Section Number | Title

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

Part 1 – General

References/Regulatory Requirements

All work shall be subject to inspection by the following agencies as appropriate to the stage of construction:

- State Fire Marshal's Office
- State Risk Management Office
- State Boiler Inspector
- NAU Risk Management Office
- NAU Facility Services Code Inspectors
- NAU Facility Services Planning, Design and Construction
- NAU Facility Services Trades

All work shall conform to the requirements of all Federal, State and local laws, including but not limited to Codes and Standards referenced in section 01 41 00 of this Project Manual.

Campus Energy Infrastructure

North Campus

A central steam generation plant is located in Building 24 on North Campus with a steam supply and condensate systems routed through a subterranean network of tunnels and enclosed pipe chases. Process, domestic and comfort heating to all new buildings in proximity to the distribution grid is to be provided by the central distribution system. Maximum design steam pressure is 150 psig, design operating conditions are saturated at 60 psig. Heat shall be transferred from the campus distribution system to building hydronic systems via tube in shell heat exchangers. Condensate return is pumped from atmospheric receivers at each building to the plant. Pump discharge pressure varies from 25 psig to 50 psig and must be calculated for each new building system depending on location and head required. Steam pipe and heating water extensions from the distribution system of greater than 100 LF shall be in walkable tunnels (7 ft x 7 ft minimum). Extensions less than 100 LF may be in enclosed concrete structures, provided reasonable access to serviceable components (ie valve expansion joints and drip assemblies) is provided from above, and the lid can be removed to allow pipe replacement. Compensation for thermal stress shall be considered in all steam and condensate pipe design. Pipe stress supporting calculation shall be provided.

A central chilled water production and distribution system is located in building 24 on North Campus with a direct buried supply and return water distribution grid. Process and comfort cooling to all new buildings in proximity of the distribution grid is to be provided by the central system. The chilled water system is configured as Direct Primary, Variable Flow, with a single set of distribution pumps located within the plant. The central utility pumping is controlled to provide a differential pressure of 15 psig across building piping entry point. Internal building piping and coils shall be designed to meet peak anticipated demands without the use of secondary booster pumps or hydraulic decoupling within the building. Central chilled water supply temperature setpoint in summer time is 42 F. The chilled water supply temperature may be reset upward to 48 F in wintertime to allow use of the plant hydronic economizer. Building coils designed for dissipation of internal winter loads shall accommodate elevated (48 F) chilled water supply temperature. The University prefers that new air handler coils be selected for peak anticipated design at 42 F with a 20 F degree temperature split. At a minimum, all new building coils (including fan coils) shall be specified to provide a 16 F temperature rise under peak load with 42 F supply. All coils (including fan coils) shall be controlled with two way valves that modulate based on leaving air temperature.

<u>South Campus</u>
A central high temperature hot water plant is located in Building 67 on South Campus with a heating water supply and return distribution system routed through a subterranean network of tunnels and enclosed pipe chases. Process, domestic and comfort heating to all new buildings in proximity of the designated grid shall be provided by the central system. Any modification or extension to the high temperature heating water system shall be designed under ASME piping code for 600 psig pressure and 400° F temperature. The university operates the system at 160 psi, 250° F supply and 210 returns (40 degree split). Heat shall be exchanged from the high temperature loop to the building system via tube in shell heat exchangers, selected to meet peak anticipated building demand with 250 F campus supply and a 40 F temperature split.

A central chilled water production and distribution system is located in Building 67 on South Campus with a direct buried supply and return water distribution grid. Process and comfort cooing to all new buildings in proximity of the distribution grid shall be expanded by the central system. The chilled water system is configured as Direct Primary, Variable Flow, with a single set of distribution pumps located within the plant. The central utility pumping is controlled to provide a differential pressure of 15 psig across building piping entry point. Internal building piping and coils shall be designed to meet peak anticipated demands without the use of secondary booster pumps or hydraulic decoupling within the building. Central chilled water supply temperature setpoint in summer time is 42 F. The chilled water supply temperature may be reset upward to 48 F in wintertime to allow use of a plant hydronic economizer. Building coil design for dissipation of internal winter loads shall accommodate elevated utility chilled water supply temperature. All building coils shall be specified to provide a 20 F temperature split under peak load with 42 F supply. All coils shall be controlled with two way valves that modulate based on leaving air temperature.

Local Environmental Conditions
Building design shall account for the ambient environmental conditions in Flagstaff. The Design Professional shall familiarize himself with special altitude and climatic conditions experienced in Flagstaff, and adapt the designs and specifications to suit.

Among important considerations for HVAC system designs are:

Elevation
All equipment, as appropriate, shall be de-rated for operation at 7,000 feet altitude. Design Professional shall request verification of BTU and specific gravity content of supplied gas in order to specify altitude corrections. Other equipment requiring de-rating includes, but may not be limited to, transformers, motors, fans, blowers and air moving equipment, ducts, controls, atmospheric heat exchangers, and motor speed controls. Motors, variable frequency drives and control equipment enclosures shall be specified to account for altitude effect on temperature dissipation.

Design low temperature
All air handling units with outside air shall be equipped with freeze stats with manual reset, outside air dampers and low-limit controls. All heating water valves shall fail to heating position. Design all HVAC systems for -20 F minimum outside air temperature.

Design high temperature
Building HVAC systems shall be designed to satisfy peak anticipated load under a 90 F outside air dry bulb.

Design wet bulb temperature
Outside air coils, evaporative media and cooling towers shall be specified to meet design performance under a wetbulb of at least 65 F

Diurnal Temperature Swing
Mechanical systems shall be designed to accommodate, and respond to, diurnal freeze-thaw cycle of as much as 50 F.

Solar Radiation
Characteristics of solar radiation shall be considered under all seasonal conditions. Solar gain effect of low winter sun angle on south facing vertical fenestration shall be evaluated.

Design maximum snowfall
Periodic occurrence of snowfall in excess of five feet and potential for drifting snow shall be considered in location of outside air intakes, along with relief and exhaust systems. Use of exterior ducting and equipment is discouraged.

Fly snow
Frequent occurrence of light, dry, crystalline “fly” snow shall be considered in design of outdoor air intake ducting and transitions. Baffles, stilling wells and drain pans may be required.

Wind Rose, gust velocity and intermittency
Seasonal wind direction shall be considered in location and design of building exhaust, intake, relief louvers and in placement of emergency generator exhaust. Wind gust velocity and intermittency shall be considered in design and location intake and exhaust louvers and of natural ventilation systems.

Building System Design Criteria

HVAC Baseline
An HVAC system with which NAU has considerable long term operating experience and consider being their baseline system is described as follows:

Central Utility Connections
Utilizes Campus 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
Consideration of alternative HVAC systems that offer the potential of substantial improvement in energy efficiency, maintainability, first cost, or a legitimate potential to better achieve the Universities sustainability goals is encouraged. A Life Cycle 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 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. The baseline system described above shall be among the alternatives compared. The life cycle is the expected life of the system, or twenty years, whichever is shorter. Technical and economic assumptions used in life cycle cost analysis shall be coordinated with NAU Project Manager prior to submittal of result. Life cycle cost will be one of several criteria used by NAU 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 NAU Shop Personnel, 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. NAU 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 Evaluation.

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 20 year life cycle cost analysis of all alternatives demonstrates it to be the most cost effective for the 20 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 Designer 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 NAU Director of Utilities with drawing submissions.

HVAC Design Requirements

The University prefers 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 University Project Manager.

Noise level volumes of air movement and equipment shall be designed and installed as compatible for intended functions within building spaces. The Design Professional will be held 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. Where possible, IT and Computer Server rooms shall be located at an exterior wall.

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 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. 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.

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 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 and 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 the Director of Utilities.

<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.

Installers and sub-contractors shall have at least three years experience in installation of similar equipment on similar projects. All sub-contractors shall have a proven track record of response to complaints or problems during and after the warranty period.

Design Professional Requirements

The Design Professional through his sub-consultants shall be responsible for defining the coordination of all systems including but not limited to: electrical systems, control systems, heating and cooling systems, plumbing systems, and any other mechanical systems included in the building design. This responsibility to prepare a coordinated design extends to Federal, State, and local agencies, and franchised service companies.

Performance specifications shall not be used in lieu of designed systems unless specifically authorized by the Project Manager on an item-by-item basis.

Design Document Requirements

The Design Professional shall submit a set of General Arrangement 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. General arrangement 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 Close Out Materials

At a minimum, one set of “As Built” drawings and one set of O&M manuals shall be provided to the HVAC department.

Design Professional shall include in contract documents the requirements that NAU is provided with the following minimum submittal information and close out materials:

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NOTE: 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

All close-out submittals shall be indexed to the specifications, separated by dividers and bound in three ring binders.

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Provide product extras as applicable from the following:
Desktop computer, programming devices or applicable software
Thermometers, each type.
Two sets keys/wrenches for any covers.
Spare belts for all fans.
Spare thermostats.
Chemical test kits as appropriate.
One set of filters installed just prior to final balancing.
One extra set of filters.
One set of any proprietary trouble shooting or maintenance tools.
Two copies any proprietary computer software for systems control, program back-up, troubleshooting or maintenance.
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.
Specialty tools specific to system operations

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.

Warranty
All HVAC systems equipment and components shall be warranted for 2 years minimum.

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 polyphase, 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

Part 2 – Products

All motors shall be high efficiency with sizing and winding insulation specified to compensate for altitude. (7,000 ft)

All motors shall be Premium Efficiency

Part 3 – Execution

All pump motors located remote from the master 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

Section Includes:

Flexible, ball-joint, packed expansion joints.
Expansion-compensator packless expansion joints.
Metal-bellows packless expansion joints.
Pipe loops and swing connections.
Alignment guides and anchors.

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 Professional Engineer and submitted to NAU.

Construction drawings shall contain sufficient detail to clearly identify location and method of support for pipe anchors, thrust blocks, guides, expansion compensators, arresters, etc. Details shall be such that the contractor has no question of how the work is to be accomplished.

Section Number	Title

Part 2 – Products

Steam/Condensate distribution system: Hyspan 3500 externally pressurized bellows joint.

High Temperature Heating Water systems: Barco Ball Joint.

Part 3 – Execution

Space anchors, guides and supports per manufacturers requirements.

23 05 19 Meters and Gages for HVAC Piping

Part 1 – General

Specify Totalizing meters for
chilled water
steam/condensate
reclaimed water
natural gas
domestic water

Specify additional meters to comply with additional project requests (e.g. ASHRAE 189.1).

Utility meters shall be designed and specified by the Design Professional. Project Contractor shall furnish and install all utility meters. Utility meter commissioning shall be a joint effort between the Project Contractor, Design Professional, Commissioning Agent, (where applicable) and the University. The University will not energize any utility until the meter has been shown to be fully functioning and operational.

Design and construction documents to specify, schedule and require furnishing, installing, and commissioning of all utility meters. Documents shall include a flow meter schedule that explicitly defines:
Utility service
Meter type
Meter size
Maximum, minimum and normal Flow range
BTU range
Temperature and pressure

Design documents shall include meter installation details that are complete and include all necessary information, including, but not limited to, length of straight pipe required upstream and downstream, distance required from valves or fittings, any required concentric reducers and location of temperature and pressure sensors.

Utility meters shall be specified to provide a local readout- either in transmitter head or in a suitably rated box on an adjacent wall. In either case meter readout shall be designed to be readily accessible- between 4 and 5'6" AFF.
Utility meters shall communicate with the University's campus EMS system. Specify all necessary components and communication protocols to assure meter information can be mapped to campus Building EMS Web Page.

Part 2 – Products
All gas and steam flow meters shall be temperature and pressure compensating.

South Campus

Chilled and Heating Water Meters
All items necessary to allow the chilled water flow sensors to function as energy meters shall be specified and shown on the drawings and included in installation details.
Output of energy meter shall be in BTU's and totalized in MBTU's.
These additional items shall include, but are not limited to, temperature sensors, BTU totalizing computer, connection requirements to the campus EMS system, programming requirements and software.
Delta temperature transmitters shall be platinum 1000 OHM RTD, Where 1000 ohms equals 32^0 F.
Delta temperature sensors shall be matched pairs of calibrated sensors with an accuracy of 0.12^0 F.
Flow transducers shall be selected for the expected flow range encountered at present design conditions, pipe size and material. Particular attention shall be made to design minimum flow conditions.
For all installations an energy totalizing computer will be required.
Insertible Magnetic Flow Meter- Onicon F3500 with Onicon Series 10 Totalizer

Steam Meters
All items necessary to allow the steam flow sensors to be fully functional shall be specified and shown on the drawings and included in installation details.
Output of energy meter shall be in lbs/hr with pressure/temperature compensated conversion to BTU and totalized in MBTU's.

These additional items shall include, but are not limited to, flow (in lb/hr) totalizing computer, connection requirements to the campus EMS, programming requirements and software.
Temperature transmitters shall be platinum 1000 OHM RTD, Where 1000 ohms equals 320 F.
Flow transducers shall be selected for the expected flow range encountered at present

design conditions, pipe size and material. Particular attention shall be made to minimum flow conditions.
For all installations an energy totalizing computer will be required.
Insertion type vortex meter Onicon F2500 with Onicon Series 2500 totalizer

Domestic and Reclaim Water Meter
Positive displacement meter with pulse counter and totalizing head
Specify compound meter where necessary to manage high (maximum – minimum) turn down
Onicon meter

Pressure Gages
Specify 6" minimum diameter, liquid filled gages 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
Pneumatic Controls
Main steam supply line
Static pressure gauges on all static controlled fans

Thermometers
Specify 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
The supply of any utility to a building shall not be activated until the specified metering is in place, functional, and has been commissioned.
During the final phase of the project and before final close out, project contractor shall be required to prove that all utility meters are installed properly and function as designed and specified. The utility meter commissioning shall be accomplished by the contractor in conjunction with the Design Professional, Commissioning Agent (where applicable) and the University.
Require calibration data, O & M manuals, details, etc., to be submitted after

meters accepted.
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 ".

Meter EMS Displays: Displays within the EMS for meters shall include the following when applicable.

HTHW: flow in GPM, energy flow in BTU/hr, totalized Energy in BTU's, maximum and minimum instantaneous GPM and BTU/hr with the date and time that point was reached.

Steam: Flow BTU/hr, totalized energy in BTU's, pressure in psi, maximum and minimum BTU/hr with the date and time that point was reached.

Chilled Water: Flow in GPM, energy flow in BTU/hr, totalized energy in BTU's, maximum and minimum GPM, BTU/hr and peak load in tons with the date and time that point was reached.

Domestic Water: Flow in GPM, totalized in gallons. Peak flow rate with the date and time that point was reached.

Reclaimed Water: Flow in GPM, totalized in gallons. Peak flow rate with the date and time that point was reached.

Electric: demand in KW, Totalized in kWh, total voltage, voltage per phase, total amperage, amperage per phase, total power factor, and power factor per phase.

All maximum and minimum values shall have a button to reset when those values were tracked from. Multiple meters may be required to record maximum and minimum flows. Trends on flow rate and totalized energy must be setup within the EMS prior to substantial completion.

23 05 23 General Duty Valves for HVAC Piping

<u>Part 1 – General</u>
<u>Section Includes:</u>
Brass ball valves.
Bronze ball valves.
Iron ball valves.
High-performance butterfly valves.
Chainwheels.

Part 2 – Products
Valves

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

Steam valves and steam pressure regulators shall be as 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 and have two year warrantee. University prefers valves to be manufactured by 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 universities EMCS and shall be Belimo or approved equivalent.

Part 3 – Execution
All valves underground or in vaults shall be gate valves.

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

Specify and show isolation valves on drawings at all equipment and on all main branch take-offs.

Specify automatically controlled Heating valves as **fail to heat** (normally open). Domestic steam valves shall **fail closed.**

Specify and show unions 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 allow use of 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 General Contractor shall hire the Test and Balance firm, but shall have approval from by the 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.

Specify that all air distribution systems shall be balanced in the **heating** mode *and have flows measured in cooling mode*.

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

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

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

Specify that 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.

Four hard copies of the air system testing, adjustment, and balancing report shall be provided to NAU with one copy provided to the HVAC department.

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 directed by NAU Project Manager, indoor space temperatures shall be specified to be maintained at a maximum of 72° 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.

Unless otherwise directed by NAU Project Manager, indoor space temperatures shall be specified to be maintained at a minimum of *76*° F. in a cooling mode as measured 4' above the floor and 2' from any exterior walls.

Large classrooms/conference rooms may have large temperature variations across the room. DP is to develop a control strategy to maintain heating and cooling temperature setpoints in the center of the room.

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

Design and specify installation of temperature sensors for outside air, return air, mixed air on each air handler or variable box.

Design and Specify systems with sufficient instrumentation that energy efficiency can be trend monitored. This is to include filter pressure gages, 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 be specified to integrate with the NAU head end, located in the HVAC department. Specify that every control contractor is required to furnish all labor, hardware and applicable software and graphics necessary to integrate and maintain the system.

Design Submittal Requirements

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
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 the Facility Services HVAC department.

Part 2 – Products

All DDC controls shall be native BAC net and fully communicate with existing Campus system . The preferred control component manufacturer is Alerton.
Controls contractor to provide one work station with computer, hard drive, keyboard, monitor, and mouse in a locked cabinet.
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.

System requirements are listed below:

Processor:	2.8 GHZ Intel Pentium (Minimum)
Memory:	4GB DDR3 SDRAM Memory
Cache:	16 MB
Hard Drive:	1 TB 7200 RPM SATA (Minimum)
Video Card:	1 GB Meg AGP Video Card
DVD Drive:	16 Speed High Density DVD-RW +/- Optical Drive
Operating System:	Microsoft Windows 7 Professional
Keyboard/Mouse:	Standard ASCII Keyboard/ Wireless Intellimouse
Monitor:	22" LCD Type, 1280x1024, noninterlaced

Network Interface	Integrated 1—100-1000 Base T Ethernet NIC
Modem:	56K Modem
Printers	600 dpi Color Laser Printer

A back-up software controls program for the building shall be provided by the controls contractor to the HVAC department. The controls contractor shall provide service or warranty work within 24 hours of notification by NAU, excluding weekends and holidays.

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.

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

Sequence of operations and control diagrams and shop drawings require sign off approval by Facility Services HVAC department.
The system shall be user programmable.

Pneumatic Control Systems
All control panels, consoles, etc., shall have a minimum of 3' clearance to the front.
Gauges shall be installed on all controller inlet and outlet ports.

Control air tubing shall be copper when located in close proximity to any heat source. Plastic tubing shall be laid in troughs or installed in conduit. Unsupported tubing shall not be installed.

When plant air is used, a back-up air compressor must be installed.

All pneumatic systems shall have an air dryer installed on the main air supply and shall be equipped with an in-line outlet oil filter.

Part 3 – Execution
Maintenance training sessions shall be required to be provided on all systems. All sessions shall be scheduled through Facility Services. Sessions shall be videotaped by the University.

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 so as 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 trends on energy management components listed in part 1, meter instantaneous demand and totalized usage, and all space temperature setpoints. The design professional may indicate additional trends in the project specifications.

****END OF SECTION****

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 for the following:

Hot-water heating piping
Chilled-water piping
Dual-temperature heating and cooling water piping
Condenser-water piping
Glycol -water piping
Makeup-water piping
Condensate-drain piping
Blowdown-drain piping
Air-vent piping
Safety-valve-inlet and -outlet piping

Part 2 – Products

Pipe Schedule - Above Ground

Size	Pipe	Fittings	Joint
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 Below Ground			
Up to 2” Seamless hard drawn	Copper Type “K”	Wrought Copper	6% silver solder
2-1/2” Seamless hard drawn	Copper Type “K”	Wrought Copper	15% silver brazed

Mechanical pipe joining systems such as Victaulic or groove lock are not allowed without express written permission of University Project Manager and HVAC Supervisor.

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

Pipe Gasketing - Water Services – Garlock. Spiral wound metallic for high temperature hot water, steam and condensate.

Expansion Tanks
Provide diaphragm-type compression tank with replaceable diaphragm.

Air Vents
Provide automatic float and trap air vents in mechanical rooms only.

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.

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 part ball valve on blow down. Provide hose thread connection on blow down port 3/4" and below.

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 ".

Piping Systems Flushing and Testing
Specify that each system (steam, water, condensate) shall be flushed, checked for leaks, corrosion inhibitors added where applicable, disinfected for domestic water and otherwise made ready for acceptance. Notice of such tests will be given to Facility Services and Coconino County Health Department.
Design Professional shall specify testing on all backflow preventers. Testing shall be performed by a certified tester and results shall be submitted in writing to Facility Services.
Specify that Domestic water supply systems shall be charged with a sterilization solution conforming to Federal Specification 0-8-441, Grade D (chlorine).

Specify that Solution shall remain in system (8) Hours. System shall then be flushed and test results provided to the NAU PM or CM.

Specify that all pressure tests shall be performed using a certified gauge which has been approved for use by the HVAC Manager.

Specify that 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.

Specify that pressure testing procedure is to test the new system at 1.5 times the operating pressure for a period of two hours. A testing procedure needs to be submitted to the HVAC Manager and approved prior to any testing.

23 21 23 Hydronic Pumps

Part 1 – General
This Section includes the following:

Close-coupled, in-line centrifugal pumps
Close-coupled, end-suction centrifugal pumps
Separately coupled, horizontal, in-line centrifugal pumps
Separately coupled, vertical, in-line centrifugal pumps
Separately coupled, base-mounted, end-suction centrifugal pumps
Separately coupled, base-mounted, double-suction centrifugal pumps
Separately coupled, vertical-mounted, double-suction centrifugal pumps
Automatic condensate pump units

Dual system back-up pumps shall be specified in the base bid 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
All HVAC pumps shall be Bell & Gossett.

All pump motors shall be specified for high efficiency and sizing shall be compensated for altitude.

Part 3 – Execution
All heating hot water and domestic hot water circulating pumps shall be designed to have back-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.

All pumps shall be selected for minimum maintenance, such as in-line circulators where appropriate. Specification for all coupled pumps shall require laser alignment after installation, and alignment documentation shall be provided to University.

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, specification shall not allow use of momentary starters.

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

Design and specify housekeeping pads for all base mounted pumps. After completion of alignment and testing grout pumps to pads with non-shrink grout.

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 and Piping

Part 1 – General

This Section includes the following for steam and condensate piping:

Pipe and fittings
Strainers
Flash tanks
Safety valves
Pressure-reducing valves
Steam traps
Thermostatic air vents and vacuum breakers
Steam and condensate meters

Part 2 – Products

Pipe Schedule

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	15% silver
		Seamless, black		brazing
		steel		

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

Pipe Gasketing - Steam services – Spiral wound – “Flexataulic”.

Brass, copper and bronze fittings and/or valves shall not be 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.

Steam and Condensate Valves

Condensate valves to be steam rated ball valves
Steam valves to be steam rated ball valves or high performance butterfly

Pressure Gauges Shall Be:

Rated for steam service

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 Shall Be:
Screwed 250# cast-iron, threaded through 2"
Flanged (150 lb.) 2 1/2" and larger cast iron
Size 100 mesh

Steam Traps preferred manufacturers are:
Armstrong bucket for end of line drip and main lines
TLV float & thermostatic for modulating service
Pressure Regulators Shall Be:
Fisher, Industrial Type 92B
Globe valve in by-pass
Vented to exterior of building through relief valve

Expansion Joints Shall Be:
Externally pressurized bellows type, weld end Hyspan 3500

Condensate Pumps shall be:
Duplex electric pump
Cast-iron housing

Part 3 – Execution
Design to provide isolation valves at all equipment and on all main branch take-offs.

Design to include pressure gages on both sides of all pressure regulators and at all steam using equipment.

Design to provide strainers with isolation valves and piped blow down ahead of steam traps and control valves. Design to provide unions 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.

Steam piping design shall include location and detailing of drip legs sufficient to ensure dry steam supplies, and to prevent water hammer.

Steam system design shall be such that use of steam pressure is not necessary to raise condensate through any heat exchanger, or in any area where steam hammer noise will be objectionable.

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

Design and specify steam piping to use eccentric reducers in to assure level bottom. Design and specify piping systems such that steam and condensate piping pitch downward in direction of flow at 1/2" per 10 ft.

The use of thermostatic or orifice type traps is discouraged.

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 air-conditioning applications. Design and specification are not to allow use of pre-charged line sets.

Part 2 – Products

Pipe Schedule - Above grade

Service	Size	Pipe	Fittings	
Refrigerant 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
Refrigerant Piping	All	Type "K" ACR	Wrought Copper or Cast Brass	15% Silver Solder Brazed

Use long radius fittings only

Part 3 – Execution

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

Refrigeration isolation valves shall be designed and detailed to 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. Design to detail installation of isolation valves between split system components.

Refrigerant piping systems shall be designed, detailed and specified to be installed with:
Piping supports at a minimum of 6 feet
Line size traps at a minimum of every 25 feet of vertical lift
Liquid line filter drier before any expansion valve
Suction line filter drier before compressor
Shraeder valves on suction and liquid line and across filter driers
Specification to require installation by qualified technicians
Piping to be installed per ASHRAE standards

Include explicit requirements that:
Nitrogen purge to be provided during soldering
NAU 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

Section Includes:
Metal Ductwork, Flexible Ductwork, Exhaust Ductwork
Sheet metal materials
Sealants and gaskets
Hangers and supports

The University prefers low pressure, low velocity (2000 FPM max, 2" WG max) air distribution systems. Designs involving higher velocity and/or pressure shall be reviewed and approved in writing by University.

Noise level volumes of air movement and equipment shall be designed and installed as compatible for intended functions within building spaces. The Design Professional will be held responsible for maintaining acceptable sound levels in all systems.

The design documents will call out in the specification and show locations on the drawings for all dampers, fire dampers, extractors and other controls. Duct pressure classes are to be shown on duct layout drawings.

Part 2 – Products

Supply, Return, General Exhaust

Galvanized Steel shall be ASTM A 527, G90 of lock forming quality.

Heating & cooling supply and return, non-chemical exhausts – minimum 24 gauge and as required by SMACNA.

Ductwork downstream of air handling units shall be constructed in accordance with 100% effective duct length as per ASHRAE and latest SMACNA standards.

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 gage
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.

Coated Galvanized Steel
Under special circumstances, with University 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 with University.

Duct Sealants
Specify use of Use 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

Ductwork to be constructed per latest SMACNA HVAC Duct Construction Standards.

90^{o} bends and offsets in ductwork will be kept to an absolute minimum. When they are required, they will be designed with long radius sweeps to avoid turbulence in the duct.

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

Require that Ductwork 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 will be acceptable.

Specify and balancing dampers at all branch ducts and show location on drawings.
Specify use of single thickness turning vanes only in ductwork up to 2” pressure class.
Specify airfoil type vanes for higher pressure class Install per SMACNA.
Specify that turning vanes are not allowed in reducing elbows.

Design to utilize 45° branch duct entries with main duct size reduction downstream for medium and high velocity systems.
Design to utilize 45˚branch duct entries or full conical taps for low pressure ductwork. No Bellmouth, Flanged or Notch Spin-In connections permitted except at terminal/diffuser take-offs.

Specify that no extractors allowed.

Design with 15° convergence and divergence preferred. Absolute maximum of 30° divergence or 45° convergence.

Flexible Ductwork
Specify maximum flexible ductwork lengths - 18" on high pressure systems, 48" on low pressure systems.

Design and specify that high pressure flexible ductwork shall not be used for changes in direction.

Design and specify that 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.

Specify that 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 AIHA Industrial Ventilation manual.

Design all exhaust ductwork within the building to 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 shall 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 33 00 Air Duct Accessories

Part 1 – General
Section Includes:
Backdraft and pressure relief dampers
Barometric relief dampers
Manual volume dampers
Control dampers
Fire dampers
Ceiling dampers
Smoke dampers
Combination fire and smoke dampers
Corridor dampers
Flange connectors
Duct silencers
Turning vanes
Remote damper operators
Duct-mounted access doors
Flexible connectors
Flexible ducts

Part 2 – Products
N/A

Part – Execution
The Design Professional will call out in the specification and show locations on the drawings for all dampers, fire dampers, extractors and other controls.

23 34 00 HVAC Fans

23 34 16 Centrifugal HVAC Fans

Part 1 – General
Section Includes:

Air Handling fans, blowers and accessories
Design and selection of all air handling fans and blowers shall consider air density effects of NAU's 7000 ft elevation.
The University prefers that no centrifugal fan or blower 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 NAU.

Centrifugal fans handling more than 1,000 CFM shall have backward inclined blades unless approved in writing by University.

Variable frequency drives shall not be specified for forward curved fans unless approved in writing by University.

Design and specify 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 design air flow 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 design air flow and pressure without vibration and noise problems, and to enable air balancing without fan or blower over-speed.

Toilets, 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 University through life cycle analysis, heat recovery shall be specified.

Part 2 – Products
Specify that fans shall be tested in accordance with ANSI/ASHRAE STD 51 and ANSI/AMCA STD 210.]

Standard Products – Specify use of same manufacturer for multiple installations for the same type.
Preferred centrifugal fan manufacturers; Greenheck, ILG, Trane.

Specify that fans shall be statically and dynamically balanced at the factory.

Specify that 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.

Specify short coupled, multi-belted fans to utilize companion sheaves in lieu of variable pitched sheaves.

Specify drain connection in bottom of fan housing - minimum size 3/4".

Specify access doors to blower section - minimum size 18" x 18".

Design duct systems such that fan are located indoors. Where fans must be located

outdoors, specify weather-proof package.
Min. height of discharge stack for chemical exhaust fan to be minimum 10' above adjacent accessible roof.

All control dampers shall be Tampco Damers.

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
This section includes:
Single-duct air terminal units
Dual-duct air terminal units
Fan-powered air terminal units
Induction air terminal units
Shutoff, single-duct air terminal units
Diffuser-type air terminal units

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 Campus EMS. Prefer DDC controllers are 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.

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

Part 3 – Execution

Design and specify duct systems such that minimum of 18" clearance access for service and maintenance is available. Show service access clearance requirements in graphic form on drawings.

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

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.

END OF SECTION

Section Number | Title

23 50 00 CENTRAL HEATING EQUIPMENT

23 52 00 Heating Boilers

Part 1 – General

Section Includes:

Stand Alone Gas Fired Boilers

University prefers that all facilities are connected to existing central heating utilities. Design use of standalone boilers only when permitted in writing by University.

Boilers shall be specified for operation at 7000 ft. elevation. This may require modification of standard factory unit. Specify that boiler/burner shall be stamped for design performance at 7000 ft. elevation.

Part 2 – Products

Specify all boilers to be commercial/industrial quality.

Specify that make and model of boiler shall have been continuous commercial service in the continental US 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 Facility Services Gas/HVAC department. Submit proposed manufacturers for written approval before finalizing specifications.

Part 3 – Execution

Design all stand alone boiler installations to allow for 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

This Section includes shell-and-tube exchangers.

Design and specify building heat, domestic heat and preheat exchangers with 100% redundancy. Dual heat exchangers are required for all applications.

Design physical layout of heat exchangers in building mechanical rooms to provide service access. Heat exchangers are to be located no more that 5' above finish floor. Heat exchangers are not to be mounted to ceiling.
Demonstrate adequacy of mechanical room geometry for purpose of heat exchanger service clearance in Design Development drawings.

Specify Isolation valves and unions 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.

Specify all glycol to be Propylene Glycol with inhibitors. NAU 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 make-up water connection. Design, specify and detail a mixing tank and pressurization pump for this application.

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

Size and specify glycol recovery tank with volume sufficient to allow complete system drainback.

<u>Part 2 – Products</u>
Domestic Water Heater Exchangers refer to Section 22 35 00.

Specification of factory assembled heat transfer skids, including heat exchangers, pumps, air separator, piping and controls is acceptable, provided a minimum of 36" outboard of skid is provided and maintenance access to all components is provided. Require complete manufacturer dimensional shop drawings showing all components and service access, including tube bundle pull space to be shown graphically.

Specification of field erected heat transfer systems is acceptable. 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. Require contractor submit complete shop drawings including dimension plan, elevation and isometric for engineer review and approval prior to construction.

<u>Part 3 – Execution</u>
All heat exchangers used for space heating purposes shall have controls that fail to the heating mode.

****END OF SECTION****

23 60 00 CENTRAL COOLING EQUIPMENT

23 62 00 Packaged Compressor and Condensate Units

Part 1 – General

This Section includes air and water cooled condensing units.

Mechanical air conditioning systems shall be utilized ***only*** when specifically authorized by NAU in writing. Life cycle costing shall be utilized to determine the most appropriate type of cooling or mechanical refrigeration as described in 23 00 00 and below

The selection of the type of air conditioning to be used shall be based on a 15-year life cycle cost analysis of all viable alternatives. This analysis shall include all expenses including equipment purchase and anticipated replacement costs, maintenance, refrigerant handling, replacement, and disposal costs, and anticipated costs of energy and water. Where applicable, the efficiency of equipment shall be calculated, and used in the life cycle cost analysis, for all expected load ranges. Electrical rates used in life cycle cost analysis shall be actual demand and consumption costs, not "average" costs.

As a baseline, 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. All central air conditioning systems shall have air-side economizers with enthalpy controls. Wet side economizers shall be evaluated using life cycle cost analysis.

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.

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.

Part 2 – Products

Specify only commercial or institutional grade refrigeration equipment.

Specify equipment to operate with refrigerant 410A unless otherwise approved in writing by University.

Crank case heaters shall be installed on all compressors.

All necessary valves and equipment to permit refrigerant recovery/recycle.

Specify low ambient controls for equipment that operates year around. Specify head pressure or equivalent control. Variable speed for primary condenser fan is preferred.

Provide hail guards on outdoor condensers.

Part 3 – Execution
Provide 3 feet clearance around rooftop units or remote condensing units.

Provide maintenance access to all equipment requiring service.

All outdoor compressor units shall be located under permanent covers. Designer shall consider potential of snow drifting or falling icicles in placement of outdoor unit.

Provide low ambient controls on outdoor condensers.

23 64 00 Packaged Water Chillers

23 64 23 Scroll Water Chillers

Part 1 – General
Section Includes:

Packaged, water and air-cooled, electric-motor-driven, scroll water chillers.

Systems to be designed with scroll water chillers only when connection to central chilled water service is not possible, when full backup plant redundancy is required, and when with written permission of University.

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

Design Scroll chiller equipment rooms within existing codes, EPA regulations and ASHRAE design standards, in particular ASHRAE 15 including the separation of refrigerant and combustion equipment and provision of alarms.

Part 2 – Products
Specify only commercial or industrial grade equipment.

Acceptable manufacturers: 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
Shell and tube design manufactured in accordance with ASME standard, fully insulated and equipped with a drain connection.

Condensers
Copper tube aluminum fin pressure tested to ASHRAE standards. Provide head pressure control.

Electrical
All electric installations shall comply with the latest NEC standard. 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 unloading where applicable. Provide variable speed condenser fan. Provide hail guard on air cooled condenser.

Refrigerant
Specify Use 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.

23 65 00 Cooling Towers

Part 1 – General
Section Includes:

Closed-circuit, forced-draft cooling towers
Closed-circuit, induced-draft cooling towers
Open-circuit, forced-draft cooling towers.
Open-circuit, induced-draft, counterflow cooling towers
Open-circuit, induced-draft, crossflow cooling towers

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.

It is preferred that sumps drain to storage rather than to waste for freeze protection.

Consider noise, drift and proximity to outside air intakes in location of cooling towers.

Part 2 – Products
Marley, Evapco, Baltimore Aircoil

Specify stainless steel cold water basin

Part 3 – Execution
All systems shall be specified to be equipped with chemical feed systems as coordinated by the University's chemical treatment consultant. Tower sump and evaporative cooling sumps shall have TDS controlled blowdown; continuous blowdown is not acceptable.

****END OF SECTION****

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
Section Includes:

Constant-air-volume, single-zone air-handling units
Constant-air-volume, multizone air-handling units
Constant-air-volume, dual-duct air-handling units
Variable-air-volume, single-zone air-handling units
Variable-air-volume, dual-duct air-handling units
Universities Preferred *s*ystem design is based on Single Duct VAV Concept
AHU to be 'draw-thru' type.
Fan Coil Units
Size AHU to meet latest edition of ASHRAE Standard 62.

Consider location of 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 and specify OA intakes to be hard ducted through Mechanical Rooms.

Design to ensure access is provided to both sides of AHU fans to allow 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 to be specified to provide 'minimum' of one fan impeller diameter upstream of fan.

Provide vibration safety switches on all Vane Axial type fans.

When Vane Axial 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 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. Energy Labs, Hunt Air or equivalent. Fan Coil Units to be Carrier, Trane, or McQuay or equivalent.

Minimum Air Handler specification shall include the following:

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 AHU to have inspection windows in access doors.

AHU shall have interior inspection lights.

Side access doors for slide in/slide out filter tanks.

Removable side panels in fan sections to allow for fan and shaft removal/replacement.

Utilize only 'premium efficiency' motors in AHU's.

Part 3 – Execution
Design and specify that all air handling units with outside air shall be equipped with freeze stats with manual reset, outside air dampers and low-limit controls. All heating water valves shall fail to heating position. All outside air dampers shall fail closed.

Specify that all heating coils that may be exposed to outside air shall be protected by a low 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-gasing of interior furnishings prior to occupancy. Fit AHU with temporary 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

Mechanical air conditioning systems shall be utilized ***only*** when specifically authorized by NAU in writing. Life cycle costing 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 Freon 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

Part 1 – General

This Section includes the following types of air coils that are not an integral part of air-handling units:

Hot-water
Chilled-water
Steam
Refrigerant

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 be closed and a hot water valve shall be opened.

Part 2 – Products
N/A

Part 3 – Execution
Provide 3 feet clearance around rooftop units or remote condensing units.
Provide maintenance access to all equipment requiring service.

23 83 00 Radiant Heating Units

23 83 13 Radiant-Heating Electrical Cables

Part 1 – General
Provide electric-resistance snowmelt cabling at rooflines. Coordinate requirements with NAU Roofing Shop and NAU Electric Shop prior to design.

Ground fault equipment protection for circuits is required.

Provide automatic controller.

Provide receptacle connection for each snowmelt cable.

Sidewalk electric snowmelt shall not be used; this application requires hydronic snowmelting.

Part 2 – Products
N/A

Part 3 – Execution
N/A

****END OF SECTION****