DIVISION 23 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

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Unless stated otherwise, the standards in this Facilities Design Manual (FDM) are directed to the Design Professional to incorporate into the Project.

Although the Owner encourages improved concept, method and product recommendations by the Design Professional, deviation from these standards, including product requests for "approved equivalent" status, requires written justification from the Design Professional and written approval from the Owner's Representative before completion of Design Development Documents.

23 05 00 HVAC COMMON WORK RESULTS

A. REFERENCE ABBREVIATIONS

1. AMCA Air Movement & Control Association International Inc
2. ARI Air conditioning and Refrigeration Institute
3. ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers
4. ASTM ASTM International (formerly in the USA: American Society for Testing and Materials)
5. IEEE Institute of Electrical and Electronics Engineers Inc
6. NEMA National Electrical Manufacturers Association
7. SMACNA Sheet Metal and Air-Conditioning Contractor's National Association

B. GENERAL

1. Prepare documents and correspondence required by the Iowa Department of Natural Resources for environmental emission permits required for the Project.
   a. Verify requirements with the Owner's Representative.
2. Verify the following conditions with the Owner's Representative.
   a. Utility availability at the site
   b. Chilled water temperature changes as a result of seasonal conditions
3. Specify the Contractor consult the Owner's Representative to coordinate service connections to existing systems.
   a. See FDM Part 2/Div 33 Utilities.pdf.
4. Specify equipment furnished with the manufacturer's installation, operating and maintenance instructions.
5. For standard details, see FDM Part 2/Support Docs for Div 21-23/HVAC Details.
6. For pipe material, see FDM Part 2/Support Docs for Div 21-23/ISU Standard Pipe Schedule And Specifications.pdf.

C. DESIGN REQUIREMENTS

1. Comply with the State Building Code and Boiler And Pressure Vessel Rules.
   a. See paragraphs under sub-section 02.02 and 02.05 in FDM Part 1/Sec 02 Codes And Regulations.pdf.
2. For ordinary space, including offices, classrooms, and residence rooms, design using 2-1/2 percent and 99 percent for wind and heating and 1 percent for cooling in the ASHRAE Handbook of Fundamentals.
3. For indoor summer and winter design temperature and humidity, see paragraphs under subsection 03.09 in FDM Part 1/Section 03 Space And Site Design.pdf.
   a. For computer rooms, classrooms and other special room that may need higher humidity, consult with the Owner's Representative.
4. Design using minimum outside air to occupied space.
5. Design to provide positive ventilation in equipment rooms to prevent damage from heat and humidity.
6. Design to maintain shops, laboratories and studios where hazardous materials are used under negative pressure with respect to areas of lower hazard such as corridors and offices.
   a. Exhaust air directly to the outside.
7. Locate outside air intakes to prevent outside air from being contaminated by fume hood exhaust, building exhaust or motor vehicle exhaust.
8. Do not design using electric heating coils or electric heat without approval by the Owner's Representative.

9. Design systems that provide heating and cooling year-round to accommodate the desired occupancy.
    a. Provide a life cycle cost analysis for the proposed system.
        1) Consider the impact of central system zoning.
            a) Include operating costs of building as operated and not based on square foot costs alone.
            b) Zone systems by occupant function.
            c) Zone systems to permit shutdown of areas occupied only during Owner business hours.
        2) Include impact of maintenance cost as well as energy cost during system selection.
    b. Provide each room with independent temperature control.
    c. Wherever possible, design using energy sources from the campus power plant.
        1) Design using campus steam as the source for heating in all cases.
        2) Design using campus chilled water as the source for cooling.
        3) Design using campus steam as the source for humidification, unless the cost of operation dictate use of another method, such as evaporation.
            a) Do not use direct steam from the campus power plant for humidification.
10. When radiation systems are provided, specify radiation units connected independently to supply and return piping instead of connected in series.
11. Design hydronic heating and cooling coils for counterflow using a reverse return for building piping systems.
12. Design using chilled cooling water for special laboratory equipment such as lasers, growth chambers, etc.
    a. Where auxiliary cooling equipment is utilized, do not route central campus chilled water directly through condensers.
13. At the inlet and outlet of each main line strainer, design using valved sensing points piped to a common pressure gauge.
14. Except for control valves on fin tube and unit heaters, locate strainers upstream of pumps and control valves in chilled water and hot water applications.
15. Except for convectors, fin tube and cabinet unit heaters, locate strainers ahead of control valves and traps in steam applications.
16. Design using dirt legs at least 12 inches long.
17. In lower level mechanical rooms, design using water-on-floor alarms connected as an alarm point on the Building Automation System (BAS).
    a. For BAS information, see FDM Part 2/Div25 Building Automation.pdf.

D. FREEZE PROTECTION

1. In systems in danger of freezing, specify water solutions of propylene glycol to suppress freezing/bursting temperatures.
    a. Specify closed loop heating and ventilation systems with a 35 percent solution of DOWFROST HD or approved equivalent that contains corrosion inhibitors to keep pipes free from corrosion without fouling.
        1) Specify industrially inhibited fluid with phosphate-based and copper corrosion inhibitors to passivate the system and buffer the acidic degradation products of glycol.
            a) Do not specify silicate-based inhibitors typically found in automotive antifreeze.
        2) Specify fluid with glycol concentration easily analyzed, and inhibitor concentration easily analyzed and adjusted using replacement inhibitor readily available from the fluid manufacturer.
        3) For a system that contains more than 250 gallons of fluid, specify an annual analysis report submitted by the fluid manufacturer at no cost to Owner, to include the following information.
            a) Glycol concentration and recommendation for additional glycol, if needed

b) Freeze point temperature

c) Inhibitor level and recommendation for additional inhibitor, if needed

d) pH level

e) Reserve alkalinity

f) Contaminants such as, but not limited to, chloride, sulfate, nitrite and nitrate

g) Total hardness

4) Specify the fluid must pass ASTM D1384 (less than 0.5 mil penetration per year for all system metals).

5) Specify that available fluid dilution water meet the following requirements.

a) Distilled, deionized, or contains less than 25 ppm each of chloride and sulfate

b) Contains less than 50 ppm each of hard water ions (calcium and magnesium as calcium carbonate)

c) Total hardness not to exceed 100 ppm

6) If water meeting these requirements is not available, specify the fluid manufacturer to furnish both fluid and water to meet system specifications.

b. Specify the Contractor to furnish the Owner with the required liquid volume of fluid for each glycol system, properly dispose of excess glycol and water and perform the following operations.

1) Hydrostatically test the system to ensure it is leak free.

2) When retrofitting systems which may have contained automotive antifreeze, clean to remove silicates and other contaminants.

3) Clean and flush the system to remove contaminants prior to filling with heat transfer fluid.

a) Fill the system with high quality water and 1 to 2 percent Tri-Sodium Phosphate or approved equivalent cleaning solution.

b) Circulate solution for 8 to 12 hours and flush solution from the system with high quality water.

c) Circulate the flushed system with clean water for a minimum of 72 hours.

d) After 72 hours, take samples to verify the system is free of particulates, mil scale, weld scale, solder, flux, rust, metal filings, oil, grease, chlorides, sulfates, silicates, and other foreign matter that could degrade the heat transfer fluid.

c. Design heating systems to prevent antifreeze solution from coming into contact with temperatures higher than 250 degrees F.

1) If heating systems or components contain aluminum, design to prevent antifreeze solution from coming into contact with temperatures higher than 150 degrees F.

2) Do not specify galvanized piping, valves, fittings or other components containing zinc.

E. MOTOR REQUIREMENTS

1. Except where otherwise specified for motors in mechanical and electrical work sections, specify the following requirements.

a. Motors 1/2 horsepower and smaller powered by 115 volt, single phase

b. Motors 3/4 horsepower and larger powered by 3 phase, 208 volt or 480 volt

1) Specify 3 phase motors are rated 200 volts for use on 208 volt systems.

2) Specify 3 phase motors are rated 460 volts for use on 480 volt systems.

3) Do not specify motors rated 220 volts or 230 volts.

4) Where a manufacturer furnishes equipment powered by an integral fractional horsepower motor, an exception may be made if approved by the Owner's Representative.

c. Single phase motors of the following type as selected for individual application and approved by the Owner's Representative.
    1) Capacitor start
    2) Split phase
    3) Shaded pole
d. Polyphase motors of squirrel-cage induction type.
    1) Variable speed achieved by using silicone controlled rectifier (SCR) variable frequency drives.
e. Multi-speed motors of the following type as selected for individual application and approved by the Owner's Representative.
    1) Squirrel-cage induction type
    2) Three-speed
    3) Single or double winding
    4) Constant or variable torque

2. Where motor type, horsepower, speed, or other essential data are not specified in the detailed specification of the individual equipment unit or indicated on schedules, specify to obtain this information from the manufacturer of the equipment unit and have it approved by the Owner's Representative before ordering.
3. Do not specify motors furnished under mechanical and electrical work from more than 2 manufacturers.
    a. When a motor is of fractional horsepower or is furnished integral with driven equipment unit as a manufacturer's standard, an exception may be made if approved by the Owner's Representative.
4. Specify motors from the following manufacturers.
    a. General Electric (http://www.geindustrial.com/cwc/products?famid=23)
    b. TECO-Westinghouse (http://www.tecowestinghouse.com/Products/stock_motors.html)
    c. Baldor (http://www.baldor.com/products/default.asp)
    d. Reliance (http://www.reliance.com/prodserv/motgen/motinfcnt.htm)
    e. Toshiba (http://www.toshiba.com/ind/group_display.jsp?&id1=6)
    f. Louis Allis (http://www.louisallis.com/nema.html)
    g. Equivalent approved by the Owner's Representative
5. Specify motors comply with NEMA standards as minimum requirements for motor design and performance, except where otherwise approved by the Owner's Representative.
6. Specify motors are suitable for load, duty, voltage, frequency and hazard for service and intended location.
7. Specify NEMA classifications of motor enclosures apply when motor types are specified as open drip proof, splash proof, totally enclosed, etc.
8. Specify motors have ball or roller type bearings with pressure grease lubrication.
    a. Sleeve type bearings may be approved by the Owner's Representative if the method of oil lubrication is acceptable.
9. Specify motors rated for continuous duty under full load.
10. Specify maximum temperature rise as follows.
    a. 40 degrees C for open type
    b. 50 degrees C for drip-proof and splash-proof types
    c. 55 degrees C for explosion proof and totally enclosed types
11. Specify motors capable of withstanding momentary overloads of 50 percent without injurious overheating.
12. For belt drive motors, specify adjustable base.

13. For direct drive motors, specify the coupling aligned, coupled and doweled to the base plate at a minimum of 2 points.
    a. Also specify the drive unit to be doweled at 2 points.
14. Specify motors to be quiet operating as follows.
    a. Measure sound level at no load complying with IEEE Standard 85.
    b. For polyphase squirrel-cage induction motors, do not exceed the following maximum level readings under no-load conditions.

Overall Sound			
		Power Level Decibels, A - Weighted	
Frame Designation	Synchronous Speed Rpm	Drip- proof	Totally enclosed Fan Cooled
143T, 145T	3600	76	87
182T, 184T	3600	80	91
213T, 215T	3600	82	94
254T, 256T	3600	86	98
284T, 286T	3600	89	100
364T, 365T	3600	94	101
404T, 405T	3600	98	102
444T, 145T	3600	101	104

    c. For other types of motors, consult with the Owner's Representative.
15. Specify motors have a name plate that provides the following information.
    a. Manufacturer's name
    b. Volts (V)
    c. Phase
    d. Electrical power frequency in Hertz (Hz)
    e. Horsepower (HP)
    f. Revolutions per minute (RPM)
    g. Full load current in amps (A)
    h. Service factor.
16. Specify that motors less than 5 horsepower have flexible power leads of sufficient length to extend 3 inches minimum beyond the face of the conduit terminal box.
17. Specify motors 5 horsepower and larger have terminal lugs.
18. Specify motors have a service factor of not less than 1.15.
19. Specify motors 5 horsepower and larger are of the energy efficient type.
20. Specify submittals from the manufacturer include, as a minimum, the following information.
    a. Physical dimensions or NEMA frame size
    b. Bearing information
    c. Performance curves for power factor and efficiency at various loads per NEMA Standard MG112.53a (IEEE 112 Method B)
    d. Name plate data including NEMA nominal efficiency per NEMA Standard MG112.53b
    e. Maintenance recommendations
21. For motors over 200 horsepower, specify each motor is completely tested and that certified test data sheets are submitted to the Owner's Representative for approval.

22. Specify motor warranties of not less than one year from the start-up date.
    a. For installations related to new building construction, specify warranties start on the building substantial completion date.

F. VIBRATION AND SOUND CONTROL

1. Specify all areas associated with the building comply with the Sound and Vibration Control section of the latest ASHRAE Handbook.
    a. Design duct systems to not transmit excessive airborne or radiated noise to occupied spaces.
        1) Evaluate fan selection, duct construction, air velocity and sound attenuators to produce acceptable noise levels.
    b. Where needed, design using sound attenuation to reduce room to room noise transmission.
2. Specify all mechanical rotating equipment be within the FAIR range of the "General Machinery Vibration Severity Chart" by IRD Mechanalysis Inc at the time of building acceptance.
    a. See FDM Part 2/Support Docs for Div 23/General Machinery Vibration Severity Chart.pdf.

G. IDENTIFICATION

1. Equipment
    a. Identify equipment using Field ID Numbers comprised of the Owner's Field ID Codes as shown in the Building Systems Nomenclature Dictionary plus a unique sequential number; for example, AHU1 (see FDM Part 2/Support Docs for Div 21-23/Building Systems Nomenclature Dictionary.doc).
        1) Label associated components with the same Field ID Number.
            a) Examples of associated components include, but are not limited to, disconnects, motor starters, power distribution equipment and electrical panel directories.
        2) Except as described in 1) above, avoid duplicate Field ID Numbers in a building.
        3) Consult the Owner's Representative for any equipment or component that is not listed in the Building Systems Nomenclature Dictionary.
    b. In construction document schedules, include a column for Field ID Numbers and specify to identify installed equipment and components using only the Field ID Numbers.
    c. Specify to clearly identify systems and equipment with an engraved laminated plastic label.
    d. If adding equipment to existing space, use existing Field ID Number format and do not duplicate existing Field ID Numbers.
        1) Consult with the Owner's Representative to obtain Field ID Number sequences available for use.
2. Insulated System Components
    a. Specify components concealed by insulation are labeled on the outside of the insulation covering.
        1) Examples of components include, but are not limited to, valves, strainers, unions and balance dampers.

23 05 93 TESTING, ADJUSTING AND BALANCING

A. GENERAL

1. Specify the Testing and Balancing Contractor furnish all labor, materials, tools, equipment, and services to test, balance and adjust all mechanical systems as required by the Contract Documents.
2. Specify complete coordination with work of other trades.
3. Specify all supplementary or miscellaneous items, appurtenances and devices be furnished and installed for a sound, secure and complete installation.
4. Specify the Balancing Contractor is a subcontractor to the General Contractor and not an employee of the Mechanical Contractor or its subsidiaries.

5. Specify the following systems are tested, balanced and adjusted.
    a. Air distribution systems including fans
    b. Circulating water systems, including pumps
    c. Instrumentation and control system
    d. Refrigeration system, chilled water system

B. QUALITY ASSURANCE

1. Specify an independent balance and testing agency approved by the Owner's Representative.
2. Specify submitting proof of completing at least five successfully projects of similar size and scope.
3. Specify balancing comply with the following standards.
    a. SMACNA, "Testing, Balancing, and Adjusting of Environmental Systems" ratio or percentage method
    b. ASHRAE Guide
    c. Associated air balance council procedures only if 2 or more passes of the system are made

C. TESTING AND BALANCING AGENCY RESPONSIBILITIES

1. Specify direct responsibility to the Owner and as follows.
    a. Report any balancing problem to the Owner’s Representative for resolution.
    b. No contractual relationship with the installing contractor.
2. Specify component parts of the complete system are checked for their independent functions and their composite operation in the system so that all capacities and requirements comply with the Drawings and Specifications.
3. Specify inspection of the installation and operation of mechanical piping systems, sheet metal work, temperature controls and other component parts of heating, ventilating, and air conditioning systems relating to proper arrangement and adequate provisions for testing and balancing.
    a. Advise the Owner’s Representative of necessary adjustments and corrective measures.
4. Specify work scheduled with the trades involved.
5. Specify system components are checked, adjusted and balanced to obtain optimum conditions in each conditioned space.
6. Specify the preparation and submission of reports to the Owner's Representative for all tests.

D. CONTRACTOR RESPONSIBILITIES

1. Specify startup of all systems and keep in correct operation during balancing operations.
2. Specify personnel assigned as required to make necessary adjustments and corrections to balance systems.
3. Specify accessibility to test locations and devices requiring adjustment is maintained.

E. JOB CONDITIONS

1. Specify balancing at time determined by the Owner’s Representative.
    a. If balancing is not done during the peak cooling season, demonstrate satisfactory balancing during next peak cooling season.

F. CORRECTIVE WORK

1. Specify an extended warranty of 90 days, after completion of test and balance work, during which time the Owner’s Representative may, at his discretion, request recheck or resetting of any equipment or system which is not performing satisfactorily.
    a. Specify technicians are furnished to assist as required to conduct such tests.

G. SUBMITTALS

1. Specify the following information be submitted to the Owner's Representative.
    a. Qualifications of the balancing agency.
    b. Balancing reports that include all specified data.
        1) Use forms similar to those published by the Associated Air Balance Council, latest addition.

H. EXECUTION - GENERAL

1. Specify the following general procedures.
    a. Accurately calibrate and maintain all test instruments in good working order.
    b. If requested, conduct tests of instruments in the presence of the Owner’s Representative.
    c. If requested, conduct balancing tests in the presence of the Owner’s Representative.
    d. Do not begin balancing until system(s) have been substantially completed and are in good working order to permit preliminary measurements of total air or water volumes and system pressures.
    e. Proceed with final balancing and adjustments when systems are 95 to 100 percent complete.
    f. Record all inspections, tests and adjustments.

I. AIR BALANCING REQUIREMENTS

1. Specify each air system served by air filters is balanced using artificial static loading of the system to demonstrate, test and obtain system pressure drop data.
    a. Specify the following general requirements.
        1) Provide dirty filter pressure drop conditions on system at approximate 80 percent of peak pressure drop value.
        2) Do not use high efficiency filters (75 percent and above) in testing and balancing.
        3) Static pressure losses may be simulated by using wood or sheet steel blanking plates in high efficiency filter racks and housings.
        4) Do not install blanking plates within 2 feet of any low efficiency filter unit or rack.

J. AIR BALANCE TESTING PROCEDURE

1. Specify that tests and system balancing are performed complying with the following procedures.
    a. Verify that all fire dampers are open.
    b. Verify that all smoke dampers are open prior to fan startup.
    c. Verify that all thermostats are connected and will operate the air terminal units for both heating and cooling.
        1) If thermostats are not connected, arrange with the controls contractor to place all terminal units in full cooling position.
    d. Determine and verify equipment RPM to design requirements.
    e. Determine motor load amperes.
    f. Take readings of all air flow stations if installed or make pilot tube traverse of main supply, return and exhaust air ducts.
        1) Obtain volume of air in cubic feet per minute (CFM) at fans at both maximum and minimum outside air operation.
    g. Determine system static pressures at suction and discharge of each fan, midpoint of supply and return ductwork system, and inlet to end of system air terminal unit.
        1) If volumes and static pressures are within plus or minus 10 percent of design, proceed with system balancing.
        2) If volumes and static pressures exceed 10 percent of design, confer with the Owner’s Representative and determine if fan speeds are to be adjusted prior to any system balancing.

h. Determine and adjust outside air system design CFM for both maximum and minimum quantities.

i. Determine coil entering air temperatures:

1) Dry bulb degrees F heating and cooling.

2) Wet bulb degrees F cooling.

j. Determine leaving air temperatures from heating and cooling coils.

1) Dry bulb degrees F heating and cooling.

2) Wet bulb degrees F cooling.

k. Adjust all exhaust and return air ducts to proper design CFM.

l. If each air terminal unit has not been factory set for maximum and minimum CFM, set controllers or dials to correct CFM.

m. Test and adjust each diffuser, grille, and register served by an air terminal unit to within 10 percent of design requirements.

1) If the air terminal unit is not supplying design CFM, adjust each diffuser so the air volume out of each is determined by the "Ratio Method."

a) Identify location and area of each grille, diffuser, and register.

b) Identify and list size, type and manufacture of diffusers, grilles, registers.

c) Use the manufacturer's ratings on all equipment to make required calculations.

d) For readings and tests of diffusers, grilles, and registers, include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.

e) Adjust all diffusers, grilles, and registers to minimize drafts.

n. In cooperation with control manufacturer's representative, set automatically operated dampers to operate as indicated.

1) Check all controls for proper calibration and list all controls requiring adjustment by control installers.

o. Balance supply, return, and exhaust air to provide the designed pressure relationships to adjacent areas.

p. After all air terminal units and exhaust and return air systems are balanced, take a second set of CFM and static pressure readings at suction and discharge of each supply, return and exhaust fan.

1) If air quantities are not within plus or minus 10 percent of design, notify the Owner’s Representative.

2) The Owner’s Representative will notify the Contractor or fan supplier to adjust or replace the fan drives to obtain proper fan air quantities.

q. Adjust installed fume hood fans to CFM requirements as indicated.

1) Test fume hood enclosures to ensure face velocities comply with codes and design requirements.

K. WATER BALANCE PROCEDURE

1. Complete air balancing before commencing water balancing.
2. Specify the following procedures.

a. Use a combination of test plugs (Pete's Plugs) at pump suction and discharge connections plus flow measuring devices or additional Pete's Plugs at each piece of equipment.

1) For information on Pete's Plug II, see http://www.petesplug.com/4pagelit.pdf.

b. Open all control valves to full open position.

c. Check operation of all relief valves.

d. Examine water in system and determine if water has been treated and cleaned.

e. Check pump rotation.

f. Check expansion tanks to determine they are not air bound and system is completely full of water.

g. Check for installation and proper operation of air vents at high points of water systems.

h. Set temperature controls for all coils at maximum cooling.

1) Check for full closure of all automatic valves at coils and chiller.

2) Use a similar procedure for checking valves on hot water coils at maximum heat setting.

i. After completing coil balancing, test hot and chilled water pressures and flows at the pumps and readjust if required.

j. Adjust coil valves:

1) Use differential pressure gages and Pete's Plugs on the control valve and read the pressure drop through the coil at a flow rate for maximum cooling, and again for maximum heating.

2) Set the pressure drop across the coil to match the coil maximum flow pressure drop.

3) Adjust the flow rate through each coil in coil banks.

k. Check the following at each cooling and heating unit.

1) Inlet water temperatures

2) Leaving water temperatures

3) Pressure drop of each coil

4) Pump operating suction and discharge pressures and final total dynamic head

5) Total differential heads at pump flanges and also across the system downstream of the balancing valves

6) Water metering device readings

l. List all mechanical pump specifications.

m. Record nameplate and actual operating amperages of pump motors.

L. OPERATING TEST

1. After the systems are balanced, specify an operating test of not less than 8 hours duration to demonstrate to the satisfaction of the Owner's Representative that the systems comply with requirements of the Drawings and Specifications, and that all equipment and controls are functioning properly.

23 07 00 HVAC INSULATION

A. GENERAL

1. Specify cold piping and ductwork to be insulated and have complete vapor barrier protection.

B. DUCT

1. Thermal Insulation

a. For cold single wall sheet metal ductwork, including outside air ducts, specify the following requirements.

1) Seal duct joints air tight using a product specifically manufactured for this purpose.

2) Install adequate insulation to entirely cover the exterior of the duct.

3) Install a vapor barrier membrane to entirely cover the insulation and completely seal membrane joints.

b. To prevent possible water damage, specify exterior air duct insulation on the duct exterior covered with a moisture inhibitor acceptable to the Owner's Representative.

c. Insulate ductwork as required by service.

d. Do not specify duct liner type insulation.

2. Sound Insulation

a. For sound attenuation material installed in a ducted air path, such as inside a variable air volume terminal unit, specify the material with a Mylar air barrier.

C. EQUIPMENT

1. Specify not to insulate chilled water control valves in fan coils units.
    a. Specify valves are located over drain pans.
2. Specify the following equipment is insulated.
    a. Chiller evaporators
    b. Heat exchangers
    c. Air eliminating units

D. PIPING

1. Specify pipe insulation conform to or exceed minimum thicknesses stated in ASHRAE/IES 90.1-1989, Codified Version.
2. Specify the following systems are insulated.
    a. Refrigerant suction piping
    b. Chilled water piping, valves and accessories
    c. Condensate drain piping
    d. Heating hot water piping
    e. Steam piping
    f. Condensate return piping

23 08 00 HVAC COMMISSIONING

A. CLEANING OF NON-POTABLE WATER PIPING USED FOR AIR CONDITIONING AND HEATING

1. Specify the following procedure and requirements.
    a. Flush pipe and components with clean water until discharge from the system is clean.
    b. Maintain minimum velocities of 5 feet per second at all points in the system.
    c. Ensure flow is in the same direction as when the system is in normal operation, and that discharge is from low points of lines, ends of headers, and as otherwise required to flush the entire system.
    d. Drain or blow out residual water after flushing.
    e. Fill the system with clean water and run circulating pumps for 30 minutes, then stop the pumps and drain the system.
    f. Fill the system again with clean water and run the circulating pumps, adding 5 pounds of Tri-Sodium Phosphate for every 100 gallons of system capacity.
        1) Maintain 150 degrees F in the system.
        2) If heat not available or for cleaning cooling systems, add 6 pounds of Tri-Sodium Phosphate for every 100 gallons of system capacity.
    g. After circulating chemical cleaner within the system for 6 hours at 150 degrees F, or 12 hours at less than 90 degrees F, connect fresh water to the system and allow discharge to a drain.
        1) Keep circulating pumps running and continue flushing until discharge water is clear.
    h. Once the system water is clear, remove, clean and replace the strainers.
2. During final inspection, water samples may be taken by the Design Professional to verify the system is clean.
    a. If the system is not clean, specify the Contractor to repeat the entire process at no cost to the Owner.

B. CLEANING OF STEAM AND STEAM CONDENSATE PIPING

1. Specify the following procedure and requirements.
    a. Flush pipe and components with clean water until discharge from the system is clean.

b. Maintain minimum velocities of 5 feet per second at all points in the system.

c. Ensure flow is in the same direction as when the system is in normal operation, and that discharge is from low points of lines, ends of headers, and as otherwise required to flush the entire system.

d. Drain or blow out any residual water after flushing.

e. Use 80 to 90 psig compressed air if steam and condensate pipes are cleaned.

1) Maintain adequate airflow to obtain velocities of 5 feet per second.

f. Clean and replace strainers after completion of pipe cleaning.

C. TESTING OF NON-POTABLE WATER PIPING USED FOR AIR CONDITIONING AND HEATING

1. Specify the following procedure and requirements.

a. Test underground pipes, or pipes in chases and walls, before piping is concealed.

b. Test pipes before insulation is applied.

1) If insulation is applied before pipe testing and a leak occurs which ruins the insulation, specify damaged insulation is replaced with new insulation by the Contractor at no cost to the Owner.

c. Test pipe with 100 psig water pressure.

d. Hold test pressure for a minimum of 8 hours.

e. Test witnessed by Design Professional if requested by Owner's Representative.

D. TESTING OF STEAM PIPING AND CONDENSATE PIPING

1. Specify the following procedure and requirements.

a. Test underground pipes, or pipes in chases and walls, before piping is concealed.

b. Test pipes before insulation is applied.

1) If insulation is applied before pipe testing and a leak occurs which ruins the insulation, specify damaged insulation is replaced with new insulation by the Contractor at no cost to the Owner.

c. Test piping with water pressure at 150 percent of maximum operating pressure.

d. Hold pressure for a minimum of 2 hours.

2. Specify the test witnessed by the Design Professional if requested by the Owner's Representative.

23 09 00 HVAC INSTRUMENTATION AND CONTROL

A. GENERAL

1. See FDM Part 2/Div 25 Building Automation.pdf.

23 11 23 NATURAL GAS PIPING

A. REQUIREMENTS FOR LABORATORIES

1. Emergency Shutoff Switch

a. Provide space for Owner-furnished sign and keyed switch to stop the flow of natural gas.

1) See FDM Part2/Support for Div 21-23/HVAC Details/Lab Gas Shutoff Detail and Schematic.pdf.

b. Coordinate the switch location with the Owner's Representative.

23 20 00 HVAC PIPING AND SPECIALTIES

A. HYDRONIC

1. Specify backflow preventers where city water could be contaminated through siphoning or backpressure.

2. Specify chemical pot feeders on all hot water and chilled water systems that are independent of utility chilled water systems.

B. STEAM AND CONDENSATE

1. Specify steam trap capacity at twice the maximum rating of the anticipated load requirements.
2. Design piping to allow easy servicing of traps.
3. Locate traps a minimum of 12 inches below the outlet of the devices they serve.
4. Specify safety valves have the appropriate ASME stamp.
5. Specify steam traps from the following manufacturers.
    a. Armstrong (http://www.armstronginternational.com/steam-trapping-steam-tracing-equipment)
    b. Hoffman (http://www.hoffmanspecialty.com/HS-General-Catalog.asp#STEAM_TRAPS)
    c. Mepco (http://www.mepcollc.com/SS.htm)
    d. Spirax Sarco (http://www.spiraxsarco.com/us/navigation/prod_overview.asp?grp_ref=5&sec_ref=1)
6. Design using safety valves sized to meet state Boiler and Pressure Vessel Rules.
    a. For information on state Boiler and Pressure Vessel Rules, see paragraphs under subsection 02.05 in FDM Part 1/Section 02 Codes and Regulations.pdf.
7. Specify steam pressure-reducing valves provide a tight shut off for "dead end" service to prevent safety valve pop off.
8. Specify the capacity of the manual bypass valve at the steam pressure reducing station not to exceed the safety valve capacity.
9. For flanged steam and condensate return lines, specify gasket by The Flexitallic Group (http://www.flexitallic.com/download_brochures.html) or approved equivalent

C. REFRIGERANT

1. Specify vibration isolators in the suction and discharge lines of all refrigeration compressors.

D. AIR AND DIRT SEPARATORS

1. Specify an air and dirt separator assembly on all closed-loop hydronic piping systems.
2. Specify units sized and installed strictly following manufacturer's recommendations.
    a. Specify unit maintenance instructions furnished to the Owner.
3. Specify only combination air and dirt coalescing type assemblies from one of the following manufacturers.
    a. Armstrong DAS/DASH Series (http://www.armstrongpumps.com/)
    b. Spirotherm Spirovent VDT/VHT Series (http://www.spirotherm.com/)
    c. Taco 4900-AD Series (http://www.taco-hvac.com/)
    d. Thrush Aar-O-Vent SVR/HVR Series (http://thrushco.com/)
    e. Wessels WVA/WVA-HV Series (http://www.westank.com/)
4. Specify installation of manual air vents at the high points of all closed-loop hydronic piping systems.

23 30 00 HVAC AIR DISTRIBUTION

A. DUCTWORK

1. Show ductwork with double lines representing duct width to scale on the Drawings.
2. Specify duct material, thickness and construction.
3. Design outside air ducts subject to snow or water infiltration with drain pans piped to floor drain.
4. Specify low-pressure ductwork joints sealed with hard cast type gypsum based tape and adhesives.
5. Specify medium and high-pressure ductwork leak tested per SMACNA standards.
    a. Clearly specify the class of ductwork leakage test required for each type of ductwork.
6. For exposed galvanized sheet metal duct scheduled to be painted, specify duct furnished with an exterior surface ready to receive paint without field preparation other than normal cleaning.

7. See 23 07 00 B for insulation and vapor barrier requirements.

B. DUCT ACCESSORIES

1. Locate manual dampers at trunk duct branches.
2. Specify manual dampers with a locking type quadrant at the duct exterior.
3. Do not specify splitter type dampers.
4. Specify air blenders to mix outside air and return air to prevent stratification.
5. Specify low leakage type automatic dampers with replaceable seals.
6. Specify fire dampers have an access panel for inspection and show locations on Drawings.
7. Specify insulated and quick opening access panels.
8. Specify flexible connections not to exceed 6 inches in width.
9. Specify flexible duct only where approved by the Owner's Representative.
    a. Where approved, specify flexible duct no longer than 3 feet at any single location in the system.

C. CENTRIFUGAL FANS

1. Specify fans meet Class III standard when this class is available for the fan size involved.
2. Specify housings constructed of continuously welded steel to assure no air leakage.
3. Specify housing and bearing support constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
4. Specify fan wheels of the non-overloading backward inclined centrifugal or air foil type and as follows.
    a. Wheels statically and dynamically balanced
    b. Wheel cone and fan inlet cone carefully matched
    c. Precise running tolerances for maximum performance and operating efficiency
5. Specify turned, precision ground and polished steel shafts sized so that the first critical speed is at least 25 percent over the maximum operating speed for each pressure class.
6. Specify heavy duty grease lubricated bearings of either the self-aligning ball bearing or roller pillow block type.
    a. Specify bearings selected for a minimum B-l0 life of 200,000 hours at the specified operating condition.
7. Specify fan performance based on tests conducted in compliance with AMCA Standard 210 test code for air moving devices.
    a. Specify licensed fans that bear the AMCA Certified Ratings Seal.
8. After assembly, specify each fan is given a final balance test at the specified operating RPM to ensure smooth, vibration free operation and meet sound and vibration control requirements.
9. Specify variable frequency drives for volume control.
10. Specify fan coatings and/or explosion proof motors as required for service.

D. POWER VENTILATORS

1. Specify fan coatings and/or explosion proof motors as required for service.
2. Specify drip pans installed below power roof ventilators which do not have ductwork connected.
3. Specify drains from rooftop exhaust fans be run to the nearest roof drain, not drained onto roofing material.
4. Do not locate a discharge from an exhaust fan near a building outside air intake.

E. AIR TERMINAL UNITS

1. Specify units are pressure independent and quiet in operation.
    a. Specify and locate fan powered units to ensure quiet operation.

b. Specify the RC noise rating to not exceed RC35(N).

F. CUSTODIAL ROOM EXHAUST

1. Design a custodial room exhaust system to accommodate battery operated floor scrubber storage and recharging as required by the Building Program.
   a. Specify a 3 slot type hood approximately 32 inches long located with its bottom near scrubber height.

G. FUME HOOD EXHAUST

1. To ensure fume hood exhaust duct inside the building is under negative pressure, locate the exhaust fans on the roof.
   a. Specify the fume hood exhaust fan discharge a minimum of 10 feet above the roof.
   b. Specify an exhaust fan for each fume hood.
2. Specify utility set type fume hood exhaust fans with special lining and construction as required.
   a. Do not specify lining for fume hood exhaust ducts.
3. Specify stainless steel or other non-corrosive ductwork.
   a. Verify project requirements with the Owner's Representative.
4. For isotope fume hood ductwork specify special filters, housing, and manometer located directly above the hood as required by the Building Program and approved by the Owner's Representative.
5. For perchloric acid fume hood exhaust ducts, specify a water wash down system.

H. FUME HOOD UNITS

1. Thermo Scientific Hamilton Concept Fume Hood
   a. Specify a minimum of 80 feet per minute (FPM) face velocity with sash full open.
2. Other brand fume hood
   a. Specify a minimum of 100 FPM face velocity with sash full open.

I. REQUIREMENTS FOR LABORATORIES WITH FUME HOODS

1. Specify 8 air changes per hour (ACH) when occupied.
2. Specify 4 ACH when unoccupied.
3. Emergency Laboratory Exhaust Damper Switch
   a. Specify a manually resettable electrical switch to operate the general laboratory exhaust damper to full open position when actuated.
   b. Locate the switch adjacent to the exit door and slightly above the light switch.
   c. Provide space for an Owner furnished and installed sign mounted on the wall near the switch.

23 40 00 HVAC AIR CLEANING DEVICES

A. GENERAL

1. Design a filtration system that provides a healthy environment for the average person at a life cycle cost acceptable to the Owner's Representative.
2. Because low ventilation rates of variable air volume systems tend to concentrate contaminants, discuss VAV system design with the Owner's Representative.

B. AIR HANDLING UNITS

1. Design to allow adequate space for easy filter, coil and fan shaft replacement.
2. Design using non-freeze steam coils with 1 inch tubes.
3. Specify 1/2 inch ball valves with 3/4 inch hose connection installed on supply and return piping at coils to allow venting and drainage.

4. Specify a weatherproof type interior light at air handling units with interior mounted motors.
5. Specify variable frequency drives for volume control.
6. Design to include coil drying connections.
    a. For details, see FDM Part 2/Support Docs for Div 23/HVAC Details/Cooling Coil Drying Connections.pdf.

23 50 00 CENTRAL HEATING EQUIPMENT

A. BOILERS

1. Specify boiler package installed with all necessary accessories for operation to comply with all local, state, and federal codes.
2. Specify type of system and installation based on life cycle cost.
3. Design equipment arrangement with sufficient space and clearances for easy maintenance.
4. Specify steam safety discharges piped through an exterior wall and directed toward the ground or in the air.
5. Specify units meet or exceed minimum efficiencies required by ASHRAE 90.1-1989 codified version.

B. BOILER FEEDWATER EQUIPMENT

1. Specify water softeners and chemical feed pots.
2. Specify backflow preventers on all water lines feeding the equipment.

C. FURNACES

1. Do not specify unless approved by the Owner's Representative.

D. DUCT HEATERS

1. Do not specify unless approved by the Owner's Representative.

E. UNIT HEATERS

1. Specify units using steam or hot water.
    a. Specify gas or electric units only where steam or hot water is not available.
        1) Verify with the Owner's Representative.

F. HEAT EXCHANGERS

1. Specify check valve vacuum breakers on the shell of steam/water heat exchangers to assure free condensate drainage when the control valve closes.
2. Do not design using plate type steam-to-water heat exchangers.
3. Specify pressure vessels are stamped with the proper designation in compliance with the state Boiler and Pressure Vessel Rules.

23 60 00 CENTRAL COOLING EQUIPMENT

A. REFRIGERANT COMPRESSORS

1. For compressors with a nominal capacity of 5 tons or more, specify them equipped to control capacity using unloaders, variable speed, step control, etc.
2. For compressors placed outdoors, specify them equipped with crankcase heaters.
3. Specify compressors to have the following safety controls.
    a. Combination high and low pressure cutout
    b. Oil failure switch
4. Do not specify refrigerants R-11 or R-12.
5. Specify units meet or exceed minimum efficiencies required by ASHRAE 90.1-1989 codified version.

B. PACKAGED COMPRESSOR AND CONDENSER UNITS

1. Specify the following equipment for condensing units located outdoors.
    a. Head pressure stabilization control, either by condenser fan control or a head pressure control valve
    b. Heat tape on the condenser receiver
    c. Compressor crankcase heater
2. For compressors in condensing units, comply with guidelines in paragraphs under Section 23 60 00 A.
3. For units with nominal 10 tons of cooling capacity or less, specify the following.
    a. Capable of using a condenser air fan motor speed control device for head pressure control.
    b. Have provisions for low ambient starting when the low-pressure switch is connected at the liquid line service valve port.
4. For units with nominal 50 tons of cooling capacity or greater, specify the following.
    a. Have a discharge pressure operated damper that opens and closes to control condenser airflow.
    b. Have a timer that momentarily bypasses the low pressure switch to permit the unit to start up during low ambient conditions.
5. Do not specify Refrigerants R-11 and R-12.
6. Specify units meet or exceed minimum efficiencies required by ASHRAE 90.1-1989 codified version.

C. REFRIGERANT CONDENSERS

1. Specify air-cooled condensers have head pressure stabilization control, either by condenser fan control or a head pressure control valve.
2. Specify all condenser coils are easily accessible for cleaning.
3. Where water cooled condensers are cooled with city water, specify piping to the storm sewer.
    a. Consult with the Owner's Representative prior to design.
4. Specify water flow controlled by discharge temperature with an automatic valve.
5. Where there are multiple water-cooled condensers that normally use city water, specify the condenser water recirculated through a chilled water-condenser water heat exchanger to avoid wasting water.

D. WATER CHILLERS

1. Specify units have freeze protection on the evaporator heat exchanger.
2. See applicable guidelines in paragraphs under Sections 23 60 00 A. and 23 60 00 C.
3. Specify units meet or exceed minimum efficiencies required by ASHRAE 90.1-1989 codified version.

E. COOLING TOWERS

1. Do not locate indoors or on roofs.
2. Specify ceramic towers wherever possible.
3. Specify condenser water treatment.

23 70 00 CENTRAL HVAC EQUIPMENT

A. ENERGY RECOVERY EQUIPMENT

1. Specify use of energy recovery units when economics are based on payback acceptable to the Owner's Representative.
    a. Exercise special care if adapted to laboratory air exhaust streams because maintenance of such a system may not be possible.
    b. Submit payback information to the Owner's Representative for review prior to incorporating into the design.

23 80 00 DECENTRALIZED HVAC EQUIPMENT

A. HEAT PUMPS

1. Do not specify heat pumps unless approved by the Owner's Representative.

B. AIR COILS

1. Specify chilled water coils for air handlers have minimum 0.035 inch wall thickness copper tube, minimum 0.049 inch wall thickness bends or cast iron headers, and aluminum fins.
    a. Specify certified to ARI Standard 410.
    b. Specify design using chilled water as follows.
        1) 40 degree F entering water temperature
        2) 60 degree F leaving water temperature
2. Provide according to good construction techniques and application of coil integral drain pans and center supports.
3. For fan coil units using chilled water, specify 0.020 inch wall thickness copper tube and aluminum fins.
4. For coils in air handlers using steam or hot water, specify 0.035 inch wall thickness tube.
    a. Specify non-freeze type coils have 1 inch tube diameter and 0.035 inch wall thickness.
5. Specify all water coils provided with integral minimum 1/2 inch vent and drain extended to the outside of the housing and valved.
6. Specify cooling coils not to exhibit condensate carry over.
    a. Specify cooling coil face velocity of 500 FPM or less.
7. Specify no more than 6 rows for any single coil.
    a. If more rows are required, specify coils installed in series.
    b. Specify space is provided between coils to allow for coil repair and cleaning.
8. Specify drains for chilled water coils routed to a storm drain.

C. HEATING TERMINAL UNITS

1. For steam and hot water unit heaters, convectors, and finned tube radiation, specify the following.
    a. Coils easily accessible for cleaning
    b. Individual automatic control for each unit

D. HUMIDIFIERS

1. Specify steam grid dry bar type units with jacketed manifolds.
2. Specify steam-to-steam exchanger type packaged units, or a steam fired steam boiler serving grid type units.
    a. If a boiler is used, specify it to meet all requirements of the state Boiler and Pressure Vessel Rules.
        1) Specify softened make-up water.
    b. Do not specify building steam directly injected into the air stream.
3. Locate the unit in the air system where design conditions will allow the humidifier to work properly.

E. DEHUMIDIFIERS

1. Specify piping condensate from dehumidifiers to a storm drain.
2. Where dehumidifiers with water cooled condensers are cooled with city water, specify piping to the storm sewer.
    a. Consult with the Owner’s Representative prior to design.
3. Specify water flow controlled by discharge temperature with an automatic valve.

4. Where possible, design to cool using building chilled water instead of city water.

END OF DIVISION 23 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)