DIVISION 23 – HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

See Division 20 – General Mechanical for common standards related to HVAC.

23 00 00 - HVAC
A. All steam and chilled water utility equipment and accessories must be reviewed and approved by the District Energy Manager.

23 05 48 – VIBRATION CONTROL
A. See 23 34 00 – HVAC Fans for fan construction standards.
B. Fan Vibration Specification:
   1. Fans with greater than 5,000 cfm flow, greater than 1,500 wheel rpm, wheels 12 inches and larger, or that have been identified as serving a “critical” application by the University Representative are subject to a vibration analysis through consultation and coordination with Facilities Management's Vibration Consultant. For fan wall arrays, total cfm for the entire array is used for determining if the array qualifies for vibration analysis, not individual fan flow. The following procedures and specifications shall be adhered to. Additional design requirements, which must be followed, are listed in the next subsection on Fans. A waiver excluding any qualifying fan or fan system from this process may only be granted by the University Representative, in writing, during the design phase of the project.
   2. Fans that do not qualify in the above paragraph are not subject to a vibration analysis, however, these fans must still meet the applicable, installed vibration criteria listed below. The contractor is responsible for reducing vibration that exceeds this standard.
   3. The Owner will, at their expense, employ a Vibration Consultant to perform “design resonant speed calculations” based upon the factory assembly drawings. The results of the analysis may require structural changes to the fan support system. The Manufacturer shall make these changes without cost to the Owner, or choose to assemble the fan and perform both a factory and an “as-installed” vibration test to demonstrate compliance with the vibration limits referenced below. Compliance with the vibration limits is the responsibility of the fan manufacturer.

The Vibration Consultant shall be provided by the A/E with a set of drawings (full or partial depending upon size and complexity of project) at the Design Development (DD) phase. These drawings shall identify the proposed fan manufacturer, maximum, minimum, and average air flows in cfm, an anticipated maximum, minimum, and average fan speed, the fan location and the method of fan and/or air handling unit attachment to the building structure. As described in the following subsection on fans, vibration isolators of any kind are not allowed without written permission from the University Representative.

Driving fan motors beyond nameplate rpm with a VFD is not permitted (max VFD output frequency = 60 Hz).

Loading fan motors beyond nameplate horsepower is not permitted.

The design resonant speed of the fan system shall be a minimum of 25% above the fan maximum operating speed considering both wheel mass and inertia. The design resonant speed is that speed which corresponds to the natural frequency of the system consisting of the rotating components, bearing lubrication and housing, and supporting pedestal. The
supporting floor, foundation, etc., may be considered to be infinitely rigid to provide an analysis boundary condition. The design resonant speed shall be provided by the Vibration Consultant, and shall be calculated based on submitted factory fan assembly drawings and building structural drawings.

The anticipated maximum fan speed shall be 120% of the fan speed required to provide design air flows in order to provide extra capacity for future changes. These two speeds shall be identified in the DD set.

4. The fan assembly manufacturer shall provide a fan according to the following specifications and provide submittals as noted:
   a. Rotor shafts shall be solid steel. Hollow shafts are not permitted.
   b. The Vibration Consultant shall be provided with fan assembly or fabrication drawings from the factory following the Submittal phase. Assembly or fabrication drawings are not the same as cut sheets or submittal drawings, and must be to scale, include dimensions, and show material, dimensions, and fastening methods for all structural members for the fan and air handler (e.g. floor joists).
   c. Fan assembly details including dimensions and thickness of steel frames and bases, rotor shaft dimensions, wheel weight, bearing types and center-to-center distance shall be provided. The Manufacturer shall not withhold this information for proprietary or any other reasons.
   d. The fan assembly shall not be released for construction until the assembly drawings have been approved by the Vibration Consultant.

5. The following CSU vibration criteria apply to in-situ acceptance tests at any speed within the operating range. In this case it is important to ensure that all the major components of the machine and structure are installed when testing is carried out. The operating range is defined as 120 rpm through the rated speed of the installed motor. In order to comply with this standard, field vibration measurements, as performed/verified by CSU’s Vibration Consultant, must fall within the acceptance criteria.

Vibration measurements performed on site by the CSU Vibration Consultant must be made in accordance with ISO 10816-1, section 3.2 Measuring positions. Per ISO 10816-1, two radial readings orthogonal to each other must be collected at each bearing and a minimum of one axial reading per shaft must be collected.

   a. Vibration acceptance criteria for fans of all types with standard electric motors with a power of less than 300 kW (400 hp) are defined by ISO 14694 (international fan standard).
   b. The Manufacturer is responsible for balancing the fan-impeller assembly to a minimum balance quality grade of G 6.3. For a detailed explanation of balance quality, refer to ISO 1940-1.
      i. The fan manufacturer may include other rotating components (shaft, coupling, sheave/pulley, etc.) in the rotating assembly being balanced.
      ii. In addition, balance of individual components may be required. See ISO 4863 and ISO 254 for balance requirements for couplings and pulleys.
      iii. Whenever possible, the fan impeller should be mounted on the shaft that will be used in operation. If a mandrel is used, care should be taken to avoid eccentricity due to a loose hub-to-mandrel fit.
      iv. Calculation of residual unbalance shall comply with 6.2.3 of ISO 1940-1.
   c. Vibration limits used shall be for a rigidly mounted system for the balance quality grade cited above, as published in ISO 14694.
d. If written permission has been given for the use of isolators, then the vibration limits shall be for a flexibly mounted system for the balance quality grade cited above, as published in ISO 14694.

Fan or motor vibration that exceed the levels, as described above, during operation in the start-up or warranty period shall be reduced by the contractor, in coordination with the manufacturer to preserve the warranty. The Contractor can choose to dynamically balance the fan in place using a recognized specialist, replace bearings, or make structural modification to reduce the vibrations.

6. Documentation
   a. In-situ Vibration
      i. Written certification of the vibration level achieved for an individual fan shall be provided. In such cases, the following information must be included in the vibration certification report:
         1. Instrument used;
         2. Attachment of transducer;
         3. Fan operating speed;
         4. Flexible or rigid mount;
         5. Description of measurements:
            a. Position and axis,
            b. Units of measure used and reference levels,
            c. Frequency, bandwidth, filter-in or filter out.
         6. Allowable vibration level(s);
         7. Measured vibration level(s);
         8. Acceptance criteria: pass/fail;

   b. Balance
      i. Written certification of the balance achieved for an individual rotor shall be provided by the Manufacturer. This balance-certification report shall be submitted before the unit(s) are shipped. The balance-certification report must include:
         1. Balance machine manufacturer and model number;
         2. Overhung or between centres;
         3. Balance method, single plane, two-plane;
         4. Mass of rotating assembly
         5. Rotating components (shaft, coupling, sheave/pulley, etc.) included the rotating assembly that was balanced
         6. Residual unbalance in each correction plane;
         7. Allowable residual unbalance in each correction plane;

23 05 93 – TESTING, ADJUSTING AND BALANCING

A. Standards:
   2. TAB results shall be certified by a professional engineer registered in the State of Colorado.

B. Submittals:
   1. Procedure Submittal - Prior to commencing work, submit to Engineer and University
Representative a written procedure of how balance will be performed and a description of equipment and instruments to be used. Facilities Management-Environment Shop shall review procedure. The submittal shall include the following.

a. List of preliminary checks to be performed at the job site such as confirmation that manual volume dampers are present, filters are installed, frequency drive units operational, location of control sensors, etc.

b. Identify how air outlets will be measured and type of instruments to be used.

c. Locations of pitot traverses and type of instruments to be used.

d. Modes of operation that the system will be placed in during balancing and testing, i.e., full cooling and heating, maximum and minimum outside air flows, maximum and minimum sash positions for fume hoods, toilet fans on or off, etc.

e. Position of doors and windows during balance, i.e. labs should be balanced with doors shut.

f. Operating static pressures for terminal devices and pressure sensors for controlled devices.

g. Method of adjusting outside and return air quantities at air handling units.

h. Initial test procedures for preliminary balance.

i. Final test procedures.

j. List of deficiencies in mechanical system that will hinder the balance work such as missing or leaky dampers, incomplete systems, inadequate fans, etc.

k. Sample of data sheets and test forms to be used in final report.

l. Identification of equipment to be used on project and proof of last calibration on each piece.

1. Progress Reports - Report in writing to Engineer and Project Manager all deficiencies or problems with air or water systems that affect balance work. Include items that affect system performance such as broken thermostats, damaged ductwork, excessive noise, etc.

2. Final Report - Submit final report as described below.

3. Full scale drawings - Submit one set of drawings with all labeling and identification.

C. General Requirements for Air Systems:

1. TAB contractor shall not be responsible for calibrating HVAC equipment. Controls contractor shall calibrate, test and verify operation of work before balance work begins.

2. TAB contractor shall not begin work until all systems are operational and General Contractor has provided notice of such to Project Manager.

3. Acceptable tolerances for typical outlet terminals are +5 to -5 percent.

4. Spaces with pressure gradients or directional airflow requirements shall be adjusted to meet specifications rather than designated air flows. Verification of performance shall be made with pressure gradient measurements, smoke tests in presence of Owner's representative, or hot wire anemometer across door cracks etc. Pressure differential measurements are preferred unless gradient is too small (under 0.01 inches w.c.) by specification.
5. Filters shall be loaded or restricted to increase pressure drop to 50 percent of span between initial pressure drop and final recommended pressure drop for setting final airflows for fans.

6. Airflow rates shall be balanced at room outlets. Totals of airflow rates from outlets shall be compared to pitot traverses. Identify in writing discrepancies between the two.

7. Pitot traverses shall be performed for fan total air flows. Pitot traverses for hot and cold decks, for large zones in multi-zone systems and for each floor in large systems shall also be specified. Locations of pitot traverses shall be marked on reduced drawings in final report.

8. Balancing devices shall be permanently marked with spray paint indicating final position. Grease markers are not permitted.

9. Fixed pitch sheaves shall be installed for final speed settings on all fans regardless of size. Sheaves and belts shall be compatible. Report discrepancies in writing.

10. Outside air quantities shall be set and mixed air dampers or economizer controls shall be adjusted and operation observed and reported for minimum and maximum airflows.

D. Requirements for Constant Volume Systems:

1. Constant volume reheat systems shall be balanced in full airflow mode only.

2. Constant volume dual duct systems shall be balanced at the boxes for full cooling and full heating airflows. The fan shall be balanced with all the boxes on full cooling. The total fan supply shall be recorded with the boxes on full heating.

E. Requirements for Variable Air Volume Systems:

1. VAV boxes shall be balanced for full cooling, full heating, and minimum airflows.

2. VAV fans shall be balanced by placing a certain number of the VAV boxes in full cooling mode. This number shall be equal to the system diversity and shall include boxes that are at the end of the system, that are on duct branches with high static loss and serve critical areas. With the system in this mode the fan shall be at 60 Hz and be sheaved to maintain the static pressure required to control the worst case VAV box.

F. Fume Hood Balancing:

1. Fume hood exhaust fans shall be balanced to meet face velocity requirements. Face velocity is determined by Environmental Health Services through the Project Manager. See Division 11 – Equipment for information about fume hood face velocity standards.

2. Hoods shall be balanced with the building supply and exhaust systems in normal operation, with doors and windows in typical position and hoods empty and clean. These conditions shall be recorded in report.

3. Vertical sash hoods shall be set at prescribed opening of 18 inches. The fan shall be adjusted to provide the required face velocity measured every foot across sash opening equally spaced at sash plane using a multi-point anemometer. The average of the three measurements shall be corrected for temperature and altitude and recorded. A sticker furnished by Facilities Management through the Project Manager shall be placed at the 12-inch sash height.

4. Horizontal sash hoods shall be set with a 12-inch space centered in front of the hood. If an odd number of sashes exist, the opening shall be the most distant from the exhaust point inside the
hood. The fan shall be adjusted to provide the required face velocity measured at three centerline measurements equally spaced at sash plane using a multi-point anemometer. The average of the three measurements shall be corrected for temperature and altitude and recorded. The sash shall be moved to find the position where 75 fpm face velocity is achieved. This position shall be marked with a second sticker furnished by Facilities Management through the Project Manager.

5. Other specialty hoods require different balancing conditions which shall be provided by Environmental Health Services through the Project Manager.

G. Requirements of Work for Hydronic Systems:

1. All hydronic systems shall include throttling and measuring stations.

2. Flow rates in primary loops shall be measured and recorded for both full flow and bypass conditions to terminal equipment.

3. Balancing devices shall be permanently marked and positions recorded indicating final position.

H. Final Report:

1. Report shall include the following information.
   a. A general discussion preface summarizing all abnormalities or problems encountered during the project and what course of action was taken. The preface should be assembled from the written progress reports described earlier, and include responses from Engineer or Project Manager or Contractor regarding each problem.
   b. Copies of correspondence if related to the performance and balance of the systems.
   c. Status of doors, windows and other static conditions during balance work.
   d. Reduced, but readable, as-built drawings.

2. The Contractor shall submit six (6) bound copies and a digital copies (PDF) of the final testing and balancing report at least fifteen (15) days prior to Substantial Completion, unless otherwise stated in Division 1. Digital copies are to include scans of all drawings as well as data and supplementary information stated elsewhere in this section. Digital copies shall be submitted on CD.

I. Review of Report and Retainage:

1. Reports will be reviewed during the commissioning phase by Facilities Management-Environment Shop through the Project Manager as well as the Engineer. Prior to delivery of final reports and payment of retainage all corrections and punch list items must be resolved. Retainage of general contractor payment shall also be withheld until approval of balance work. Final as-built drawings and balance reports must be in the possession of the Facilities Management Project Manager prior to Final Acceptance.

J. Guarantee of Work:

1. TAB contractor shall guarantee the balancing for a period of 90 days from date of acceptance of report without exception by the Engineer and CSU Facilities Management – Environmental Shop. During this period, the TAB contractor shall make personnel available at no cost to the Owner to verify measurements and/or correct deficiencies in the balance.
23 09 00 – INSTRUMENTATION AND CONTROL

A. Building Automation Systems Acceptable Manufacturers:
   1. Allerton
   2. Johnson Controls

B. General Guidelines for Building Automation Systems:
   1. Facilities Management Controls Shop uses a campus-wide Building Automation System (BAS) for control, alarming and energy management purposes. All new construction shall utilize this technology.
   2. All control systems shall be of one manufacturer for each building, both in new construction and in remodel projects. Mixing different manufacturers of control systems and their components is not permitted.
   3. Wireless communication of any kind is not allowed.
   4. Control systems shall be DDC. DDC systems shall be tied into the Campus control network.
      a. DDC systems shall be able to integrate with an OPC User Interface. Iconics is the software platform that CSU has installed and is using for this purpose. All DDC applications and/or systems must be able to integrate with the Iconics platform.
      b. CSU uses BACnet/IP or Modbus/IP as primary OPC communication protocols. For BACnet systems, CSU uses the SCADA Engine Application Process Interface (API) that is built by Chris Gurtler. Modbus configuration and API are contained within the Iconics software solution.

CSU BACnet systems shall be compliant with ANSI/ASHRAE Standard 135-2008, including all addendums.

All BACnet device instance numbers shall be supplied by CSU Controls Shop.

Modbus registry tables shall be built by the contractor using the Iconics Modbus Configurator.

5. All new equipment shall be fully capable of “stand-alone” operations in the event of loss of communication with the Campus control network.

6. All new self-contained systems such as lighting control, specialized equipment automation, etc., shall be OPC-compliant DDC systems. Use of controlling devices other than OPC-compliant equipment will be allowed only with the written consent of the CSU Facilities Controls Shop Supervisor through the University Representative, prior to construction.

7. Controllers that are capable of BACnet/IP communications do not need an intermediate supervisory device to connect to the SCADA Engine API (i.e. Phoenix servers).

8. All supervisory controllers shall be connected to “smart” Uninterruptible Power Source (UPS), capable of Ethernet TCP/IP protocols with SNMP capabilities.

9. All supervisory/global devices shall be located in a telecommunication room or an area that has adequate HVAC and has been approved by the CSU Controls Shop.
10. Fire alarm and fire suppression systems shall not be controlled or monitored by the BAS. Independent systems shall be used for fire alarm systems. See Division 28 – Electronic Safety and Security Systems.

11. All packaged equipment shall be able to communicate with the BAS System using BACnet protocol. Units shall be able to function independently during a loss of communication with the BAS Network.

12. Control drawings developed by the Engineer are required during the design phases prior to issuing projects for bidding. The vendor shall become established at or before the release of the SD phase documents to allow the specified Contractor adequate time to evaluate the project and provide design support. The Engineer shall consult the Controls Company for assistance in designing the system. The resulting diagrams and controls sequence shall be submitted to Facilities Management Controls Shop no later than the 75% Construction Document progress milestone.

13. Revised control flow charts and control drawings for the control system must be accepted without exception by Facilities Management Controls Shop through the University Representative before final construction documents are issued. FM Environment Shop is responsible for timely review and comment.

14. Control contractor drawings shall contain detailed sequence of operations as programmed in the controller, not a "copy and paste" of the engineers' original sequence.

15. Once control contractors have finished programming for all major systems they shall be required to review their programming code with FM Environment Shop for acceptance before downloading and commissioning.

16. All controlled equipment shall be defined and mapped into the control system to comply with the existing hierarchy.

17. Controlled points shall be defined in a sub hierarchy that will allow a sequential load shedding opportunity. Equipment shall be designated by the engineer and defined by the equipment’s level of importance in the overall building operations for three annular cycles: Summer operations, winter operations, Transitional operations and daily cycles: Occupied and unoccupied, coincident demand control. The resulting data should be sufficient enough to facilitate a 10%, 20% or 30% load shedding opportunity in the six possible combinations.

C. Control Panels:

1. All panels in extreme heat (over 85 def. F.) or extreme cold (below 40 deg. F.) must have adequate external temperature control for protection. In these conditions, the BAS will provide a temperature sensor to monitor and alarm enclosure temperatures in case of HVAC failure.

2. There shall not be any wire-nuts as a means of connections in the control panels. All connections in panels must be on a terminal block and no more than two wires per terminal connection.

3. All BAS control panels shall not have any voltage exposed more than 50V according to NFPA 70e Handbook Article 130.2A(3).

D. Variable Frequency Drives: see Division 26 - Electrical.

E. VAV Box Controllers:

1. Controllers shall be BACnet/MSTP and networked to the CSU Interface using BACnet/IP protocol.
F. Control Valves:
   1. Control valves shall be installed in a position consistent with manufacturer’s recommendation. There shall be adequate spacing so that the installation is in a manner that is easily accessible to maintain and/or replace and shall have unions on both sides.
   2. All modulating control valves shall have a 0-10 VDC control signal unless otherwise approved by FM Environment Shop.

G. Thermostats:
   1. Retrofit projects providing pneumatic thermostats shall use equipment comparable to JCI T4002. All DDC thermostats must be networked and visible from the BAS.
   2. Generally electronic thermostats with an adjustable occupant controlled set point are recommended in nonpublic areas. The range of adjustment shall be a programmable point in the BAS. Thermostats located in public areas shall have concealed components and set points with locking covers.
   3. Room thermostats shall have a number of the box it controls labeled inside of cover, corresponding to box schedule number on drawing. Thermostats tied into the BAS shall be labeled with the appropriate BAS information and address.
   4. Room thermostats must be arranged to control heating units in such a way that the controlled zone is not too large. Large areas should be divided into several zones with separate thermostats. Attention should be given to common influences that may be present when creating zoning, i.e. proposed room usage and size, exterior face and number of exposures (including floor elevation), etc.

H. Sensors and Controllers:
   1. HVAC units shall have low temperature sensor. Located adjacent to the most vulnerable coil and mounted in such a way to gain full representation of the coil. Sensor shall stop fan(s), close outside air damper(s) and activate a building alarm in the BAS at set point.
   2. Controllers for heating and/or cooling should include outside air-reset control. This can be provided by controller or programmed in BAS.
   3. The combination of equipment and control sequence shall allow automatic and override control and alarming of the building mechanical system for energy conservation purposes. At a minimum the BAS shall include provisions for energy management (economizer function), building static control, building temperature control, and IAQ control. The resulting sequence should reflect the input of Facilities Controls group, the controls contractor and engineer.
   4. Standard Parts List
      - Panel Pilot Lights IDEC A Series
      - Controls Terminal Blocks DINnectors Single Level (All connections must be labeled)
        DN-T100RG-A for +24V
        DN-T10BR-A for -24V
        DN-T10B-A for Communication connections
DN-T10-A for all other connections
- Control Transformers
  Panels
  Functional Devices PSH Series
  Multiple Circuits
  Functional Devices PSH300A
  Functional Devices PSH500A
- Voltage Surge Suppressor
  Kele HSP-121BT1RU
- Air Static Pressure Safety Switches
  Cleveland Controls AFS-460-DSS
- Water Differential Pressure Sensors
  Setra M230 Series with Bypass Valve Assembly BVA-5
- Air Differential Pressure Sensors
  Veris PXULX05S
- Water Pressure Transmitter
  Kele P51 Series with option E-G and 47b-1 Snubber
- Panel Relays
  IDEC RH Series with Indicator Light (minimum of DPDT)
- Remote Mount Relays
  Functional Devices RIB Pilot Series
- Motor status
  Senva C2320L
  If application has a VFD use Torque settings for status only
- Air Flow Monitoring Stations
  Ebtron Gold Series
- District Chilled Water DP Control Valve
  Flow Control Industry EDP Series
- Building Static Pressure Reference
  S.O.A.P.

I. Verification of Flow:

1. Pressure differential switches should be used across pumps and fans to prove flow. Paddle type flow switches are not permitted. In cases of low-pressure differential, verification of power to pump or fan through auxiliary contacts is still preferred over paddle flow switches.

J. Sequence of Operation:

1. Energy conservation must be given prime equal consideration when designing operation sequences, controls and equipment. However, complicated control schemes requiring excessive controls and equipment should be carefully evaluated. Simple payback on incremental costs of 5 years or less should be used as a guideline.

2. Direct digital controls shall be used for all new installations and remodels.

3. Allow for after hours shutdown or setback of fans, dampers, and temperatures for economical operation. This shall be accomplished through the BAS.

K. Fume Hood Face Velocity and Exhaust System Control:

1. Control of face velocity is desirable if proven to be economical. Variable volume exhaust systems or multiple position exhaust systems should be evaluated for each project.

2. Hood exhaust system control shall be integrated with supply side system control to maintain proper lab pressurization.
3. Pressure type control is not acceptable.

L. Controls commissioning:

1. All Building Automation controls and supporting equipment are subject to Test and Verification. All control sequence and as-built documentation shall be submitted to Facilities Management - Environment Control through the University Representative at least 10 working days prior to the test and verification date.

M. Controls Graphics

1. Construction projects are to adhere to the following specifications to create uniformity with existing CSU graphics packages.

2. Data Field Points: The data fields in the graphics shall adhere to the CSU standard color scheme for piping and status of the data field.

3. Symbol Design: All graphic symbols that are bound to the BASobject must be designed with aliases in the data source field. The tag must contain separate aliases in the network name, system and object at a minimum. (i.e. <<NET>>, <<SYS>>, <<OBJ>>).

4. New Buildings: When Graphics for a new building is added to the system, a building graphic shall be generated showing links to the system and floor plans in that building. A link to the building shall be shown on the campus map. Each system graphic and building graphic shall be bound to the network using the component binder.

5. Client/Server Setup: All Graphics added to the system shall be loaded on the archive (server) PC. The graphics shall be viewable from the client workstations without loading any graphics or data files on the client PC.

6. Component Binder Database: Entries into the component binder database (m-bind.mdb) shall be done using the component binder on-site or a 3rd party program that merges the new graphic entries without overwriting existing records in the database.

7. Mapped Points: All direct mapped BASobjects shall be incorporated in the graphic for a system.

8. Equipment Locator: The Graphics shall incorporate a equipment locator feature that is accessible from every graphic. Upon selection of this feature, a popup window shall be displayed showing all HVAC systems and panels. These entries shall be stored in a single database that is accessible across the network. The equipment items can be grouped and categorized to allow searching by building and type of equipment. When the equipment item is selected to be located, the appropriate building floor plan will be displayed with intended equipment selection flashing.

9. Operator Notes: The graphics shall be incorporated with an operator notes feature that is accessible from every graphic. Upon selection of this feature, a popup window shall be displayed showing all operator notes for the current graphic system dynamics. The operator shall be able to enter a text description of a note, date/time of the entry, Operator name and a note priority. These graphics shall be stored in a single database that is accessible across the network. The popup window shall show notes for the current system and all historical information including all critical notes, all warnings notes and all general notes that were entered in the previous twenty four hours. The graphics shall provide a visual dynamic indicator that will show the priority and the number of notes that are active for the system graphic.

10. As Built Drawings: The Graphics shall incorporate a button that allows the current graphic system
as built drawings to be displayed in Adobe Acrobat (PDF) format. The system PDF file shall contain the flow diagram, panel layout, panel wiring, sequence of operation, and point list for that system.

N. Controls Alarms

1. In regards to HVAC alarming, the controls contractor is responsible to provide a binary value with a normal state being a value of "0" and an alarm state being a value of "1". A list of these points shall be delivered in an Excel spreadsheet to Facilities Management Controls Shop. All alarm points shall be built within the Iconics Alarmworx software. Unless there is a prior, written approval to the contractor from the CSU Facilities Management Controls Shop, these alarms shall be built by the CSU Controls Shop staff at the project/contractor expense.

O. Controls Trends

1. The commissioning agent/controls contractor is responsible to provide a list of desired long term trend points and shall be delivered in an Excel spreadsheet to Facilities Management Controls Shop. All trended points shall be built within the Iconics Trendworx software. Unless there is a prior, written approval to the contractor from the CSU Facilities Management Controls Shop, these alarms shall be built by the CSU Controls Shop staff at the project/contractor expense.

P. Electronic O&M Manual

1. All as-built drawings, schedules, operation & maintenance data, product sheets, and technical documentation shall be converted to Adobe Acrobat PDF format. A bookmark menu shall be incorporated into the main title page of the electronic O&M manual allowing navigation to each section of the manual. A summary of the vendor and JCI parts shall be shown along with links to each manufacturer’s cut sheet for that part. Each system in the title page shall be linked to the appropriate system in the data. All O&M PDF documents shall be cataloged and indexed using Acrobat Catalog to allow all documents to be searched.

2. The PDF files shall be organized on a CD-ROM and have an installation program that allows the user to either run the O&M manual from the CD-ROM or install the O&M PDF files on the computer.

Q. Integration of Electronic O&M Manuals with the Graphics:

1. The user shall be able to “click on a button” on each system graphic and the as-built controls drawings for that system shall be displayed with Adobe Acrobat Reader. The drawings that are used shall come from the electronic O&M as previously specified.

23 10 00 – FACILITY FUEL SYSTEMS

A. Gas Piping

1. Most buildings are served through a University-owned master metered distribution system. Main gas pressure is 5 psig.

2. See Section 02680 - Fuel and Steam Distribution for metering and buried pipe requirements.

3. Provide shut-off cocks on all branch lines, and lab benches, and make cocks easily accessible for service and operation. Provide drip legs at all equipment connections.
4. All fixtures and outlets shall have isolation valves.

5. Schedule 40 black iron pipe will be used for distribution within the building. Piping shall be threaded for sizes 2 inches and smaller and welded for 2-1/2 inch and larger. Pipe shall be painted according to specifications (see Division 9.)

6. Flex connector lines to equipment and fixtures shall be stainless steel with epoxy coating on both sides, UL stamped. Other types are prohibited.

7. Threaded pipe shall be sealed with pipe dope or teflon tape. Pipe dope shall be teflon based. Oil based dope is not permitted.

8. All underground utility piping shall also conform to the requirements Nonmetallic Utility Lines in Division 33.

23 21 00 - HYDRONIC PIPING AND PUMPS

A. Balancing and Measuring Stations:

1. The balancer shall provide certified (non-invasive) ultrasonic measuring equipment to perform all balancing functions

B. Piping Arrangements:

1. See Drawing Appendix for coil piping arrangements.

2. Integral balancing and measuring stations such as circuit setters are acceptable for pipes up to 2 inches in diameter. Venturi flow stations are not allowed. Balancing cocks and/or setters are allowed on larger piping.

3. See Division 20 – General Mechanical for balance and flow valve information.

4. Pressure and temperature (P&T) plugs shall be installed across pumps, coils, and heat exchangers.

5. If pressure independent control valves are installed, balance devices are prohibited.

23 22 00 - STEAM AND CONDENSATE PIPING AND PUMPS

A. General Information:

1. Pipe penetrations at building walls, valve pits, etc., shall be sealed with link-seal type mechanical seal with sleeve in concrete to assure watertight penetrations. See Appendix A - Detail M-24.

2. All flanged connection on steam and condensate line shall use spiral wound gaskets with 150 psi rating.

B. Steam Piping:

1. Expansion loops are preferred over mechanical expansion devices. Where expansion loops are not practical, provide bellow type expansion devices, not mechanical seal types.

2. All branch line or equipment taps in buildings and the distribution system shall be made at the
top of the steam line or 45 degrees from vertical. If the above taps are not possible, then side taps shall be made. Taps made on the bottom of the lines are not acceptable.

3. Drip legs shall be provided upstream of bends, risers, isolation valves or expansion joints. In straight runs of pipe containing none of the above, drip legs shall be provided at intervals not to exceed 300 feet. See Drawing Appendix for Steam Drip Detail.

4. Drip leg length, as measured from the bottom of the steam line to the centerline of the trap leg tap, shall be 1.5 times the nominal diameter of the steam line or 12", which ever is greater. The length of the drip leg below the trap leg tap shall be at least 6". See Drawing Appendix.

5. Drip leg diameter shall be the same diameter as the steam line for pipe sizes up to and including 4". Drip leg diameter shall be 4" up to pipe sizes of 8" and shall be ½ the pipe diameter for sizes greater than 8".

6. Branch lines of 10’ in length or less shall be sloped back to the main line. Branch lines of greater than 10’ shall be sloped to the building.

C. Condensate Piping:

1. All condensate piping shall be schedule 80 carbon steel or schedule 40 stainless steel Type 304.

D. Sole Source Products:

1. Steam to Hot Water Heat Exchangers for Hydronic Heating – see Sole Source Appendix

E. Acceptable Products:

1. Steam Traps – Armstrong Series 2011 only for bucket traps; Armstrong or approved equal for F&T traps. Hoffman ITT or approved equal for thermostatic bellows.

2. Steam Radiator Temperature Control Valves – Macon or approved equal.


4. Condensate Return Systems – Spirax Sarco PTC Pivotrol, Spiraz Sarco PPEC, or approved equal.

5. Steam Relief Valves - Consolidated or Kunkle Valve Co., Inc.

F. Steam Supply:

1. Steam is distributed from the Central Heating Plant in utility tunnels and direct buried lines. Steam piping will be designed to 150 psi. Nominal distribution pressure is 40 psig but under extreme operating conditions may drop to 30 psig. Check with Facilities Management-Environment Shop through the University Representative for each application.

2. At this time steam is available 24 hours per day, 7 days per week. Future plans may involve shut down of the steam system during summer months. Where practical, new installations should make provisions for alternate sources of heat or steam. Discuss with Facilities Management-Environment Shop through the University Representative.

3. Gaskets at flanges, valves, etc. shall be spiral-wound type.
G. Pressure Reducing Stations:

1. Pressure regulators shall reduce steam from 40 psig to necessary process pressure. See Drawing Appendix. Detail M-1D is for a process load such as an instantaneous domestic hot water heater and steam powered condensate return systems.

2. The piping arrangement shall include a gate valve on each side of the regulator valve and a strainer with blow down valve ahead of each regulator. A bypass around the regulator with a globe valve in the center shall be provided. Inlet and outlet pressure gauges shall be installed with isolation gauge cocks and pigtails, and where they are clearly visible from the operating level of the reducing station. PRV sensing line tap shall be located at least 10 pipe diameters downstream of the PRV.

3. Control of process pressure reducing stations shall be with electric actuation or pilot operated regulator and shall fail closed to protect the building system and occupants in case of failure.

4. An ASME rated safety relief valve with blow-back feature on the low pressure side is required. Vent safety relief valve with full sized piping through roof and provide drip pan elbow. Relief valve shall be located upstream of any branch lines on the low pressure side or of any isolation valves that will isolate it from the PRV station (not including valves at the PRV outlet).

5. Steam for building heat shall not be reduced in pressure. Heat exchanger equipment shall be designed for 40 psig operation but rated for 150 psig. Process steam may be reduced in pressure as necessary.

H. Condensate Return Systems:

1. Steam condensate is returned to the Central Heating Plant through piping in utility tunnels or direct buried lines. Condensate in each building should be returned to a central receiver by gravity and then pumped to the main return line. Main condensate piping is gravity return.

2. Condensate return systems shall be Liqui-Mover by The Johnson Corporation for primary building condensate systems larger than 2,500 lbs. per hour. Systems smaller than 2,500 lbs. per hour shall use either Johnson Corporation Liqui-Mover or Armstrong Pumping Trap. A minimum clearance of 4’ shall be provided above the liquid mover or pump trap to facilitate probe or float assembly removal.

3. These systems shall use steam as the prime mover to return condensate from buildings to the main return line. Probe liquid level controllers are required for primary building condensate systems and float type controllers are permitted only for smaller systems as described above. See Drawing Appendix - Detail M-1E.

4. Condensate receivers with mechanical pumps are not permitted without approval by Facilities Management-Environment Shop through the University Representative. If a receiver/pump system is used, they shall be of the centrifugal duplex type with cast iron receiver. Switching for alternate service shall be accomplished by a float operated mechanical alternator. Receiver capacity shall be sized for 25 percent future capacity. Flash tanks shall be installed ahead of receivers.

5. The required condensate pump discharge pressure will be 30-psig minimum. Higher discharge pressures may at times be required. Check with Facilities Management-Environment Shop through the University Representative.

6. Methods and locations of condensate return shall be specified on drawings and/or specifications.
I. Steam Traps:

1. Steam trap type shall be selected to match type of service. Inverted bucket traps are generally required where steam pressure is constant as in steam mains. Float and thermostatic traps are generally required where steam pressure is not constant, but varies during operation as in heat exchangers and coils. Thermostatic traps are generally required for fin tube radiation and radiators.

2. Avoid lifting condensate higher than necessary to ensure good condensate return. Contact Facilities Management-Maintenance Engineer through the University Representative for assistance.

3. Specific methods and locations of trapping shall be specified on drawings and in specifications. See Drawing Appendix for Steam Traps.

J. Steam Equipment

1. Steam fintube radiation shall have piping sloped 1/4 inch per foot towards steam traps for typical installations. Long pipe runs may use 1/8 inch per foot if necessary.

2. Steam coils shall have sloped coils as an integral feature of the appliance or the appliance shall be tilted to slope condensate towards steam traps.

3. Steam heat exchangers shall be piped according to Appendix A - Detail M-1E Heat Exchanger Piping.

23 25 00 - HVAC WATER TREATMENT

A. General Information:

1. Facilities Management has an in-house water treatment technician and maintains a contract with a water treatment company for supplies and consulting. New projects should consult with the Facilities Management District Heating Plant and chemical vendor through the University Representative to determine a proper chemical treatment program.

2. Coordinate all start-ups with water treatment technician and vendor by notifying the University Representative.

3. Chemical tanks shall be polypropylene or epoxy-lined and shall be made air tight to prevent chemical fumes from escaping to surrounding areas. Each tank shall be equipped with secondary containment to minimize the release of chemicals to floor drains.

4. Chemical treatment sites shall be over concrete dams with a retainage volume equal to the volume of the chemical tank.

5. Propylene glycol shall be Dowfrost by Dow Chemical or equal. Equal substitutions shall meet requirements of compatibility as established by Dow Chemical Company. All of the existing University systems have Dowfrost or compatible solutions. Substitution fluids shall be a minimum of 95 percent (by weight) propylene glycol with 5 percent phosphate based inhibitor and water. Uninhibited or automotive antifreeze with silicate based inhibitors are prohibited. Specific gravity shall be 1.05 to 1.08. Reserve alkalinity shall be a minimum of 10.6 ml. The Ph shall be 9.0 to 10.0 in a 50 percent glycol and distilled or deionized water solution. Standard ASTM D1384 shall determine the relative corrosion protection for various metals. The weight loss shall not exceed
0.5 mils per year.

Fluids for systems of more than 250 gallons of mixed volume shall qualify for free annual analysis by fluid manufacturer.

Material Safety Data sheets shall be provided in O&M manuals.

6. Freeze protection of systems exposed to outside air conditions shall be separated into those requiring burst protection and those requiring freeze protection. Systems that have some expansion capability will remain dormant during the winter and will not require automatic start-up during cold weather but shall be protected with concentrations of 30 percent. Systems that have no expansion capability or will require start-up during cold weather shall be protected with concentrations of 46 percent.

B. Hydronic Piping Systems:

1. Hot water heating systems, including convertors, pumps, coils and piping shall be cleaned with a solution of trisodium phosphate. This cleaning also applies to glycol systems prior to filling.

2. All closed recirculating water systems not using glycol are to be equipped with a pressure pot feeder, sized to accept water treatment chemicals in any common commercial form such as solution, flake balled etc. Arrange for shot feeding or for continuous feed as appropriate. Feeder shall be a minimum 1 gallon size, epoxy lined, piped from suction to discharge header so chemicals can be fed regardless which pump is in use.

3. Ethylene glycol is prohibited without approval of University Representative.

4. Propylene glycol shall be specified for hydronic systems subject to freeze-up conditions. Specifications shall be based upon Dow Chemical Dowfrost inhibited propylene or compatible equivalents as described above. Minimum of 30% glycol protection.

C. Steam and Condensate Systems:

1. Before placing a steam piping system in service, the piping shall be thoroughly blown out with steam to remove dirt, rust, scale or other contaminants.

2. Place the steam system in operation and waste condensate for a period of three hours. Following approval by Facilities Management-Environment Shop through the University Representative, return condensate to collection system.

D. Open Water Systems:

1. Open systems shall use automated controllers which start and stop pumps to feed corrosion inhibitors and biocides.

23 30 00 - AIR DISTRIBUTION

A. Ductwork:

1. All air distribution work in occupied and unoccupied buildings shall be protected from contamination in conformance with SMACNA Indoor Air Quality Guidelines for Occupied Buildings Under Construction. Work that has not been adequately protected shall be disassembled, cleaned and reinstalled at the Contractor’s expense, including all costs related to delay, out-of-sequence work and general conditions.
2. Sheet metal work shall be installed following SMACNA standards. Ductwork and housings shall be so constructed as to be airtight and watertight. The specifications shall be written to reserve the right to reject any work that is not 'airtight' in the sense of the current standards of the industry.

3. Duct liner is not permitted on inside of air supply or return ducts. External insulation and sound attenuators shall be installed to provide thermal and acoustic control. Attenuators shall be accessible for future replacement.

Duct liner may be approved in cases where attenuators are not practical such as the discharge of small packaged units. For these applications, short sections of lined air ducts will be permitted, but the length shall be limited and the ducts should be arranged to permit future replacement.

a. Duct liner shall be closed-cell foam, mold resistant, plenum-rated, erosion resistant, smooth surface, nondusting, cleanable, self-adhering, meeting NFPA 90A and 90B.

4. Sound attenuators shall be located in accessible locations with room for future removal and replacement. Duct access doors shall be installed upstream and downstream to permit inspection.

5. Fiberglass ductwork is not permitted.

6. Ducts shall not be sealed with pressure sensitive tape such as "duct tape". Hardcast or other sealants shall be used.

7. Flexible duct shall be limited to a maximum of 6 feet and shall be installed without sharp curves, excessive sags or unnecessary lengths with proper support.

8. Air diffusers, registers and grilles which will have flexible duct connections shall have a rigid sheet metal elbow installed at diffuser if flexible duct is not connected straight into diffuser, ie. do not permit flexible duct turns at diffusers.

B. Duct Accessories:

1. Dampers shall be installed in duct systems to permit balancing of air quantities. Main duct runs must have dampers to permit proper division of air quantities in the duct systems. Each supply outlet and each exhaust branch must have a damper control.

2. Dampers that are integral parts of supply or exhaust diffusers or grilles are permitted but must be approved during the design phase.

3. Fire dampers shall be installed where required for ducts which pass through rated firewalls or ceilings. Ducts shall be fitted with fire dampers and frames such that its fire resistance shall be equal to that of the wall or ceiling in which it is located. Dampers shall be sized to provide full duct size opening through wall, partition, or ceiling.

Where fire dampers are installed, paint duct red at damper, provide tight fitting access doors sealed with gaskets for inspection and replacement of fusible links. Doors shall be installed on side of fusible link. Where these doors occur on concealed ducts, provide access doors in walls or ceiling properly aligned to permit the servicing of the fusible links. Mark ceiling or walls according to accepted identification.

C. Variable Air Volume Box Controller:

1. VAV Box Pneumatic Controller - See Sole Source Appendix.
2. All VAV boxes shall use the type of controller specified in the Sole Source Product List. This controller should be available and compatible with most every VAV box manufacturer. Notify the Project Representative if this is not the case. Do not substitute other models. In dual duct applications it is preferred that box construction be such to facilitate separate air temperature and volume control.

D. Diffusers:

1. Supply air diffusers should have removable cores to allow easy cleaning.

23 34 00 – HVAC FANS

C. Fans:

1. For fans with 12 inch and larger wheels acceptable fan manufacturers include Temtrol, Governair, Haakon, Greenheck, New York Blower, Peerless and Twinn City or approved equal.

2. Fan specifications and accessories for all fans shall include the following:
   a. V-belt drives shall be rated at not less than 200 percent of motor nameplate rating. Belt speeds shall not exceed 4500 feet per minute.
   b. Center distances between driver and driven sheaves must meet the manufacturer's minimum and maximum.
   c. All sheaves shall be fixed pitch type.
   d. Fans shall be provided with accessibility for balancing and cleaning. Fans with inlet and outlet duct connections shall have housing access doors regardless of size.
   e. All fans shall have belt and pulley guards.

3. Fan specifications and accessories for all critical application fans 12 inch and larger wheel shall include the following.
   a. Fans shall be belt driven. Direct drive fans are permitted only for fanwall applications.
   b. Fans shall be hard-mounted to support surface. Spring isolators are not permitted. Refer to 23 05 48 Vibration Control for information on structural assistance for fan mounting.
   c. Building air handling unit fans shall be provided with external bearings only. Shafts 3/4 inches and larger shall have spherical roller bearings. No internal bearings recessed into fan housing shall be allowed. All bearings shall be accessible for lubrication and maintenance.
   d. All fans shall have stamped metal data/nameplates fastened to housing with screws or rivets. Pressure sensitive plates are not acceptable.

4. In-line type fans are not desirable and when necessary shall be belt driven and have removable access doors.

5. All connections between fans and ductwork shall be with flexible connections.

6. Fan speed changes above maximum operating speed, as defined in 23 05 48 Vibration Control,
are not permitted without approval of the Vibration Consultant through the University Representative. Unauthorized speed changes may result in damage to bearings and shafts.

7. Fan roof curb and housekeeping foundations are shown in the Drawing Appendix.

8. Contractor shall be responsible for correction of excessive fan vibrations if the vibration criteria described in the above section is applied.

9. Aluminum wheels are not allowed except for spark proof applications.

**23 35 00 – SPECIAL EXHAUST SYSTEMS**

A. Exhaust Systems:

1. Exhaust systems which may transport offensive odors, noxious gases, etc., are to be separate systems. Provide identifying labels on exterior stacks per Environmental Health Services instructions through the University Representative.

2. Fans shall be located so that negative pressure exists in all exhaust ducts within buildings. Install weatherproof housing over motor and drive when exposed to weather. Metal interior casings and wheels shall be coated if fumes are corrosive.

3. Outside air supply shall compensate for air exhausted by fume hoods, kitchen hoods, or other special exhaust equipment.

B. Fume Hood Exhaust Systems:

1. Fume hood design shall comply with the American National Standard for Laboratory Ventilation ANSI/AIHA No. Z9.5-1992 or newer.

2. Acceptable types of fume hoods (auxiliary, bypass etc.) are identified in Section 11600 - Laboratory Equipment.

3. Exhaust fans shall have standard arrangements. See Drawing Appendix for Fume Hood Exhaust Fan for fan and stack arrangement. Coatings or alternate materials shall be specified as necessary.

4. Where hoods are installed, care must be taken to insure an adequate supply of tempered air whenever the hood exhaust fans are operating. This supply air shall not require operation of the main building system for only a few hoods.

5. It is desirable in lab buildings to make allowances in the HVAC and exhaust systems for the future addition of fume hoods.

6. The face velocity is determined by Environmental Health Services through the University Representative. This face velocity is to be specified in the design documents, and the balancer shall balance the system to this value. The actual total exhaust rate that the fan pulls will be more than the face area exhaust rate. See Division 11 for additional information.

7. The method of balancing fume hoods is described in Section 23 05 93 - Testing, Adjusting and Balancing.

8. Exhaust duct materials may be galvanized duct, PVC duct or stainless steel type 304 or 316. Each application must be evaluated to determine which material is appropriate. PVC duct systems should have glue used in joints checked for compatibility. When welded joints are
required, duct thickness shall be 16 gauge or less.

9. Exhaust ducts shall have a minimum velocity of 1200 fpm. Discharge stacks shall terminate a minimum of 10 feet above the roof with a minimum terminal velocity of 2000 fpm.

10. Exhaust system controls such as variable volume systems are described in Division 25 – Integrated Automation. Economic analysis of alternate schemes shall be provided for each application.

11. Manifolded exhaust systems are encouraged where compatibility of fumes is not a problem and where construction cost savings would be realized. Manifolding shall occur before fan and multiple fans with separate discharge stacks and shall be sized for redundancy in capacity, such as two fans sized for 100 percent load with frequency drives or inlet vanes to control fans at necessary flow requirements.

12. Perchloric fume hoods and exhaust systems require special design parameters listed below.

   a. Perchloric hoods can only be used for perchloric work and cannot be used for other types of service, especially organics.

   b. Stainless steel fume hoods designed for perchloric work.

   c. Separate exhaust fan. Perchloric hoods cannot be combined with other hoods. Fans shall be made of fiberglass reinforced plastic (FRP) with vinyl ester resin such as Derakane 510A40 by Dow Chemical or equal. A surface veil should be provided if available in fan size. Provide FRP B1 wheel dynamically balanced with metal hub and pillow block bearings. Shaft and fasteners encapsulated with FRP with viton shaft seal. Flanged inlet and outlet connectors with neoprene gaskets, 1 inch threaded housing drain, bolted inspection port. Steel welded base, enamel coating on exterior metal with weatherproof cover/belt guard suitable for exterior use.

   d. Stainless steel type 316 welded ductwork or PVC as described below.

   e. PVC (unplasticized) ductwork with plastic welded, flanged connections with neoprene gaskets. Glued fittings are not permitted.

   f. Ductwork shall not have sharp corners or edges where perchloric crystals could accumulate. Slope ductwork to drain. Discharge stack from fan shall be continuous and terminate 7 feet above roof.

   g. Wash down system with type 316 stainless steel or PVC nozzles with pipe unions at duct penetration every 6 feet, at elbows and fans. Wash down nozzles shall also be installed inside hoods. Include drainage piping. Provide heat tape and insulation on exterior piping. Provide multiple valve arrangement for draining of wash pipe for freeze protection with control at hood. Provide written procedure for use of wash down system to be laminated and installed at hood.

23 40 00 – HVAC AIR CLEANING DEVICES

A. Filtration

1. All air supplied to the building shall be filtered. Main building ventilation systems shall filter the air at central filter banks. Central filter banks shall have pre-filters of 25 percent medium efficiency (MERV 8) pleated type with a standard size of 24 x 24 x 2 inches. Final filters shall be 85 percent bag or 85 percent rigid filters (MERV 13) with a standard size of 24 x 24 inches.
The depth shall be dependent upon pressure drop and space requirements.

2. Bag filters shall be accessible for either upstream or downstream servicing. Pleated panel filters shall be removable from the upstream side without disturbing the bag filters.

3. Provide pressure differential gauge on all filter banks. Buildings with BAS control shall have filter differential pressure sensors connected to system.

4. Systems shall not be operated during construction without the pre-filters in place. New pre-filters and bag filters shall be furnished as part of the contract at time of substantial completion.

5. Exhaust air systems that have filters for protection of heat recovery coils shall be 2 inch pleated filters of 25 percent efficiency (MERV 8). Filters shall be removable through side access frames.

6. Air handling units which do not require 85 percent bag filters shall have 2 inch pleated filters with a minimum of 25 percent efficiency (MERV 8).

B. Building Air Inlets and Outlets:

1. In buildings where exhaust air may be contaminated, the building air supply intake shall be located to avoid recirculation of the building exhaust air. Ground level intakes are not desirable.

2. Louvered openings must be arranged to exclude all types of moisture or safely dispose of it. Design should accommodate required airflow without excessive noise or pressure drop. Screens shall have \( \frac{\text{2}}{\text{inch}} \) openings. Provide bird screens or side to prevent entry of birds or debris. Provide adequate hoods and low face velocities below 300 fpm through net free area where snow may plug air inlets.

23 57 00 - HEAT EXCHANGERS FOR HVAC

A. Steam and Condensate:

1. See Section 23 33 00 for details on steam and condensate piping.

B. Water Heating Systems:

1. The preferred heating system is a hydronic system using a steam-to-hot-water heat exchanger. See Drawing Appendix for piping arrangement.

2. Heat exchangers shall be ASME constructed and stamped.

3. The hot water heating system shall have duplex (2) heat exchangers and duplex main circulating pumps each capable of meeting the load individually. Add: System must also work as a lead/standby with automatic switchover from the BAS.

4. Maximum pump speed shall be 1800 rpm. Mechanical seals shall be selected for the intended temperature service.

5. High points in hot water piping systems shall be fitted with manual air vents of type described in Division 20. Low points shall be fitted with drain valves.

6. Furnish and install flow balancing stations in the main system and each major branch.
7. Valves shall be provided at top and bottom of risers in hot water supply and return systems.
8. Valves shall be installed at each branch line, each floor and each zone.
9. All heat exchangers shall be located to allow removal of tube bundles without interference.
10. Provide air/dirt separators on systems where appropriate.
11. Provide hot water reset schedule based upon outside air temperature or other approved means from the BAS.

C. Steam Humidification:
1. Central plant steam shall not be used directly for space humidification.
2. Natural gas, electric, ultrasonic, or indirect water-to-steam heat exchangers using central plant steam shall be used for space humidification. Humidifiers shall be self-cleaning if available as an accessory.

23 60 00 – CENTRAL COOLING EQUIPMENT

A. Acceptable Products:
1. 3-100 Ton Packaged A/C Systems - Carrier, Lennox, or equal.
2. 50-300 Ton Rotary Screw Chillers - Carrier, McQuay, or equal.
3. 250-500 Ton Centrifugal Chillers - Carrier, McQuay, York or equal.

B. General Information:
1. Equipment cooling with domestic water is prohibited by the University and by a City of Fort Collins ordinance. Chillers, connection to District Cooling Utility, cooling towers or other air-water heat exchangers shall be proposed.
2. Acceptable refrigerants are 134a and 410a.
3. R-22 refrigerant is prohibited.

C. Certification and Submittal Requirements:
1. All contractors, service companies and Facilities Management technicians who work on air conditioning and refrigeration systems shall be registered with the State of Colorado and certified by EPA for the type of appliance to be installed or serviced.

Copies of registration and certification shall be submitted to the University Representative during shop drawing submittal phase. The representative shall forward them to the CFC Program Manager for record.

2. Contractors shall submit a written procedure for refrigerant gas conversion projects to the CFC Program Manager through the University Representative for review and approval prior to proceeding with work. This procedure shall include a verification of compressor, system and alternate refrigerant compatibility with respective manufacturers.

Contractors shall provide a final conversion report in the O&M Manual which includes the
requirements described above, describes the conversion work, lists the total quantity of refrigerant removed and installed and records the performance parameters of the new system.

3. Verification of proper disposal of retired appliances and all refrigerants, oils, etc. shall be included in the O&M Manuals.

D. Refrigerant Gas Control and Recycling:

1. Purchase, handling, storage, charging, and discharging of refrigerants shall be in accordance with Fort Collins City Ordinance No. 93, 1990 which establishes Article IV of Chapter 12 of the Code of the City of Fort Collins, State of Colorado Regulation No. 15 and EPA Section 608 of the Clean Air Act.


3. The intent of the above regulations shall be to prohibit intentional venting or avoidable release of refrigerants from refrigeration systems during installation, servicing, maintenance and removal.

4. All existing systems that are to be removed and disposed of shall have refrigerants removed either prior to or after removal. Proof shall be supplied to University Representative that demonstrates the capture and containment of the refrigerant. Such proof shall include written identification of refrigerant removal equipment either portable or at Contractor’s shop.

5. Recovered refrigerant is the property of Colorado State University and will be stored or disposed of by Facilities Management Mechanical Services Shop.

6. Refrigerants should be recovered by Facilities Management Mechanical Services Shop. Should other contractors ever remove refrigerants, the gas shall be returned to Facilities Management Mechanical Services Shop through the University Representative in a DOT and ASME approved storage and recovery vessel suitable for the type and quantity of refrigerant. The cost of removal of refrigerant and the cost of the vessel shall be included in bid work.

Facilities Management Mechanical Services Shop will either recycle the refrigerant or dispose of it according to local, state and federal regulations.

7. All new systems installed after July 1, 1992 shall include refrigerant isolation/service valves which permit pump down of refrigerant into condenser coil or liquid receivers to permit servicing of systems without venting of refrigerant. Isolation/service valves shall also permit removal of refrigerant through a recovery machine to a DOT and ASME approved storage vessel.

8. All new systems with 20 or more pounds of refrigerants shall be provided with a pressure activated release plug with a re-seatable pressure valve to minimize loss of refrigerants.

E. Design and Specification Requirements:

1. All projects that affect CFC appliances shall be reviewed by the CFC Program Manager through the University Representative.

2. All new CFC and HCFC appliances shall be registered with the CFC Program Manager through the University Representative.

3. Appliance gas conversion projects shall have the conversion procedures described in the project design documents. These procedures shall follow compressor and gas manufacturers recommendations. The project documents shall also require the refrigeration and/or
mechanical contractor to verify compressor and system compatibility with alternate gases with the respective manufacturers. See previous section for submittal requirements.

F. Chillers:

1. Flanges shall be provided at each condenser and chilled water connection to chiller. Piping connections to flanges shall be no longer than 3 feet with a second set of flanges provided to permit removal of pipe section and header for cleaning condenser and evaporator bundles.

2. Centrifugal chillers with oil coolers, which are cooled with chilled water, should have pressure and temperature gauges installed on inlet outlet of chiller out of the influence of the oil cooler circuit.

3. Provide a 4 foot (or smaller) section of pipe with flanges at inlet and outlet of chilled and condenser water connections to chiller. Isolation valves shall be placed on piping to permit removal of 4 foot sections for cleaning of evaporators and condensers.

4. Electric submeters shall be provided for all chillers 20 ton and larger.

G. Condensing Units:

1. Low ambient accessory packages for air-cooled condensers for intermittent winter cooling requirements down to about 40°F outside air temperature shall be, at a minimum, variable speed condenser fan control based upon the outside air temperature or refrigerant gas temperature/pressure. Thermostatic expansion valves shall be provided with these systems. Orifice type valves are not permitted.

2. Continuous and critical winter cooling requirements shall be flooded condenser control with liquid receiver and 3-way head pressure control valve. As described above, thermostatic expansion valves are required.

3. Hail guards shall be installed on all condenser coils.

H. District Cooling System:

1. A District Cooling System exists at the University. Underground piping may be available for connections to new buildings or to meet existing cooling loads.

2. A/E should check with University Representative about connecting to the District Cooling System.

3. Chilled Water Plant and Loop Operating Criteria

   a. CHW Supply Temperature: 43°F at building.
   b. CHW Return Temperature: 63°F at building for maximum load.
   c. Delta Temperature: 20°F.
   d. System Static Pressure: 40-50 psig.
   e. System Dynamic Pressure: Approximately 15 psig differential at building.
   g. System Fluid: Water - no glycol.

4. Building Cooling System Design Requirements

   a. Temperature Control Valves: Sole Source "DP valve" control valves from Flow Control Industries. These are pressure independent control valves and shall be used for all coils and heat exchangers connected directly to the utility.
b. Coil Pumps: May be required at coil for constant coil flow.

c. Heat Exchangers: Use if glycol is required in building system, the building system has dirt
or static pressure problems, or for freeze protection.

d. Freeze Protection: All RTU’s shall have glycol at coil. Units in conditioned space shall not
have glycol. Control valves shall be driven 100% open, adj. on freeze stat trip.

e. Utility BTU Meters: Ultrasonic, strap-on flow meters only. See Sole Source Appendix.
Output signal from the utility BTU meter shall be read into District Energy control system.
Contact District Energy Manager through the University Representative for detail.

f. Pressure Differential: Sensors shall read supply and return pressures at building into the
BAS.

g. Temperature Differential: Sensors shall read supply and return temperatures at building
into the BAS.

23 65 00 - COOLING TOWERS

A. General Information:

1. For sizing a cooling tower capacity refer to Division 20.

2. The tower outlet water temperature shall be 5 °F lower than the required chiller inlet water
temperature.

3. Cooling towers shall be supplied with 2-1/2 inch minimum size drain outlet in bottom of sump
and located on opposite side of suction outlet of sump. Drain lines to be piped to nearest
sanitary drain. Towers shall not be drained into storm drains. Indoor sumps should be
considered as an alternative with the benefit of cold weather operation.

4. All tower sections shall have access ladders from top to bottom in accordance to OSHA
standards.

5. All tower sections shall have 1/2 inch x 1/2 inch screening to prevent birds from entering.

6. The preferred location of tower fan motors should be outside of the tower for access for
maintenance and not in air stream.

7. Consider closed loop, evaporatively sprayed cooling towers to use in conjunction with heat
exchangers for systems which have winter cooling requirements.

8. Access openings to sumps, valves, motors, belts, sheaves sprays, etc., shall be provided.

9. Water treatment piping shall include bleed solenoid valve with a wye strainer and blow down
ball valve upstream. Lockout timer shall have a 3 hour minimum. Coordinate water treatment
program with Facilities Management-Utilities Services through the University Representative
as described in Section 23 25 00.

23 70 00 – CENTRAL HVAC EQUIPMENT

A. See Section 23 34 00 – HVAC Fans for fan design, manufacturing, installation and vibration
standards.

B. Air Handling Units:

1. Heating and cooling coils shall be sized for load capacity plus 20% for future growth.

2. Heating and cooling coils shall be drainable and have manual air relief vent of type described in Section 15120 - Piping Specialties placed at high point. See Appendix A - Details M-10 through M-11 for piping arrangements.

3. Preheat coils for 100 percent outside air shall be designed with heat exchangers and 30% propylene glycol to prevent freeze problems. Steam preheat coils are not permitted.

4. Allow access for cleaning coils from both sides. Provide a means to catch and dispose of cleaning solutions with pipe to drain on larger coils.

5. Provide space for removing and repairing coils and other components.

6. High-pressure casings shall have panels 4 inches thick and filled with sound absorbing fill. Exterior panel sheet to be 18 gauge galvanized steel and interior panel sheets 22 gauge perforated galvanized steel. Doors shall be 24 inches wide and 60 inches high. Doors shall be made of 18 gauge-galvanized steel, both sides. Doors shall open against the air pressure.

7. Votex Dampers are not an accepted method air volume and/or back draft control. This shall be accomplished with VFD and down stream high pressure back draft equipment.

8. HVAC supply units with mixed air capability shall have a programmable return air CO2 sensor sequence to regulate the OSA damper. Separate built up AIQ sections in the fan housing are not acceptable unless adequate blending can be accomplished prior to the hydronic coils during temperature extremes.

9. Air handling units for computer rooms, museums, and other spaces requiring tight humidity control shall provide capacity for heating, cooling, humidification and dehumidification.