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23 00 00 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

Part 1 – General

Building System Design Criteria

HVAC Baseline

An HVAC system with which the Owner has considerable long-term operating experience and considers the baseline system is described as follows:

Central Utility Connections

Utilizes Owner's central heating and cooling distribution systems.

Building Core

Single Duct, indoor unit with terminal reheat variable air volume boxes.

Ducted return.

Digital controls on air handler and terminal devices.

Full outside air enthalpy based economizer with return/relief and outside air dampers.

Single Class II supply fan selected and sized with fan speed less than 1500 RPM.

Air side pressure drop external to unit less than 1.5 inch water column.

Heating coils and terminals utilizing building heating water loop.

For systems with nominal outside air requirement in excess of 50%, a separate glycol loop to preheat coil is allowed.

Air to Air heat recovery for systems operating year around with more that 50% outside air.

Air handler freeze stat with manual reset

Chilled water cooling coil and/or direct evaporative section with face and bypass dampers are included. Cooling components sized for operation at less than 450 fpm face velocity.

Building Perimeter

Fin tube or convector units with sufficient tube surface to satisfy full heating load with 160 F heating water supply.

Life Cycle Cost Analysis

Consider alternative HVAC systems that offer the potential of substantial improvement in energy efficiency, maintainability, first cost, or a legitimate potential to better achieve the Owner's sustainability goals. A lifecycle cost analysis that compares a proposed alternative system against the baseline system shall be provided for all energy consuming HVAC systems and sub-systems and shall conform to the requirements of Arizona Revised Statute §34-454. Life cycle costs shall be calculated based on owning, operating, and maintaining each system. Included are such factors as initial construction cost, fuel, energy, maintenance labor, replacement consumables and components, long term cost of service, and estimated useful service life. Electrical rates used in life cycle cost analysis shall be actual demand and consumption costs, not average costs. These can be requested from Owner.

The baseline system described above shall be among the alternatives compared. The life cycle is the expected life of the system, or twenty-five years, whichever is shorter. Technical and economic assumptions used in life cycle cost analysis shall be coordinated with Owner (Project Manager) prior to submittal of result. Life cycle cost will be one of several criteria used by Owner in accepting use an alternative HVAC system. Other criteria include demonstration that the system or product proposed has been in satisfactory service in similar applications and environments for at least three years, necessity of special training or maintenance skills by Owner, local availability of service parts and track record of vendor or service contractor in resolving issues raised during and after the warranty period. Quality of environmental control may be a factor. Owner reserves the right to reject alternative system proposals.

The suitability of using evaporative cooling, whether alone or in addition to a mechanical or indirect evaporative system, shall be evaluated. For wet wall installations, face and bypass dampers must be used for temperature control. Wet wall pump cycling shall not be an option for temperature control. Bypass dampers shall be sized to allow full air flow around the wet wall. Where possible, evaporative cooling will be among cooling alternatives considered in life cycle cost analysis.

The use of any electrical source heating equipment, including heat pumps, heat tape, baseboard heat, and electric domestic hot water heaters, shall not be considered unless a minimum of 25 year life cycle cost analysis of all alternatives

demonstrates it to be the most cost effective for the 25 year life cycle. The determination of energy costs must include both kwh and demand charges.

System sizing

All utility service and supply systems, including, but not limited to, steam, high temperature hot water, natural gas, domestic water, waste, and electrical, shall be sized for peak anticipated demand throughout the project and shall be sized as far back as the main meter or central distribution system. The adequacy of any central distribution system to carry all added peak loads shall be determined by the Design Professional, and no loads shall be connected to any such system that is determined to be undersized. Calculations demonstrating adequacy of existing infrastructure shall be provided to Owner with drawing submissions.

HVAC Design Requirements

Owner requires low pressure, low velocity (2000 FPM max, 2 inches WG max) air distribution systems. Designs involving higher velocity and/or pressure shall be reviewed and approved in writing by Owner (PM and HVAC department).

Noise level volumes of air movement and equipment shall be designed and installed as compatible for intended functions within building spaces. The Design Professional is responsible for designing systems that maintain acceptable sound levels as defined by ASHRAE.

The Design Professional shall evaluate the potential for overheating of building spaces. Particular attention shall be paid to areas which house computer or other electronic equipment. Evaluation shall consider all factors including but not limited to equipment, passive solar gain, and occupant loads. Where such potential exists, the value and cost effectiveness of mechanical cooling shall be analyzed.

All mechanical rooms shall be ventilated. Location and size of louvers and vents to the outside shall be coordinated with piping and equipment to preclude the possibility of thermal stratification and/or freeze up. Any ventilated space which houses water piping, vessels, or equipment, such as equipment rooms, shall be heated to a minimum of 50^{o} F. When equipment rooms must be ventilated to provide boiler combustion air, the heat source shall be independent of the boiler. Provision for temporary mechanical ventilation shall be provided in vaults and chases that are not normally accessible.

All mechanical rooms and spaces shall be adequately sized, lighted and arranged so that any and all repair and maintenance that may be necessary can be performed. Owner prefers main air handling, heat exchangers, and pump

equipment to be floor mounted. Controls, mixing boxes, balance dampers, fire dampers, valves, filter banks, heat exchanger coils, pumps, belts, etc., shall be accessible for repair or replacement, and shall not be obstructed by any pipe, conduit, or other obstacle. Heat exchanger tube bundle and coil pull space shall be provided and shown graphically on the design drawings, along with vendor required service space for all HVAC equipment and Code required clearance for all electrical equipment and panels. Where possible, mechanical rooms are to be located at grade, on an exterior wall, and provided with an exterior door of sufficient size to move the largest piece of equipment through. Equipment rooms not located at grade shall be provided with a conventional access stair or elevator. Access to mechanical equipment room by means of a ladder is not acceptable. Access for handling component replacement, such as motors, shafts, drives and coils shall be provided. Where equipment must be raised vertically through a hatch, a structurally designed overhead lifting beam of sufficient capacity shall be provided. Main air handling equipment must have a catwalk with permanent ladder and overhead lifting beam, if not floor mounted.

Ample minimum access shall be provided to overhead mechanical equipment, such as in-line exhaust fans, terminal boxes, or fan coil units and shown graphically on design drawings. Ample minimum access is defined as access that is sufficient to allow 2’ 6” of clearance in front of a service technicians head when standing on a ladder with shoulders at the level of the equipment.

Gauges, thermometers, and isolation valves shall be specified for all HVAC equipment.

No underground storage tanks of <u>any</u> type shall be specified without signed prior approval by Owner (Director of Utilities).

<u>Part 2 - Products</u>

<u>Quality Assurance</u>

The selection of products or service companies shall be from those firms whose products or services have proven satisfactory in similar service for not less than three years. Repair or replacement parts, or required service, shall be readily available, and the supplier of products or services shall have a proven track record of response to complaints or problems during, and after, the warranty period.

All parts or products shall be of commercial or industrial quality, and shall be suitable for heavy-duty use.

Contractor shall provide one (1) set of filters installed just prior to final balancing.

Part 3 – Execution

Quality Assurance

Experienced, qualified personnel shall be on the job. Experience and qualifications are defined by three years of experience in installation of similar equipment on similar projects. All subcontractors shall have a proven track record of response to complaints or problems during and after the warranty period. Proof of experience is required before the start of work.

Design Document Requirements

The Design Professional shall submit a set of mechanical floor layout drawings at the Schematic and again at the Design Development stage. Locations and sizes of major HVAC equipment, including fans, air handlers, pumps, heat exchangers and steam control stations will be shown on these drawings along with electrical equipment and panels. Mechanical floor layout drawings will demonstrate code clearances along with **maintenance and service access.**

The Design Professional shall provide a process and instrumentation diagram drawing at Design Development and Construction Documents depicting all pressure gauges, thermometers and flow meters required for the project. Included on this drawing shall be actual design flows pressures and temperatures for each and every system.

Submittal Information and Closeout Materials

Sequence of control diagrams shall be required to be submitted within 21 days of notice to proceed.

Provide Shop Drawings and product data prior to start of construction as applicable for the following:

- Equipment room layouts, drawn to scale, showing all equipment, piping and accessories and clearances for operation and servicing.

Provide submittal information including equipment cut sheets for at a minimum, the following components and equipment:

- All HVAC equipment including boilers, heat exchangers, pumps, tanks, valves, hangers, air handlers, filters, louvers and dampers, relief valves, strainers, traps and drip legs, etc. All terminal equipment including volume control boxes, registers, grills, diffusers, etc.
- Design curves and characteristics of fans, blowers and pumps.

- Control diagrams and sequence of operations for all HVAC equipment.
- HVAC and motor control wiring or pneumatic diagrams.
- Plumbing fixture cuts, trim and fittings, rough-in dimensions and special supports.
- Plumbing fixtures, equipment and specialties.
- Piping materials, fittings, specialties.
- Expansion loops, joints, guides, and anchors.
- Foundations, supports, hangers and inserts.
- Drains (roof/floor) carriers, cleanouts, downspout nozzles.
- Insulation materials and finishes, duct and piping.
- Mechanical identification.
- Converters with saddles and relief valves.
- Gauges and thermometers.
- Flow fittings.
- Utility sets with vibration isolation.
- Dampers - back draft, volume, smoke, fire, combination smoke/fire.
- Temperature control equipment, schematics and diagrams.
- Panel boards, gauges and thermometers.
- Fire protection system - hydraulic calcs.
- Fire protection equipment and specialties (wet, dry and chemical).
- Wiring diagrams and motor control equipment. (Wiring diagrams must be project specific, manufacturer's standard diagrams will not be accepted).
- Pressure testing procedure

Provide attic stock as applicable from the following:

- Two (2) sets keys/wrenches for any covers.
- Chemical test kits as appropriate.
- One (1) extra set of filters.
- One (1) set of any proprietary trouble shooting, maintenance tools, or specialty tools.
- Two (2) copies any proprietary computer software for systems control, program back-up, troubleshooting or maintenance.
- Reference Owner form FS #76 – Attic Stock, Warranty, As-built Log for additional requirements.

Provide Manufacturer's certificates or test results for the following:

- Air balance reports.
- Heat exchangers.
- Boilers and chillers

- Chemical treatment products, application limits, test methods, and apparatus.
- Glycol mixing formula.
- Backflow preventers (per R18-4-232).
- Potable water system purification.
- Hydrostatic test on sprinkler system.
- Hydronics balancing.
- Field test make up air units and fans.
- Final inspection from Mechanical Engineer.

Other Closeout Requirements to Provide:

- 1 - 3 day start-up training as applicable (coordinated with Facility Services.) To be videotaped by the University.
- Valve tag index mounted under rigid clear protection in the mechanical room(s) and diagram submitted with the O & M manuals.
- Hard copies of all control codes and sequence of operations.

Warranty

Owner's standard 2-year warranty. Reference Owner form FS #76 – Attic Stock, Warranty, As-built Log for additional requirements.

****END OF SECTION****

Section Number | Title

23 05 00 Common Work Results for HVAC

23 05 13 Common Motor Requirements for HVAC Equipment

Part 1 – General

Section includes general requirements for single-phase and poly-phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation. All motors shall be high efficiency with sizing and winding insulation specified to compensate for altitude (7,000 ft).

Part 2 – Products

All motors shall be Premium Efficiency.

Part 3 – Execution

All pump motors located remote from the motor control center shall have a local disconnect that may be locked out.

23 05 16 Expansion Fittings and Loops for HVAC Piping

Part 1 – General

Design Professional shall calculate thermal pipe stress and design compensation system. Pipe stress analysis of steam and high temperature hot water system to be sealed by Design Professional and submitted to Owner.

Construction drawings shall contain sufficient detail to clearly identify location and method of support for pipe anchors, thrust blocks, guides, expansion compensators, arresters, etc.

Part 2 – Products

Steam/Condensate distribution system:
Owner has pre-approved the following product to be in compliance with these standards: Hyspan 3500 externally pressurized bellows joint.

High Temperature Heating Water systems:
Owner has pre-approved the following product to be in compliance with these standards: Barco Ball Joint.

Part 3 – Execution

All products to be installed per manufacturer’s recommendation.

Section Number | Title

23 05 19 Meters and Gauges for HVAC Piping

Part 1 – General
N/A

Part 2 – Products
Pressure Gauges
Specify 6" minimum diameter, liquid filled gauges with snubbers, stand offs and isolation cocks. Pressure gauges shall normally read at 60% of total gauge pressure capability. Pressure gauges shall be required on all inlet and outlet lines of the following:

- Boilers
- Converters
- Pumps – Only inlet
- Main steam supply line
- Static pressure gauges on all static controlled fans

Thermometers
Thermometers to be provided on all of the following:

- Air Handlers (mixed air, hot deck, cold deck)
- Boilers
- Converters
- Cooling equipment, chillers
- Heat recovery systems
- Heat transfer coils with pipe size greater than 2 inches.
- Building chilled water point of entry and exit.

Part 3 – Execution
Provide air vent in pipe riser. Install automatic air vents in equipment rooms and manual air vents elsewhere, with isolation valve at all system high points and piped to drain. Minimum vent piping size is 1/2 ".

23 05 23 General Duty Valves for HVAC Piping

Part 1 – General
N/A

Part 2 – Products
Valve Requirements:

Service	Size	Type	Material	Connections
Natural Gas (inside building)	All	Ball Valve	Iron or Bronze Body	Threaded
Hydronic Piping	Thru 2.5”	Ball	Bronze Body	Threaded
2.5” & Larger		Butterfly	Iron Body with Bronze Disk	Lug Type flange
Steam	Thru 2”	Ball	Bronze Body	Threaded
Steam	Above 2”	HP Butterfly	Carbon Stl Body	Lug type flange
Condensate	All	Ball	Bronze Body	Threaded
HTHW	All	Ball on HP Butterfly	Stainless Steel	Lug Type Threaded

Steam valves and steam pressure regulators.
Owner has pre-approved the following manufacturers to be in compliance with these standards: Manufactured by Fisher (TYPE 92B).

Ball valves shall be 100% full port, full line size.
Butterfly valves to have 100% bubble tight-shut-off and full port sizing.

Valves shall be domestic manufacturer. Owner has pre-approved the following manufacturer to be in compliance with these standards: Milwaukee.

Provide and secure brass identification tags to all valves. Incorporate in valve tag index.

Automatic Valves
All automatic valves must be able to communicate with the Owner’s Building Management System (BMS). Owner has pre-approved the following manufacturers to be in compliance with these standards: Belimo.

Part 3 – Execution
Install all valves for easy access for operation, repair and maintenance without use of ladders. Chainwheels are required where floor access to valve handle is not possible and valves are 4” and over and located 7’0” AFF.

Section Number | Title

Isolation valves shall be at all equipment and on all main branch take-offs.

Automatically controlled heating valves shall fail to heat (normally open). Domestic steam and HTHW valves shall fail closed.

Unions shall be installed on the downstream side of all non-flanged valves for access and repair of systems.

Provide isolation valves on each side of strainers and full port ball valve on blow down.

Provide ball valves with hose end threads for system drains and strainer blow down.

When an existing system "hot tap" is necessary, specify a full port ball valve to isolate the new branch line.

Do not use circuit setter as isolation valve.

Provide relief valves on piping and equipment as needed to meet code requirements.

Provide plug cock valves at connections to gas-fired equipment and in all branch piping.

23 05 93 Testing, Adjusting, and Balancing for HVAC

Part 1 – General

Test and Balance Firm Considerations

The Contractor shall hire the test and balance firm, but shall have approval from Owner on who they receive bids from and who they contract with.

The air distribution system shall be tested and balanced by an independent firm licensed, bonded and certified to perform such work in the State of Arizona.

The work of the test and balance contractor shall be specified in the Construction Documents by the Design Professional.

Design and Specification Considerations

The air flows shall be specified to be set within 3% of the design requirements.

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All air distribution systems shall be balanced in the heating mode and have flows measured in cooling mode.

The Design Professional shall specify all the necessary dampers, controls and sheaves required to meet the balance conditions.

The Design Professional shall specify final mechanical system noise levels that are to be compatible with intended functions within the building spaces.

The final air balance will be conducted after all systems are in place and operational and have been accepted.

All systems start-up, testing, balancing, Final Operations & Maintenance Manuals and training shall be completed on or before, and is a requirement of, Substantial Completion.

Test and Balance Submittal Requirements
Contractor shall submit test and balance firm's certifications along with a test and balance plan including but not limited to where test points shall be taken, any traverse test being performed, and any potential complications.

The testing agency shall provide verification that systems operate at 50% to 75% and at 100% capacity as designed.

Final balance report shall include copies of pump and fan curves.

Part 2 – Products
N/A

Part 3 – Execution
N/A

23 09 00 Instrumentation and Control for HVAC

Part 1 – General

Design Considerations
Heating Ventilating and Air Conditioning system design shall be zoned to differentiate between north, south, east and west exposures, internal areas, locations of large glass areas with independent controls for each zone, and shall include outside air and zone temperature reset, and solar gain compensation.

A maximum of 4 individual rooms shall be ganged on a single thermostatically controlled temperature zone, provide the rooms have compatible exposure, occupancy and setpoint conditions, unless otherwise approved by Owner in writing.

Indoor space temperatures shall be specified to be maintained at a maximum of 69^{o} F. in a heating mode, as measured 4' above the floor and 2' from the exterior wall shielded from the sun and artificial heat sources.

Indoor space temperatures shall be specified to be maintained at a minimum of *75*^{o} F. in a cooling mode as measured 4' above the floor and 2' from any exterior walls.

Large classrooms/conference rooms shall have reasonable sampling of the temperature.

In general, air handlers shall be configured with 100 % outside air economizers using enthalpy based control logic.

Temperature sensors for outside air, return air, mixed air on each air handler or variable box are required

Sufficient instrumentation that energy efficiency can be trend monitored is required. This includes filter pressure gauges, air handler valve and damper position feedback, terminal box flow, temperature and valve position, VFD speed indication, running amps of large motors and motor driven equipment

Every building control system shall integrate with Owner's head end, located in the HVAC department. Every Contractor is required to furnish all labor, hardware and applicable software and graphics necessary to integrate and maintain the system.

<u>Design Submittal Requirements</u>
Design Professional shall write a detailed sequence of operations in plans. Any proposed changes to the sequence shall be done through a RFI and included in the as-builts and controls O&M's.

Design Professional submittals shall include:

- Piping and Instrumentation Diagram, Control System
- Control system architecture diagram
- Points list
- Control component specification

- EMS sequence of operation

Control system architecture diagram shall depict in single line the communication interfaces between campus head end, building energy management, air handler and plant controllers and all terminal controllers, along with interface to building metering and monitoring devices.

Installation of control systems shall not proceed without sign off approval of sequence of operations and control diagrams and shop drawings by Owner (HVAC inspector).

Part 2 – Products

All direct digital controls (DDC) shall be native BACnet and fully communicate with Owner's existing system. The control component manufacturer is Alerton.

Wireless access is to be provided in mechanical and electrical rooms for technician access to the campus head end.

Major equipment such as Chillers, Boilers, VFDs, Fume Hood and Room/Lab Pressurization systems shall be fully integrated and communicate with the BACnet DDC System. Hardwire start/stops are required.

Factory set (pre-programmed) HVAC control modules are not acceptable. Proportional authority percentage (re-set) shall be field adjustable.

Sequence of operations and control diagrams and shop drawings require sign off approval by Owner (HVAC department) prior to installation and programming.

Part 3 – Execution

The controls contractor shall be a first tier sub to the Contractor.

Maintenance training sessions shall be provided on all systems. All sessions shall be scheduled through Owner (Project Manager). Sessions shall be video recorded by the Contractor and given to Owner.

All required close-out diagrams, sequence of operations and O/M manuals shall be on-site and available at the time of the scheduled training sessions. All training shall be completed in such a manner to assure proper end-user competency.

Training shall include both on-site, in-building efforts and remote site training at Control contractor's facility.

Controls contractor shall set up all trends required by commissioning on energy management components listed in part 1 of this section, meter instantaneous demand and totalized usage, and all space temperature setpoints. The Design Professional or Commissioning Agent may indicate additional trends in the project specifications.

Air handling systems shall be provided with freeze protection controls which are hardwired for failsafe operation as well as controlled by the DDC system. Fail safe, hardware protection shall include a manually reset low temperature switch, freeze-stat, activated by a sensor, capillary tube, downstream of the preheat or heating coil or between the heating coil and the chilled water coil which drives outside air damper close, opens heating hot water valve and opens chilled water valve and shuts down the fan. Access doors shall be provided for low temperature switch, freeze-stat, for removal and service.

Pneumatic Control Systems

When removing sections of pneumatic installations the piping shall be taken back to the point of origin and capped.

****END OF SECTION****

Section Number | Title

23 20 00 HVAC PIPING AND PUMPS

23 21 00 Hydronic Piping and Pumps

23 21 13 Hydronic Piping

Part 1 – General

This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties

Part 2 – Products

Pipe Requirements - Above Ground

Size	Pipe	Fittings	Joints
Up to 2"	Copper Type "L" seamless hard drawn	Wrought copper	Less Than 0.2% Lead Alloy Solder
2 1/2" larger	Copper Type "L" seamless hard drawn	Wrought copper	15% silver brazed
	Or	Or	Or
Schedule 40 Black Steel		Forged carbon steel	bevel welded
Pipe Schedule BelowGround			
Up to 2" Seamless hard drawn	Copper Type "K"	Wrought Copper	6% silver brazed
2-1/2" Seamless hard drawn	Copper Type "K"	Wrought Copper	15% silver brazed

Press fit coupling systems such as ProPress are not allowed without express written permission of Owner (Project Manager and HVAC Supervisor).

Pipe Gasketing – Steam and High Temperature Hot Water Services

Dialectric nipples shall be installed whenever joining dissimilar metals. Dialectric unions are not to be used. Spiral Wound. Owner has pre-approved the following manufacturer to be in compliance with these standards: Flexitallic gaskets.

Expansion Tanks

Provide diaphragm-type compression tank with replaceable diaphragm.

Part 3 – Execution

Copper: Maintain a minimum of 50% penetration of brazed joints.
Steel: Perform a minimum of three passes on weld joints (root, filler, cap).

Route piping to allow sufficient access to all equipment, valves, controls, etc., for maintenance. Install all equipment, valves, controls, etc. in a manner to perform maintenance from the deck.

In general, piping shall be installed below electrical conduits not requiring maintenance access.

All chilled water coils and DX coils located in a fan coil unit above the ceiling shall have a secondary drain pan under the fan coil unit. The secondary drain pan shall drain to a custodial sink. Such piping shall be directly connected to the secondary drain pan and maintain a minimum horizontal slope in direction of discharge of not less than one-eighth unit vertical in 12 units horizontal (1-percent slope).

Piping shall be secured at each trapeze hanger or support.

All hydronic piping, heating hot water or chilled water shall not be exposed to the weather elements; all piping shall be within the building structure.

Install piping sufficiently below structure to allow top air vents.

Provide isolation valves on each side of strainers and full port ball valve on blow down. Provide hose thread connection on blow down port 3/4" and below.

Provide air vent in pipe riser. Install air vents with isolation valves at all system high points. Automatic air vents are to be piped to drain. Minimum vent piping size is 1/2".

Piping Systems Flushing and Testing

Each system (steam, water, condensate, etc.) shall be flushed, checked for leaks, corrosion inhibitors added where applicable, and otherwise made ready for acceptance.

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Testing on all backflow preventers is required. Testing shall be performed by a certified tester and results shall be submitted in writing to Owner on the NAU Facility Services Backflow Testing form.

Solution shall remain in system (8) Hours. System shall then be flushed and test results provided to the Owner (Inspector).

All pressure tests shall be performed using a certified gauge which has been approved for use by Owner (Inspector).

Pressure testing needs to be conducted on the new system only. The new system needs to be isolated from the existing system during the pressure testing.

Pressure test the new system at whichever is higher between 1.5 times the operating pressure or as code requires for a period of two hours. A testing procedure needs to be submitted to the Owner (HVAC Supervisor) and approved prior to any testing.

23 21 23 Hydronic Pumps

Part 1 – General

Dual system back-up pumps shall be specified and installed on all new building and water heating and cooling systems. All heating, cooling, and domestic hot water circulation pumps shall have back-up. Automatic switch over in case of failure is to be required on heating water pumps.

This standard does not apply to design of pumps for use in central plant.

Part 2 – Products

HVAC Pumps

Owner has pre-approved the following manufacturer to be in compliance with these standards: Bell & Gossett.

Part 3 – Execution

All heating hot water and domestic hot water circulating pumps shall be backed-up, and shall have automatic change-over on HHW pumps.

All critical area chilled water pumps for stand-alone chiller systems shall be backed-up, and provided with automatic change-over.

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All pumps shall be selected for minimum maintenance, such as in-line circulators where appropriate. All coupled pumps shall require laser alignment after installation, and alignment documentation shall be provided to the Owner (Inspector).

All pumps shall have in-line strainers installed upstream of suction.

All pumps shall automatically restart after a power outage.

All HVAC equipment shall be connected to a Hand/Off/Auto starter. Momentary starters shall not be used.

All pump motors located remote from the motor control center shall be designed with a local disconnect that may be locked out.

Housekeeping pads shall be installed for all base mounted pumps. Grout pumps to pads with non-shrink grout prior to alignment and testing.

Ball isolation valves shall be installed so that the pump can be isolated for repair. No butterfly valves shall be used on pipe under 4" in size at suction and discharge of pump.

23 22 00 Steam and Condensate Piping and Pumps

23 22 13 Steam and Condensate Heating Piping

Part 1 – General
N/A

Part 2 – Products
Pipe Requirements

Service	Size	Pipe	Fittings	Joints
Steam	Up to 2"	Sch. 40	Forged carbon	threaded, bevel,
		Seamless, black	steel	weld or welded
				socket
Steam	2 1/2 " and	Sch. 80	Forged carbon	bevel welded
	larger	seamless, black	steel	
		steel		
Condensate	All	Sch. 80	forged carbon	Welded or Threaded

		Seamless, black		
		steel		

All steel piping for steam and condensate duty shall be domestic.

Brass, copper and bronze fittings and/or valves are not permitted for steam service. Valves 2" and smaller shall be carbon steel, quarter turn ball valves. Valves larger than 2" shall be high performance butterfly, bubble tight shutoff, and bi-directional if the piping can or will be pressurized from two directions.

Pressure Gauges:

- Rated for steam service up to 150 psi.
- Cast aluminum with 4 1/2" dial
- Selected with normal operating range at the midpoint of the scale
- Furnished with pressure snubber and shutoff valve

Strainers:

- 250# cast-iron, 2" - threaded through
- 2 1/2" and larger - Flanged (150 lb.) cast iron
- Size 100 mesh
- Provide isolation valves on each side of strainers and full port ball valve on blow down. Provide hose thread connection on blow down port 3/4" and below.

Steam Traps:

- The use of thermodynamic traps requires written approval from Owner (HVAC Supervisor).
- The use of orifice type traps is prohibited.
- Owner has pre-approved the following manufacturers to be in compliance with these standards:
    - Armstrong bucket or Float & Thermostatic for end of line, drip legs, and main lines as code requires.
    - TLV float & thermostatic for modulating service

Pressure Regulators:

- Globe valves are required in bypass.
- Vented to exterior of building through relief valve
- Owner has pre-approved the following manufacturer to be in compliance with these standards:
    - Fisher, Industrial Type 92B

Expansion Joints:

- Externally pressurized bellows type, weld end
- Owner has pre-approved the following manufacturer to be in compliance with these standards:
    - Hyspan 3500

Condensate Pumps:

- Duplex electric pump
- Cast-iron housing

Part 3 – Execution

Provide isolation valves at all equipment and on all main branch take-offs.

Include pressure gauges on both sides of all pressure regulators and at all steam using equipment.

Provide strainers with isolation valves and piped blow down ahead of steam traps and control valves. Provide unions or flanges to allow disassembly of strainer.

All steam and condensate piping shall be designed and detailed to include adequate expansion joints or loops, and such joints or loops shall compensate for expansion of the supply piping that it is connected to.

Design to detail location of atmospheric vent lines and pressure relief vent lines out of doors in a safe location. Include drip pan elbow for all pressure relief vent lines.

Use eccentric reducers to assure level bottom.

Steam and condensate piping pitch downward in direction of flow at 1/2” per 10 ft.

Direct - buried steam and condensate systems are not allowed. All steam and condensate lines to be in accessible location.

23 23 00 Refrigerant Piping

Part 1 – General

This Section includes refrigerant piping used for refrigeration and air-conditioning applications.

Pre-charged line sets are not allowed.

Part 2 – Products

Pipe Requirements - Above grade

Service	Size	Pipe	Fittings	Joints
Refrigernat Piping	All	Type 'L' ACR 15% Silver Solder Brazed	Wrought Copper Or Cast Brass	15% Silver Solder

Pipe Schedule - below grade

Service	Size	Pipe	Fittings	Joints
Refrigernat Piping Use long radius fittings only	All	Type 'K' ACR 15%	Wrought Copper Or Cast Brass	15% Silver Solder Brazed

Part 3 – Execution

All refrigerant piping shall be designed, sized and detailed to comply with manufacturer's recommendations concerning size, rise, insulation, etc. to ensure that oil migration does not occur.

Refrigeration isolation valves shall be installed at each refrigerant section (i.e. compressor, condenser, and evaporator) so that the charge does not have to be removed for repair and maintenance. Install isolation valves between split system components. Canister style changeable filter driers shall have refrigerant rated ball valves for isolation. Use Shrader valves on suction and liquid line a.

Refrigerant piping systems shall be designed, detailed and specified to be installed with:

- Piping supports to code.
- Line size traps at a minimum of every 25 feet of vertical lift
- Specification to require installation by qualified technicians
- Piping to be installed per ASHRAE standards
- Filter Drier:
    - Line Filter before expansion valves.
    - Suction Line filter before compressor.
    - Canister style used for 50 tons and above.

Nitrogen purge to be provided during soldering.

Owner reserves the right to cut into any two fittings to confirm the use of nitrogen purge.

****END OF SECTION****

Section Number | Title

23 30 00 HVAC AIR DISTRIBUTION

23 31 00 HVAC Ducts and Casings

23 31 13 Metal Ducts

Part 1 – General
N/A

Part 2 – Products

Supply, Return, General Exhaust
Galvanized Steel shall be ASTM A 527, G90 of lock forming quality.

Flexible Ductwork
Ductwork to be constructed in accordance with NFPA 90A, 90B, UL181 Class 1

Chemical Fume Exhaust
Fume hood branch duct, manifolded main ducts and any duct subject to concentrated chemical fumes shall be:

- Stainless Steel shall be ASTM A 240, type 316, minimum 22 gauge
- Spiral or welded for fumehood applications.
- Fittings shall be continuously welded – liquid tight.
- Spiral duct, with flanged connections.
- Joints will be constructed with a process equal to the Thermofit Wrap-around Duct Bands manufactured by Raychem.
- Longitudinal, all welded seams shall be specified for perchloric or other highly corrosive applications.
- Balancing valves are required at the take offs from the main trunk line.

Coated Galvanized Steel
Under special circumstances, with Owner permission, coated galvanized steel ducts may be used for manifolded general chemical exhaust plenums which are large enough to allow duct internal inspection and repair of coating. Specification for coating type and thickness shall be reviewed and approved by Owner.

Duct Sealants
Specify use of Hardcast AFG-1 402 Foil-Grip tape, Hardcast DT-Tape with FTA-20 adhesive, or water based paint-on duct sealant for indoor use, or RTA-50 adhesive for outdoor use, to seal all duct joints.

Part 3 – Execution

Supply, Return, General Exhaust

Use long radius (center radius of 1.5 times duct width (minimum)) on tees, bends, and elbows.

Ductwork shall be stored in a clean location prior to installation. Openings shall be covered to prevent entry of dust, moisture and general construction dirt/debris. Plastic sheeting securely taped over open ends is acceptable.

Balancing dampers on all branch ducts at the main trunk shall be used and show location on drawings.

Use single thickness turning vanes only in ductwork up to 2" pressure class.

Use airfoil type vanes for higher pressure class. Install per SMACNA.

Turning vanes are not allowed in reducing elbows.

No bellmouth, flanged or notch spin-In connections permitted except at terminal/diffuser take-offs.

No extractors allowed.

Flexible Ductwork

Maximum flexible ductwork lengths - 18" on high pressure systems, 48" on low pressure systems.

High pressure flexible ductwork shall not be used for changes in direction.

Low pressure flexible ductwork may only be used to accommodate a total of a 45° change in direction. Hard elbows shall be used at diffusers.

Flexible ductwork shall be secured utilizing steel draw-band clamp.

Chemical Fume Exhaust

Chemical exhaust ductwork to conform to ANSI/AI HA standard 29.5 – 1992.

Exhaust system designs shall conform to American Industrial Hygiene Association (AIHA) Industrial Ventilation manual.

All exhaust ductwork within the building shall be under negative pressure, with the exception of a limited length of pressurized duct from the fan discharge to outside.

Design exhaust ductwork connections to equipment to allow for proper drainage flow.

Fumehood exhaust ductwork can be manifolded only if multiple exhaust fans are used.

Fume hood exhaust systems are to be designed and specified to prevent any inside surface protrusions especially at joint connections that can catch condensation of fume hood vapors. This includes screwed duct connections.

Filters shall be 2" thick, pleated, 300 FPM maximum velocity, mean efficiency of 36% according to ASHRAE 52-68.

23 34 00 HVAC Fans

23 34 16 Centrifugal HVAC Fans

Part 1 – General

Section Includes:

Air Handling fans, blowers and accessories

Selection of all air handling fans and blowers shall consider air density effects of Owner's 7000 ft elevation.

No centrifugal fan or blower is to be operated at greater than 2000 RPM. Specific applications requiring centrifugal fans to operate at greater than 2000 RPM shall be reviewed and approved in writing by Owner (HVAC Supervisor).

Centrifugal fans handling more than 1,000 CFM shall have backward inclined blades.

Variable frequency drives shall not be specified for forward curved fans.

Utility fans serving fume hoods to discharge out top of stack at a minimum velocity of 3000 f.p.m.

All air handling fans and blowers shall be selected and specified to deliver designed airflow and pressure at less than maximum fan RPM of fan pressure class specified.

All air handling fans and blowers shall be selected and specified to deliver designed airflow and pressure without vibration and noise problems, and to enable air balancing without fan or blower over-speed.

Bathrooms, shower rooms, laundries, and kitchens shall be designed to be individually power exhausted and not tied into any other building exhaust or ventilating systems. Unless approved by Owner through life cycle analysis, heat recovery shall be specified.

Part 2 – Products

Fans shall be tested in accordance with ANSI/ASHRAE STD 51 and ANSI/AMCA STD 210.

Standard Products – The same manufacturer shall be used for multiple installations for the same type. Owner has pre-approved the following manufacturers to be in compliance with these standards: Greenheck, ILG, Trane.

Fans shall be statically and dynamically balanced at the factory.

Bearings shall be heavy-duty split pillow block, self-aligning ball bearings with seals and grease nipples, minimum service life of 200,000 hrs. Permanently lubricated bearings are not acceptable.

Short coupled, multi-belted fans shall utilize companion sheaves in lieu of variable pitched sheaves.

Minimum size of drain connection in bottom of fan housing is 3/4".

Minimum size of access doors to blower section is 18" x 18".

Fan to duct systems shall be located indoors. Where fans must be located outdoors, specify weather-proof package.

Minimum height of discharge stack for chemical exhaust fan is 10' above adjacent accessible roof.

Control Dampers

Owner has pre-approved the following manufacturer to be in compliance with these standards: Tampco Dampers.

Part 3 – Execution

In-line fans/blowers shall have adequate access panels for service and maintenance.

Grease fittings shall be extended for easy access without the need for equipment shutdown.

Design and detail centrifugal fan installation such that fan shaft and wheel can be removed without disassembly of adjacent equipment.

23 36 00 Air Terminal Units

Part 1 – General

Specification for terminal box test submittal data shall require compliance with ADC/ARI Standard 880-89.

Part 2 – Products

Specify use of only 'long' terminal boxes for any air volume control application requiring accuracy greater than +/- 25%.

Specify Terminal Box controllers to be Direct Digital and compatible with Owner's EMS. DDC controllers shall be factory mounted.

Specify that all Terminal Box controls and actuators shall be externally mounted.

Specify minimum press drop across Terminal Box to be 0.1" wg with control damper fully open.

Specify maximum sound power level to meet HVAC acoustical requirements.
Specify terminal Boxes to have screwed access doors if serviceable items are enclosed.

Box damper leakage shall not exceed 2% of nominal box rating at 4" static pressure.

Part 3 – Execution

Duct systems require a minimum of 18" clearance access for service and maintenance of equipment components. Show service access clearance requirements in graphic form on drawings.

Provide detail of terminal box support system on drawings. Detail to require trapeze hanger where possible. Sheet metal strap hangers screwed to side of terminal box is not allowed.

Section Number | Title

Detail and specify acceptable box entry and exit conditions. Design high velocity ductwork to provide sufficient straight duct and low turbulence to meet manufacturer's requirements. Specify maximum allowable offset in flexible duct connection to inlet of box.

23 38 00 Ventilation Hoods

23 38 13 Commercial-Kitchen Hoods

Hoods and Ventilation Systems

Hood lighting shall be vapor-proof or explosion proof, depending upon the intended purpose of the hood. Light bulbs shall be accessible for changing outside the hood.

Each sink under a hood shall be individually trapped.

Surface Fire Protection System

Surface fire protection systems shall be included in all food service hoods.

****END OF SECTION****

Section Number | Title

23 50 00 CENTRAL HEATING EQUIPMENT

23 52 00 Heating Boilers

Part 1 – General
N/A

Part 2 – Products
Boilers shall be rated for operation at 7000 ft. elevation. This may require modification of standard factory unit. Boiler/burner shall be stamped for design performance at 7000 ft. elevation.

All boilers to be commercial/industrial quality.

The make and model of boiler shall have been manufactured for continuous commercial service in the continental USA for more than three years.

Parts and service for specified boiler shall be readily available through a distribution system in the continental US.

Boiler manufacturer, make and model require prior written approval by Owner (HVAC department). Submit proposed manufacturers for written approval before finalizing specifications.

Part 3 – Execution
All stand-alone boiler installations shall have a three-foot clear working area around all sides of the boiler, including the top.

All safeties shall be non-lockout, unless codes require otherwise.

23 57 00 Heat Exchangers for HVAC

Part 1 – General
Heat exchangers are to be located no more that 5’ above finish floor. Heat exchangers are not to be mounted to ceiling.

In Design Development drawings, demonstrate adequacy of mechanical room geometry for purpose of heat exchanger service clearance for removal and replacement.

Isolation valves and unions are required on all heat transfer units on both sides of heat exchanger, both sides of pumps, at strainers and air separators. All Isolation valves shall be ball valves.

All glycol to be propylene glycol with inhibitors. Owner uses Dowfrost in the glycol system.

Design outside air preheat loops with 40/60 glycol mixture for freeze protection, use closed loop with no City of Flagstaff make-up water connection. There shall be a mixing tank and pressurization pump for this application.

For applications with extensive outdoor glycol piping, provide 50/50 mix for freeze protection.

Glycol recovery tank shall allow complete system drain back.

Part 2 – Products

Factory assembled heat transfer skids, including heat exchangers, pumps, air separator, piping and controls is acceptable upon written approval by Owner (HVAC Supervisor), provided a minimum of 36" outboard of skid is provided and maintenance access to all components is provided. A complete manufacturer dimensional shop drawings showing all components and service access, including tube bundle pull space to be shown graphically.

Heating Water Exchangers: Field erected heat transfer systems are required. Design drawings to provide sufficient detail to show all components and minimum service access clearances. Service access, including tube bundle pull space to be shown graphically. Contractor shall submit complete shop drawings including dimension plan, elevation and isometric for Owner to review and approve prior to construction.

Tube bundle in tank heat exchangers are required. Heat exchangers shall be stainless steel or cupro-nickel alloy.

Part 3 – Execution

All heat exchangers used for space heating purposes shall have controls that fail closed.

****END OF SECTION****

Section Number | Title

23 60 00 CENTRAL COOLING EQUIPMENT

23 62 00 Packaged Compressor and Condensate Units

Part 1 – General

Direct evaporative cooling, whether alone or in addition to a mechanical or indirect evaporative system, shall not be used.

For wet wall installations, face and bypass dampers must be used for temperature control. Wet wall pump cycling shall not be an option for temperature control. Bypass dampers shall be sized to allow full air flow around the wet wall.

Part 2 – Products

Specify only commercial or institutional grade refrigeration equipment.

Equipment to operate with refrigerant 410A unless otherwise approved in writing by Owner.

Crank case heaters shall be installed on all compressors.

Service valves are required on anything over 5 tons.
Specify low ambient controls for equipment that operates year around. Specify head pressure or equivalent control. Variable speed for primary condenser fan is required.

Provide hail guards on outdoor condensers.

Part 3 – Execution

Provide 3 feet clearance around rooftop units or remote condensing units.

23 64 00 Packaged Water Chillers

23 64 23 Scroll Water Chillers

Part 1 – General

Design and specify air and water-cooled scroll chillers up to 100 tons.

Part 2 – Products

Specify only commercial or industrial grade equipment.

Owner has pre-approved the following manufacturers to be in compliance with these standards: Trane, Carrier, York, McQuay.

Unit Description
Liquid chillers can be semi hermetic or scroll compression design. Separate refrigerant circuits shall include the following: liquid line solenoid valve, filter dryer, sight glass, thermostatic expansion valve and service valves.

Unit efficiency shall meet ASHRAE 90.1

Evaporator
Exterior units shall have a glycol mixture, be fully insulated, and equipped with a drain connection.

Air Cooled Condensers
Provide head pressure control.

Electrical
Include motor starters with equipment.

Controls
All equipment shall be complete with leaving water control and unloading capability, low/high pressure switches, low ambient, freeze stat, flow switch and motor overload safeties, low oil pressure safety switches.

Receivers
Shall be capable of entire refrigerant charge pumpdown.

Head Pressure / Load Control
Shall be capable of running in low load and low ambient conditions. Provide compressor cylinder for any semi-hermetic system. Provide variable speed condenser fan. Provide hail guard on air cooled condenser.

Refrigerant
Refrigerant shall be of R-410A.

Part 3 – Execution
Remote Interface - provide interface with building/campus energy management system for alarms, start/stop, status, water temperatures.

All systems are to be dehydrated, leak tested charged and tested for proper control and operation.

Section Number | Title

23 65 00 Cooling Towers

Part 1 – General

Towers used for water-cooled condensing or for indirect evaporative cooling shall be designed and specified to be protected from freeze damage. Whenever condenser water is pumped through a coil located in a tower, redundant pumping with automatic start of the alternate pump is required. These systems shall be remotely alarmed upon loss of flow through the coil.

Sumps shall drain to storage rather than to waste for freeze protection.

Part 2 – Products

Cold water basin shall be stainless steel.

Owner has pre-approved the following manufacturers to be in compliance with these standards: Marley, Evapco, Baltimore Aircoil

Part 3 – Execution

Systems shall be equipped with chemical feed systems as coordinated by the Owner's chemical treatment consultant. Tower sump and evaporative cooling sumps shall have total dissolved solids (TDS) controlled blowdown; continuous blowdown is not acceptable.

****END OF SECTION****

Section Number | Title

23 70 00 CENTRAL HVAC EQUIPMENT

23 73 00 Indoor Central-Station Air-Handling Units

23 73 13 Modular Indoor Central-Station Air-Handling Units

Part 1 – General

Owner's baseline system design is a Single Duct VAV Concept. Energy Models with total cost of ownership calculations are required when proposing other systems.

AHU to be 'draw-thru' type. Fan walls with backdraft dampers with a minimum of 4 fans are preferred.

Fan Coil Units

Size AHU to meet latest edition of ASHRAE Standard 62.

Consider location of Outside Air (OA) intakes in concept design. Preferred location is above roof level - not ground level. However, avoid location of AHU outside air intake in vicinity of exhaust louvers, plumbing vent stacks, emergency generator stacks, loading dock areas, smoking area. Consider potential for drift snow and fly snow in sizing and placing outside air intakes.

Design physical layout of AHU in building mechanical rooms to provide service access. AHUs are to be located no more that 5' above finished floor. AHUs are not to be mounted to ceiling.

OA intakes to be hard ducted through mechanical rooms.

Access is required to both sides of AHU fans to allow for bearing replacement.

Design to ensure smooth, uniform inlet and discharge flow conditions to and from AHU to avoid significant static pressure penalty of system effect.

Air handler manufactured to provide a 'minimum' of one fan impeller diameter upstream of the fan.

Fan wall air handlers shall be manufactured so that motor can be removed with the fan blade attached.

Provide vibration safety switches on all vaneaxial type fans.

When vaneaxial fans are used, ensure suitable access is provided for

servicing/removal.

Control valves shall be located outside of air handler enclosure.

All chilled water coils and direct expansion (DX) coils located in fan coil unit above the ceiling shall have a secondary drain pan under the fan coil unit. The secondary drain pan shall drain to a custodian sink. Such piping shall be directly connected to the secondary drain pan and maintain a minimum horizontal slope in the direction of discharge of not less than one-eight unit vertical in 12 units horizontal (1-percent slope).

Part 2 – Products

Air handlers to be institutional grade.

Minimum air handler specification shall include the following:

- Heating coil shall be upstream of the cooling coil.
- Double walled casing - minimum 18 gauge. AHU shall not be constructed using porous or semi porous materials.
- Hinged access doors to both sides of coils, fans, filters and damper sections.
- Large (Above 10,000 CFM) AHU to have inspection windows in access doors.
- AHU shall have interior inspection lights.
- Side access doors for slide in/slide out filter tanks. All filters shall be specified as 24x24x2 to 24x24x12.
- Removable side panels in fan sections to allow for fan and shaft removal/replacement.
- Utilize only “premium efficiency” motors in AHU's. All motors shall be inverter rated.

Owner has pre-approved the following manufacturers to be in compliance with these standards: Energy Labs, Hunt Air.

Fan Coil Units

Owner has pre-approved the following manufacturers to be in compliance with these standards: Carrier, Trane, or McQuay.

Part 3 – Execution

All air handling units with outside air shall be equipped with freeze stats with manual reset located between the heating and cooling coil, outside air dampers and low-limit controls. All heating hot water valves shall fail to heating position. All outside air dampers shall fail closed.

Section Number | Title

All heating coils that may be exposed to outside air shall be protected by a low limit temperature control, located downstream of the heat or preheat coil, which will open the supply valve upon failure to maintain the minimum temperature set point. Further, any fan or blower that moves air across such a coil shall shut down upon failure to maintain a minimum temperature, which should have a lower set point than the supply coil low limit. Outside air dampers shall be closed and a hot water valve shall be opened.

Ensure coil drain pans and condensate pipework is pitched to drain, (minimum pitch 1/4" per foot). Provide a secondary drain pan outside of the air handler unit and fan coil unit and provide piping from secondary pan to visible building drain like a custodial closet.

In new construction, utilize AHU to 'flush' building to reduce off-gassing of interior furnishings prior to occupancy. Fit AHU with temporary filters of same quality as permanent filters during this period.

Replace filters before system balancing.

23 74 00 Packaged Outdoor HVAC Equipment

23 74 13 Packaged, Outdoor, Central-Station Air-Handling Units

Part 1 – General
Outdoor air handlers are not allowed.

Part 2 – Products
N/A

Part 3 – Execution
N/A

****END OF SECTION****

Section Number | Title

23 80 00 DECENTRALIZED HVAC EQUIPMENT

23 81 00 Decentralized Unitary HVAC Equipment

23 81 26 Split System Air Conditioners

Part 1 – General

Refrigerant air conditioning systems shall be utilized ***only*** when specifically authorized by Owner in writing. Life cycle cost analysis shall be utilized to determine the most appropriate type.

Summertime cooling systems shall have economizer cycles with 100% outside air capability. Enthalpy controls shall be provided on all systems that run continuously. Indirect evaporative cooling shall be considered as an additional capacity system.

When A/C systems are proposed to run year round for critical areas, refrigerant receivers and suction line accumulators shall be used. All critical area A/C systems shall be redundant or a parts inventory shall be included in close-out submittal requirements to cover emergency repairs. This inventory shall include any and all controls motors or equipment required to make the system operational in an emergency.

Crank case heaters shall be installed on all compressors.

All outdoor compressor units shall be located under permanent covers.

Provide all necessary valves and equipment to permit refrigerant recovery/recycle.

All air-cooled condensers shall have low ambient temperature controls, and head pressure sensing or equivalent controls. Variable speed for the primary condenser fan is preferred.

Part 2 – Products

N/A

Part 3 – Execution

N/A

23 82 00 Convection Heating and Cooling Units

23 82 16 Air Coils

Section Number | Title

Part 1 – General

Coil Section
Consider high dewpoint outside conditions when sizing cooling coils.

Select cooling coils with water temperatures of 42/62°F EWT/62°F LWT (summer) and 48/60°F EWT/62°F LWT (winter).

Select heating coils with a 40°F water temperature differential.

Maximum coil face velocity 400 fpm.

Maximum coil pressure drop 0.5" SP.

All heating coils that may be exposed to outside air shall be protected by a low temperature control, located downstream of the coil, which will open the supply valve upon failure to maintain the minimum temperature set point. Further, any fan or blower that moves air across such a coil shall shut down upon failure to maintain a minimum temperature, which should have a lower set point than the supply coil low limit. Outside air dampers shall fail closed and a hot water valve shall fail open.

Part 2 – Products
Chilled water coils shall be counter flow with a minimum of 7 rows.

Part 3 – Execution
Provide maintenance access to all equipment requiring service.

23 83 00 Radiant Heating Units

23 83 13 Radiant-Heating Electrical Cables

Part 1 – General
Electric heating cables shall not be used; this application requires hydronic heating.

Part 2 – Products
N/A

Part 3 – Execution
N/A

Section Number	Title
23 83 16	Radiant-Heating Hydronic Piping Polyethelene (PEX) or approved equal piping. High pressure radiant units.

****END OF SECTION****