller, or room temperature sensor.

4. VAV unit controls:

    a. Differential pressure/flow transducer:

        1) The transducer shall be able to utilize the pneumatic airflow pick-up furnished by the VAV unit manufacturer. Air variance in the airflow pick-up signal shall be compensated for through programming. Transducer accuracy shall be plus or minus 1 percent of calibrated span.

    b. Damper actuator:

        1) The damper actuator shall be replaceable. The actuator shall produce a minimum torque of 40 inch-pound at the damper axle and be capable of rotating through 45 degrees in less than 2 minutes while fully loaded. The actuator shall be powered directly from the VAV unit DDC controller.
        2) Actuator motor shall be of the non-stall type and shall de-energize when the damper has reached the signaled position.
        3) The damper actuator shall provide a minimum of six positions of feedback for the damper movement.
        4) Refer to the sequence of operation for the fail position of the actuator. If a fail position is not indicated, use fail in last position.

    c. Provide pressure independent control capable of controlling the primary airflow within 5 percent of setpoint.

5. Occupant override:

    a. Provide each unitary DDC controller that controls space heating and cooling with an occupant override feature that consists of an occupied/unoccupied push button and a separate temperature setpoint gradual dial.
    b. The occupant override shall be an integral part of the space temperature sensor, if available. If not available, provide a separate device that is mounted adjacent to the space temperature sensor and provide it with a hinged cover that matches the space temperature sensor.
    c. If enabled by the BAS operator, the occupant override feature shall allow the occupant to:

6. Change from unoccupied mode to occupied mode for a predetermined time period that is established by the BAS operator.
7. Adjust the temperature set point within predetermined limits that are established by the BAS operator.

C. System Control Panel:

1. Provide a system control panel located adjacent to each stand alone DDC controller satisfying the following requirements:

    a. Design the panel for grouping and protecting various, electric, and/or electronic components that are not an integral part of the DDC controller. The control panel shall be Underwriter's Laboratories listed for line voltage applications. The panel shall be a NEMA 250 Type 1 enclosure for inside mechanical equipment rooms.
    b. Construct the panel of at least 18 gauge steel. Support the front panel using a non-removable piano hinge which runs the entire height of the cabinet. Fit the panel with a key locking latch. Each panel shall not exceed 36 inches wide by 48 inches high. Common key the locks, and provide one pair of keys per panel.

c. Provide brackets to mount the panel on a wall or a floor supported structural channel frame.
d. Paint the control panel exterior with enamel at least 5 mils thick. Match the color with the DDC controller enclosure. Finish the panel interior in white.
e. Size the control panel to provide at least 25 percent spare area on the sub-panel.
f. Arrange the control panel so similar type equipment is grouped together, and a barrier is installed between electrical and electronic equipment.
g. The interior ambient temperature shall not rise above manufacturer's recommended maximum operating temperature for products installed within the panels. Provide filtered louvers and circulating fans, when necessary, to meet this criteria.
h. The panel shall serve as a central electrical tie-in point for electrical control devices such as electric switches, relays, switches, remote sensors, transmitters, transducers, power supplies and transformers.

    1) Factory install internal wiring in conformance with specified standards.
    2) Terminate wiring using a electric terminal strip with heavy duty terminal blocks. Provide spare terminals, equal to not less than 10 percent of the used terminals. Provide spare lugs for stranded wire. Install a maximum of two wires on each side of a terminal.
    3) Develop, an Architect/Engineer approved, wire numbering system and utilize that system to identify and tag wiring within the control panel.

i. Factory install panel air piping. Polyethylene tubing may be used within the panel enclosure, in place of copper.
j. Supply each control panel with a complete set of as-built schematics, tubing, and wiring diagrams that are bound in a 3-ring protective binder and located within the panel.
k. Mount equipment within the control panel on an internal panel(s). Provide equipment with nameplates. Provide engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4 inch high lettering.
l. Route tubing and wiring located inside the control panel within a raceway that has a continuous removable cover.
m. Enclosure basis of design: Hoffman A series.

2.6 DAMPER ACTUATORS

A. Damper Actuators:

1. General:

a. Size damper actuators to operate the related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and the proper speed of response at the velocity and pressure conditions to which the damper is subject.
b. Actuators shall produce sufficient torque to close off against the maximum system pressures encountered. Size the actuators to close off against the fan shut-off pressure, as a minimum.
c. The total damper area operated by an actuator shall not exceed 80 percent of the manufacturer's maximum area rating. Provide one actuator for each damper assembly.

d. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
e. Use line shafting or shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
f. Provide mounting hardware and linkages for connecting the actuator to the damper.
g. Provide actuators arranged for "Fail Safe" operation in the event of a power failure. Refer to the drawings for fail positions.

2. Electric Actuators:

a. Provide hydraulic or gear type electric actuators.
b. When operated at rated voltage each actuator shall deliver the torque required for continuous uniform movement of the control device from limit to limit.
c. Provide an end switch to limit travel and design the actuator to continuously stroke without damage.
d. Actuators shall function properly within a range of 85 to 120 percent of line voltage.
e. Actuators with input power less than 100 watts may use fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings and pressed steel enclosures.
f. For actuators with input power greater than 100 watts the gears shall be ground steel, oil immersed, the shaft shall be hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast iron, cast steel or cast aluminum housing.
g. For an actuator greater than 400 watts input, provide totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
h. Two position actuators shall be of the single direction, spring return or reversing type.
i. Proportioning actuators shall be capable of stopping at all points in the cycle and starting in either direction from any point.
j. Reversing and proportioning actuators shall have limit switches to limit travel in either direction.

2.7 VALVES AND VALVE ACTUATORS

A. Control Valves:

1. General:

a. Determine the control valve sizes and flow coefficients by ISA S75.01.
b. Modulating control valve body dimensions shall conform to ISA S75-03.
c. Control valve characteristics and rangeability shall conform to ISA S75.11.

2. Design criteria:

a. Unless otherwise specified, rate control valves in water systems for 200 psig at 200 degrees.
b. Control valve shut-off classifications are not less than Class IV based upon ANSI 70-2.
c. Water valves are three-way or straight through pattern as indicated on the schedules and sequences.
d. Modulating straight through pattern control valves shall have equal percentage flow throttling characteristics.

e. Provide modulating three-way pattern water valves with linear flow throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
f. Modulating butterfly valves shall have either linear or equal percentage flow throttling characteristics.
g. Chilled water valves shall fail closed, and hot water valves shall fail open, unless otherwise indicated. Steam valves are fail open, unless otherwise indicated.
h. Size control valves to pass the design flow required with not more than 95 percent of stem lift, unless otherwise noted on the drawings. Consider viscosity, flashing, and cavitation corrections.
i. In water systems, size modulating control valves at terminal equipment for a pressure drop of 3-5 psid at design flow, unless otherwise noted on the drawings.
j. Size modulating valves in steam service with a pressure drop at design flow equal to the lesser of:

1) 50 percent of the valve inlet pressure.
2) 50 percent of the absolute steam pressure at the valve inlet.

k. Use line size two position control valves, unless otherwise indicated.
l. In water systems, use globe style control valves for two position control valves through 2 inch and butterfly style for larger sizes. In steam systems, use globe style control valves regardless of size.
m. Two position control valves shall provide a smooth opening and closing characteristic. Provide an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from 0 to 10 seconds. Opening and closing times shall be independently adjustable.

3. Globe style valves:

a. General:

1) Construct the valves to be serviceable from the top.
2) For cage guided valves, provide interchangeable trim for other valve flow characteristics such as, linear and quick opening.
3) Reduced trim for one nominal size smaller shall be available for all valve sizes 1 inch and larger.
4) Replaceable seats and plugs.
5) Furnish each control valve with a corrosion resistant nameplate, permanently fastened with drive-screws and stamped as follows:

a) Manufacturer's name, model number, and serial number.
b) Valve action on power failure.
c) Operating range and bench setting.
d) Body and trim size.
e) Body and trim materials.
f) Trim type.
g) Body and flange rating.
h) Instrument tag number in accordance with the data sheets. In addition, each valve shall include the following: A tag indicating the type of packing and lubricant. On the body, an arrow indicating the direction of flow.

b. Straight through valves through 2 inch:

1) Globe style, single port.

2) Cast bronze body.
3) Screwed end connections.
4) Screwed bonnet.
5) Teflon V-ring packing.
6) Top guided plug.
7) Stainless steel plug, seat and stem.
8) Basis of design: Johnson Controls, VG 7000 series.

c. Straight through valves 2-1/2 inches through 4 inches:

1) Globe style, single port.
2) Cast iron body.
3) Flanged end connections.
4) Bolted bonnet.
5) Teflon cone-ring packing.
6) Either top or bottom guided plug.
7) Stainless steel plug, seat and stem.
8) Basis of design: Johnson Controls.

a) Fail open: Model V-5210.
b) Fail closed: Model V-5410.

4. Ball Style Valves:

a. ANSI 150 rating in accordance with ANSI B16.34.
b. Face to face dimensions comply with ISA S 75.04.
c. Cast steel ASTM A 216 WCB body.
d. Flanged or flangeless body. Suitable for mating to 150 Class ANSI B16.5 flanges.
e. 316 stainless steel ball, 17-4 PH stainless steel shaft.
f. Reinforced teflon seat (ball seal).
g. Teflon v-ring packing, 316 stainless steel packing follower.
h. Replaceable seat, ball and shaft packings.
i. Replaceable 316 stainless steel shaft bushings with teflon linings.
j. Furnish each control valve with a corrosion resistant nameplate, permanently fastened with drive-screws and stamped as follows:

1) Manufacturer's name, model number and serial number.
2) Valve action on air failure.
3) Operating range and bench setting.
4) Body size.
5) Body and trim materials.
6) Trim type.
7) Body and flange rating.
8) Instrument tag number in accordance with data sheets. In addition, each valve shall include an arrow indicating direction of flow.

k. Basis of Design: Fisher V150 or V200 series.

5. Electric Solenoid Valves:

a. Provide the action of the electric solenoid for either normally open, or normally closed valve operation in the event of electrical power failure, as required by the sequence of operation.
b. Size the actuator to close against the system pressure.
c. Provide the valve with manual override capability.

d. Heavy duty solenoid valve assembly, UL listed. NEMA Type 4, watertight and dust tight solenoid enclosure.

B. Valve Actuators:

1. General:

a. Size actuators to shut-off against pump shut-off head. Size chilled water valve actuators for at least 100 feet of water. Size hot water valve actuators for at least 100 feet of water.
b. Provide a position indicator and graduated scale on each actuator. Indicate the word "OPEN" and "CLOSED" at the stem travel limits.

2. Electric Actuators:

a. Provide hydraulic or gear type electric actuators.
b. When operated at rated voltage each actuator shall deliver the torque required for continuous uniform movement of the control device from limit to limit.
c. Provide an end switch to limit travel and design the actuator to continuously stroke without damage.
d. Actuators shall function properly within a range of 85 to 120 percent of line voltage.
e. Actuators with input power less than 100 watts may use fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings and pressed steel enclosures.
f. For actuators with input power greater than 100 watts the gears shall be ground steel, oil immersed, the shaft shall be hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast iron, cast steel or cast aluminum housing.
g. For an actuator greater than 400 watts input, provide totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
h. Two position actuators shall be of the single direction, spring return or reversing type.
i. Proportioning actuators shall be capable of stopping at all points in the cycle and starting in either direction from any point.
j. Reversing and proportioning actuators shall have limit switches to limit travel in either direction.

3. Manufacturer: Belimo (match existing)

2.8 FLOW INSTRUMENTS

A. Liquid thermal dispersion flow sensors:

1. Type 1:

a. Confirm the range and setpoint to ensure the product is suitable for the application.
b. The pressure rating shall be at least 2 times the system design pressure and at least 2000 psig.
c. Construct the body of Type 316 stainless steel.
d. Construct the wetted parts of Type 316 stainless steel.
e. House the switch in a NEMA 250 Type 4 enclosure constructed of die cast aluminum.
f. Vane length to suit installation.

B. Magnetic Flow Meter: System consisting of a magnetic flow sensor and remote mounted transmitter complying with the following:

1. Magnetic Flow Sensor: Welded carbon steel body, flange mounted, with standard process sensor, sealed coil housing, utilizing pulsed DC technology.

a. Available Sizes: 1/2” to 36”.
b. Velocity Range: 0-39FPS.
c. Accuracy: 0.25% of flow.
d. Coil Resistance: 350Ω.
e. Minimum Process Fluid Conductivity: 5 microsiemens/cm.
f. Grounding Accessories: Standard, grounding rings or bullnose grounding electrodes where necessary.
g. Standard, grounding and bullnose electrodes.

2. Remote Mounted Transmitter: Remote mounted transmitters shall have a Local Operators Interface (LOI) with dedicated configuration buttons. Meter setup, calibration and diagnostics and shall be available through the LOI. Transmitters shall incorporate the following features:

a. Enclosure: NEMA 4X.
b. Display: Two (2) line, 16 character operator interface display.
c. Power Supply: 90 to 250VAC or 12 to 42 VDC.
d. Power Consumption: 10Watts maximum.
e. Coil Drive Current: 500mA.
f. Ambient Temperature Operating Conditions: -20 to 140°F.
g. Ambient Humidity Operating Conditions: 0 to 100% RH to 120°F.
h. Mounting: Remote mounting brackets.
i. Safety Approvals: FM & CSA Class 1, Division 2 for non-flammable fluids.
j. Process Signal: 4-20mA output signal.
k. Flow Range: User selectable including bi-directional flow capabilities.
l. Frequency Adjustment: Scalable, 0 to 10,000Hz
m. Communications Interface: HART Protocol superimposed on 4-20mA signal.
n. Diagnostic information:

1) Empty pipe indication.
2) Electronics temperature indication.
3) Coil fault.
4) Transmitter fault.
5) Reverse flow.
6) High process noise (DA1).
7) Grounding/Wiring fault (DA1).
8) Electrode coating (DA1).
9) SMART meter verification (DA2).
10) 4-20ma Loop verification (DA2).

3. Manufacturer and Model: Rosemount model 8705/8712E.

2.9 PRESSURE INSTRUMENTS

A. Air pressure sensors:

1. Duct static pressure sensors:

a. Type 1:

1) The duct static pressure sensor insertion length shall be at least 4 inches. The sensor shall have at least 4 radially drilled holes, each 0.04 inches diameter.
2) Construct the sensor of brass.
3) Provide the sensor with a threaded end support, sealing washers and nuts.
4) Provide at least 1/4 inch compression fitting for connection to pneumatic copper tubing.
5) The sensor shall be suitable for rectangular, round, or flat oval duct installations.
6) Basis of design: Dwyer Model A 301.

B. Air pressure transmitters:

1. Duct pressure differential transmitters:

a. Furnish at least a 2 wire 4-20 milliamp output signal with a drive capacity of at least 600 ohms at 24 volts DC.
b. House in NEMA 250 Type 2 enclosure.
c. Construct the assembly so that shock, vibration, and pressure surges of up to 5 times the calibrated span, but not less than 10 inches water column, will neither harm the transmitter, nor affect its accuracy.
d. Provide the transmitter with an adjustable zero and span.
e. Performance:

1) 0 to 3.0 inches water column for (ductwork) installations.
2) Accuracy: Within 0.5 percent of the span.
3) Hysteresis: Within 0.02 percent of the span.
4) Repeatability: Within 0.05 percent of the calibrated span.
5) Stability: Within one percent of span per year.

f. Basis of design: Ashcroft Model XLDP.

C. Air pressure switches:

1. Air pressure differential switches:

a. Confirm the range and set point to ensure the product is suitable for the application.
b. Diaphragm operated to actuate a single pole double throw snap switch. Switch contacts shall be platinum alloy, silver alloy or gold plated.
c. The motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage.
d. Physical data:

1) Housing: At least 16 gauge steel, zinc plated.
2) Power diaphragm: Rubber. Approximately 7 inches in diameter.
3) Sealing diaphragm: Rubber.
4) Calibration spring: Stainless steel.
5) Mount the switch/diaphragm within at least a 16 gauge galvanized steel weatherproof enclosure. Full face of the enclosure shall be removable and gasketed.

e. Operating data:

1) Rated pressure: At least 10 psig.
2) Switch setpoint range:

a) On-Off status: Between 0.05 and 0.25 inches water column.
b) Positive pressure limit cutout: 2 inches to 6 inches water column.
c) Negative pressure limit cutout: 2 inches to 6 inches water column.
d) Filter status: 0.2 inch to 1 inches water column.

3) Switch setpoint:

a) Select at the midpoint of the setpoint range:
b) On-Off status: 0.15 inches water column.
c) Positive pressure limit cutout: 4 inches water column, unless otherwise indicated in the sequence of operation.
d) Negative pressure limit cutout: 4 inches water column unless otherwise indicated in the sequence of operation.
e) Filter status: 0.75 inches water column.

4) Dead band:

a) On-Off status: 0.05 inches water column, maximum.
b) Positive pressure limit cutout: 0.25 inches water column, maximum.
c) Negative pressure limit cutout: 0.25 inches water column, maximum.
d) Filter status: 0.08 inches water column, maximum.

5) Repeatability: Within 1 percent.

f. UL listed.
g. Provide each switch used as pressure limit cutout with a manual reset local to the switch.
h. Each switch shall have visual indication of setpoint differential pressure.
i. Basis of design: Dwyer Model 1638.

2.10 TEMPERATURE INSTRUMENTS

A. Air temperature sensors:

1. Resistance temperature sensors:

a. General:

1) Resistance temperature sensors shall conform to the International Practical Temperature Scale of 1968 and to DIN 43760 and BS1904.

b. Resistance temperature detector (RTD):

1) Platinum with a value of 1000 ohms at 0 degrees C and a temperature coefficient of 0.00385 ohms/ohm/degree C.
2) Encase single point sensors in a 300 series stainless steel sheath with an outside diameter of 0.25 inches. Encase averaging sensors in either a copper or stainless steel sheath.
3) Provide 2 teflon insulated, at least 24 gauge, stranded copper lead wires.
4) Performance characteristics:

a) Range: Minus 45 to plus 260 degrees C.
b) Interchangeable accuracy: At 0 degrees C plus or minus 0.26 degrees C.
c) Repeatability: Plus or minus 0.25 degrees C.
d) Response time: 62.8 percent of change in 5 seconds with 76 degrees C water flowing across sensor at 3 feet per second.
e) Self heating: Negligible.

c. Basis of design: TCS Series 1000.

2. Room (space) temperature sensors:

a. Sensor assembly shall include a temperature sensing element mounted under a blank metal cover.
b. Metal cover shall have a satin chrome, brushed aluminum or brushed stainless steel finish.
c. Provide a mounting plate that is compatible with the surface shape that it is mounted to and the electrical box used.

3. Space temperature sensors for unitary DDC controllers (only):

a. Temperature sensors shall be either a 100 or 1000 ohm platinum RTD, nickel RTD or a thermistor.
b. Thermistors shall be pre-aged and burned in and shall be coated with glass, inserted in a metal sleeve and the entire unit encased in epoxy. Thermistor drift shall be less than plus or minus 0.5 degrees F over 10 years.
c. Provide a temperature transmitter with each 100 ohm RTD. Transmitters are optional for other RTDs, contingent upon compliance with the end to end control accuracies specified.
d. Provide an LED or LCD digital display of sensed temperature.

B. Air temperature transmitters:

1. House the electronics in a NEMA 250 Type 3 or 4 enclosure, except space transmitters can be NEMA 250 Type 1.
2. Furnish the enclosure with 1/2 inch conduit connections.
3. Functional characteristics:

a. Input: 100 ohm platinum RTD temperature coefficient of 0.00385 or 1000 ohm 2 or 3 wire sensors.
b. Span (adjustable):

1) Space: 40 to 90 degrees F.
2) Airstream: 0 to 100 degrees F.
3) Outdoor: Minus 40 to 160 degrees F.

c. Output: 4-20 milliamps DC linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24 volts DC.
d. Zero and span adjustments shall be 100 percent field adjustable for any range.
e. Match sensor with temperature transmitter.

4. Performance characteristics:

a. Accuracy: Within 0.1 percent of the specified span.

b. Stability: Within 0.2 percent of the specified span for at least 6 months.

5. Basis of design: TCS TX Series.

C. Air temperature switches:

1. Temperature setpoint range: 20 to 50 degrees F or greater.
2. Provide visual indication of setpoint.
3. Manual reset.
4. Line voltage with bellows actuated switch.
5. Twenty foot capillary.
6. Responsive to the coldest one foot section of its length.
7. Double pole single throw switch with one switch leg hardwired to de-energize the fan and one switch leg to signal the BAS.
8. When installed in the airstream or outdoors, house in a NEMA 250 Type 4 enclosure.

2.11 HUMIDITY INSTRUMENTS

A. Humidity Transmitters: Humidity transmitters shall be solid state Non Dispersive Infrared Detector (NDIR) type electronic devices with field replaceable electronics on the duct mounted models. The measurement accuracy shall not be affected by dust, water vapor, or most chemicals.

1. Furnish at least a 2-wire 4-20 milliamp output signal with a drive capacity of at least 500 ohms at 24 volts DC.
2. Measurement Range: 0 – 100%.
3. Accuracy: ±2% (at 0 – 90%), ± (at 90 – 100%.
4. Temperature Dependence: 1.5% full scale/°F.
5. Response Time: 15 Seconds (90%).
6. Output Signal: 4-20 milliamp, or 0-10V
7. Electronic Housing: Cast Aluminum NEMA 4 for duct mounting, ABS plastic for wall mounting.
8. Options & Accessories:

a. Provide with field calibration kit.

B. Basis of Design:

a. Provide Vaisala Model HMW70 for space wall or ceiling mount applications.
b. Provide Vaisala Model HMD70 for duct mounted applications.
c. Alternate manufacturers: Greystone

2.12 CARBON DIOXIDE INSTRUMENTS

A. CO_2 Transmitters: CO_2 transmitters shall be solid state Non Dispersive Infrared Detector (NDIR) type electronic devices. Transmitters shall use diffusion aspirated single beam dual wave technology consisting of an infrared source, sample cell, a tunable solid state interference filter and an IR detector. The measurement accuracy shall not be affected by dust, water vapor, or most chemicals.

1. Furnish at least a 2-wire 4-20 milliamp output signal with a drive capacity of at least 500 ohms at 24 volts DC.

2. Measurement Range: 0 - 2,000PPM.
3. Accuracy: ±2% of full scale.
4. Long Term Stability: ±5% full scale/5 years. (Recommended recalibration frequency of 5 years)
5. Temperature Dependence: 0.05% full scale/°F.
6. Response Time: 60 Seconds
7. Output Signal: 4-20 milliamp, 0-10V.
8. Electronic Housing: NEMA 4
9. Options & Accessories:

    a. Provide with software calibration kit.
    b. Provide with field calibration kit.
    c. Provide with LonWorks module.
    d. Provide with digital display and relay output option.
    e. Provide with analog temperature module. Temperature module shall comply with the following:

        1) Output Signal: 0-10V
        2) Accuracy: ±0.9°F.
        3) Measurement Range: 32 - 122°F.

10. Basis of Design:

    a. Provide Vaisala Model GMW21 for space wall or ceiling mount applications.
    b. Provide Vaisala Model GMD21 for duct mounted applications.
    c. Alternate manufacturers: Greystone.

2.13 ACCESSORIES

A. Limit (damper end) switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250 type 13 oil tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Relays:

1. Control relays: Rate control relay contacts for the application, provide at least 2 sets of Form C contacts enclosed in a dustproof enclosure. Provide the relays with gold contacts having a life span rating of at least one million operations. 20 milliseconds or less, operating time, with release time of 10 milliseconds or less. Equip relays with coil transient suppression limiting transients to non-damaging levels.
2. Time delay relays: Rate time delay relay contacts for the application with at least 2 sets of Form C contacts enclosed in a dustproof enclosure. Provide the relays with gold contacts having a life span rating of at least one million operations. Equip relays with coil transient suppression devices to limit transients to non-damaging levels. Adjustable delayed contact opening or closing from one to 60 seconds with a minimum accuracy of plus or minus 2 percent of setting.
3. Latching relays: Rate latching relay contacts for the application. Provide at least 2 sets of Form C contacts enclosed in a dustproof enclosure. Provide relays with gold contacts having a life span rating of at least one million operations.

4. Current sensing relay:

    a. Monitors AC current.
    b. Independent adjustable controls for pickup and dropout current.
    c. Energized when supply voltage is present and current is above pickup setting.
    d. De-energizes when monitored current is below dropout current.
    e. Dropout current is adjustable from 50 to 95 percent of pickup current.
    f. Provide a current transformer, if required.
    g. Install the current sensing relay and current transformer in its own NEMA enclosure. Use a NEMA 250 Type 12 enclosure for indoors and a NEMA 250 Type 4 for outdoors.
    h. Basis of design: Square D type DIA.

5. Relays not on I/O card shall be enclosed plug-in type with 3 pin octal plug with contacts and operational function as required to satisfy control requirement. Protected with a heat and shock resistant dust cover.

C. Control transformers:

1. Size each transformer for the total connected load, plus an additional 25 percent of the connected load.
2. Each transformer shall be at least 100 volt amps.
3. Provide the transformer with both primary and secondary fuses.

D. 25 Volt dc power supply:

1. Plug-in style suitable for mating with a standard 8-pin octal socket. Provide the power supply with a mating mounting socket.
2. Enclose circuitry with a housing.
3. Provide both line and load regulation to ensure a stable output. To protect both the power supply and the load, provide the power supply with an automatic current limiting circuit.
4. Performance:

    a. Output voltage nominally 25 volts dc within 5 percent.
    b. Output current up to 100 milliamps.
    c. Input voltage nominally 120 volts ac, 60 hertz.
    d. Load regulation within 0.5 percent from 0 to 100 milliamp load.
    e. Line regulation within 0.5 percent at a 100 milliamp load for a 10 percent line change.
    f. Stability within 0.1 percent of rated volts for 24 hours after a 20 minute warm-up.

5. Basis of design: ATM Model 49-15-401.

E. Equipment and instrument identification:

1. Engraved tag bearing the equipment or instrument identification:

    a. Identification: Example: DDC-1.01.

2. Letter size shall be minimum 0.25 inches high.
3. Letter type shall be sans serif gothic bold style.
4. Lettering and background color scheme:

a. Instrument air: White letters on black background.

5. Tag shall be engraved phenolic a minimum size of 4 inches by 2 inches. Tag constructed of 3 layers of one sixteenth inch pressure rigid laminate. Top and bottom layers are color coded, contrasting white center is exposed by engraving through the outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive or non-corrosive.
6. Tag shall have be fastened to equipment/instrument with drive pins.
7. Basis of design: Brady B-1.
8. Equipment and instruments furnished with identification tags provided by original manufacturer do not require an additional tag.

F. Conduit and raceway identification.

1. In accordance with Division 26.
2. Paint cover plates on junction boxes and condulets the same color as the tape banding for conduits. After painting, label the cover plate "BAS", using an engraved phenolic tag.
3. For conduit housing pneumatic tubing, add in addition to the color tape, a phenolic tag, labeled “BAS Instrument Air”.

2.14 Software

A. BAS computer software:

1. BAS computer software shall include as a minimum:

a. Real time multitasking/multiuser 32 bit operating system allowing concurrent multi-station operation and concurrent execution of multiple real time programs and custom program development. Operating system shall be capable of operating DOS applications as well as WINDOWS applications.
b. Data base manager managing all data on an integrated and non-redundant basis. Additions and deletions to the data base shall be without any detriment to the existing data. Provide cross linkages so that no data required by a software program may be deleted by the operator until that data has been deleted from its respective programs.
c. Communications control shall manage and control multi bus communications to assure the exchange of global information and execution of global programs.
d. Operator interface software shall include; day to day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and on line data modification capability.
e. Provide a scheduler to schedule centrally based time and event programs, temporary, and exception day programs.
f. Provide other software required to implement the control objectives, concepts and sequences specified.

2. Operator Interface Software:

a. Operator interface software shall minimize operator training through the use of English language prorating and English language point identification.
b. The operator interface shall minimize the use of a typewriter style keyboard through the use of a pointing device similar to a mouse.
c. Provide a full interactive graphical selection means of accessing and displaying system data to the operator. Provide at least five levels with the penetration path operator assignable (for example, site, building, floor, air handling unit, supply

temperature loop). Native language descriptors assigned to menu items are to be Operator defined and modifiable under password control.

d. Operator access to the system is to be under password control. Alphanumeric password is to be field assignable to each operator using the operator's keyboard. Operators shall be able to access data from stations in the BAS by entry of the proper password. Passwords shall be the same for each operator station. Additions or changes made to passwords shall be updated automatically at every station.

e. Sign off from a station can be either a manual operation using a sign off key or if no keyboard activity takes place, an automatic sign off shall occur. The automatic sign off period shall be field programmable from one minute to sixty minutes in 1 minute increments on a per operator basis. Record all sign on/sign off activity on the printer.

f. Assign each system operator an access level, or levels, for controlling the data which is accessible to a specific operator. Provide at least 5 access levels. Each menu item in the system shall be assigned an access level so that a one for one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to the menu item. Display menu items to the operator with those capable of access highlighted. Menu and operator access level assignments shall be on-line programmable and under password control.

g. Provide data segregation for control of specific data routed to a station, to an operator assigned to a station, or to a given output device such as a printer. Provide at least 32 segregation groups. "Segregation groups" shall be selectable such as, fire points, fire points second floor, space temperature points, HVAC points, etc. Points shall be assignable to multiple segregation groups. Display and/or output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and the point segregations. Alarms shall be displayed and printed at each peripheral to which segregation allows but only those operators assigned to the peripheral and having proper authorization level will be allowed to acknowledge alarms. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be on line programmable and under password control.

h. Graphic interface software: Provide a hierarchical linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. The interface shall utilize a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of the system. Provide at least ten levels of graphic penetration with the hierarchy operator assignable. Descriptors for graphics, points, alarms, etc. shall be modified through the operator's station under password control.

    1) Graphic displays shall be on-line user definable and modifiable using the hardware and software provided. Systems which require factory or vendor dependent graphic generation/modification are not acceptable.
    2) Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication channel or point type (temperature, humidity, etc.). Graphics are to be on-line programmable and under password control. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation. Graphics shall also contain software points.
    3) Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding. The "backtrace" shall permit the operator to move upward in the hierarchy using a pointing device. The backtrace shall show all the previous penetration levels. Provide the operator with the option of showing each graphic full screen size

with the backtrace as the horizontal header or by showing a "stack" of graphics, each with a backtrace.

4) Display operator accessed data on the monitor. The operator shall select further penetration using the pointing device to click on an area, building, floor, fan, etc. The defined linked graphic below that selection shall then be displayed. Dynamic data shall be assignable to graphics. Provide the operator with a means to directly access graphics without going through the penetration path.
5) Display points (physical and software) with dynamic data provided by the system with appropriate text descriptors, status or value, and engineering unit. Use color or other highly visible means to denote status and alarm states. Color shall be variable for each class of points, as chosen by the operator.
6) Points shall be dynamic with operator adjustable update rates on a per point basis from 1 second to over a minute.
7) For operators with the appropriate privilege(s), points shall be commanded directly from the monitor using the pointing device. For an analog command point such as setpoint the current conditions and limits would be displayed and the operator could position the new set point using the pointing device. For a digital command point such as a valve position, the valve would show its current state (i.e., CLOSED) and the operator could select OPEN using the pointing device. A keyboard equivalent shall be available for those operators with that preference.
8) Operator shall be permitted to split or resize the viewing screen to show one graphic on the left half of the screen and another graphic or spreadsheet, bar chart, word processing, curve plot, etc., on the right half screen. This will allow real time monitoring of one part of the system while displaying other parts of the system or data from the systems to facilitate system operation.
9) Provide an on-line context-sensitive help utility to facilitate operator training and understanding. The help feature shall have the ability to bridge to further explanation of selected keywords. The document shall contain text and graphics to clarify system operation. At a minimum, help shall be available for every menu item. If the help utility does not have this ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word processing program which shall run concurrently with the operating system software. Provide index items for each system menu item.
10) Provide graphic generation software to allow the operator to add, modify, or delete system graphic displays.

    a) Provide libraries of symbols depicting HVAC symbols (i.e., fans, cooling coils, filters, dampers, pumps etc.) and electrical symbols similar to those used by the Architect/Engineer.
    b) The graphic development package shall use a pointing device in conjunction with a drawing program to allow the operator to perform at least the following:

        (1) Define background screens.
        (2) Define connecting lines and curves.
        (3) Locate, orient and size descriptive text.
        (4) Define and display colors for all elements.
        (5) Establish correlation between symbols or text and associated system points or other displays.

11) Provide graphics documentation and display for the BAS system including, but not limited to, the following:

a) Site plan showing each building, and additional site elements which are either being controlled or monitored by the BAS.
b) A floor plan for each floor and roof plan of each building. Show as a minimum the following:

(1) Room layouts with room names and identification numbers.
(2) Locations and identification of BAS controlled equipment.
(3) Location and identification of each BAS control or monitor point.

c) A control schematic for each of the following. Each control schematic shall include a graphic system schematic representation similar to that shown by the Architect/Engineer, a sequence of operation and a control logic diagram. All of which should include point identification with setpoint and dynamic value indication.
(1) Each boiler/hydronic system.
(2) Each air handling unit.
(3) Each VAV unit.
(4) Each booster coil
(4) Each exhaust fan.
(5) Each pump.
(6) Each fan served through the interlock schedule.

d) A graphic display for each piece of equipment that is connected to the BAS through a communications link (protocol). Provide dynamic indication of all points associated with the equipment.
e) A riser diagram showing schematically the layout and routing for the entire site of the following:

(1) Network communications bus(es).
(2) DDC controller bus(es).

i. The operator interface shall allow the operator to perform commands including, but not limited to, the following:

1) Start or stop selected equipment.
2) Adjust setpoints.
3) Add/modify/delete time programming.
4) Enable/disable process execution.
5) Lock/unlock alarm reporting for each point.
6) Enable/disable totalization for each point.
7) Enable/disable trending for each point.
8) Override PID loop setpoints.
9) Enter temporary override schedules.
10) Define holiday schedules.
11) Change time/date.
12) Enter/modify analog alarm limits.
13) Enter/modify analog warning limits.
14) View limits.
15) Enable/disable duty cycle for each load.

j. Reports shall be generated automatically and manually, and directed to either monitor displays, printers, or disk files. As a minimum, the system shall allow the operator to easily obtain the following types of reports:

1) A general listing of points in the network.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

k. Provide summaries for specific points, for a logical point group, for a operator selected group of groups, or for the entire facility without restriction due to hardware configuration.

3. Customizing software:

a. Provide software to modify and tailor the BAS to the specific and unique requirements of the equipment installed, the programs implemented and to staffing and operational practices. Provide on line modification of system configuration, program parameters, and data base using menu selection and keyboard entry of data into preformatted display templates. As a minimum, provide the following modification capability.

1) Operator assignment capability shall include designation of operator passwords, access levels, point segregation and auto sign off.
2) Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup consoles and printers, designation of console header points and enabling/disabling of print out of operator changes.
3) System configuration/diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to the network, DDC controller enable/disable, assignment of command trace to points and application programs, and initiation of diagnostics.
4) System text add/change capability shall include English or native language descriptors for points, segregation groups and access levels; and action messages for alarms, run time and trouble condition.
5) Time/schedule change capability shall include time/date set, time/occupancy schedules, exception/holiday schedules and daylight savings time schedules.
6) Point related change capability shall include system/point enable/disable, run time enable/disable; assignment of points to segregation groups, calibration tables, lockout, run time and to a fixed input or output value; and assignment of alarm/warning limits.
7) Application program change capability shall include enable/disable of BAS programs, BAS program changes; assignment of comfort limits, global points, time and event initiators, time and event schedules and enable/disable time and event programs.

b. Provide software which will allow the operator to add points, or groups of points, to the system and to link them to control energy management programs. Additions

and modifications are to be on line programmable using the operator's keyboard, downline loaded to distributed processing units, and entered into their data bases. After verification of point additions and associated program operation the data base shall be upline loaded and recorded on hard disk and floppy disk (as an archived record).

c. Provide a high level language programming capability for implementation of custom DDC programs. Software shall include a compiler, a linker and upline/downline load capability. In addition, provide a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences and shall include as a minimum:

1) Proportional control, proportional plus integral (PI), proportional plus integral plus derivative (PID), and intelligent control (self learning). The intelligent control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed. The algorithm shall operate in a continuous self learning manner and shall retain in memory a stored record of the system dynamics so that on system shut down and restart, the learning process starts from where it left off and not from ground zero.
2) Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select analog output, lowest select analog output, analog controlled digital output, analog control analog output, digitally controlled analog output.
3) Logic, arithmetic and relational operators (AND, OR, NOT ... ; ADD, SUBTRACT, MULTIPLY ... ; EQUAL TO, NOT EQUAL TO, LESS THAN ...; etc.) which are to be a standard set available with a high level language.

4. Alarm handling:

a. Provide alarm handler software to respond to alarm conditions sensed and transmitted from DDC controllers. First in, first out handling of alarms in accordance with alarm priority ranking (fire alarm first, security second, etc.) is required with buffer storage in case of simultaneous and multiple alarms. Alarm handler shall be active in both the signed on and signed off modes to assure that alarms will be processed even though an operator is not currently signed on.
b. Alarms display shall include, as a minimum the following:

1) Indication of alarm condition; such as, ABNORMAL OFF, HI ALARM/LO ALARM, ANALOG VALUE or STATUS, group and point identification, native language point descriptor, (such as, SPACE TEMPERATURE, Building 1, 2nd Floor, Room 202).
2) A discrete per point alarm action taking message, such as, Call Maintenance Dept. Ext- 5561.
3) Provide an extended message capability to allow assignment of, and print out of, extended action taking messages on a per alarm point basis. Extended messages shall be operator programmable and assignable.

c. Alarms are to be directed to appropriate stations, printers, and operators per privilege level and segregation assignments.
d. Alarms shall be categorized and processed in accordance with the alarm class.

1) Class 1 alarms, those associated with fire, security and other extremely critical equipment monitoring functions are to have alarm, trouble, return to normal, and acknowledge conditions printed and displayed. Unacknowledged alarms to be placed in unacknowledged alarm buffer. All

conditions shall cause an audible to sound and shall require individual acknowledgment to silence the audible.

2) Class 2 alarms are critical, but not life safety related, and are to be processed the same as Class 1 alarms. These alarms, however, will not require individual acknowledgment but may be acknowledged via the multiple alarm acknowledgment key.

3) Class 3, general system monitoring alarms, are to be printed, displayed on the CRT screen, and placed in the unacknowledged alarm buffer queues. Every new alarm received shall cause the audible to sound. Audible shall be silenced by "acknowledging" the alarm or by pressing the "silence" key. It shall be possible to "acknowledge" queued alarms either on an individual basis or via a multiple acknowledge mode. Alarms returning to normal condition shall be printed, shall not cause an audible or require an acknowledgment.

4) Class 4, routine maintenance warning alarms, are to be printed only with no display, no audible, and no acknowledgment required.

e. Provide an unacknowledged alarm indicator on the CRT display to alert the operator that there are unacknowledged alarms in the system. The operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key depending on the alarm class.

f. To assure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of the primary alarm printer.

B. DDC controller internal software:

1. Provide software to accomplish the following functions, fully implemented and operational, within the DDC controller.

a. Scanning of inputs and outputs.
b. Report to the BAS computer, field changes.
c. Integral real time clock, automatically corrected from the BAS computer once per day.
d. Analog alarm limit checks for DDC controller resident applications programs.
e. Digital inputs alarm recognition.
f. Constraints checks (before command issuance).
g. DDC controller diagnostics.
h. Control functions.

2. The DDC controller shall contain an operating system that controls and schedules DDC controller activities. The operating systems shall be interrupt driven in order to perform the DDC controller real time functions. The DDC controller shall maintain a point data base in its RAM that includes the latest value or status and any other parameters specified.

a. The execution of DDC controller application programs shall utilize the data in this RAM resident file.
b. Operating systems shall include a real time function that maintains the day of week, hours, minutes, and seconds.
c. The operating system shall allow local loading of software and data.

3. Each command shall be executed by the DDC controller only after constraint checks have been passed. Each command point shall have unique constraints assigned; a unique "reasonableness" value shall be assigned to each analog input.

a. Report binary status changes and alarms to the BAS computer.
b. Report analog point values to the BAS computer when requested or when the analog point value changes to an alarm.
c. Each individual point shall be selectively disabled (deleted from scan) by the operator from the BAS computer. Disabling a point shall prohibit the DDC controller from reporting any further changes of that point.

4. Provide each DDC controller with self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise RAM and verify PROM.
5. Provide the DDC controller with startup software that causes automatic start of operation without human intervention.

    a. The startup software shall establish communications with the BAS computer.

6. Operational modes:

    a. Provide software to perform operational modes at the DDC controller, including:

        1) Communications mode.
        2) Stand-alone mode.

7. Communicating mode:

    a. Provide software to perform DDC controller functions and applications programs using commands and updated parameters, including time control unit updates transmitted from the BAS computer. The DDC controller software shall execute commands received from the BAS computer or DDC controller, after performing constraints checks in the DDC controller.
    b. Transmit alarms and other designated data to the BAS computer for data base update and alarm acknowledgment.
    c. The DDC controller shall accept program updates downloaded from the BAS computer. Constraints parameters shall reside at the DDC controller.

8. Stand-alone mode:

    a. Provide software to perform DDC controller functions and DDC controller resident applications programs using data obtained from the data environment and based upon the DDC controller real time clock.
    b. In this mode, applications programs resident at the DDC controller shall continue stand-alone operation.

        1) Clock updates and parameters will not be received from the BAS computer in this mode.

9. Failure mode:

    a. Provide software resident in nonvolatile memory, as part of the start-up routine to force DDC controller outputs to a predetermined state.
    b. Upon low battery conditions perform an orderly shut down and force the DDC controller outputs to a predetermined state.

10. Self diagnostics and alarm reporting:

a. Provide diagnostic software that continuously monitors the proper operation of the unit.
b. The software shall display messages to inform the operator of a diagnosed malfunction of the unit.

1) Nature of the malfunction.
2) Control unit affected.

c. The system shall allow on-line diagnosis from the BAS computer.

11. Direct digital control functions:

a. Execute temperature, pressure and flow control functions within the DDC controller.

1) Execute loop control using direct digital control algorithms.

b. Control loops shall support any of the following control modes:

1) Two position.
2) Proportional (P).
3) Proportional plus integral (PI).
4) Proportional, integral, plus derivative (PID).
5) Adaptive control/automatic control loop tuning.

c. Control loops shall use PID control.
d. Provide means to fully create, modify or remove control functions within a specific DDC controller while it is operating and performing other control functions.

1) Each control loop shall be user definable.

12. DDC controller applications software:

a. Provide the following applications programs, associated constraints, and interlocking resident and executed at the DDC controller:

1) Time schedule program:

a) The program shall provide at least fifty two 8-day (7-day week, plus special holiday program) start-stop time programs. These programs shall allow any number of system loads to be assigned to any time program. Loads may be started and stopped at least ten times daily.
b) To prevent rapid loading of electrical equipment, provide an adjustable time delay between successive starts and stops.
c) Make provisions for manual overriding of each schedule by an appropriate operator.

2) Optimum start/stop program:

a) Inputs to this program:

(1) Day of week.
(2) Time of day.
(3) Equipment schedules.

(4) Building occupancy schedule.
(5) Space temperature.
(6) Building thermal inertia coefficient.
(7) Outside air temperature.
(8) Required space temperature at occupancy.
(9) Equipment constraints.

b) Outputs from this program are start-stop and open-close commands to points shown on the input/output summary.
c) This program shall continuously monitor the space temperature and outside air temperature of each system specified to be under optimized start-stop control. The control algorithm shall start the system at the latest possible moment necessary to warm the space or to cool the space before the scheduled occupancy.
d) The temperature shall be field programmable from the operator's terminal.
e) Base the initial set-up of the program on calculations considering the building construction, orientation, and mass. Structure the program so that job site tuning may be done by simple keyboard entry of one multiplier to the empirical formula results.
f) The program shall use heuristic methodology to develop the optimum start time data base.
g) As loads are started and stopped under this program, output a print out of space, outside air temperature and time:

(1) At optimized start-up time.
(2) At programmed occupancy time.

h) In the event of control failure or other malfunction, the program shall revert to the time/program calendar.

b. Event program:
1) The program shall provide for at least 200 event initiated programs (EIP).

a) Event initiators may be digital data point in the system, real-time values, or analog an alarm limit. Structure the EIP's so that one initiator may set and reset the EIP as it goes from normal to off-normal and back to normal, or one initiator may set the program and a second initiator reset the program, or reset may be manual via the console keyboard.

2) Setting an EIP shall cause a series of start or stop commands to be executed.

a) Resetting the EIP shall cause the opposite commands to be executed to programmed EIP points.

3) EIP's shall have priority assignments to allow them to override other programs in the set mode when desired.
4) Develop and implement event initiated programs requested by the Owner.

c. Operational modes:

1) Provide the capacity to define occupancy schedules for the facility and operational schedules for the equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions under which the BAS system will be installed.

B. Notify the Architect/Engineer in writing of unsatisfactory conditions.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:

1. Furnish and install products required to satisfy the requirements of the contract documents.
2. Install plumb, parallel, and perpendicular with building lines.
3. Install properly supported.
4. Install in compliance with applicable codes.
5. Provide proper operation of the system.
6. Provide roof, floor, and wall opening and sleeves required that are not provided by other trades. Before proceeding with drilling, punching or cutting of the structure, inform the Architect/Engineer of intentions, check locations of concealed parts or services and receive the approval of the Architect/Engineer. Patch, flash, grout and refinish openings made.
7. Welding requirements:

    a. Restrict welding and burning to supports and bracing. No equipment shall be cut or welded without permission of the Architect/Engineer. No welding or cutting is permitted which might damage adjacent mechanical equipment.
    b. Welding, where required, shall be by inert-gas electric arc process and shall be performed by qualified welders in accordance with the applicable welding code. If requested by the Architect/Engineer, submit satisfactory evidence of welders ability before being allowed to perform welding work.
    c. Comply with the Owner's requirements for fire protection and follow such procedures strictly while performing welding or cutting.

8. Fastening hardware:

    a. Do not use Stillson wrenches, pliers or other tools likely to cause injury to or mar the surfaces of rods, nuts or other parts, for work of assembling or tightening nuts.
    b. Tighten the bolts and nuts firmly and uniformly, and take care not to overstress the threads by excessive force, or by wrenches of excessive lengths.
    c. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

9. Install products in accordance with manufacturer's written instructions and in a location that is accessible that will permit calibration and maintenance from the floor, equipment platforms, or catwalks.
10. Identify wiring and tubing with an identification system. Each piece of wire and tubing shall have the same designation at each end. The identification system shall be approved by the Architect/Engineer.

11. Locate the products (except pressure gauges) in steam, liquid and liquid sealed service below their process connection point. Slope connections down to the instrument with a minimum slope of one inch per foot.
12. Locate products in dry gas and non-condensable vapor service above their process connection point. Slope process connection lines up to the instrument with a minimum slope of one inch per foot.
13. Support products on stands and brackets to prevent vibration and movement.

B. Electrical power distribution:

1. Furnish and install an electrical power distribution system to implement the work under this Section, not provided under Division 26. Electrical power distribution shall include power for items such as, but not limited to:

    a. Transmitters.
    b. Electric solenoid valves.
    c. Control panels.
    d. DDC controllers.
    e. Actuators.

2. Power shall be available in the form of 120/208 volts, 3 phase, 4 wire from electrical panels throughout the facility. Space shall be available at each panel for work under this Section.
3. Furnish and install circuit breakers that match the existing, power wiring and conduit.
4. Electrical power distribution shall be in accordance with Division 26.

C. BAS network installation:

1. Use stranded copper cable for the LANs.
2. Coordinate the routing of the BAS networks with the Architect/Engineer and the Owner to assure that a preplanned routing is used. Where indicated by the electrical drawings, cable trays may have space available for BAS use.

D. Wiring and conduit:

1. Control and communications wiring and cables located above ceilings may be installed without conduit provided it is plenum rated and hung from cable hooks. All other control and communications wiring shall be installed in conduit. All power wiring and cables shall be installed in conduit.
2. Use EMT conduit and install wiring and conduit as specified in Division 26 and as specified below.

    a. Cables serving a common system may be grouped in a common conduit. Do not group conductors from different systems, or different voltages.
    b. Install the BAS in accordance with the manufacturer's recommendations and with NFPA 70.
    c. Conduits 1/2 inch in diameter shall be the smallest size.
    d. Install conduit expansion joints where conduit runs exceed 200 feet, and runs across building expansion joints.
    e. Install conduit to avoid pipes. Maintain a separation of at least 3 inches where conduits run parallel to, or across, pipes.
    f. Continuous above grade conduit runs shall not exceed 100 feet in length without pull or junction boxes installed.
    g. Do not install raceways or electrical items on any rotating equipment.
    h. Do not fasten conduits onto the bottom side of a roof.

i. Use flexible conduit only where flexibility is required. Runs of flexible conduit shall not exceed 3 feet in length, unless detailed otherwise.
j. Conduit shall be continuous from outlet to outlet, from outlet to cabinets, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
k. Direct bury conduits installed underground. Use rigid non-metallic Schedule 40 PVC in accordance with the Division 26 specification. Provide a burial depth in accordance with NFPA 70, but not less than 24 inches.
l. Secure threaded conduit entering a cabinet, box, and trough, with a locknut on the outside and on the inside, such that the conduit system is electrically continuous throughout. Provide a bushing on the inside. Bushings shall be metal with insulated throats. Locknuts shall be the type designed to bite into the metal, or on the inside of the enclosure shall have a grounding wedge lug under the locknut, as manufactured by Thomas and Betts, or equal.
m. Conduit box type connectors for conduit entering enclosures shall be the insulated throat type.
n. Connect conduit entering enclosures in wet locations with approved box type connectors, or with watertight sealing locknuts or other fittings approved by the Architect/Engineer.
o. Offset conduits where they enter surface mounted equipment. Wiring installed in panels and other enclosures shall be neatly looped and laced.
p. Seal conduit runs which extend from the interior to the exterior of a building to prevent the circulation of air. This is to be accomplished by the installation of sealing fittings.

3. Provide cables with protective sheathings that are waterproof and capable of withstanding continuous temperatures of 90 degrees C with no measurable effect on the physical or electrical properties of the cable.

   a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

4. Do not install cable closer than one foot from transformers and electrical power cables. Provide a system free of electro-magnetic interference (EMI).
5. Identify each wire on each end and at each terminal with a number coded identification tag. Each wire shall have a unique tag.
6. Provide strain relief.
7. Terminate wiring in a junction box.

   a. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

8. Terminate wire work with terminal blocks.
9. Install signal transmission components in accordance with ANSI C2, REA Form 511a, NFPA 70, and as shown.
10. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
11. Grounding shall be in accordance with ANSI C2. Ground wire shall be copper. Demonstrate ground resistance.
12. Install control wiring in a separate conduit from power wiring.
13. Wiring shall be continuous from terminal to terminal without splices.
14. Use insulated spade lugs for wiring connection to screw terminals.

15. Use shielded wiring to transmitters.
16. Use shielded wiring to temperature sensors.
17. Perform continuity and meager testing on wiring.
18. All panels shall be bonded to ground with ground wire and grounding lug.
19. Indicate at each panel the source (Panel No., Circuit No.) for the power source for that panel.
20. Provide minimum 3/4" conduit for power wiring to each panel. Provide power disconnect switch inside each panel.

E. Pneumatic piping and tubing:

1. Materials to be used:

    a. Use hard drawn copper tubing. Use compression type fittings for connections to pneumatic devices.
    b. Use fire-resistant polyethylene tubing in control panels only. Refer to Division 26 specifications for conduit. Support polyethylene tubing the same as copper tubing.
    c. For signal to instruments in air systems use copper tubing. Instruments include, but are not limited to:

        1) Pressure transmitters.
        2) Switches.

2. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, classrooms, offices, and conference rooms. Tubing may be exposed in areas without ceilings.
3. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in the wall, architectural enclosures, or architectural cover. Get approval from Architect/Engineer before proceeding with pneumatic tubing in occupied spaces.
4. Run piping and tubing parallel to, and at right angles to the building lines.
5. Route multiple runs of tubing or piping in neat parallel lines.
6. Support pipe and tubing in accordance with MSS SP-69 table 3 unless otherwise specified.

    a. Install in a neat manner.
    b. Support copper tubing with approved copperized hangers, clips and tube trays. Do not use tapes for mounting tubing.
    c. Place a support within 1 foot of each change in direction and each branch take off.
    d. Support pipe and tubing independent of other trades, such as, pipes, ducts, cable trays, and conduits.
    e. Support tubing from building structure with suspension rods, structural shapes or channel strut. Provide sufficiently strong support and adequately braced to carry the static load plus a safety margin which will allow tubing to be worked in support.
    f. Paint or galvanize support members. Apply coatings before the tubing is installed to the support.
    g. The spacing between supports shall not exceed 5 feet.

7. Piping and tubing shall not interfere with access to valves or equipment or obstruct passageways of any kind.
8. Coordinate with other trades to prevent the proposed piping or tubing from interfering with pipe, duct or conduit space. If changes from the shop drawings are necessary, make such changes and mark the changes on the record drawings.
9. Piping and tubing shall not be attached to equipment that may be removed frequently for maintenance or which may impart vibration and/or expansion from temperature change.

10. Exposed tubing in mechanical equipment areas shall have full mechanical protection within 72 inches above the floor. Use aluminum channel reversed and secured over the tubing to protect tubing from damage.
11. Where joining or mating dissimilar metals where galvanic action could occur, provide dielectric isolation.
12. Provide tubing joints in accordance with ANSI Code for Pressure Piping B 31.1. Make screwed joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and I.P.S. thread on the other end.
13. Make tubing bends with a bending tool. Hard bends, wrinkled or flattened bends are not acceptable.
14. Provide tubing fitting make-up in strict accordance with the manufacturer's recommendations.
15. Do not make tubing connections to a fitting before completing the make-up of the pipe connection.
16. Properly align the tubing with the fitting. Springing the tube into position can result in excessive stress on both the tubing and the fitting with possible resulting leaks.
17. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending is required for a proper connection.
18. Check tubing for correct diameter and wall thickness. The tube ends shall be cut square and deburred. Exercise care during cutting to keep the tubing round.
19. Install piping and tubing with extreme care exercised to keep foreign matter out of the system. Keep the open ends of tubing plugged to keep out dust, dirt, and moisture.
20. Mark each tube on each end with a number coded identification. Each tube shall have a unique number.

F. Product installation:

1. General:

    a. Check and verify the location of thermostats, sensors, transmitters and other exposed control instruments with plans, Architect/Engineer and the Owner.
    b. Indicate mounting height for all products on the shop drawings. Do not install products without Architect/Engineer approval of mounting height and location.
    c. Provide a quick connect test plug for checking branch pressure (accessible by removal of the instrument cover) at each space mounted pneumatic thermostat and provide a permanently mounted pressure gauge at each control device indicating the instrument branch pressure.
    d. Protect products installed outside from solar radiation and wind effect with shields constructed of Type 304 or 316 stainless steel. Provide stainless steel stand-offs to minimize building effect.
    e. Mount space thermostats and space temperature sensors located on exterior walls on a 1 inch thick insulating block. Provide a finished appearance consistent with adjacent materials in the space. An acceptable installation is contingent upon Architect/Engineer approval.
    f. Mount control panels located on uninsulated exterior walls on a 1 inch thick insulating block. Cut the insulating block to match the control panel footprint.
    g. Unless otherwise indicated or required by codes or regulations, locate thermostats, space temperature sensors and transmitters 60 inches above finished floor.
    h. Seal airtight penetrations to ductwork, plenums and air handling equipment with rubber gaskets or grommets.

2. Temperature sensor installation:

    a. Space mounted analog temperature sensor and transmitter:

1) The assembly shall include a sensor and transmitter.
2) Mount the assembly in an electrical box. Provide an electrical box of sufficient size to house the transmitter and sensor. Provide the electrical box with a face plate to match the sensor cover.
3) Conceal the sensor and transmitter inside a cover.
4) In finished areas, locate the electrical box within the wall. Finished space installations shall have the electrical box face plate and sensor cover only exposed to view.
5) In unfinished areas, the electrical box may be surface mounted. Use a cast aluminum or cast iron electric box for surface mounted installations.
6) Refer to the drawings for installation details.
7) Align the sensor and sensor/transmitter assembly with other electrical devices, such as visual alarms and light switches which are located in the vicinity to provide a neat and well thought out arrangement. Where possible, align in both the horizontal and vertical axis.

b. Single point duct mounted temperature sensor and transmitter:

1) Provide single point type duct mounted supply and return air temperature sensors. Locate the sensors in the ducts with the sensitive portion of the element installed in the center of the duct cross section and located to sense the average temperature. Do not exceed 24 inches in sensor length.
2) Locate the return air sensor in a location that will sense the return air temperature without influence from outside or mixed air.
3) Rigidly support the sensor to duct using a threaded pipe flange.
4) Mount the transmitter remote from the sensor at an accessible/serviceable location.
5) Refer to the drawing for installation details.

c. Averaging temperature sensor and transmitter:

1) Provide an averaging type air temperature sensor for temperature sensors located within air-handling units.
2) Provide a sensor length to maintain coverage over the entire cross sectional area. Refer to the detail on the drawings for the minimum coverage acceptable. Provide multiple sensors and transmitters where required to maintain the minimum coverage.
3) Support the sensor using EMT conduit the entire length. Fasten the sensor with plastic clips such that the sensor is not in contact with the conduit.
4) Terminate the sensor leads in a connection head.
5) Mount the transmitter in an accessible/serviceable location.
6) Refer to the drawings for the installation detail.

3. Low limit temperature switch installation:

a. Provide the required number of low limit switches to maintain coverage over the entire cross sectional area. Refer to the detail on the drawings for the minimum coverage acceptable.
b. Provide the capillary length required, but not less than 20 feet. Minimize the number of low limit switches required.
c. Support the capillary its entire length using EMT conduit. Fasten the capillary to the conduit using plastic clips.
d. Mount switches to provide easy access for manual reset.
e. Install low limit switch(es) on the entering side of the cooling coil.
f. Refer to the drawings for installation details.

4. Duct mounted static pressure sensor installation:

    a. Provide the quantity of duct mounted static pressure sensors indicated in the control sequences, and schematics.
    b. Maintain the manufacturer's recommended upstream and downstream distances when locating the sensors.
    c. Unless indicated on the drawings, locate the duct mounted static pressure sensors on the longest hydraulic run within 10’ of the last box on the system. The final location of sensors shall be approved by the Architect/Engineer before installation.
    d. Provide mounting hardware and gaskets to make the sensor installation airtight.
    e. Route 3/8 inch diameter pneumatic tubing from the sensor to the transmitter. Use compression fittings at terminations.
    f. Install the sensor in accordance with the manufacturer's instructions. Support the sensor to withstand air velocities of 10,000 feet per and vibrations encountered without any deformation or mechanical failure.

5. Transmitter installation:

    a. Install temperature transmitters (except space type) and differential pressure and flow transmitters for liquid or steam service in the vicinity of the process connection. Locate transmitters in an accessible/serviceable area in mechanical equipment rooms, equipment platforms or catwalks. Do not locate transmitters in finished areas. Mount the transmitter on pipe stands. The transmitter manufacturer shall provide appropriate mounting brackets.
    b. Install differential air pressure transmitters for duct service in their respective system control panel.

6. DDC controller and system control panel installation:

    a. Install DDC controller(s) at locations indicated on the drawings.
    b. Mount DDC controller to walls where indicated on the drawings or to a free standing structural channel frame where they are not wall mounted.
    c. Install respective system control panel(s) adjacent to the DDC controller(s).
    d. Refer to the drawings for mounting details.

7. Actuator installation:

    a. Furnish and install actuators required to implement the BAS system sequences of operation that are not furnished and/or installed under other Division 23 sections.
    b. Provide the mounting hardware and linkages for the installation of the actuators to the dampers.
    c. Size each actuator. Identify each actuator using the point description number.
    d. Locate the actuators to provide ease of maintenance and repair.

8. Pressure differential switch installation:

    a. For air switches, use at least 3/8 inch diameter pneumatic tubing from switch to point of system connection.
    b. For liquid switches, use at least 1/2 inch diameter process tubing from switch to point of system connection. Provide isolation valves.
    c. Do not mount switches on equipment.
    d. Mount switches in a location free from vibration, heat or adverse effects which could damage the switch and hinder accurate operation.
    e. Install switches in an easily accessible and serviceable location. Locate the switches at approximately 60 inches above the finished floor.

f. Install switches in accordance with manufacturers recommendations.

9. Equipment and instrument identification tag installation:

a. Identification tagging shall be limited to the following:

1) Control panels.
2) DDC controllers.
3) Damper actuators and positioners.
4) Venturi flow devices.
5) Temperature sensors and transmitters.
6) Temperature switches.
7) Pressure transmitters.
8) Pressure switches.

b. Locate tag where easily read.

G. Colorgraphics:

1. Use the system schematics provided under this section as a starting point for colorgraphics generation.
2. Develop a job specific library of symbols for representing system equipment and products.
3. Seek Owner input in development of colorgraphics.
4. Final development and Owner, Architect/Engineer review of the colorgraphics shall be done on site using the installed BAS as the development tool.
5. Final acceptance of colorgraphics is contingent upon approval from the Owner and Architect/Engineer.

H. Fire alarm and detection system interface:

1. Provide all pneumatic products including pneumatic to electric (PE) switches and electric to pneumatic (EP) switches (valves) required by the fire alarm trade to operate the systems in accordance with the control sequences of operation.
2. Interface the BAS system with the Fire Alarm and Detection System to operate the systems in accordance with the control sequences. Provide hardware and software required for interface.
3. Coordinate the BAS system design, installation and operation with the Fire Alarm and Detection System.

3.3 CLEANING

A. General:

1. Execute cleaning, during progress of the work, and at completion of the work, as required by the General Conditions.
2. Conduct cleaning and disposal operations to comply with codes, ordinances, regulations, and anti-pollution laws.

B. Materials:

1. Use only those cleaning materials which will not create hazards to health or property and which will not damage surfaces.

C. During construction:

1. Execute periodic cleaning to keep the work, the site and adjacent properties free from accumulations of waste materials, rubbish and windblown debris, resulting from the construction of BAS.
2. Provide on-site containers for the collection of waste materials, debris and rubbish.
3. Remove waste materials, debris and rubbish from the site periodically and dispose of at legal disposal areas away from the site.

D. Final cleaning:

1. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surface.
2. Wash and shine glazing.
3. Polish glossy surfaces to a clean shine.

3.4 BAS START-UP PROCEDURES

A. Check-out:

1. Before calibration, testing and check-out of the instruments installed in the field. Use this procedure before any continuity, loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or any other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material and support.
5. Verify the air supply for each instrument is properly installed.
6. Pressure instrument check-out:

    a. Verify the piping slope and see if the valve manifold is properly installed.
    b. Verify that the self-contained pressure regulators are installed correctly with respect to flow.

7. Temperature instrument check-out:

    a. Verify the sensing element for proper material and length.
    b. Verify that the wire is correct.

8. Control valve check-out:

    a. Verify that the control valves are installed correctly with respect to flow.

9. Damper check-out:

    a. Verify that proper blade alignment, either parallel or opposed, has been provided.

10. DDC system check-out:

    a. Verify that DDC controllers power supply is from the emergency power supply, if applicable.
    b. Verify that wires at the 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.

B. Calibrating and adjusting:

1. Calibrate every instrument in the system.
2. For each analog instrument, make a three point test of calibration for both linearity and accuracy.
3. Equipment and procedures used for calibration shall meet the requirements of the instrument manufacturer's recommendations. Test equipment used in the calibration of instruments shall have an accuracy at least double that of the instrument being calibrated.
4. Calibrate each instrument according to the accuracy outlined in the instruction manual supplied for the instrument by the manufacturer.
5. Control system inputs and outputs:

    a. Check analog inputs using a precision voltage or current source at 0 percent, 50 percent and 100 percent of span.
    b. Check analog outputs using a milliampere meter at 0 percent, 50 percent and 100 percent output.
    c. Check digital inputs using a jumper wire.
    d. Check digital outputs using an ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0 percent, 50 percent and 100 percent of span using a precision resistant source.

6. Pressure:

    a. Calibrate pressure transmitters at 0 percent, 50 percent, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts as per the specifications, with adjustable differential set at the minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0 percent, 50 percent and 100 percent of span using a precision resistance source.
    b. Calibrate temperature switches to make or break contacts as specified.

8. Stroke and adjust control valves and dampers without positioners following the recommended procedure from the manufacturer, such that the valve and damper is 100 percent open and closed at the specified air pressure.
9. Field calibrate each VAV units' controls.
10. Replace out of tolerance instruments failing the test.
11. Provide diagnostic and test instruments for calibration and adjustment of system.
12. Provide a written description of the procedures and equipment for calibrating each type of instrument. Submit the procedures for Architect/Engineer review and approval before initiating start-up procedures.

C. Testing:

1. Test every point in every system to verify safety and operating control setpoints are as specified and as required to operate the system safely while obtaining optimum performance from the equipment controlled. Test every point throughout its full operating range.
2. Test every control loop of every system to verify the system functions in a stable accurate mode of operation and is in accordance with specified sequences of operation. Adjust proportional, integral and derivative actions to meet end to end accuracies specified.

3. Test every system for proper operation under the sequence of operation.
4. Test software and hardware interlocks.
5. Test the operation of each variable air volume unit.

D. Inspection:

1. When complete, submit a written certification to the Architect/Engineer that:

   a. Contract documents have been reviewed.
   b. Work has been inspected for compliance with the contract documents.
   c. Work has been completed in accordance with the contract documents.
   d. Equipment and systems have been tested and meet the requirements of operational stability, accuracy, performance and function in accordance with the sequences of operation.
   e. Work is completed and ready for inspection.

2. The Architect/Engineer shall make an inspection to verify the status of completion with reasonable promptness after receipt of such certification.
3. Should the Architect/Engineer consider the work to be incomplete or defective:

   a. The Architect/Engineer will promptly notify the BAS trade in writing, listing the incomplete or defective work.
   b. Take immediate steps to remedy the stated deficiencies, and send a second written certification to the Architect/Engineer that the work is complete.

4. When the Architect/Engineer finds that the work is acceptable in accordance with the contract documents, make close out submittals and begin BAS acceptance procedures.

3.5 BAS ACCEPTANCE

A. General

1. After completion of installation and start-up procedures, commence the specified 4-phase BAS acceptance procedures:

   a. Follow with the order specified.
   b. Each testing phase shall be satisfactorily completed before entering the next phase.

2. Before entering each phase of the sequence, submit a written agenda to the Architect/Engineer describing in detail the procedure to be followed to meet the requirements.
3. Submit a sample of the test report proposed.

   a. Identify project.
   b. Provide a list of all points, arranged in numerical order of point addresses.

      1) Show point descriptor and location of each.
      2) Indicate system panel and or DDC controller which processes each point.
      3) Use the list as a basis for the specified report form.

   c. Signatures of participants and observers.
   d. Results.

e. Description of adjustment or corrections of points in error.
f. Date.

4. Provide schedule of tests. Estimate dates of significant events.
5. Provide results.
6. BAS acceptance procedures may be witnessed by the Owner, and Architect/Engineer if deemed appropriate by said parties.
7. Provide personnel and diagnostic instruments at both the central and remote locations.
8. Provide testing stimulants for temperatures and alarms.
9. Use digital meters of double the accuracy of the instruments being calibrated.

B. Phase 1:

1. Submit an agenda describing the procedures to be followed in adjusting and verifying operation of each point.
2. Operate each analog point in the BAS:

a. At a point in the upper quarter of its range.
b. At a point in the lower quarter of its range.
c. At the mid point of its range.

3. Exercise each digital point in the BAS.
4. Read and record each value at the BAS workstation and DDC controller and observe the actual function at the field instrument for every point in the BAS. The value displayed at the BAS workstation shall match the value observed at the field instrument.
5. Submit an operation report for each point in the BAS, in an Architect/Engineer approved format, and describe any corrective and adjusting action taken.

C. Phase 2:

1. Furnish, install and debug software to implement the software functions specified.
2. Submit an agenda and report format for the software demonstrations to the Architect/Engineer.
3. Demonstrate the software operates the systems according to the sequences of operations and performs software programs and functions specified and intended. Make modifications to the software as required by the Owner and Architect/Engineer at no additional cost.
4. Demonstrate compliance with response time:

a. Simulate normal heavy load conditions (NHLC).

1) Normal heavy load (NHL) shall be an occurrence wherein 50 percent of the total connected digital changes of value (COV's), one-half of which represent an "alarm" condition, and 50 percent of the total connected analog COV'S, one-half of which represent an "alarm" condition, are initiated simultaneously on a one-time basis.

b. Initiate ten successive occurrences of NHLC and measure response time to typical alarms and status changes.
c. Measure with a timer having at least 0.1 second resolution and 0.01 percent accuracy.
d. The purpose of this test is to demonstrate system reaction to changes of value (COV's) as well as alarm conditions during a normal heavy load occurrence. Additionally, the tests demonstrate the system's ability to update the BAS computer's database during the normal heavy load occurrence.

e. Acceptance of successful NHL testing is contingent upon:

1) Alarm reporting at the printer beginning no more than 2 seconds following the initiation (time zero) of NHL occurrence.
2) Completion of the alarm reporting at the printer occurring within 120 seconds of initiation (time zero) of the NHL occurrence.
3) All alarms, both digital and analog, are printed (none are lost).
4) Compliance with response times specified.

5. Provide written documentation of the demonstration, signed by representatives of the BAS trade, Owner and Architect/Engineer.

D. Phase 3:

1. Verify calibration and function of each point in the BAS.

a. Verify analog points at the operating value.
b. Record on an approved form.
c. Make approved adjustments to out of tolerance points.

1) Identify these points for reference.
2) Simulate abnormal conditions to demonstrate proper function of safety devices.

2. Simulate cooling and heating requirements and demonstrate proper sequence of control.
3. Readjust settings to design values and observe the ability of the controls to establish the desired conditions.
4. After the verification procedure is completed, record on an approved form all corrected points and all points requiring correction. Replace instruments that measurements indicate are out of specified tolerances. Identify on the form any points (instruments) that have been replaced.
5. At least 24 hours after the verification procedure is completed:

a. Reverify corrected points and points that required additional correction.
b. Record on an approved form.
c. Identify points requiring correction.

6. After 24 hours, reverify and correct.

a. Continue reverification testing until the point is normal on two consecutive reverifications.
b. Record tests and corrections.

E. Phase 4; endurance test:

1. Demonstrate correct operation and calibration of the monitored and controlled points as well as the operation and capabilities of sequences, reports, specialized control algorithms, diagnostics, and other software.

a. Correct defects of hardware and software when it occurs, before resuming the test.
b. Down time shall be defined as whenever any point in the system is unable to fulfill the required functions.

c. A failed point constituting down time is defined as a point failing to perform its intended function consistently and a point physically failed due to hardware and software.

2. Operate the system for at least 30 calendar days.

a. This period shall start at the beginning of the initial test period in this phase.
b. Log down time and operational problems.

1) Identify the source of the problem.
2) Describe the corrective action.
3) Record the length of down time.
4) Maintain the log and in addition to the above mentioned log information, show the time of occurrence, description of occurrence, and comments. Down time for each failed point will be shown on the log, and will be the elapsed time between the time the failure is confirmed by the BAS trade (The maximum time interval between failure occurrence and confirmation shall be 30 minutes) and the time the point is restored to service. The down time will be logged in hours to the nearest 0.1 hour. The log shall be available to the Owner and the Architect/Engineer at any time during the test period.

c. Total down time during the 30 day test period shall not exceed 1 percent of the total operating time.

1) Power outages shall not count as down time, but shall suspend the test.
2) Hardware or software failures caused by power outages shall count as down time.

d. During the 30 day test period, man the control room at least eight hours per day, five days per week.
e. Failure to meet the specified operating level requires that the test be continued until the system qualifies. Testing of a failed system (system which exceeded 1 percent down time over a 30 day test period) shall continue until down time is less than 1 percent of total test time.
f. Evaluation of down time will be as follows: as specified, the maximum allowed down time is 1 percent. The time will be counted on a point-hour basis; that is, the total number of point hours in the test is equal to the number of points multiplied by the number of test hours. The following is an example of the calculation for maximum allowable down time:

1) Maximum allowable down time for 30 day endurance test when the system contains 1000 individual points (combined analog and digital) is computed by 30 days x 24 hours per day x 1000 points x 1 percent equals 7,200 point hours maximum allowable down time.
2) A point hour of down time is one point down for one hour. Three points down for 5 hours is a total of 15 point hours. Four points down for one-half hour is 2 point hours.

3.6 CLASSROOM INSTRUCTION TO OWNER

A. At a time manually agreed upon during or after BAS acceptance give 16 hours of instruction to the Owner on the operation of BAS equipment . Describe its intended use with respect to the programmed functions specified. Operator orientation of the BAS shall include, but shall not be

limited to, the operational program, equipment functions (both individually and as part of the total integrated system), commands system generation, advisories, and appropriate operator intervention required in responding to the system's operation. Use the Owner's operation and maintenance manual prepared for this project in addition to the instruction. A classroom will be provided on the Owner's premises for instruction. Instruction shall occur on two different days approximately 30 days apart or as directed by the owner.

B. As a minimum, instruct the Owner on the following during the 8 hours of instruction specified above. Additional instruction time as deemed necessary by the Owner may be obtained on the basis negotiated.

1. Sequence of operation review.
2. Sign on; sign off.
3. Selection of each display and report.
4. Commanding of points, English and graphic mode.
5. Modifying English text.
6. Modifying alarm limits and start-stop times.
7. System initialization.
8. Download and initialization of DDC controllers.
9. Purge and/or dump of historical data.
10. Use of operator's terminal.
11. Troubleshooting of sensors (determining bad sensors).
12. Creating and modifying color graphics.
13. Password assignment/modification (supervisor only).
14. Operator assignment/modification (supervisor only).
15. Operator authority assignment/modification (supervisor only).
16. Point disable/enable (supervisor only).
17. Station data segregation/modification (supervisor only).
18. Software review of sequence of operation programs.
19. Modification of control programs.
20. Add/delete/modify data points.
21. Use of diagnostics.
22. System maintenance procedures.
23. Upload/download and off-line archiving of all system software.

C. Base training and instruction defined in this paragraph upon 5 persons.

END OF SECTION 23 09 10

SECTION 23 10 00 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Variable frequency drives shall be provided by the Mechanical Contractor and installed by the Electrical Contractor.

B. Extent of variable frequency drives work is indicated by drawings and schedules, and by requirements of this section for the following equipment:

1. Pumps.

C. The variable frequency drives for this project shall be Pulse Width Modulation type.

D. Refer to other Division-23 sections for motors, pumps, air handling equipment, and controls not factory installed.

E. Refer to Division-26 sections for the following work:

1. Power wiring for unit.

F. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections.

1. Control and interlock wiring between operating controls, indicating devices, unit temperature control panels and variable frequency drive.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of variable frequency drives, of types and capacities required, where products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: A firm specializing and experienced in variable frequency drive installations for not less than 5 years.

C. Codes and Standards:

1. Electrical Standards: Provide electrical components of variable frequency drives which have been UL-listed and labeled, and comply with NEC standards.
2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices.
3. ETL Compliance: Provide variable frequency drives with ETL approved label.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring for variable frequency drives. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.

D. Maintenance Data: Submit maintenance data and parts list for each variable frequency drive, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of Section 23 00 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle variable frequency drives carefully to prevent damage, breaking, denting and scoring. Do not install damaged units or components; replace with new.

B. Store variable frequency drives in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading variable frequency drives and moving units to final location for installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Basis of Design Manufacturers: Subject to compliance with requirements, provide variable frequency drives of one of the following:

1. ABB (ASEA Brown Boveri) Model No. ACH550

B. Alternate Manufacturers: Subject to compliance with requirements, provide variable frequency drives of one of the following:

1. Graham Company
2. Square D

2.2 GENERAL

A. Establish requirements for variable voltage variable frequency motor controls, for speed control of fans, blowers, or pumps driven with AC motors.

B. Contractor shall coordinate exact locations of all motors controlled from a pulse width modulated VFD and provide motor with Class F insulation rating.

2.3 VARIABLE FREQUENCY MOTOR CONTROL

A. Pulse Width Modulation VFD:

1. The controller shall produce an adjustable AC voltage/frequency output. It should have an output voltage regulator to maintain correct output V/Hz. despite incoming voltage variations.
2. The controller shall have a continuous output current rating of 100% of motor nameplate current.
3. 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.
4. The inverter output shall be generated by power transistors or IGBT's (isolated gate bipolar transistors).
5. The logic control section shall be microprocessor based.

2.4 SPECIFICATION

A. Verify power input requirements with drawings.

1. Nominal input voltage +/-10%
2. Input frequency stability +/-5%

B. Provide minimum 3% Line Reactor.

C. Output power; 3 phase, 1.5 to 60 Hz with variable voltage to give proper and efficient operation of variable torque load.

D. Overload capacity of 125% for 1 minute.

E. Displacement power factor - Minimum of 90% over the entire speed range.

F. VFD shall be rated for HP rating indicated on drawings. Additionally amp rating shall not be less than National Electrical Code, Table 430-250 for corresponding HP size indicated. HP and current ratings noted above shall be minimum values after any/all derating factors such as frequency, etc. have been applied.

2.5 MINIMUM REQUIREMENTS FOR CONTROL OPERATION

A. Fused input door interlocked disconnect.

B. Isolated 115VAC control transformer.

A. Operator Interface: Provide detachable multifunction control panel with full graphic LCD display and multiple language capability. Control panel shall have a green power on and red fault LED indicators, and shall display fault indication, operational parameters, and time clock functions. The control panel shall contain a keypad to scroll through and set or display operational parameters. Operator interface shall include Hand-Off-Auto (HOA) selector switch.

B. Annunciated fault and limit functions for:

1. Thermal overload relay trip
2. Microprocessor self-check function

3. Output overcurrent trip
4. DC bus overvoltage trip
5. Inverse time overload trip
6. Heat sink overtemperature trip
7. DC bus fuse open
8. DC bus overvoltage (regen. limit)
9. Output ground fault
10. Inverter ready light
11. Inverter run light
12. Bypass run light
13. Bypass safety lockout light (red)
14. Inverter safety lockout light (red)
15. Power line on light
16. Control voltage enabled light

2.6 MINIMUM REQUIRED STANDARD FEATURES

A. Where indicated, VFD's shall be provided with a bypass to allow operation of motor(s) across the line.

B. Provide fused disconnect integral to enclosure on load side of VFD's with integral electronic bypass. Disconnect shall be capable of being locked in the open position.

C. Provide fused input disconnect switch or circuit breaker on line side of VFD and also on line side of Bypass supply for VFD's with external bypass. Disconnect shall be capable of being locked in the open position.

D. Provide fused disconnect for each motor when one VFD serves more than one motor. Provide overload relays for each motor.

E. Door Mounted Components:

1. Inverter run indication
2. Bypass run indication
3. Remote safety indication
4. Digital speed (frequency or percent speed) and motor ammeter
5. Manual speed potentiometer
6. Inverter / Off / Bypass switch
7. Reset push-button for fault and enable
8. Manual / Auto reference selector switch
9. Annunciation as in Section 2.04

F. DC bus charged indicator

G. Current limit circuit active to prevent nuisance tripping during accel or run conditions.

H. Regeneration limit circuit active to prevent nuisance OV tripping during deceleration.

I. Minimum and maximum speed set, separate and non-interactive.

J. Power loss restart selectable for Auto Restart in auto mode only.

1. Automatic restart from undervoltage, power failure, or control fault, or both.

K. Critical frequency lockout for up to 2 points, available from 10 to 100% speed with at least a 6 Hz bandwidth.

L. Only non-filament type indicating lights may be used.

M. Control shall survive without component failure, and annunciate, output phase to phase and phase to ground faults.

N. The VFD shall be provided with the following resident serial communications protocols and/or fieldbus adapter modules to allow integration to the Building Automation System (BAS):

1. Serial Communications protocols:

a. Modbus RTU
b. BACnet

2. Fieldbus Adapter Modules:

a. Ethernet/IP
b. Modbus/TCP
c. Profinet IO

O. Control shall have the following isolated instrument signal follower:

1. 4 to 20 madc
2. 0 to 10 vdc
3. 3 to 15 psi (optional)
4. Floating point (optional)

P. Loss of reference protection, VFD shall reset to predetermined minimum speed until such time as the control is commanded to stop or the analog reference returns to normal.

Q. Control shall have available 15 selectable volts per hertz patterns.

R. Volts per hertz ratio shall be automatic, tracking motor load requirements to achieve most efficient operation within the parameters set by the volts per hertz pattern. Potentiometer adjustments not allowed.

S. VFD shall have automatic restart capabilities and be capable of starting into a spinning motor.

T. Control must be capable of starting into a spinning motor and switching from inverter to bypass back to inverter without delay and without tripping off line of the inverter, also must be capable of stopping a motor rotating in the reverse direction and then accelerating that motor in the proper direction.

U. Control shall have a fused door interlocked disconnect with fuses rated for proper branch circuit protection.

V. All components must be supplied in an enclosure.

W. Electronic Bypass Control: An integrated electronic bypass control shall be provided for the purpose of running the AC motor at full speed with line power while the VFD is inoperative. Bypass and drive shall be electronically interlocked. VFD shall be serviceable while operating in the bypass mode. The bypass control shall include:

1. Safety Circuit Terminal Strip
2. Door Interlocked Disconnect
3. Drive Off-Line Selector
4. Power On Light
5. VFD Output Contactor
6. VFD Select Light
7. Overload Relay
8. Line Select Light
9. 115 VAC Control Transformer

X. Manual Bypass Control. A bypass control shall be provided for the purpose of running the AC motor at full speed with line power while the VFD is being serviced. Bypass and drive shall be electrically interlocked. The VFD package shall be configured so that the VFD can be removed for service with the bypass control left in place. The bypass control shall include:

1. NEMA 1 Enclosure
2. Safety Circuit Terminal Strip
3. Door Interlocked Disconnect
4. Drive Off-Line Selector
5. Bypass Contactor
6. Power On Light
7. VFD Output Contactor
8. VFD Select Light
9. Overload Relay
10. Line Select Light
11. 115 VAC Control Transformer

Y. BAS Integration: Variable frequency drive shall be provided with the resident serial communications protocol or interface module necessary to integrate the drive with the Siemens BAS. Resident serial communications protocol or interface module shall provide all microprocessor operation and diagnostics information to the Siemens BAS for a fully integrated system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which variable frequency drive systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF VARIABLE FREQUENCY DRIVE SYSTEMS

A. General: Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable Division-26 sections of these specifications. Mount controllers at convenient locations and heights.

3.3 ADJUSTING AND CLEANING

A. Start-Up: Start-up, test, and adjust variable frequency drive systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

C. Final Adjustment: After completion of installation, coordinate with temperature control contractor to verify that all controls are operating correctly with the variable frequency drive system.

3.4 CLOSEOUT PROCEDURES

A. Owner's Instructions: Provide services of manufacturer's technical representative for one 4-hour day to instruct Owner's personnel in operation and maintenance of variable frequency drive systems.

1. Schedule instruction with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 23 10 00

This page is intentionally left blank for printing purposes

SECTION 23 21 13 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes piping systems for hot water heating, chilled water cooling, condenser water, make-up water for these systems, blow-down drain lines, and condensate drain piping. Piping materials and equipment specified in this Section include:

1. Piping and fittings.
2. Calibrated plug valves.
3. Pump discharge valves.
4. Safety relief valves.
5. Pressure reducing valves.
6. Air vents.
7. Air separators.
8. Combination air and dirt separators.
9. Compression tanks.
10. Pump suction diffusers.
11. Chemical feeder.
12. Diverting fittings.
13. Y-Pattern strainers.
14. T-Pattern strainers.
15. Basket strainers.

B. The following Division-23 sections apply to this section:

1. Mechanical General Provisions
2. Basic Mechanical Materials and Methods.
3. General Duty Valves.
4. Supports and Anchors.

C. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 23 Section "Basic Mechanical Materials and Methods" for materials and methods for sealing pipe penetrations through basement walls, and fire and smoke barriers.
2. Division 23 Section "General Duty Valves" for gate, globe, ball, butterfly, and check valves.
3. Division 23 Section "Meters and Gauges" for thermometers, flow meters, and pressure gages.
4. Division 23 Sections Mechanical Identification and Basic Mechanical Materials and Methods for labeling and identification of hydronic piping system.
5. Division 23 Section "Mechanical Insulation" for pipe insulation.
6. Division 23 Section "HVAC Pumps" for pumps, motors, and accessories for hydronic systems.
7. Division 23 Section "Building Automation System" for temperature control valves and sensors.
8. Division 23 Section "Testing, Adjusting, and Balancing" for procedures for hydronic systems adjusting and balancing.

1.2 DEFINITIONS

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

1.3 SYSTEM DESCRIPTION

A. General: The hydronic piping systems are the "water-side" of an air-and-water or all-water heating and air conditioning system. Hydronic piping systems specified in this Section include 4-pipe, hot water and chilled water piping system, and condenser water piping system. These systems are classified by ASHRAE as Low Water Temperature, Forced, Recirculating systems.

B. 4-Pipe System: The 4-pipe system includes independent chilled water and hot water supply and return piping mains in a closed loop, connecting the boilers and chillers to the terminal heat transfer units by means of primary/secondary piping loops. Circulation is accomplished by parallel, constant volume, primary pumps and independent secondary pumps. Design flow rates and water temperatures are specified in the various equipment specifications and schedules. Control sequences and temperature reset schedules are specified on the drawings.

C. Condenser Water System: This system is an open piping loop connecting the chillers to the cooling tower. Circulation is accomplished by means of parallel, constant volume pumps. Design flow rates and water temperatures are specified in the various equipment specifications and schedules. Control sequences and temperature reset schedules are specified in the temperature control specifications.

1.4 SUBMITTALS

A. Product Data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.

1. Furnish flow and pressure drop curves for diverting fittings and calibrated plug valves, based on manufacturer's testing.

B. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 1 and Division-23 Section "Mechanical General Provisions."

C. Welders certificates certifying that welders comply with the quality requirements specified in Quality Assurance below.

D. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.

E. Reports specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following:

1. ASME B 31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Selection VIII, Division 1.
3. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.
4. PPI TR-4 – Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds.
5. ASTM F 714 – Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
6. ASTM D 3035 - Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
7. ASTM D 3261 – Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
8. ASTM F 2389-07 - Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
9. CSA B137.11 - Polypropylene (PP-R) Pipe and Fittings for Pressure Applications
10. NSF/ANSI 14 – Plastic Piping System Components and Related Materials
11. Local, City, and State Codes.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 23 Section “Basic Mechanical Materials and Methods”.

B. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 SPECIAL WARRANTY

A. Manufacturer of propylene pipe and fittings shall warrant pipe and fittings for 10 years to be free of defects in materials or workmanship. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or workmanship.

1.8 EXTRA STOCK

A. Maintenance Stock: Furnish a sufficient quantity of chemical for initial system start-up and for preventative maintenance for one year from Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one of the following:

1. Calibrated Plug Valves:

a. American Wheatley.
b. Bell & Gossett ITT; Fluid Handling Div.
c. Dezurik.

d. Milliken Valve.
e. Taco, Inc.

2. Pump Discharge Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett ITT; Fluid Handling Div.
d. Taco, Inc.

3. Safety Relief Valves:

a. Amtrol, Inc.
b. Bell & Gossett ITT; Fluid Handling Div.
c. Spirax Sarco.
d. Watts Regulator Co.

4. Pressure Reducing Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett ITT; Fluid Handling Div.
d. Taco, Inc.

5. Balancing Valve System:

a. Flow Set by Flow Design, Inc.
b. Flo-Pac.
c. Macon.
d. Victaulic/TA Hydronic Series 700

6. Air Vents (manual and automatic):

a. Armstrong Machine Works.
b. Bell & Gossett ITT; Fluid Handling Div.
c. Hoffman Specialty ITT; Fluid Handling Div.
d. Spirax Sarco.

7. Air Separators:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett ITT; Fluid Handling Div.
d. Taco, Inc.

8. Combination Air and Dirt Separators:

a. Spirotherm.

9. Compression Tanks:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett ITT; Fluid Handling Div.

d. Taco, Inc.

10. Bladder-Type Compression Tanks:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett ITT; Fluid Handling Div.
    d. Wessels Company.

11. Pump Suction Diffusers:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett ITT; Fluid Handling Div.
    d. Flow Conditioning Corp.
    e. Paco.
    f. Taco, Inc.

12. Chemical Feeder:

    a. Culligan USA.
    b. Vulcan Laboratories, Subsidiary of Clow Corp.
    c. York-Shipley, Inc.

13. Diverting Fittings:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett ITT; Fluid Handling Div.
    d. Taco, Inc.

14. Dielectric Waterway Fittings:

    a. Victaulic Company of America

15. Dielectric Unions:

    a. Perfection Corp.
    b. Watts Regulator Co.

16. Y-Pattern Strainers

    a. Armstrong Machine Works.
    b. Hoffman Specialty ITT; Fluid Handling Div.
    c. Metraflex Co.
    d. Mueller Steam Specialty.
    e. Spirax Sarco.
    f. Watts Regulator Co.

17. T-Pattern Strainers

    a. Fabrotech Industries.
    b. Fluid Engineering.
    c. Islip Flow Controls.

d. Mueller Steam Specialty.

18. Basket Strainers:

a. Crane Co.
b. Metraflex Co.
c. Mueller Steam Specialty.
d. Spirax Sarco.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 Article "PIPE APPLICATIONS" for identification of where the below materials are used.

B. Annealed Temper Copper Tubing: ASTM B 88, Type K.

C. Steel Pipe: ASTM A 53, Schedule 40, welded, black steel pipe, made in USA.

2.3 FITTINGS

A. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

C. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

D. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

E. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.

F. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.

G. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:

1. Material Group: 1.1.
2. End Connections: Butt Welding.
3. Facings: Raised face.

H. Unions: ANSI B16.39 malleable-iron, Class 150, hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends. Threads shall conform to ANSI B1.20.1.

I. Dielectric Unions: Threaded or soldered end connections for the pipe materials in which installed; constructed to isolate dissimilar metals, prevent galvanic action, and prevent corrosion.

J. Flexible Connectors (Stainless Steel Type): stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250°F

operating temperature. Connectors shall have flanged or threaded end connections to match equipment connected; and shall be capable of 3/4 inch misalignment.

2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, 95-5 Tin-Antimony, for chilled water, condenser water, heating hot water, low pressure steam, make-up water and drain piping.

B. Brazing Filler Metals: AWS A5.8, Classification BAg 1 (Silver).

1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

C. Welding Materials: Comply, with Section II, Part C. ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

D. Gasket Material: Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.

2.5 GENERAL DUTY VALVES

A. General duty valves (i.e., gate, globe, check, ball, and butterfly valves) are specified in Division-23 Section "General Duty Valves." Special duty valves are specified below by their generic name; refer to Part 3 Article "VALVE APPLICATION" for specific uses and applications for each valve specified.

2.6 SPECIAL DUTY VALVES

A. Calibrated Plug Valves: 125 psig water working pressure, 250°F maximum operating temperature, bronze or ductile iron body, plug valve with calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated scale to register degree of valve opening. Valves 2 inches and smaller shall have threaded connections and valves 2-1/2 inches and larger shall have flanged connections.

B. Pump Discharge Valves: 175 psig working pressure, 300°F maximum operating temperature, cast-iron body, bronze disc and seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.

C. Pressure Reducing Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.

D. Safety Relief Valves: 125 psig working pressure and 250°F maximum operating temperature; designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted

internal working parts made of brass and rubber. Select valve to suit actual system pressure and Btu capacity.

E. Combined Pressure/Temperature Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250°F maximum operating temperature. Select valve to suit actual system pressure and Btu capacity. Provide with fast fill feature for filling hydronic system.

F. Automatic Flow Control Valves: Class 150, cast iron housing, stainless steel operating parts; threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inches and larger. Factory set to automatically control flow rates within plus or minus 5 percent design, while compensating for system operating pressure differential. Provide quick disconnect valves for flow measuring equipment. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and rate flow in GPM.

G. Balancing Valve System:

1. System Description: Furnish and install where shown on drawings complete FlowSet balancing valve system as manufactured by Flow Design Inc. or equal. This system shall consist of flow measurement venturis with pressure/temperature ports and flow setting valves with memory stops on the leaving side of the heat transfer equipment. The valves shall also contain temperature and pressure test ports. Venturis shall have a minimum static regain of 80 percent and shall be selected with a signal in the range of 24-100 inches water column. The manufacturer shall also furnish a flow meter kit for use with the system. The following system model numbers shall be used as the basis of design:

   a. FlowSet Model “F” by Flow Design Inc. for sizes 2” and smaller.
   b. FlowSet Model “EF” by Flow Design Inc. for sizes 2-1/2” and larger.

2. Flow Measurement Venturi’s:

   a. 2” and Smaller: The flow measuring venturi section shall be of bronze and brass construction integrally designed with the ball valve section and sized for maximum pressure recovery and a flow accuracy of ±2% for direct flow measurement conditions. The valve accuracy is obtained with no provision for external clearances on ball valves through 2" size. The required clearances are contained entirely within the assembly. The flow section is furnished with two dual-core temperature/pressure taps with color coded removable retained safety cap assemblies. The unit also contains a ground-joint union especially designed for minimum turbulence and to allow for full service.
   b. 2-1/2” and Larger: The flow measuring venturi section shall be of steel construction with extended inlet and integrally designed with the butterfly valve section and sized for maximum pressure recovery and a flow accuracy of ±3% for direct flow measurement conditions. The valve accuracy is obtained with no provision for external clearances on the butterfly valves or the inlet through 14" size. The required clearances are contained entirely within the assembly. The flow section is furnished with two dual-core temperature/pressure taps with color coded removable retained safety cap assemblies. The unit shall also contains a 150# raised face flange connection on the inlet and outlet to allow for full service.

3. Flow Setting Valves:

   a. 2” and Smaller: The flow setting valve shall be a ball valve rated at 400 PSIG at 250°F with bronze body, stainless steel ball, Teflon seats, blowout proof stem, Teflon packing, packing nut, and full size handle with vinyl grip and memory stops. Ball valves shall have threaded connections.
   b. 2-1/2” and Larger: The flow setting valve shall be a butterfly valve rated at 225PSIG at 250°F with cast iron body, aluminum/bronze disc, EPDM seats, 416 stainless steel stem, bronze sleeve bearings, and lug end connections. Valves shall have ten position handle and external lockable memory stop for valves 6” and smaller and gear operators with memory stop for valves 8” and larger.

4. Flow Measuring Test Kit: Furnish Flow Design Inc. Flow Measurement Test Kit Model 300.5 or equal. The flow indicating meter shall be portable with a 6" face and 270° indication. This meter shall have over range protection in either direction and shall be a liquid filled bellows type with integral temperature compensation. Accuracy of the meter shall be no less than ±1% full scale. The dial face will be furnished with removable transparent faces (covering entire valve line) and indicating flow directly in GPM. The portable meter shall be permanently mounted in a durable impact resistant plastic case complete with the following accessories:

   a. A dial indicating thermometer (0° to 220°F) for use in the dual core temperature-/pressure test ports, a pressure gauge with a range of 0 to 100# for use in determining the system static pressure.
   b. Two 10' color coded lengths of hose along with adapter needles for pressure measurement.
   c. Bleed hoses and flexible bleed line.
   d. An instruction book with flow vs differential curves for entire FlowSet product line. The kit shall become the property of the building owner after the system is accurately balanced.

H. Circuit Balancing Valve:

1. System Description: Furnish and install where shown on drawings balancing valve as manufactured by Victaulic/TA or equal:2” and smaller sizes: 300 psi (2065 kPa), threaded ends, non-ferrous Ametal brass copper alloy body, EPDM o-ring seals. Four turn digital readout handwheel for balancing, hidden memory feature with locking tamper-proof setting. Victaulic/TA Hydronics Series 700, or equal (pre-approved by Engineer).

2.7 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150 psig working pressure, 225°F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8 inch discharge connection and 1/2 inch inlet connection.

B. Automatic Air Vent; Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240°F operating temperature; and having 1/4 inch discharge connection and 1/2 inlet connection.

C. Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 375°F maximum operating temperature. Provide taps in bottom of tank for tank fitting; taps in end of tank for gage glass. Tank with taps constructed shall be tested

and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1. Furnish with the following fittings and accessories:

1. Air Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless steel ball check; sized for compression tank diameter. Design tank fittings for 125 psig working pressure and 250°F maximum operating temperature.
2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125 psig working pressure and 240°F maximum operating temperature. Fitting shall be designed to admit air to the compression tank and drain water, plus close off the system.
3. Gage Glass: Full height and have dual manual shutoff valves, 3/4 inch diameter gage glass, and slotted metal glass guard.

D. Bladder-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 240°F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a heavy duty butyl replaceable bladder. Provide taps for pressure gage and air charging fitting (standart tire valve), and drain fitting. Support vertical tanks with steel legs or ring base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1. (Note: Diaphram type tanks will not be considered as a substitute for bladder type tanks.)

E. Air Separator: Welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and 375 F operating temperature; perforated stainless steel air collector tube designed to direct released air into compression tank; tangential inlet and outlet connections; screwed connections up to and including 2" NPS; flanged connections for 2-1/2" NPS and above; threaded blowdown connection; sized as indicated for full system flow capacity.

F. Combination Air and Dirt Separator: Welded black steel; ASME constructed and labeled for minimum 150 psig water working pressure and 270 F operating temperature. Units shall be selected for less than 2 foot of water pressure drop and a velocity not to exceed 6 feet per second through the unit at the specified flow. Units shall include internal copper coalescing medium to facilitate maximum air and dirt separation and suppress turbulence. Units shall remove free and entrained air during system startup and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action. Unit shall have an air collection and venting chamber with a integral float actuated brass air vent at the top and a side tap with manual valve to flush floating dirt or liquids and for quick venting of large amounts of air during system fill. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equidistant from the top and bottom of the vessel and include a blowdown connection and valve. Unit shall also include a removable lower head to facilitate removal of the coalescing media assembly for cleaning.

G. Pump Suction Diffusers: Cast-iron body, with threaded connections for 2 inches and smaller, flanged connections for 2-1/2 inches and larger; [175][300] psig working pressure, [300][230]°F maximum operating temperature; and complete with the following features:

1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
3. Disposable fine mesh strainer to fit over cylinder strainer.
4. Permanent magnet, located in flow stream, removable for cleaning.
5. Adjustable foot support, designed to carry weight of suction piping.
6. Blowdown tapping in bottom; gage tapping in side.

H. Chemical Feeder: Bypass type chemical feeder of 5 gallon capacity, welded steel construction; 125 psig working pressure; complete with fill funnel and inlet, outlet, and drain valves.

1. Chemicals shall be specially formulated to prevent accumulation of scale and corrosion in piping system and connected equipment, developed based on a water analysis of make-up water.

I. Diverting Fittings: Cast iron body with threaded ends, or wrought copper with solder ends; 125 psig working pressure, 250°F maximum operating temperature. Indicate flow direction on fitting.

J. Y-Pattern Strainers: 125 psig working pressure cast iron body (ASTM A 126, Class B), flanged ends for 2-1/2 inch and larger, threaded connections for 2 inch and smaller, bolted cover, perforated Type 304 stainless steel basket, and bottom drain connection.

K. Basket Strainers: 125 psig working pressure; high tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless steel basket, bottom drain connection.

L. T-Pattern Strainers: Fabricated carbon steel, class 150 with buttweld or flanged end connections, Type 304 stainless steel strainer basket with 57 percent free area, bolted flange, hinged cover, or removable access cover for strainer maintenance.

PART 3 - EXECUTION

3.1 PIPE APPLICATIONS

A. Install Type L, drawn copper tubing with wrought copper fittings and solder joints for 2 inch and smaller, above ground, within building. Install Type K, annealed temper copper tubing for 2 inch and smaller without joints, below ground or within slabs.

B. Install steel pipe with threaded joints and fittings for 2 inch and smaller, and with welded joints for 2-1/2 inch and larger.

3.2 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and all branch connections.

C. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

E. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

F. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

G. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.

H. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves above grade shall be steel and pipe sleeves below grade shall be Schedule 80 PVC or reusable molded PE .

I. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 23 Section “Basic Mechanical Materials and Methods” for special sealers and materials.

J. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

K. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

L. Install branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line.

M. Install unions in pipes 2 inches and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

N. Install dielectric unions to join dissimilar metals.

O. Install flanges on valves, apparatus, and equipment having 2-1/2 inches and larger connections.

P. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration producing equipment.

Q. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 inches and larger.

R. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings and specified in Division-23 Section "Expansion Compensation."

S. PIPING INSTALLATIONS

1. Install hangers and supports at intervals specified in the applicable Plumbing or Mechanical Code and as recommended by pipe manufacturer.
2. Support vertical piping at each floor and as specified in the applicable Plumbing or Mechanical Code.
3. Fire stopping shall be provided to both be compatible with the Aquatherm Piping and meet the requirements of ASTM E 814 or ULC S115 , “Fire Tests of Through-Penetration Firestops”. Pipe insulations or fire resistive coating shall be removed where the pipe passes through a fire stop and, if required by the firestop manufacturer, for 3 inches beyond the firestop outside of the fire barrier.
4. When installed in systems with pumps in excess of 7.5 HP, piping shall be protected from excessive heat generated by operating the pump at shut-off conditions. Where the possibility exists that the pump will operate with no flow, the protection method shall be a

temperature relief valve or comparable level of protection, set to a maximum temperature of 185°F.

5. If heat tracing is specified for the piping, it should be installed on the pipe interior or exterior, and it must be suitable for use with plastic piping and self-regulating to ensure the surface temperature of the pipe and fittings will not exceed 158°F.

3.3 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors devices are specified in Division 23 Section "SUPPORTS AND ANCHORS." Conform to the table below for maximum spacing of supports:

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
2. Adjustable roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe roller complete - MSS Type 44 for multiple horizontal runs, 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers with the following minimum rod sizes and maximum spacing:

Nom. Pipe Size	Max. Span-Ft.	Min. Rod Size-Inches
1	7	3/8
1-1/2	9	3/8
2	10	3/8
3	12	1/2
3-1/2	13	1/2
4	14	5/8
5	16	5/8
6	17	3/4
8	19	7/8
10	22	7/8
12	23	7/8

D. For HDPE piping, install with the following minimum rod sizes and maximum spacing:

Nom. Pipe Size	Max. Span-Ft.	Min. Rod Size-Inches
3	6.0	1/2
4	6.8	5/8
5	7.6	5/8
6	8.3	3/4
8	9.4	7/8

E. Support vertical runs at each floor.

3.4 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

1. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.

2. Fill the pipe and fittings during brazing, with an inert gas (i.e., nitrogen or carbon dioxide) to prevent formation of scale.
3. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe fittings and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
2. Align threads at point of assembly.
3. Apply approximate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

a. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Welded Joints: Comply with the requirement in ASME Code B31.9-"Building Services Piping."

D. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contract of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.5 VALVE APPLICATIONS

A. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:

1. Shut-off duty: use gate, ball, and butterfly valves
2. Throttling duty: use globe, ball, and butterfly valves
3. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicted.
4. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.

B. Install balancing valve system on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.

C. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

D. Install check valves on each pump discharge and elsewhere as required to control flow direction.

E. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.

F. Install safety relief valves on boilers, hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code.

1. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 for installation requirements.

G. Install pressure reducing valves on make-up water to boilers, hot water generators, and elsewhere as required to regulate system pressure.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in the system, at heat transfer coils, and elsewhere as required for system air venting. For unaccessible vent locations, the vent piping shall be piped to a location where vent will be accessible.

B. Install automatic air vents at air separators as required for system air venting. Vent piping shall be piped to a floor drain.

C. Install inline air separators in pump suction lines. Install drain valve on units 2 inches and larger.

D. Install combination air separator/strainer in pump suction lines. Install blowdown piping with ball valve; extend to nearest drain.

E. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.

F. Install pump discharge valves in horizontal or vertical position with stem in upward position. Allow clearance above stem for check mechanism removal.

G. Install shot-type chemical feeders in each hydronic system where indicated; in upright position with top of funnel not more than 48 inches above floor. Install feeder across pump using globe or ball valves on each side of feeder. Pipe drain, with ball valve, to nearest equipment drain.

H. Install compression tanks above air separator. Install gage glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank. Run piping from air separator to compression tank with 1/4 inch per foot (2 percent) upward slope towards tank.

1. Support tank as detailed on the Drawings. In the absence of details provide support from the floor or structure above sufficient for the weight of the tank, piping connections, and fittings, plus weight of water assuming a full tank of water. Do not overload building components and structure members.

I. Install bladder-type compression tanks on floor as indicated. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements. Connect compression tank off bottom of hydronic system main downstream of air separator. Run piping from hydronic system to compression tank with 1/4 inch per foot (2 percent) downward slope towards tank.

3.7 FIELD QUALITY CONTROL

A. Preparation for testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:

1. Leave joints including welds uninsulated and exposed for examination during the test.
2. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Testing: Test hydronic piping as follows:

1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of that liquid.
3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
4. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code For Pressure Piping, Building Services Piping.
5. After the 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 as appropriate, and repeat hydrostatic test until there are no leaks.

3.8 ADJUSTING AND CLEANING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

C. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.9 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper direction of rotation and correct improper wiring.
4. Set automatic fill valves for required system pressure.
5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check operation of automatic bypass valves.
8. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
9. Lubricate motors and bearings.

END OF SECTION 23 21 13

This page is intentionally left blank for printing purposes

SECTION 23 21 23 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of HVAC pumps work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of pumps specified in this section include the following:

1. Vertical In-Line.
2. Base-Mounted, Close-Coupled, End Suction.
3. Base-Mounted, Separately-Coupled, End Suction.
4. Base-Mounted, Separately-Coupled, Double-Suction.

1.2 RELATED SECTIONS

A. Refer to Section 23 00 00 for equipment certification requirements.

B. Refer to Division-26 sections for the following work:

1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory- installed, by manufacturer.

C. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:

1. Control and interlock wiring between operating controls, indicating devices, and temperature control panels.

D. Refer to the following:

1. Section 23 05 00 Basic Mechanical Materials and Methods Concrete For Mechanical Work for specifications on concrete and reinforcing materials and concrete placing requirements for equipment pads.
2. Division 23 Section "Electrical Provisions of Mechanical Work and Mechanical Provisions of Electrical Work" for electrical motors, connections, and accessories.
3. Division 23 Section "Meters and Gauges" for temperature and pressure gages and connectors.
4. Division 23 Section " Building Automation System" for interlock wiring between pumps, and between pumps and field-installed control devices.
5. Division 26 Section "General Electrical" for power supply wiring including field-installed disconnects and required electrical devices.
6. Division 23 Section “Variable Frequency Drives” for variable frequency drives.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 1 Specification Sections and Section 23 01 00.

B. Product data including certified performance curves of selected models indicating selected pump's operating point, weights (shipping, installed, and operating), furnished specialties, and accessories.

C. Shop drawings showing layout and connections for HVAC pumps. Include setting drawings with templates, and directions for installation of foundation bolts and other anchorages.

D. Wiring diagrams detailing wiring for power, signal, and control systems, differentiating between manufacturer-installed wiring and field-installed wiring.

E. Maintenance data for HVAC pumps for inclusion in Operating and Maintenance Manual specified in Division 1 and Section 23 00 00.

1.4 QUALITY ASSURANCE

A. Hydraulic Institute Compliance: Design, manufacture, and install HVAC pumps in accordance with "Hydraulic Institute Standards."

B. National Electrical Code Compliance: Provide components complying with NFPA 70 "National Electrical Code."

C. UL Compliance: Provide HVAC pumps which are listed and labeled by UL, and comply with UL Standard 778 "Motor Operated Water Pumps."

D. NEMA Compliance: Provide electric motors and components that are listed and labeled NEMA.

E. Single Source Responsibility: Obtain HVAC pumps from a single manufacturer.

F. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of HVAC pumps, and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions and profiles and efficiencies do not change the design concept or intended performance as judged by the Architect.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in a dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. For storage times greater than 5 days, dry internal parts with hot air or a vacuum-producing device to avoid rusting internal parts. Upon drying, coat internal parts with a protective liquid, such as light oil, kerosene, or antifreeze. Dismantle bearings and couplings, dry and coat them with an acid-free heavy oil, and then tag and store in dry location.

E. Comply with Manufacturer's rigging instructions for handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Vertical Inline Pumps:

a. "Series 4360," Armstrong Pumps, Inc.
b. "380 Series, APCO-LIGN," Aurora Pumps.
c. "Series 80," Bell & Gossett, ITT.
d. "Type CV," Weinman, Mueller Pump.

2. Base-Mounted, Close-Coupled, End-Suction Pumps:

a. "Series 4280," Armstrong Pumps, Inc.
b. "360 Series, APCO-LIGN," Aurora Pumps.
c. "Series 1531," Bell & Gossett, ITT.
d. “Type LF” Paco Pumps
e. "Uni-Pumps, Type G, GH, GL, K, KH, AND KL," Weinman, Mueller Pump.

3. Base-Mounted, Separately-Coupled, End-Suction Pumps:

a. "Series 4030," Armstrong Pumps, Inc.
b. "360 Series," Aurora Pumps.
c. "Series 1510," Bell & Gossett, ITT.
d. Paco
e. "Uni-Pumps, Type GB, GLB, KB, KHB, AND KLB," Weinman, Mueller Pump.

4. Base-Mounted, Separately-Coupled, Double-Suction Pumps:

a. "410 Series, Model 411," Aurora Pumps.
b. "VSC & VSCS," Bell & Gossett, ITT.
c. "Series 3500, Type A," Weil Pump Company.
d. "Type L," Weinman, Mueller Pump.

2.2 PUMPS, GENERAL

A. Pumps and Circulators: Factory-assembled and factory-tested. Fabricate casings to allow removal and replacement of impellers without necessity of disconnecting piping. Type, sizes, and capacities shall be as indicated.

B. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anti-corrosion compound. Protect flanges, pipe openings, and nozzles.

C. Motors: Conform to NEMA Standard MG-1, general purpose, continuous duty, Design B, except Design C where required for high starting torque; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal- overload protection, and grease-lubricated ball bearings. Select motors that are non-overloading within the full range of the pump performance curve.

D. Efficiency: Motors shall be premium efficiency type having a minimum efficiency as indicated in accordance with IEEE Standard 112, Test Method B. If efficiency is not specified, motor shall have a higher efficiency than the "average standard industry motors," in accordance with IEEE Standard 112, Test Method B.

1. Motor Frame: NEMA Standard 48 or 54; use pump manufacturer's standard.

E. Apply factory finish paint to assembled, tested units prior to shipping.

2.3 VERTICAL INLINE PUMPS

A. General Description: Pumps shall be centrifugal, close-coupled, single-stage, bronze-fitted, radially split case design, with mechanical seals, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with threaded companion flanges for piping connections smaller than 2-1/2 inches, and threaded gage tappings at inlet and outlet connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, cast bronze, conforming to ASTM B 584, and keyed to shaft.

D. Wear Rings: Removable, bronze.

E. Pump Shaft and Sleeve: Ground and polished steel shaft, with bronze sleeve and integral thrust bearing. Provide flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

F. Seals: Mechanical Seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

G. Motor: Direct-mounted to pump casing; with lifting and supporting lugs in top of motor enclosure.

2.4 BASE-MOUNTED, CLOSE-COUPLED, END-SUCTION PUMPS

A. General Description: Pumps shall be base-mounted, centrifugal, close-coupled, end-suction, single-stage, bronze-fitted, radially split case design, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to share and secured by a locking capscrew.

D. Wear Rings: Replaceable, bronze.

E. Pump Shaft and Sleeve Bearings: Steel shaft, with bronze sleeve. Provide flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

F. Seals: Mechanical seals consisting of flushed seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

G. Motor: Direct-mounted to the pump casing with supporting legs as an integral part of motor enclosure.

2.5 BASE-MOUNTED, SEPARATELY-COUPLED, END-SUCTION PUMPS

A. General Description: Pumps shall be base-mounted, centrifugal, separately-coupled, end-suction, single-stage, bronze-fitted, radially split case design, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking capscrew.

D. Wear Rings: Replaceable, bronze.

E. Pump Shaft and Sleeve Bearings: Steel shaft, with bronze sleeve.

F. Seals: Mechanical seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

G. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

H. Mounting Frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Motor mounting holes for field-installed motors shall be field-drilled.

I. Motor: Secured to mounting frame with adjustable alignment on mounting frame. Select motors based on the following requirements:

1. The motor shall operate the driven pump under all conditions without exceeding the motor nameplate horsepower.
2. Provide a motor that is suitable for its connected power source. Coordinate the power source available with the electrical trade.
3. For motors 5 horsepower and larger, construct the motor frame and end brackets of cast iron.
4. Use either an open drip proof (ODP) or totally enclosed fan cooled (TEFC) enclosure.
5. Provide a premium efficiency design rated for continuous duty and a service factor of 1.15. The temperature rise shall not exceed 80°C with a 40°C ambient. The motor shall use at least a Class F insulation.
6. Select a nominal 1,150 or 1,800 RPM synchronous speed 4 pole design. Motors shall be premium efficiency type except that where motors are to be driven by an adjustable frequency drive, motors shall also be rated for invertor duty. Provide invertor duty motors with shaft grounding kits.
7. Factory lubricate the motor using a premium grease with rust inhibitors that are suitable for an operating range of minus 20 to 300°F. Provide the motor with grease fittings.

2.6 BASE-MOUNTED, SEPARATELY-COUPLED, DOUBLE-SUCTION PUMPS

A. General Description: Pumps shall be base-mounted, centrifugal, separately-coupled, double-suction, single-stage, bronze-fitted, axially split case design, and having an impeller mounted between bearings. Temperature and pressure ratings: 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with ANSI B16.1, Class 125 flanged piping connections, threaded gage tappings at inlet and outlet flange connections, and threaded drain plug at the bottom of the volute.

C. Impeller Construction: Statically, and dynamically balanced, closed, double-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft.

D. Wear Rings: Replaceable, bronze.

E. Pump Shaft and Sleeve: Steel shaft, with bronze sleeve.

F. Pump Shaft Bearings: Grease-lubricated ball bearings contained in a cast iron housing.

G. Seals: Mechanical seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

H. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

I. Mounting Frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Motor mounting holes for field-installed motors shall be field-drilled.

J. Motor: Flexible-coupled to pump, with adjustable alignment on mounting frame. Select motors based on the following requirements:

1. The motor shall operate the driven pump under all conditions without exceeding the motor nameplate horsepower.
2. Provide a motor that is suitable for its connected power source. Coordinate the power source available with the electrical trade.
3. For motors 5 horsepower and larger, construct the motor frame and end brackets of cast iron.
4. Use either an open drip proof (ODP) or totally enclosed fan cooled (TEFC) enclosure.
5. Provide a premium efficiency design rated for continuous duty and a service factor of 1.15. The temperature rise shall not exceed 80°C with a 40°C ambient. The motor shall use at least a Class F insulation.
6. Select a nominal 1,150 or 1,800 RPM synchronous speed 4 pole design. Motors shall be premium efficiency type except that where motors are to be driven by an adjustable frequency drive, motors shall also be rated for invertor duty. Provide invertor duty motors with shaft grounding kits.
7. Factory lubricate the motor using a premium grease with rust inhibitors that are suitable for an operating range of minus 20 to 300°F. Provide the motor with grease fittings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of HVAC pumps.

B. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation.

C. Examine equipment foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 EQUIPMENT BASES

A. Construct concrete equipment pads as follows:

1. Form concrete pads using framing lumber with form release compounds of size and location as indicated. Chamfer top edge and corners of pad. Anchor or key to floor slab.
2. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves using manufacturer's installation template.
3. Place concrete and allow to cure before installation of pumps. Use Portland Cement conforming to ASTM C150, 4,000 psi compressive strength, and normal weight aggregate.
4. Clean exposed steel form and apply 2 coats of rust-preventative metal primer and 2 coats of exterior, gloss, alkyd enamel. Color shall be as selected by the Architect.

3.3 INSTALLATION

A. General: Comply with the manufacturer's written installation and alignment instructions.

B. Install pumps in locations and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

D. Suspend inline pumps using all thread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump independent from the piping system.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until the alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims. or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.
2. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundations, after grout has been set and foundations bolts have been tightened, and after piping connections have been made.

1. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute "Centrifugal Pumps - Instructions for Installation, Operation and Maintenance."

B. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

1. Alignment tolerances shall meet manufacturers recommendations.

3.5 CONNECTIONS

A. General: Install valves that are same size as the piping connecting the pump.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

C. Install a non-slam check valve and globe valve on the discharge side of inline pumps.

D. Install a globe style silent check valve, plug valve, and butterfly valve on the discharge side of base-mounted, end-suction pumps. Plug valves are not required on variable speed pumps.

E. Install a ball valve and strainer on the suction side of inline pumps.

F. Install a pump suction diffuser and butterfly valve on the suction side of base-mounted, end-suction pumps.

G. Install flexible connectors on the suction and discharge side of each base-mounted pump. Install flexible connectors between the pump casing and the discharge valves, and upstream from the pump suction diffuser.

H. Install a pressure gage with tee fitting between the suction and discharge of each pump with isolation ball valves on each side of the tee fitting. Connect pressure gage piping to the pump at the integral suction and discharge pressure gage tappings provided.

I. Install temperature and pressure gage connector plugs in suction and discharge piping around pump. Temperature and pressure gage connector plugs are specified in Division 23 Section "Meters and Gages."

J. Electrical wiring and connections are specified in Division 26 sections.

K. Control wiring and connections are specified in other Division 23 sections.

3.6 FIELD QUALITY CONTROL

A. Check suction line connections for tightness to avoid drawing air into the pump.

3.7 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate oil-lubricated bearings.
2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
3. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.
2. Open the valve in the cooling water supply to the bearings, where applicable.
3. Open the cooling water supply valve if the stuffing boxes are water-cooled.
4. Open the sealing liquid supply valve if the pump is so fitted.
5. Open the warm-up valve of a pump handling hot liquids if the pump is not normally kept at operating temperature.
6. Open the recirculating line valve if the pump should not be operated against dead shutoff.
7. Start the motor.
8. Open the discharge valve slowly.
9. Observe the leakage from the stuffing boxes and adjust the sealing liquid valve for proper flow to ensure the lubrication of the packing. Do not tighten the gland immediately, but let the packing run in before reducing the leakage through the stuffing boxes.
10. Check the general mechanical operation of the pump and motor.
11. Close the recirculating line valve once there is sufficient flow through the pump to prevent overheating.

C. If the pump is to be started against a closed check valve with the discharge valve open, the steps are the same, except that the discharge valve is opened some time before the motor is started.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 23 21 23

This page is intentionally left blank for printing purposes

SECTION 23 25 00 – WATER TREATMENT SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of water treatment system work required by this section is indicated on drawings and schedules and by requirements of this section, and includes necessary equipment, chemicals and service to inhibit development of scale, corrosion, and biological growth in the following systems:

1. Chilled & condenser water systems.
2. Glycol Feeders.
3. Heat Transfer Fluids

B. Service Period: Provide chemicals and service program for period of one year from start-up date of condensing equipment, including the following:

1. Initial water analysis and recommendations.
2. Systems start-up assistance.
3. Training of operating personnel.
4. Periodic field service and consultation, (Minimum of 4 per year).
5. Customer report charts and log sheets.
6. Laboratory technical assistance.

C. Refer to Division-26 sections for the following work:

1. Power supply wiring from power source to power connection on water treatment equipment. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

D. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:

1. Control and interlock wiring between operating controls, indicating devices, and unit control panels.

1.2 QUALITY ASSURANCE

A. Supplier: Water treatment chemical and service supplier who has been active in field of industrial water treatment for not less than 5 years, and who has full-time service personnel located within trading area of job site.

B. Codes and Standards:

1. UL and NEMA Compliance: Provide electrical components required as part of water treatment equipment, which are UL-listed and labeled and comply with NEMA Standards.
2. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation, electrical connections, and ancillary electrical components of water treatment equipment.

3. Chemical Standards: Provide only chemical products which are acceptable under state and local pollution control regulations.

1.3 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:

1. Pumps.
2. Chemical solution tanks.
3. Agitators.
4. Control equipment and devices.
5. Test equipment.
6. Chemicals.
7. Chemical feeders.
8. Centrifugal Separators.
9. Cooling tower and evaporative condenser passivation chemicals and procedures.
10. Glycol Feeders.

B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Condenser Water-Treatment Products:

a. Garratt Callahan.
b. Nalco Chemical Co.

2. Centrifugal Separator:

a. Lakos Separators, A Claude Laval Corporation.
b. Process Efficiency Products, Inc.

3. Glycol Feeders:

    a. Neptune Chemical Pump Co., Inc.
    b. Pulsafeeder.

4. Glycol:

    a. Dow Chemical Company.

2.2 PERFORMANCE OF EQUIPMENT

A. General: Provide system sized and equipped to treat raw water available at project site to maintain the following condenser water characteristics (tested values for condenser operation):

1. Hardness: 400-500.
2. Total Alkalinity: 200-300.
3. Conductivity or TDS: 1300-1500.
4. Sequestrant (Corrosion Scale Inhibitor): 15-20.
5. pH: 8.0-8.5.

2.3 CHEMICAL FEEDING EQUIPMENT

A. Positive-Displacement Diaphragm Pump: Simplex, self-priming, rated for intended chemical with 25 percent safety factor for design pressure and temperature.

1. Adjustable flow rate.
2. Thermoplastic construction.
3. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor.
4. Built-in relief valve.

B. Chemical Solution Tanks: Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with graduated markings.

1. Molded fiberglass cover with recess for mounting pump, agitator, and liquid-level switch.
2. Capacity: 30 or 50 gallon.

C. Agitator: Direct drive, 1750 rpm, mounted on tank with angle adjustment.

1. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor.
2. Stainless-steel clamp and motor mount, with stainless-steel shaft and propeller.

D. Liquid-Level Switch: Polypropylene housing, integrally mounted PVC air trap, receptacles for connection to metering pump, and low-level alarm.

E. Packaged Conductivity Controller: Solid-state circuitry, 5 percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control-function light, output to control circuit, and recorder.

F. Cold-Water Meter: Positive-displacement type with sealed, tamperproof magnetic drive; impulse contact register; single-pole, double-throw, dry-contact switch.

1. Rotating-disc type with bronze or cast-iron body rated for 125 psig.

2. Magnetic-drive or mechanical-impulse contactor matched to signal receiver.
3. At least six-digit totalizers.
4. 120-V ac.

G. Solenoid Valves: Forged-brass body, globe pattern, and general-purpose solenoid enclosure with 120-V, continuous-duty coil.

H. Electronic Timers: 150-second and 5-minute ranges, with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.

I. Chemical Tubing: Schedule 40, PVC with solvent-cement joints; or polypropylene tubing with heat fusion.

J. Plastic Ball Valves: Rigid PVC or CPVC body, integral union ends, and polytetrafluoroethylene seats and seals.

K. Plastic-Body Strainer: Rigid PVC or CPVC with cleanable stainless-steel strainer element.

L. Condenser Water-Treatment Control Panel: Incorporate solid-state integrated circuits and digital LED displays, in NEMA 250, Type 12 enclosure with gasketed and lockable door.

1. Control dissolved solids, based on conductivity, and include the following:

a. Digital readout display.
b. Temperature-compensated sensor probe adaptable to sample stream manifold.
c. High, low, and normal conductance indicator lights.
d. High or low conductance alarm light, trip points field adjustable; with silence switch.
e. Hand-off-auto switch for solenoid bleed-off valve.
f. Bleed-off light to indicate valve operation.
g. Internal adjustable hysteresis or dead band.

2. Control inhibitor feeding, based on makeup volume, and include the following:

a. Solid-state reset counter (accumulator), with selections from 1 to 15.
b. Solid-state timer, adjustable from 15 to 300 seconds.
c. Test switch.
d. Hand-off-auto switch for chemical pump.
e. Illuminated legend to indicate feed when pump is activated.
f. Solid-state lockout timer, adjustable from 15 to 180 minutes, with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
g. Electromechanical-type, panel-mounted makeup totalizer to measure amount of makeup water.

3. Control biocide with an adjustable time programmer and include the following:

a. 24-hour timer with 14-day skip feature to permit activation any hour of day.
b. Precision, solid-state, bleed-off lockout timer (zero to nine hours) and clock-controlled biocide pump timer (zero to two and one-half hours). Prebleed and bleed lockout.
c. Solid-state alternator to enable the use of two different formulations.
d. 24-hour digital display of time of day.
e. 14-day LED display of day of week.
f. Fast and slow internal clock set controls.

g. Battery backup so clock is not disturbed by power outages.
h. Quartz timekeeping accuracy.
i. Hand-off-auto switches for biocide pumps.
j. Biocide A and Biocide B illuminated legends to indicate pump is running.

2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Existing to remain.

2.5 CONDENSER WATER FILTRATION SYSTEM (CENTRIFUGAL SEPARATOR)

A. A centrifugal vortex separator shall be furnished for installation in the liquid supply/circulation system to remove separable solids from the system. The Separator shall remove 98%, by weight, of separable solids 200 mesh (74 microns) and larger.

B. The separator shall be designed with tangential entry into the acceptance chamber. Upon tangential entry, the liquid/solids are drawn through internal tangential slots and accelerated into the reduced diameter separation cylinder. The solids heavier than the carrying liquid are centrifugally spiraled down the perimeter of the separation cylinder past the deflector stool and allowed to accumulate in the separator's collection chamber. The liquid (free of separable solids) will follow the vortex created and centered on the deflector stool up through the interior of the separation cylinder and into the vortex finder which becomes the separator outlet.

C. Quiescent solids accumulation shall be facilitated by the baffle spin arrestor below the deflector stool in the collection chamber. Separation and collection of solids shall not promote excessive wear nor require a continuous "involuntary" underflow.

D. Separator Construction:

1. The separator shall be fabricated of carbon steel (or stainless steel) with shell material and head material equivalent to schedule 40 thickness or better.
2. Paint coating shall be Mactek M-Line Enamel (Stainless steel shall be unpainted).

E. Separated Solids Purging Operation:

1. Automatic: A full port, straight-through motorized ball valve may be installed on the standard purge opening and operated as determined by automatic purge controller.
2. Continuous Bleed: A manual pinch valve is most effective, left partially open at all times to control the rate of purged solids. Periodic inspection of the valve is recommended to avoid plugging of the reduced bleed orifice.

2.6 GLYCOL FEEDERS

A. General: Provide packaged system consisting of steel frame, tank with lid, pump, motor, pipe, fittings, valves, accessories, and controls.

B. Frame: The frame shall be constructed of steel angles, plates, and channel members, designed to support the tank, feed pump, piping, and controls. Frame shall be finished with a powdercoat epoxy paint finish.

C. Tank and Lid: The tank and lid shall be polyethylene construction with a capacity of 50 gallons.

D. Pump and Motor: The pump and motor shall be a direct driven rotary gear type. Pump shall be constructed of bronze.

E. Pipe and Fittings: Piping and fittings shall be constructed of schedule 80 PVC.

F. Suction Valves and Accessories:

1. PVC ball valve.
2. Cast Iron Y-Strainer.

G. Discharge Valves and Accessories:

1. PVC ball valve.
2. PVC check valve.
3. Pressure gauge.
4. Brass relief valve with return to tank tubing.

H. Control Devices: Provide with the following control devices factory wired to the control panel:

1. System pressure switch.
2. Tank low level float switch.

I. Controls Panel: Provide NEMA 4X control panel with a solid state controller. Control panel shall have the following features:

1. Hand-Off-Auto switch.
2. Pump “On” indicator light.
3. Low Tank Level indicator light.
4. Audible alarm indication.
5. Alarm silence pushbutton.
6. Dry contacts for BAS alarm monitoring as follows:

a. Low pressure alarm.
b. Low tank level alarm.

2.7 HEAT TRANSFER FLUIDS

A. Propylene Glycol: Propylene glycol shall be an industrial grade consisting of a mixture of 94% propylene glycol and a 6% specially designed industrial package of corrosion inhibitors. The corrosion inhibitor package shall be suitable for both steel and copper piping systems. Fluid shall have the following characteristics:

1. Operating Temperature Range: -50 to 325°F.
2. Color: Fluorescent yellow.
3. Specific Gravity: 1.053 to1.063
4. Solution pH: 9.0 to 10.7
5. Minimum Reserve Alkalinity: 16.0ml.
6. Chilled Water System Concentration: Provide 30% concentration by weight for freeze protection down to 10°F and burst protection down to -10°F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine areas and conditions under which condenser water treatment systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF CONDENSER WATER TREATMENT SYSTEM

A. General: Install condenser water treatment system in accordance with manufacturer's written instructions.

B. Coordinate with other work (plumbing and heating piping) as necessary to interface components of condenser water treatment system properly with condenser cooling water system.

C. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

D. Install pressure gages, valves, and controls furnished by manufacturer, in accordance with manufacturer's instructions.

3.3 PRECLEANING

A. General: Flush condensers using precleaning chemicals designed to remove construction deposits such as pipe dope, oils, loose mill scale, and other extraneous materials. Add recommended dosages and recirculate for 6 to 8 hours. Drain and flush until total alkalinity of rinse water is equal to make-up water. Refill with treated clean water.

3.4 COOLING TOWER AND EVAPORATIVE CONDENSER PASSIVATION PROCEDURES

A. General: The cooling towers and evaporative condensers shall be passivated as early as possible upon start-up. The following are general guidelines to follow during the passivation process, consult with passivation contractor and follow his recommendations during start-up:

1. Without Heat Load on Cooling Towers and evaporative condensers:

a. Disable condenser water treatment system.
b. Drain condenser water system and fill with fresh water.
c. Add RXN-114 at a dosage of 1,200ppm or 1 gallon per 1,000gallons of water in the system. If microbiocides are needed, use non-oxidizing biocides.
d. Circulate continuously at ambient temperature and design flow rate for 4-5 days.
e. Dump and refill the system with fresh water.
f. Initiate “on-line” water treatment program and put system back on-line.

2. With Heat Load on Cooling Towers and evaporative condensers:

a. Disable condenser water treatment system.
b. Drain condenser water system and fill with fresh water.
c. Add RXN-114 at a dosage of 600ppm or 1 gallon per 2,000gallons of water in the system. If microbiocides are needed, use non-oxidizing biocides.
d. Circulate continuously at ambient temperature and design flow rate for 3-4 days.
e. Dump and refill the system with fresh water.
f. Initiate “on-line” water treatment program and put system back on-line.

3.5 START-UP

A. Start-up Procedures: During condenser cooling water system start-up, operate condenser water treatment system (after charging with specified chemicals) to maintain required steady-state characteristics of cooling water.

3.6 TESTING

A. Sample condenser cooling water at one-week intervals after condenser start-up for period of 4 weeks and prepare certified test report for each required water performance characteristic. Comply with the following standards, where applicable:

1. ASTM D 1067 - Test Methods of Acidity or Alkalinity of Water.
2. ASTM D 1126 - Test Methods for Hardness in Water.
3. ASTM D 3370 - Practices for Sampling Water.

3.7 TRAINING OF OWNER'S PERSONNEL

A. Provide services of supplier's representative for one-half day to instruct Owner's personnel in operation, maintenance, and testing procedures of condenser water treatment system.

END OF SECTION 23 25 00

SECTION 23 64 17 – CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of centrifugal chillers work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of centrifugal chillers specified in this section include the following:

1. Water-cooled hermetic centrifugal water chillers.

C. Refer to other Division 23 sections for concrete pads, piping, specialties, pumps, valves, etc., required external to centrifugal chillers for installation.

D. Refer to other Division 23 sections for vibration isolation work required in conjunction with centrifugal chillers.

E. Refer to other Division 23 sections for field-installed insulation on centrifugal chiller evaporator and other machine surfaces subject to sweating.

F. Refer to Section 23 00 00 for equipment certification requirements.

G. Refer to Division 26 sections for the following work:

1. Power supply wiring from power source to power connection to chiller power connections as applicable.

H. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control and interlock wiring between operating controls, indicating devices, and control panels.

1.2 SUBMITTALS

A. Product Data: Submit product data, including rated capacities, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.

D. Maintenance Data: Submit maintenance and operating data. Include this data in maintenance manual in accordance with requirements of Division-1 and Section 23 00 00.

E. Quality Control Submittals:

1. Submit certification of compliance with ARI, ASME, UL and ASHRAE fabrication requirements specified in Quality Assurance below.
2. Submit certification of compliance with performance verification requirements specified in PART 2 of this Section.
3. Submit quality control reports specified in PART 3 of this Section.

F. ARI 550-88 Certification Results: Submit test results of factory ARI 550-88 testing at full load and part load performance as required.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. ARI Compliance: Test and rate centrifugal chillers in accordance with ARI 550-88 "Standard for Centrifugal or Rotary Water - Chilling Packages".
2. ASHRAE Compliance: Fabricate and install centrifugal chillers to comply with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
3. UL Compliance: Fabricate centrifugal chillers to comply with UL 465 "Central Cooling Air Conditioners".
4. ASME Compliance: Fabricate and stamp centrifugal chillers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver chillers as a complete factory-assembled unit with protective crating and covering.

B. Ship chillers in a deep vacuum in one or two pieces, depending upon size.

C. Coordinate the delivery of the chiller(s) in sufficient time to allow movement into the building.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, provide centrifugal chillers from one of the following:

1. Basis of Design: Multistack MS5162FC (Flooded MagLev centrifugal)
2. Arctic Chill.

3. Smardt.

2.2 UNIT DESCRIPTION

A. Provide and install as shown on the plans a factory assembled, charged, and run tested, water-cooled packaged chiller.

B. Chiller shall include two (2) oil-free, magnetic bearing, variable speed two stage centrifugal compressor equipped with inlet guide vanes and load balancing valve. Each compressor to utilize its integrated variable speed drive in conjunction with the compressors inlet guide vanes and load balancing valve, to optimize the chillers part load efficiency.

C. The chillers evaporator, condenser, and electronic expansion valves shall be common to all compressors. The chiller shall operate with one (1) refrigerant circuit.

D. Chiller shall utilize R-134A refrigerant.

2.3 DESIGN REQUIREMENTS

A. Each chiller shall be equipped with the following:

1. One (1) flooded evaporator heat exchanger.
2. One (1) water cooled condenser heat exchanger.
3. Two (2) Compressors with integrated variable speed drive, soft start, magnetic bearings, and inlet guide vanes.
4. Two (2) or more electronic expansion valves.
5. One (1) liquid level refrigerant sensor.
6. One (1) load balance valve per compressor.
7. One (1) master chiller control panel with necessary operating controls and system safeties. All mechanical pressure safeties shall be located at each individual compressor.

B. Chiller Performance: Refer to the Chiller Schedule on the drawings.

C. Unloading: When utilizing MagLev® model TT-300 compressor (75 nominal tons), the chiller shall be capable of unloading to 15 tons. Unloaded capacity values are without the use of hot gas bypass.

D. Loading: Chiller shall be able to lead-lag compressor(s) without drastically unloading compressors on-line or creating check valve chatter on lag compressors. Total pressure ratio shall not be decreased below 2.4 pressure ratio as observed at the suction and discharge flanges of each individual compressor.

E. Acoustics: Sound data shall be measured in accordance with ARI 575-87 Standard. Unit sound performance data shall be measured at the highest level recorded at all load points. Unit sound performance shall not exceed a level of 70 DBA measured at a distance of five (5) feet.

F. Electrical: Chiller shall feature single-point power connection and shall not utilizing adjoining power cabinets as pull boxes.

G. Minimum Operating Conditions: Lowest evaporator saturated suction temperature shall not be below 34°F. Lowest leaving chilled water temperature shall not be below 38°F. Lowest entering condenser water temperature shall not drop below 55°F. A differential of 12°F between the leaving

chilled water temperature and entering condenser water temperature is required to ensure chiller can maintain minimum lift requirements.

2.4 COMPONENTS

A. Compressor:

1. Chiller shall have two (2) magnetic bearing, oil-free, two-stage, hermetic centrifugal compressors. Each compressor shall contain an integrated variable speed drive with soft start, movable inlet guide vane assembly, and shall weigh no more than 300 lbs.
2. Each compressor shall be microprocessor controlled. Each compressor shall be networked to the master controller via an Etherbus connection with a refresh rate of 50 microseconds and the microprocessor of each compressor shall control the variable speed drive and inlet guide vanes on each compressor to maximize unit efficiency.
3. Each compressor shall be capable of coming to a controlled safe stop in the event of a power outage. Unit shall be capable of auto restart in the event of a power outage, once power has been restored.
4. All compressors shall be mechanically and electrically isolated to facilitate proper maintenance, service, and or removal.
5. Each compressor shall be equipped with a minimum anti-recycle time of 5 minutes if power electronics are too warm before being allowed to restart.
6. Minimum restart time of a compressor, without a UPS, from power down until drive line is rotating, shall not exceed 3 minutes.

B. Prime Mover:

1. The prime mover shall be of sufficient size to effectively meet the compressor horsepower requirements. Prime mover shall be a one or more liquid refrigerant cooled, hermetically sealed, permanent magnet synchronous motor. Motor shall be controlled by a variable speed drive. Motor shall utilize soft start capabilities with an inrush current no greater than two (2) amps. Motor shall have internal thermal overload protection devices embedded in the winding of each phase of the motor.

C. Refrigerant Evaporator and Condenser:

1. All heat exchangers shall be built in accordance with Section VIII of the ASME code and carry a manufacturer's name plate certifying ASME compliance.
2. The evaporator shall be of shell and tube construction. Evaporator shall be constructed of a single shell. Evaporator shall be flooded type with refrigerant surrounding the tubes and water passing through the tubes. Tubes shall be enhanced and rifled. Minimum tube velocity shall be two (2) feet per second. Design shall not exceed a maximum tube velocity of eight (8) feet per second. Evaporator shall include internal intermediate tube supports, liquid eliminator baffle plate, pressure relief vent, water drains and vents. Pressure relief valve shall spring loaded self-seating type in accordance to ASHRAE 15 standard. Evaporator shall be pressure tested at a test pressure of 1.1 times the operating pressure however no less than 100 PSIG. Evaporator, water boxes, suction piping, and any other component subject to condensate shall be insulated with a UL recognized 3/4 inch closed cell insulation. All joints and seems shall be sealed so a vapor barrier is created. Factory mounted differential pressure transmitters and thermal dispersion sensors shall be provided for flow safety.
3. The condenser shall be of shell and tube construction. Condenser shall be constructed of a single shell. Condenser shall be water cooled type with refrigerant surrounding the tubes and water passing through the tubes. Tubes shall be enhanced and rifled. Minimum tube

velocity shall be two (2) feet per second. Design shall not exceed a maximum tube velocity of eight (8) feet per second. Condenser shall include internal intermediate tube supports, pressure relief tree with isolation valves, water drain and vents. Pressure relief tree to be equipped with isolation/transfer valve to prevent the loss of refrigerant when relief is removed for testing and or replacement. Rupture disks are not acceptable. Condenser shall be pressure tested at a test pressure of 1.1 times the operating pressure however no less than 100 PSIG. Factory mounted differential pressure transmitters shall be provided for flow safety.

4. Heat Exchangers shall feature tube sheets fabricated of thick carbon steel sheets welded to the shell and drilled for tubes. Tubes shall be enhanced, rifled and individually replaceable. Tubes shall be mechanically rolled into steel tube sheets and sealed with Loctite or equivalent sealant. Tubes shall be supported by intermediate tube supports at a maximum spacing of 18" apart. Waterside shall be designed to a minimum of 150 psig or 300 psig, whichever is specified. Heat exchangers shall be equipped with either dished heads or marine boxes with drain and vent ports, whichever is specified. Piping connections shall be either mechanical grooved connection or flange as specified.
5. Refrigerant Control: Chiller with multiple compressors shall feature dual electronic expansion valves with a step count of 6,386 steps to full open. A single compressor machine shall have one electronic expansion valve with 6,386 steps. Fixed orifices and float controls are not acceptable. The electronic expansion valve shall operate from minimum chiller capacity to the full load of the chiller's capacity. A high side refrigerant level sensor, constructed out of stainless steel, with a stainless steel canister with sight glass, shall be used to provide feedback to the expansion valves for proper control to ensure that a proper liquid seal is always present on the compressors power electronics. A refrigerant sight glass shall be provided on the main liquid line feeding the electronic expansion valves. Isolation valves before and after the EXV (electronic expansion valve) shall be provided for proper service without removing the entire refrigerant charge. Provide refrigerant charging and transfer connections.
6. Provide epoxy coating on the water side of the evaporator tube sheets.
7. Water Flow Monitoring Sensors: Provide thermal dispersion water flow sensors on the evaporator and condenser. Flow switches are not acceptable.
8. Fouling Factors: Fouling factors shall not exceed 0.0001 for the evaporator and 0.00025 for the condenser.

D. Variable Speed Drive:

1. The chiller shall be equipped with variable speed drives for each compressor. The variable speed drives shall utilize Insulated Gate Bi-Polar Transistors. Variable speed drive shall create its own simulated AC voltage for the motor connected to it. Applied voltage shall be 460 Volts at 60 hertz.
2. Variable speed drive in conjunction with the compressors inlet guide vanes shall be controlled via compressor microprocessor to optimally match the lift and load requirements.
3. Each compressor circuit shall have a line reactor and circuit breaker.

E. Chiller Controls:

1. The unit shall have an industrial grade Central Processing Unit (CPU) with an Intel-based processor. Chiller shall have fail to run mode. All chiller and compressor I/O shall be controlled via Etherbus with an update rate of 50 microseconds. Controller shall have 15 inch touch screen interface that can be disconnected without shutting down the chiller. Controller shall use proprietary control logic to optimize loading, unloading, and control of multiple compressors. User interface to operate the chiller shall include Human Machine Interfaces (HMI) consisting of a touch screen and a remote web connection. All system parameters, compressor status, alarms, and faults, trend graphing, fault logging, bas

communication window, manuals, wiring diagrams, log book, and control set points shall be viewable. Touch screen shall provide full commissioning and adjustment of all components on the chiller, including the compressors without an auxiliary computer or software.

2. The chiller controller shall include the following features:

    a. Hardware.
    b. Two EXV Outputs.
    c. Eight Digital Inputs.
    d. Eight Digital Outputs.
    e. Ten Analog Inputs.
    f. Eight Analog Outputs (0-10 VDC).
    g. Eight Temperature Inputs.
    h. One Compressor hub per compressor including:

        1) Addressable Bus Coupler.
        2) R5-485 Module.
        3) RS-232 Module.
        4) Four Digital Inputs.
        5) Two Digital Outputs.

    i. Windows-based industrial PC featuring Intel® Processor for maximum reliability and performance.
    j. Dual-Hard drives for maximum reliability and redundancy. Hard drives feature no moving parts to ensure nothing mechanically fails. With dual-hard drives there is no need to partition a single drive. One drive handles the operating system while the other handles all data acquisition to ensure no data is corrupted.
    k. DC Powered to ensure maximum resistance to EMI and RFI noise.
    l. Built in 2-port Ethernet Switch for easy integration to BAS interface and web control feature.
    m. Features industrial-style battery back-up in the event of a power outage.
    n. On board USB drives to support external peripheral devices including, keyboard, mouse, and printer.
    o. 15"TFT Display featuring 1024 X 768 Resolution.
    p. All hardware, including I/O is CE and UL Certified.
    q. I/O features modular design to simplify troubleshooting and or replacement if required.
    r. I/O has LED Indicators for all inputs and outputs to ease the troubleshooting process.
    s. I/O can be directly connected to without the use of terminal blocks.
    t. All wiring utilizes spring capture technology to prevent loose connections or wires from falling out.
    u. Dedicated Ethernet communication at a communication rate of 50 microseconds to all compressors and I/O.
    v. Compressor hubs feature dedicated inputs for high pressure switch, low pressure switch, dedicated compressor interlocks, and dedicated compressor communications. This allows each compressor to be handled independently by itself without affecting the rest of the system.

3. Software

    a. Can control one (1) to eight (8) compressors on single or multiple refrigerant circuits.
    b. Control System can control up to 24 EXVs with proper hardware and network all EXVs to the control system.

c. Control system capable of controlling different size compressors simultaneously.
d. HMI interface is only control system on the market with a user definable points list, tag names, and functions without special software. With this feature, end user can scale all inputs and outputs, change what controls it, change the functionality, the name of it etc.
e. Control system shall be field reconfigured through HMI to remap I/O to change functionality on the fly. This allows for customized integration into the end users system.
f. Control system shall be capable of trend graphing up to two (2) years of data without overwriting or decreasing data acquisition time.
g. Chiller controller shall utilizes the Danfoss Turbocor Compressor Software on board to allow servicing and advanced remote troubleshooting without a laptop computer.
h. Control System shall feature an easy to use web interface to allows the user to do anything remotely that could be done on sight
i. Controller shall provide trend graphing and recording for more than 200 data points in five (5) second intervals. Data shall be stored on separate 32 GB hard drive for analysis through the zoom feature. Trend graph images shall be exportable to a csv file.
j. Advanced Fault Logging featuring calendar capability for ease of use. Data shall be available for recalled up to two (2) years. Data shall be sorted by alarm type, time stamp, or compressor.
k. Data shall be color coded with green data meaning good, yellow meaning alarm, and red meaning fault or off.
l. Controller shall log when user makes any type of change
m. Controller shall be loaded with all manuals, wiring diagrams, and supporting data which can be recalled via touch screen
n. Controller shall have onboard maintenance log to store system information
o. Controller shall feature e-mail fault notification
p. Controller shall provide real time capacity and efficiency data

4. BAS Interfaces include:

a. BACnet IP, MSTP compatibility.
b. BAS interface dashboard shown on HMI. This allows the user to view what data is being written to the BAS system, if there is an error, lost communication, and how many times the data was sent or received.
c. Control system shall use proprietary optimization logic to perform accurate energy balance on all systems for maximum system performance.
d. Control system shall feature an optimum start function to ensure initial lift is always made. This prevents nuisance check valve flutter and compressor faults.

F. Vibration Isolation:

1. Provide neoprene vibration isolation pads of type and size recommended by chiller manufacturer.

2.5 FACTORY FINISH

A. Chiller manufacturer's standard factory-finish.

2.6 SOURCE QUALITY CONTROL

A. Test and Inspect: Centrifugal chillers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

B. Performance Verification:

1. Rate centrifugal chillers in accordance with ARI 550-88 "Standard for Centrifugal or Rotary Water-Chilling Packages". Provide test results of factory at full load and 3 part load points performance testing. Engineer to confirm part load points during submittal process and format for utility rebate if pursued.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install chillers in accordance with manufacturers installation instructions.

B. Install chillers plumb and level, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.

C. Install vibration isolators to concrete pad with anchor bolts and secure chiller to vibration isolators.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 23. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to machine to allow servicing and maintenance.
2. Chilled Water Piping: Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, flow switch, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, thermometer, pressure gage, and flange.
3. Condenser Water Piping: Provide flanged connections to condenser, arranged piping to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with thermometer, drain line and shutoff valve, and plugged tee.
4. Vent Piping: Provide drain piping as indicated from rupture disc to suitable drain.

3.3 FIELD QUALITY CONTROL

A. An authorized factory start agent is required. At minimum, (2) two days shall be spent on-site to ensure proper unit operation.

B. Provide the services, to include a written report, of a factory authorized service representative to supervising the field assembly of the components, installation, and piping and electrical connections.

3.4 DEMONSTRATION

A. During the start-up period, provide services of factory authorized agent to instruct the Owner's representatives and maintenance personnel on proper care and operation of the chiller.

B. Provide training as specified below.

C. Start-up Service:

1. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions if not factory charged. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.
3. Do not place chiller in sustained operation prior to initial balancing of mechanical systems for interface with chiller.

D. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the data contained in the Operating and Maintenance Manuals specified in this Section and in Division One.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

3.5 WARRANTY

A. General: Provide written special project warranty on chiller work, agreeing to replace/repair inadequate and defective materials and workmanship, including leakage, breakage, improper assembly and failure to perform as required. Include separate product warranties as indicated (if any) for specific parts or products in the work. Provide warranty signed by both the Installer and Contractor.

B. Manufacturer's Warranty: Manufacturer shall provide full parts and labor warranty coverage for entire chiller for a period of one year. All parts shall be warranted against defects in material and workmanship. Similar parts-only coverage shall be provided for the chiller compressors for a period of five years. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.

C. Under add alternate bid, provide extended 5 year comprehensive chiller parts and labor with full powertrain warranty (shaft, magnetic bearings, touchdown, bearings, and stator).

END OF SECTION 23 64 17