SUNY State University Construction Fund	**Directive: 23-1 Heating Ventilation & Air Conditioning** **Responsible Office: Design & Construction** **Last Revised Date: March 2022**

SUMMARY

This Directive provides the consultants with the requirements of the State University Construction Fund (SUCF) for SUNY projects. The requirements detailed within are to be implemented into the project's specifications and/or drawings. The intent is not for the specifications or drawings to reference back to this document for compliance nor is it intended to override or amend the applicable laws or codes where either is more stringent.

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Section 2 – GENERAL REQUIREMENTS

A. CAMPUS STANDARDS

1. Coordinate with Campus Standards, where conflicts between SUCF and Campus Standards are present bring to the attention of SUCF and the Campus for further discussion.

B. MECHANICAL EQUIPMENT ROOMS (MER)

1. General
   a. Centralized equipment is preferred over distributed systems to minimize maintenance and disruption. Central equipment shall have redundancy built in by utilizing multiple fans, pumps, compressors, etc.
   b. Locate all equipment in either a MER or penthouse.
      1) MER interior walls shall be CMU, abuse resistant gypsum board, or equivalent material.
   c. Provide thermostatically controlled heating and ventilation.
2. Maintenance and Accessibility
   a. Show on the plans the required clearances for code and equipment maintenance.
   b. Locate equipment, valves, and other components so they are readily accessible for service.
   c. Identify on the plans the removal path for the largest piece of equipment or component from each MER to the exterior of the building. Removal path should not require the removal of doors, walls, or other permanent building construction.
   d. Provide doors or removable panels which allow the removal of the largest piece of equipment or component from the MER to the exterior of the building.
   e. MERs and penthouses must be accessible by a standard egress stair or elevator. Ship's ladders are not acceptable.
   f. Provide provisions to remove equipment from the MER to the building's grade level. If direct elevator access is not available, provide a means to access a floor with an elevator or provide other alternate methods of removal from the building. For roof mounted equipment or equipment in a penthouse, provision for picking equipment off the roof and lowering to grade must be considered.
   g. Provide a concrete housekeeping pad for all floor mounted mechanical equipment.
      1) Pads shall be a minimum of 4" in height; and shall extend a minimum of 4" beyond the equipment footprint.

2) Pads for air handlers with cooling coils shall be of sufficient height to allow installation of a trap above the finished floor.

h. Provide curbs at least 4 inches high around floor openings for mechanical shafts and close off any unused portion of floor openings with structural infill matching the live load of the MER floor.

i. Provide a floor drain adjacent to all hydronic equipment requiring drainage. Cooling coil condensate shall be piped to floor drains in a manner that does not impede maintenance or create a hazard.

j. Provide lighting and electrical outlets as required to service mechanical equipment.

C. ENERGY METERING

1. Provide whole-building energy monitoring (natural gas, fuel oil, propane, steam, chilled water, hot water) and electrical energy monitoring (total electrical energy, HVAC systems, interior lighting, exterior lighting, and receptacle circuits) per ASHRAE 90.1.
2. Coordinate with campus and/or service provider if a particular model of meters is required. Include the capability to read both locally and remotely through the Building Management or Campus Energy Monitoring system.

D. VARIABLE FREQUENCY DRIVES (VFD)

1. Motor Requirements
   a. NEMA MMG-1 inverter duty premium efficiency rated
   b. Shaft grounding rings
2. VFD Requirements
   a. Pulse Width Modulation technology
   b. Integral line reactors or filters
   c. Integral overcurrent protective devices
   d. Bypasses
      1) Shall be provided on VFD's only serving critical loads such as life safety equipment or where shutdowns are not acceptable. Confirm with the Campus the equipment that requires a bypass.
   e. Do not place VFDs inside of equipment enclosures, they should be in a location that is accessible and maintainable.

E. SOUND & VIBRATION CONTROL

1. Design to the general guidelines below unless otherwise recommended by an acoustic consultant to achieve lower values.

Space Type	NC	Space Type	NC
Private Offices	30	Laboratories	40
Conference Rooms	30	Classrooms	30
Open Office Areas	35	Lecture Hall	30
Public Areas	40	Library	30
Theaters	25	Gyms/Natatoriums	45

   a. Refer to ASHRAE Handbooks for spaces not listed.
   b. For special situations, for example theaters, teleconferencing rooms, music practice rooms, laboratories, or art studios where large quantities of air are being delivered, an acoustic consultant should be retained to recommend both architectural and HVAC features that should be incorporated to ensure sound is controlled to acceptable levels.
   c. Sound attenuators shall be double-wall, pack-less where airstream contains moisture, dust, fumes, or other significant levels of contaminants.
2. All reciprocating and rotating equipment shall be vibration isolated.
3. Isolate all piping and ductwork within the MER; at or near connections to the equipment being isolated.
4. Provide concrete inertia bases for base mounted pumps located on any floor above grade.
5. Provide internally isolated fan/motor assemblies in all air handling units.
6. Mechanical rooms shall be designed to reduce sound and vibration transmission to any other space in the building.

F. MULTI-BUILDING HVAC PLANTS/SYSTEMS

1. Provide documented confirmation the existing central plant and the distribution system are sufficient to support the loads of the project (heating, cooling, compressed air, etc.).
2. Discuss with the Campus any operational and maintenance shutdowns of the shared services which will require the installation of standalone systems.

G. ENGINEERING DOCUMENTATION/CALCULATIONS

1. HVAC Load Calculations
   a. Submit standard reports from a Load Calculation Software indicating weather input data; heating and cooling plant peak loads; system level checksums and zone level checksums. Room level checksums are not required but shall be available upon request.
   b. Provide load calculations that estimate the building’s minimum loads for use in designing the HVAC equipment’s minimum operating load (turndown) requirement.
2. Energy Modeling & NZC/DER Reports – See Directive 1B-2 for more detail
3. Smoke Control System Design
4. Air Re-entrainment Study/Analysis - See Laboratories Section 9 for more detail
5. Geothermal Well Field Calculations -See Heat Pumps Section 8 for more detail
6. Geothermal Test Well Report - See Heat Pumps Section 8 for more detail
7. Fan Static Pressure Calculations
8. Pump Head Pressure Calculations
9. Ventilation Calculations

H. DESIGN DOCUMENTS (DRAWINGS)

1. General: Refer to the 1A Directive series for specific Phase submission requirements.
2. Enlarged Plans/Sections
   a. Provide enlarged plans of all mechanical spaces; drawn double line to 1/4” =1’-0” scale minimum; indicating all mechanical equipment, ductwork and piping.

   b. Provide a minimum of two sections (1 each direction) through each mechanical space; drawn double line to 1/4" =1'-0" scale minimum; indicating all mechanical equipment, ductwork and piping.
3. Ductwork Airflow/Riser Diagrams
   a. Provide a flow (one line) diagram for each air system (supply, return and exhaust). Indicate the following information on each flow diagram:
      1) The layout of the ductwork system up to the terminal units, including the ductwork sizes
      2) The identification and location of the air movement equipment and terminal units along with the maximum airflow rates of each.
      3) The identification and location of all automatically controlled dampers (fire, smoke, control, etc.).
4. Piping Flow/Riser Diagrams
   a. Provide a flow (one line) diagram for each piping system (hydronic, steam, steam condensate, refrigerant, etc.). Indicate the following information on each flow diagram:
      1) The complete layout of the piping system, including the pipe sizes.
      2) The identification and location of the water movement devices, heat transfer equipment and automatic control valves, along with the maximum flow rates for each.
5. Control System One Line Diagram
   a. Provide a schematic of the control system architecture. Indicate the following information on the control system one line diagram:
      1) All building network level equipment such as building controllers, routers, printers, etc. and network communications wiring connecting this equipment. Identify the communications protocol on the one line.
      2) All system/equipment level controllers and associated communications wiring on the one line. Where a controller type is typical for multiple pieces of terminal equipment (i.e., VAV box, unit heater, etc.); it may be shown once and noted as such.
6. Control Schematics
   a. Provide a control schematic for each mechanical system and each piece of mechanical equipment. Where a control schematic is typical for multiple pieces of equipment; it may be shown once and noted as such.
      1) Indicate control devices in the duct and pipe associated to the equipment; control dampers and valves, control devices/instrumentation; sensors, and wiring inputs/outputs to the building control system.
      2) Include a Points List for each mechanical system and each piece of mechanical equipment.

Section 3 – AIR HANDLING SYSTEMS

A. GENERAL

1. Centralized air handling systems are preferred and shall be one of the following types:
   a. Variable Air Volume (VAV) system with VAV terminal units.
   b. Dedicated Outdoor Air System (DOAS) with
      1) Fan coil units

    2) Induction units (Chilled Beams)
    3) Heat pumps
2. Systems should be designed in conjunction with a perimeter hydronic heating system to address building envelope skin loss and human comfort at exterior wall locations.
3. Provide airflow measuring devices at the AHU supply, return, exhaust, minimum outside air, and economizer outdoor air sections. Airflow measuring device should be capable of measuring the entire airflow range.
    a. Fan airflows shall be measured with direct measurement at the fan inlets. All other locations shall be achieved with duct mounted airflow stations.
4. Multi-zone vav systems shall incorporate Zone Level DCV with System Level Ventilation Optimization.
    a. Zone Level DCV shall be accomplished by dynamically determining the actual zone ventilation requirements using occupancy sensor and/or space CO2 sensors. If the primary air is rich with outdoor air due to economizer operation determined by a CO2 sensor located in the supply ductwork reduce zone primary airflow minimums, otherwise increase zone airflow minimums for critical zones to ensure required minimum outdoor air rate is never above the design rate.
    b. System Level Ventilation Optimization shall be accomplished by dynamically determining the required AHU outdoor air rate using the multiple space equation at the system level (ASHRAE 62.1). Zones with neither occupancy sensors nor space CO2 sensor shall be assumed to be always at design population during scheduled occupied periods.
    c. CO2 sensors shall include an Automatic Baseline Calibration feature.
5. The location of air intakes and exhaust outlets, as well as their separations shall be analyzed to assure MCNYS minimum requirements are being met. Do not locate intakes near building entrances, parking areas, bus stops, or loading zones. Select exhaust locations that minimize the potential for exhaust re-entrainment at the building intakes, operable windows, entry ways, and prevent accumulation on roof areas and at exterior gathering areas.
    a. ASHRAE Fundamentals Handbook “Airflow Around Building” analysis methodology should be used to evaluate intake and exhaust locations.
    b. An exhaust air re-entrainment study may be requested by the FUND for the following types of applications:
        1) Projects which include the potential to recirculate air with objectionable odors such as those associated with animal laboratories, vivarium, cooking, or diesel generators.
        2) Projects which include the potential to recirculate air containing hazardous chemicals, such as laboratories or hospitals.
2. Prevent entrainment of rain and snow into the supply air stream due to ingestion and accumulation at air intakes. Locate the intakes to minimize ingestion, use aluminum ductwork with provisions for drainage and other methods (i.e., snow melting) as required to prevent ingestion into the air stream.
3. Dehumidification is not required for standard applications beyond the amount achieved from the AHU cooling coil.
4. Humidification shall not be provided for standard applications unless requested by the Campus.

6. For spaces which require special temperature and humidity conditions (i.e., natatoriums, document storage, library archives, art storage, data centers, musical instrument storage, etc.) or requested by the campus the allowable temperature and humidity ranges shall be discussed and agreed upon with the campus.
   a. Separate equipment dedicated and selected for these applications shall be used. Year-round humidity control must be incorporated. Economizer cycle designs shall not be used.
   b. Provide temperature and humidity sensors of sufficient accuracy and located as required, to measure and control to the desired space levels. The sensors shall be part of a control system that allows the current room temperature and humidity to be read and provides a record of past room conditions. The control system shall alarm when room temperature or humidity fall outside of the acceptable range (adjustable).
   c. Humidification shall be provided by a separate "clean steam" system, isolated from any chemical treatment. Supply air ductwork shall be stainless steel downstream of the humidifier for the distance recommended by the humidifier manufacturer.
   d. If chilled water is available, chilled water-cooling coils shall be used to the maximum extent possible to provide dehumidification. If additional dehumidification is necessary, use other technologies as necessary for additional dehumidification. The engineer shall provide design information to justify the need for additional dehumidification beyond that available with cooling coils and to demonstrate the design will result in control of space humidity.
   e. The engineer shall work with the Architect during Concept Design phase to ensure walls, floors, and roofs, of rooms that require humidity control are designed to include a vapor barrier to prevent the passage of moisture. Doors and windows in rooms with humidity control are to be provided with thermally broken and gasketed frames.

B. AIR HANDLING UNITS (AHUs)

1. General
   a. All AHUs shall be AHRI certified, and UL listed. They shall be double wall, insulated construction, draw-thru units are preferred for most applications. Non-perforated inner walls shall be provided at cooling coil and humidifier locations.
   b. AHUs without energy recovery wheels
      1) Standard indoor modular units are preferred.
   c. AHUs with energy recovery wheels
      1) Semi-custom or custom units shall be specified as required to ensure that energy recovery wheels meet the level of quality indicated below.
   d. Exterior AHUs – **Requires FUND and campus approval** **unless included in the scope of work for the Project. Approval shall not be given unless other reasonable value engineering options have been presented to the Fund and Campus as described in the SUCF Project Cost Reporting Guide.**
      1) Units with casings heights of 7 foot or greater shall include an integral factory-built heated enclosed service isle of sufficient width to perform any required maintenance.
         a) The service isle shall be of the same construction as the AHU casing.
      2) Provide an access door at a width greater than 24" wide where required for suitable access.
      3) Provide sufficient power and lighting within the enclosure for maintenance work.

4) All ducts and piping shall be located within the footprint of the AHU roof curb when possible.

e. AHUs shall utilize hot and chilled water for heating and cooling.

f. AHUs with compressors or refrigerant coils in the airstream (i.e., packaged units). - **Requires FUND and campus approval**

g. Factory-mounted, waterproof LED fixture shall be provided in every section of the unit with maintenance access wired to a single switch.

h. A factory mounted GFCI receptacle shall be provided with every unit.

2. Casing

a. AHUs shall be double wall construction; thermally broken, 2" minimum wall thickness.

b. Access doors (24 inch wide minimum) shall be provided upstream and downstream of filters and coils to allow for coil cleaning.

c. Full width access doors shall be provided at fan sections.

3. Fans

a. Backward inclined or airfoil fans are preferred unless forward curved fans provide a significant performance advantage. Multiple fans shall be utilized wherever possible to provide redundancy.

b. Fan and drive shall be internally spring isolated on a steel base with internal flexible duct connections. External duct flexible connections shall not be used except where necessary for seismic design purposes.

4. Coils

a. General

1) Coil selection shall be optimized based on air and water pressure losses, impacts of physical size to the AHU cabinet and costs.

b. Heating Coils

1) Hydronic coils are preferred.

2) Steam Coils are not acceptable.

3) Provide freeze protection with propylene glycol based on ASHRAE 99.6% annual heating dry bulb temperature.

c. Cooling Coils

1) Hydronic coils are preferred.

2) Refrigerant coils shall be considered on a case-by-case. -**Requires FUND approval and campus approval**

3) Cooling coils shall be provided with provisions to drain down the coils for freeze protection.

4) Drain pans shall be full width and have enough depth to collect condensate at the maximum coil air velocity. Drain pans shall be stainless steel, pitched to drain, and externally insulated.

5) All coils should be designed around using no greater than 12 fins per inch and 6 rows or less.

5. Filters

   a. Provide for standard HVAC applications a ASHRAE Std. 52.2 MERV 8 rated pleated, cartridge or panel filter upstream of a MERV 13 box filter.
   b. Provide differential pressure gauges across each filter bank with the ability to display readings locally and alarm the BMS.
   c. Require specified equipment filters to be installed during all AHU operation (including construction and testing) and replaced prior to turning the facility over to the Campus.
   d. Include a spare set of each filter type used; to be turned over to the Campus.
6. Dampers
   a. Outdoor air dampers shall be gasketed, opposed blade type to minimize leakage, prevent blockage and permit volume control.
7. Energy Recovery Devices
   a. Air-to-Air Heat Pipe, Plate, and Rotary Heat Exchangers shall be AHRI 1060 or 1061 certified
   b. Energy Recovery Wheels
      1) Wheels manufacturer shall include a standard factory warranty of 10 years on parts and labor.
      2) Bearings shall be frame mounted pillow block type with grease fitting(s).
      3) Perimeter and cross seals shall be multi-pass labyrinth type (brush seals not acceptable).
      4) Rotor media shall be aluminum with a 3 or 4 angstrom molecular sieve desiccant.
      5) A bypass damper for economizer.
      6) Purge section or other method of preventing cross contamination of the air streams.
      7) Provide controls to prevent frosting.
      8) Examples of manufactures who can meet the above requirements, it is not intended to limit specifications to solely these: Thermotech, Innergytech, Semco
8. Controls
   a. Units shall be fully controlled by the Building Management System (BMS), using BMS sensors and system controllers. Stand-alone, unitary, integrated, or other AHU manufacturer provided controls are not acceptable.
   b. Face and bypass dampers shall not be used for temperature control.
   c. Economizer dampers shall be controlled by enthalpy (not dry bulb).
   d. Temperature control shall be by modulating control valves.
   e. Minimum outdoor ventilation rates shall be maintained by the airflow measuring devices.

C. TERMINAL UNITS

1. VAV Boxes shall include an integral.
   a. Airflow measuring device that communicates to the BMS.
   b. Reheat coil with access doors upstream and downstream for maintenance.
   c. Discharge air temperature sensor to allow for supply temperature control.
   d. Sound attenuator where required to meet space NC levels.
2. Fan Coil Units
   a. Fan coil units shall be standard height; low profile or "lowboy" units shall not be used. Units shall be a blow thru configuration to minimize noise.
   b. Fan coils units shall be selected to provide design airflows with the fan speed set to "low" to minimize noise transmission.

   c. Fan coil units shall include a drain pan piped to an acceptable point of discharge inside the building along with auxiliary and secondary drainage. Drip trays are not acceptable.
3. Induction (chilled) beams
   a. Induction beams shall have separate coils for heating and cooling.
   b. Induction beams shall be active type only; passive beams shall not be used.
   c. Induction beams shall be designed for sensible and latent cooling. Non-condensing operation is not acceptable.
   d. Induction beams shall include a drain pan piped to an acceptable point of discharge inside the building along with auxiliary and secondary drainage. Drip trays are not acceptable.

Section 4 – DUCTWORK SYSTEMS

A. GENERAL

1. All ductwork shall be designed for a maximum pressure drop of 0.08" w.c. per 100 ft.
2. Design fully ducted supply and exhaust systems.
3. Return plenums if utilized require ducted return(s) within 90 feet of the most remote space.
4. All ducts shall be Leakage Class 4.
5. Ductwork designed to operate at pressures greater than 3" w.g. shall be leakage tested per ASHRAE 90.1.
6. All ducts shall be routed within the conditioned envelope.
   a. Any ducts proposed to be outside the building envelope. - **Requires FUND and campus approval**
      1) All ducts routed outside the building envelope shall be factory prefabricated with welded seams; double wall, stainless steel, or aluminum, with flanged or mechanically coupled waterproof connections.
7. Ductwork shall be protected from any contamination during transportation to the site, when stored on site and once installed but not yet in use.
8. HVAC systems new or existing in operation shall be protected in accordance with control measures detailed in "SMACNA IAQ guidelines for occupied buildings under construction".

B. RIGID DUCTWORK

1. Galvanized ductwork shall be G90.
2. The Pressure Class of ducts shall be specified to a minimum 2" W.G or higher as necessary to meet the design.
3. Ducts shall be specified to the maximum fan external static pressure (ESP) for AHU's and for the total static pressure (TSP) of other fans.
4. To prevent a failure of the ductwork during a deadhead condition all ducts between the discharge of a fan and an automatically operated damper (control, fire, smoke) shall be designed for the maximum fan TSP.

C. FLEXIBLE DUCTWORK

1. Flexible ductwork is permitted at the connection to diffusers, lengths shall be limited to 3-foot fully stretched, installed with no more than 15% compression, and shall have elbow ductwork supports.
2. Flexible ducts shall be vapor barrier jacketed, insulated, and have a continuous inner core that shields the fiberglass insulation. Core shall be manufactured from a durable material that will not collect moisture or degrade in the air stream.

D. FITTINGS, JOINTS & SEAMS

1. Rectangular ductwork
   a. Longitudinal seams shall be made with a Pittsburgh Lock (Type L-1).
   b. Transverse joints for ductwork rated 3" W.G. and greater shall be made with Ductmate, Ward, or Nexus connections.
2. Round and oval ductwork
   a. Specify spiral seam ducts which comply with SMACNA standards.
   b. Draw band and crimp type transverse joints (RT-3 and RT-5 respectively) shall not be permitted.
   c. Pleated, adjustable, and mitered elbows shall not be permitted. Segmented elbows shall be specified with a minimum of five segments.

E. BRANCHES

1. All branch duct takeoffs shall be made with 45° entry fittings; splitter dampers and extractors are not allowed.
2. Volume dampers are required at each supply, return, and exhaust air sub main, branch main, and branch takeoff. The requirement for the dampers must be shown on the floor plans and in the specifications.

F. INSULATION

1. Plenum and duct lining shall not be used, except in the low velocity connection downstream of the VAV box where design analysis shows a sound attenuator alone cannot meet the required sound level. Lining shall be installed per SMACNA.
2. Rectangular ductwork insulation shall be externally applied rigid board fiberglass or fiberglass duct wrap with a factory applied, reinforced aluminum foil vapor barrier anchored and sealed at all points.
3. Round and oval ductwork insulation shall be externally applied fiberglass duct wrap with factory applied reinforced aluminum foil vapor barrier secured to ductwork per manufacturer's installation instructions.
4. Duct wrap insulation shall have a 1.5 lb. per cubic foot density and rigid board insulation shall have a 3 lb. per cubic foot density.
5. Insulation is not required on the exterior of exposed ductwork in constantly conditioned spaces.
6. Mechanical room rectangular ductwork insulation shall be rigid board fiberglass.

G. DEVICES/SPECIALTIES

1. Access doors shall be provided upstream of all in-duct-mounted equipment (fire/smoke dampers, coils, fans). Ceilings shall be marked to identify the location of this equipment.

Section 5 – PIPING SYSTEMS

A. GENERAL

1. Connections
   a. Branch connections shall be made with tee fittings (mechanically extracted collars not acceptable). Weld-o-lets and thread-o-lets are acceptable for steel branch connections 2 or more sizes smaller than the main. Holes for weld-o-lets and thread-o-lets shall be machined (torch cutting not acceptable).
   b. Make connections to equipment using unions or flanges to allow removal of piping for equipment servicing.
2. Valves
   a. Provide shut-off valves at all branch connections, with exception of runouts to a single piece of equipment or coil.
   b. Provide shut-off valves as required to isolate floors and floor areas for local repairs; without need to shut down the entire building system.
3. Where multiple pipes penetrate the roof, enclose in a premanufactured pipe curb with graduated boot pipe penetration systems in lieu of horizontal penetrations with pitch pockets in the roof membrane.

B. HYDRONIC SYSTEMS (≤250°F)

1. General
   a. Two pipe changeover systems shall NOT be used; provide independent heating and cooling piping systems; and specify 4 pipe terminal heating and cooling equipment.
   b. Chilled and hot water temperature reset controls that automatically reset supply water temperature based on building load or outdoor air temperature shall be provided.
   c. Water treatment shall be provided on all systems (hot water, chilled water, condenser water). Manual systems shall be used on closed systems. Automatic systems shall be used on open systems.
2. Pumps
   a. Pumping systems shall be either primary/secondary decoupled type with dedicated primary pumps and variable speed secondary pumps; or variable primary systems with provisions made to maintain minimum flows through generating equipment as required.
   b. Pumping systems shall use a differential pressure bypass valve to control maximum pressure and provide minimum pump flow. The differential pressure transmitter shall be located at the most hydraulically remote flow demand.
   c. Pumping systems shall include redundancy such that the design provides 100% capacity in the event of a single pump failure.
3. Valves

   a. Ball valves are preferred for hydronic piping 2” and less; butterfly valves are preferred for piping 2.5” and larger. Valves and flanges shall be Class 150.
   b. Control valves shall be characterized ball or globe type; controlled by a sensor tied into the temperature controls system. Self-regulating control valves shall not be used.
4. Specialties
   a. Expansion tanks shall be full acceptance, floor mounted bladder type with a specified pre-charge pressure listed.
   b. Air separators shall include a strainer and automatic air vent; located at the point of lowest solubility, with full line size pipe connections.
   c. Provide manual air vents at all high points in the system and drains at all low points.
   d. Provide an RPZ backflow preventer to protect make up water supply to hydronic systems.
   e. Provide a separate calibrated flow control valve and shutoff valve for all branch and pump circuits.
   f. Provide strainers upstream of all terminal units and control valves.
   g. Provide vent and drain for all hydronic coils.
5. Glycol
   a. Provide a separate glycol piping loop (including heat exchanger and pumps) for air handling units with heating coils.
   b. Where air handling units are located remotely from each other; provide individual glycol systems (including heat exchangers and pumps) locally in each mechanical room or penthouse.
6. Piping Specifications
   a. General: where more than one material is indicated for a given application; either or both may be specified at consultants’ discretion.
   b. Chilled Water and Hot Water (<250°F); Located Indoors
      1) 2” and Smaller:
         a) Copper; Type L, Drawn, ASTM B88 with Copper fittings and soldered joints.
      2) 2” and Smaller:
         a) Steel, Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106; with steel fittings and threaded joints.
      3) 2.5” and Larger:
         a) Steel, Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106, with steel fittings and welded joints.
      4) Insulation: Fiberglass will all service jacket and PVC fitting covers. Provide vapor barrier for chilled water service insulation.
      5) Option: Copper and steel piping in mechanical spaces ONLY (with adequate drainage) may utilize grooved joints.
   c. Chilled Water and Hot Water (<250°F); Located in Tunnel
      1) All sizes:
         a) Steel, Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106; with steel fittings and welded joints.
      2) Insulation: Mineral wool with field applied metal jacket.

d. Chilled Water and Hot Water (<250°F); Direct Buried
    1) All sizes:
        a) Copper, Type L, Drawn, ASTM B88 with Copper fittings and brazed joints.
        b) Steel, Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106; with steel fittings and welded joints.
    2) Insulation: Factory pre-insulated with polyurethane foam and HDPE jacket.

e. Condenser Water; Located Indoors or In Tunnel
    1) 2" and Smaller:
        a) Copper; Type L, Drawn, ASTM B88 with Copper fittings and soldered joints.
        b) Steel; Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106, with steel fittings and threaded joints.
    2) 2.5" and Larger:
        a) Steel; Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
    3) All Sizes:
        a) PVC; Schedule 40; Pressure Pipe, ASTM D1785 with PVC fittings and solvent welded joints.
    4) Insulation: Not required.
    5) Option: Copper and Steel piping in mechanical spaces ONLY (with adequate drainage) may utilize grooved joints.

f. Condenser Water; Direct Buried
    1) All Sizes:
        a) Steel; Schedule 40, Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
        b) PVC; Schedule 40; Pressure Pipe, ASTM D1785 with PVC fittings and solvent welded joints.
    2) Insulation:
        a) Steel piping shall be factory pre-insulated with polyurethane foam and HDPE jacket.
        b) Insulation not required for PVC piping.

g. Cooling Coil Condensate
    1) All Sizes:
        a) Copper Type DWV, ASTM B306, soldered joints, Copper or Copper Alloy fittings.
        b) PVC Schedule 40, Type DWV, ASTM D2665 or D 2949, PVC fittings, with solvent welded joints.
    2) Insulation:
        a) Fiberglass with all service jacket and vapor barrier
        b) Elastomeric

C. LOW PRESSURE STEAM & CONDENSATE (≤15 PSIG)

1. Valves
    a. Gate valves shall be used for shut-off duty and globe valves shall be used for throttling duty. Valves and flanges shall be Class 150.

b. Control valves shall be characterized ball or globe type; controlled by a sensor tied into the temperature controls system. Self-regulating control valves shall not be used.
c. If pressure reducing valves are necessary, provide parallel valves sized for 1/3 and 2/3 of the load where capacities are 10,000 lbs./hr. and greater, or where the variance between maximum and minimum load is 10 to 1, or greater.
d. Noise level from pressure reducing valve stations, either single or parallel, shall not exceed 70 dBA five (5) feet away from the valves with the specified piping insulation installed. Use sound attenuation blankets to reduce levels.

2. Piping Specifications
   a. Low Pressure Steam; Indoors
      1) 2” and Smaller:
         a) Steel, Schedule 40; Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and threaded joints.
      2) 2.5” and Larger:
         a) Steel, Schedule 40; Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
      3) Insulation: Fiberglass with all service jacket and PVC fitting covers.
   b. Low Pressure Steam; Located in Tunnel
      1) All Sizes:
         a) Steel, Schedule 40; Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
      2) Insulation: Mineral wool with field applied metal jacket.
   c. Low Pressure Steam; Direct Buried
      1) All Sizes:
         a) Steel, Schedule 40; Grade A or B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
      2) Insulation: Factory pre-insulated with polyisocyanurate foam and HDPE jacket.
      3) Refer to website for Direct Bury Piping systems specifications. It is the intent of the Fund that this specification will be inserted into the Project Manual. Any modification to this specification **requires FUND approval**.

D. HIGH PRESSURE STEAM & CONDENSATE (≥16 PSIG)

1. Valves/Flanges
   a. Valve and flange ratings shall be Class 300 for High Pressure Steam & Condensate.
   b. Flanges shall be weld neck type; slip on or threaded flanges are not acceptable.
   c. Gaskets shall be 304 stainless steels, spirally wound, with graphite filler.
   d. Valves shall be ASTM 216 Grade WCB with replaceable seats and trim.
   e. High performance butterfly valves (triple offset) are preferred; but gate valves may be used with Campus approval.
   f. Where gate valves are used and a positive shutoff is required (equipment connections; drains, vents, etc.); two valves shall be installed in series.
   g. Pneumatic actuators are preferred for High Pressure Steam control valves; but electric actuators may be used with Campus approval. Valves shall fail to the closed position.

h. Control valves may be located on the supply or return side of equipment per Campus preference.
   1) Where control valves are installed in supply piping; a check valve shall be included in the return piping.
i. Where control valves are installed in return piping; a two-way safety shutoff control valve shall be included in the supply piping. This is to provide protection in the event of a tube failure.
j. If pressure reducing valves are necessary, provide parallel valves sized for 1/3 and 2/3 of the load where capacities are 10,000 lbs./hr. and greater, or where the variance between maximum and minimum load is 10 to 1, or greater.
k. Noise level from pressure reducing valve stations, either single or parallel, shall not exceed 70 dBA five (5) feet away from the valves with the specified piping insulation installed. Use sound attenuation blankets to reduce levels.

2. Piping Specifications
   a. High Pressure Steam & Condensate (≥16 PSIG); Located Indoors or In Tunnel
      1) All Sizes:
         a) Steel; Grade B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints. Schedule 40 for Steam and Schedule 80 for Condensate.
      2) Insulation: Mineral wool with field installed metal jacket.
   b. High Pressure Steam & Condensate (≥15 PSIG); Direct Buried
      1) All Sizes:
         a) Steel; Grade B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints. Schedule 40 for Steam and Schedule 80 for Condensate.
      2) Insulation: Factory Pre-Insulated Class A conduit system with mineral wool or aerogel on the carrier pipe; polyurethane on the conduit; and HDPE jacket.
      3) Refer to the SUCF website for Direct Bury Piping systems specifications. It is the intent of the Fund that this specification will be inserted into the Project Manual. Any modification to this specification **requires FUND approval.**
3. Third party testing (Operating pressures of 125 psig or greater)
   a. The Consultant shall retain the services of an independent testing agency to perform non-destructive testing and inspections of all welds. The scope of the testing agency shall include at a minimum the following.
      1) Visually inspect all pipe welds after the final weld pass.
      2) Radiographically inspect all pipe welds on piping located indoors and in walk-in tunnels.
      3) Radiographically inspect 10% of the pipe welds on direct buried piping within manholes and box tunnels.
         a) Any unacceptable defects encountered during the radiographic examination shall be repaired at no additional cost to the Owner. All repairs will be re-inspected. In addition, if any weld joints of the first 10% of the total are found unacceptable, a second 10% of the total pipe welds will be selected by the Owner for radiographic examination. The additional examination shall continue until a full block of 10% of the selected weld joints is found acceptable at the first testing of the joint. All costs

associated with retesting failed welds and testing of additional welds because of failed welds will be the responsibility of the Contractor.

4. Welds that are unable to be examined by radiographic examination shall have a surface examination utilizing magnetic particle for ferrous piping and liquid penetration examination for non-ferrous piping.
   a. Air pressure test HDPE jackets and field joints on direct buried piping systems.
5. A copy of all testing and inspection records (reports, photos, films, etc.) shall be turned over to the Fund.

E. MEDIUM (≥250°F) AND HIGH TEMPERATURE WATER (≥350°F)

1. General
   a. Medium temperature water systems shall be designed for a minimum of 300°F at 300 PSIG unless the campus has more stringent operating parameters. High temperature water systems shall be designed for a minimum of 400°F at 400 PSIG unless the campus has more stringent operating parameters. These operating conditions shall be reflected in pipe stress analysis, insulation thicknesses, and thermal expansion calculations.
   b. Connections to heat exchangers shall be made such that the heating fluid (Medium or High Temperature Water) is on the tube side.
   c. Piping systems shall be chemically cleaned after installation. Design shall include equipment bypasses with provisions for cleaning and flushing.
   d. Welding qualifications and inspection acceptance criteria shall be ASME B31.1.
2. Valves/Flanges
   a. Valve and flange ratings shall be Class 150 for Medium Temperature Water and Class 300 for High Temperature Water.
   b. Flanges shall be weld neck type; slip on or threaded flanges are not acceptable.
   c. Gaskets shall be 304 stainless steel, spirally wound, with graphite filler.
   d. Valves shall be ASTM 216 Grade WCB with replaceable seats and trim.
   e. High performance butterfly valves (triple offset) are preferred; but gate valves may be used with Campus approval.
   f. Where gate valves are used and a positive shutoff is required (equipment connections; drains, vents, etc.); two valves shall be installed in series.
   g. Pneumatic actuators are preferred for Medium and High Temperature Water control valves; but electric actuators may be used with Campus approval. Valves shall fail to the closed position.
   h. Control valves serving heating loads that will vary widely shall be configured in a 1/3 - 2/3 arrangement to allow for accurate load tracking.
   i. Control valves may be located on the supply or return side of equipment per Campus preference.
      1) Where control valves are installed in supply piping; a check valve shall be included in the return piping.
      2) Where control valves are installed in return piping; a two-way safety shutoff control valve shall be included in the supply piping. This is to provide protection in the event of a tube failure.

3. Specialties
   a. Provide a strainer with blowdown upstream of all heat exchangers and control valves.
   b. Provide a balancing valve in the return piping from heat exchangers and equipment.
   c. Provide a thermometer and pressure gauge in the supply and return piping connections to heat exchangers and equipment.
4. Piping Specifications
   a. Medium and High Temperature Water; Located Indoors or In Tunnel
      1) All Sizes:
         a) Steel, Schedule 40; Grade B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
      2) Insulation: Mineral wool with field installed metal jacket.
   b. Medium and High Temperature Water; Direct Buried
      1) All Sizes:
         a) Steel, Schedule 40; Grade B, ASTM A53 (E or S) or ASTM A106 with steel fittings and welded joints.
      2) Insulation: Factory Pre-Insulated Class A conduit system with mineral wool on the carrier pipe; polyurethane on the conduit; and HDPE jacket.
      3) Refer to the SUCF website for Direct Bury Piping systems specifications. It is the intent of the Fund that this specification will be inserted into the Project Manual. Any modification to this specification **requires FUND approval.**
5. Third party testing
   a. The Consultant shall retain the services of an independent testing agency to perform non-destructive testing and inspections of all welds. The scope of the testing agency shall include at a minimum the following.
      1) Visually inspect all pipe welds after the final weld pass.
      2) Radiographically inspect all pipe welds on piping located indoors and in walk-in tunnels.
      3) Radiographically inspect 10% of the pipe welds on direct buried piping within manholes and box tunnels.
         a) Any unacceptable defects encountered during the radiographic examination shall be repaired at no additional cost to the Owner. All repairs will be re-inspected. In addition, if any weld joints of the first 10% of the total are found unacceptable, a second 10% of the total pipe welds will be selected by the Owner for radiographic examination. The additional examination shall continue until a full block of 10% of the selected weld joints is found acceptable at the first testing of the joint. All costs associated with retesting failed welds and testing of additional welds because of failed welds will be the responsibility of the Contractor.
6. Welds that are unable to be examined by radiographic examination shall have a surface examination utilizing magnetic particle for ferrous piping and liquid penetration examination for non-ferrous piping.
7. A copy of all testing and inspection records (reports, photos, films, etc.) shall be turned over to the Fund.

F. GROUND SOURCE HEAT PUMPS

1. Piping Specifications
   a. Ground Source Heat Pump Exterior Piping
      1) Polyethylene (PE) pipe, CSA B137.1, ASTM D2737, ASTM D3035, ASTM F714 with ASTM D2683 Socket type heat fusion, ASTM D3261 butt-type heat fusion or ASTM F1055 electrofusion-type PE fittings.

G. REFRIGERANT PIPING

1. General
   a. Refrigerant piping shall be fully designed and shown on the plans, including size, routing, and number of lines, installation, and trap details. Refrigerant piping lengths shown on the plans need to be verified with all manufacturers listed in the specification.
2. Piping Specifications
   a. Refrigerant Piping; Located Indoors or Outdoors
      1) All Sizes: Copper, Type ACR, Drawn, ASTM D280, with copper fittings and brazed joints.
      2) Insulation: Flexible Elastomeric, with field installed PVC jacket with UV protection or UV protective coating for piping installed outdoors.

Section 6 – BOILERS (Emergency or Specialty)

A. GENERAL

1. New fossil fuel boilers are prohibited, see Directive 1B-2. Installation of new fossil fuel boilers **requires FUND approval** and shall be solely for emergency, or specialty processes.
2. Specified boiler type **requires FUND and Campus approval**.
3. Multiple boilers shall be provided to maximize efficiencies, match loads, and minimize short cycling. Provide N+1 redundancy.
4. Water treatment specified should be coordinated by the consultant with campus to be consistent with existing treatment utilized.

B. REGULATORY

1. No boiler shall be operated until an internal and external inspection has been made for the New York State Department of Labor Code; Rules 4 and 14.
2. Boilers shall be supplied with access ladders, platforms, and catwalks to permit inspection per New York State Department of Labor Code; Rules 4 and 14. Factory supplied components, if available, shall be provided. Confirm with the campus if any additional equipment for inspection is required beyond code minimums.
3. Burner designs (new and retrofit) shall comply with the New York State Department of Environmental Conservation Regulation 6 NYCRR Part 227.
4. See Directive 1D-8 “NYS and EPA Permitting Requirements for Air Contamination Sources” for boiler permitting information.

C. HYDRONIC BOILERS

1. Specify condensing boilers

a. Design water temperature should be selected to maximize efficiencies.
b. Return fluid temperature change across the boiler shall be 20°F - 40°F.
c. Supply an acid neutralization system for condensate.

D. FUEL/BURNERS

1. Natural gas fuel trains shall comply with GE GAP Global guidelines, GAP.4.1.0 and GAP.4.1.3 (These guidelines replace IRI {Industrial Risk Insurers} requirements).
2. Utilize modulating burners to maximize efficiencies, load match and minimize short cycling.
3. Boiler burners and fuel feed controls shall have a local, lockable means of electrical disconnect as required by ASME CSD-1.
4. Boiler emergency shutdown for boilers with a fuel input of 12,500,000 Btu/hr. or less, shall be provided by a manually operated, remote shutdown switch(es) located at the boiler room personnel access door(s).
   a. Activation of the emergency shutdown switch shall immediately shut off the fuel or energy supply to all boilers in the boiler room as required by ASME CSD-1. Use NFPA 85 for boilers with a fuel input greater than 12,500,000 Btu/hr.

E. COMBUSTION AIR & VENTING

1. Combustion air shall be ducted directly from the outdoors; and may be PVC, CPVC, galvanized steel or as recommended by the manufacturer.
2. Exhaust vents shall be factory built double wall stainless steel, UL1738 listed and labeled for Category IV appliances, and shall include a means to drain flue gas condensate.

F. CONTROLS

1. For new boiler installations and burner/boiler controls replacements on existing boilers, provide a burner control and boiler operation control system to maximize operating efficiency and assure safe operations of the boiler system.
2. Specify a master controller to manage and optimize boiler plants which include multiple boilers.

Section 7 – CHILLERS

A. GENERAL

1. Existing centralized chilled water systems are the preferred source of cooling. Confirm systems' available capacity prior to incorporating into the design.
2. The choice of building water-cooled versus air-cooled chilled water systems should be evaluated using life cycle costs.
3. When dedicated outdoor air systems are incorporated into a project for ventilation air, air-cooled systems are preferred because of their operational characteristics.
4. Chilled water systems shall be designed using a 12°F to 16°F temperature differential across the chiller and the coils.
5. The location of cooling towers, and air-cooled condensers shall consider noise, appearance, and exposure to mist plume.

6. Water treatment specified should be coordinated by the consultant with campus to be consistent with existing treatment utilized.

B. COMPRESSORS

1. Chillers shall be selected to maximize efficiency while providing capacity control down to 15% through multiple and or variable speed compressors, and refrigerant circuits. Hot gas bypass shall not be used.
2. Oil free compressors are preferred.
3. Compressor anti-short cycling control shall be provided.

C. AIR COOLED CHILLERS

1. The preferred method for air-cooled systems is to use air-cooled condensers with indoor compressors and evaporators for maintenance ease, longevity and to avoid glycol use.
2. Systems that have water components installed outdoors must use propylene glycol. Draining of chiller systems and heat tracing piping should not be counted on as freeze protection.

D. WATER COOLED CHILLERS

1. Cooling towers, or closed-circuit coolers shall have their drains, overflows, and blowdown piping indirectly connected to the buildings sanitary drainage system. Indirect connections to the sanitary within the building shall be in a room that also has a floor drain installed. Using the storm drainage system and/or roof drain system shall be prohibited.

E. CONTROLS

1. Specify chillers with factory integral controls that are connected to the BMS.
2. For multiple chiller configurations specify a chiller plant control system to manage and optimize the operation of the entire plant including pumps, and heat rejection equipment.

Section 8 – HEAT PUMPS

A. GENERAL

1. General
    a. Heat pumps are preferred to be located centrally in a mechanical equipment room and not distributed throughout the building. If decentralized heat pumps are desired discuss with the FUND and Campus the reasons and advantages for the decentralized approach.
    b. Heat pumps that generate both hot and chilled water are preferred.
    c. Heat pumps shall include multiple compressors in an N+1 arrangement for redundancy and highest efficiency at part load conditions. Heat pump with refrigerant coils in the airstream (i.e., packaged units) shall not be used unless **approved by the Fund**.
    d. Heat pumps shall be capable of simultaneous heating and cooling operation; and shall be capable of recovering energy from the cooling process to be used for heating.
    e. Heat pumps that isolate the ground loop fluid (glycol); from the building loop fluid (water) are preferred (6 pipe design). Where these fluids are not isolated; a separate heat exchanger shall be included.
    f. Heat pump systems are to be capable of and configured for variable flow.

g. Where site constraints do not allow for a well field of sufficient size to meet the entire heating and cooling demands cooling towers, fluid coolers and/or boilers, alternative heat source are to be incorporated. The arrangement of the auxiliary equipment shall not inject energy into the well field.

B. WATER SOURCE - RESERVED

C. AIR SOURCE - RESERVED

1. Variable refrigerant flow (VRF) systems shall be the type which distribute water and not refrigerant to the terminal units. The system shall be selected to operate down to a design day, if it is not capable another means shall be provided to maintain heating and/or cooling.

D. GROUND SOURCE

1. Design Parameters
    a. Preliminary sizing estimation of well field shall assume well depths of 499 ft spaced 20 ft on center with a 2.5 ton/well capacity until a detailed calculation is completed utilizing the data from the test wells.
    b. The well field ground loops are to be
        1) A closed vertical bore design.
        2) Designed with a fluid flow rates between 2.0 and 3.0 gpm/ton.
        3) Configured in a reverse return piping arrangement.
        4) Designed for ground loop return temperatures
            a) During cooling of 20°F to 30°F above undisturbed ground temperature
            b) During heating of 8°F to 15°F below undisturbed ground temperature
        5) The depth of the wells shall not exceed 499 feet.
        6) Sized to account for short-term (monthly and annual) and long-term (minimum 30 years) variations in the well field ground temperatures.
2. Design Procedure
    a. The following steps shall be followed in Ground Source Heat Pump design:
        1) Calculate peak zone cooling and heating loads and estimate off-peak loads.
        2) Estimate annual heat rejection into and absorption from loop field to account for potential ground temperature change.
        3) Select preliminary loop operating temperatures and flow rates to begin optimization of first cost and efficiency.
        4) Correct heat pump performance at rated conditions to actual conditions.
        5) Select heat pumps to meet cooling and heating loads, and locate units to minimize duct cost, fan power and noise.
        6) Arrange heat pumps into ground loop circuits to minimize system cost, pump energy and electrical demand.
        7) Conduct site survey to determine ground thermal properties and drilling conditions.
        8) Determine and evaluate possible loop field arrangements that optimum for building and site.
        9) Determine optimum ground heat exchanger dimensions with software.

   10) Iterate to determine optimum operating temperatures, flows, loop field arrangement, depth, bores, grout/fill materials, etc.
3. Calculation Software
   a. Software performing calculations shall:
      1) Utilize hourly climatic data.
      2) Account for peak, monthly and annual energy rejected and extracted.
      3) Account for daily variations in occupancy, lighting, and miscellaneous equipment power, and building thermal setpoints.
      4) Account for thermal mass effects.
      5) Account for the specific capacity and efficiency of specified manufacturers equipment including part load performance curves.
      6) Account for long-term ground storage thermal storage effects.
      7) Allow specific modeling of the ground heat exchanger configuration.
      8) Modeled for a minimum of a 30-year period
   b. Examples of acceptable software for well field design:
      1) Gaia Geothermal; GLHEPRO; Trace 700; Wrightsoft.
4. Test well
   a. Test well is to be drilled to a depth of 499 feet unless site conditions discovered during drilling prevent it.
   b. Select a location of the test well so that it can be used as part of the final well field. If there are to be multiple well fields in vastly different locations provide a test well at each location.
   c. Thermal tests are to be performed as required per ASHRAE RP-1118.
      1) Test should operate for 36 to 48 hours with a heat rate of 15 to 25 W/ft of bore.
      2) Flow rates should be sufficient to provide a differential loop temperature of 6°F to 12°F.
5. Design Documentation
   a. Submit as part of the Design Manual phase the following information for the Funds review:
      1) The results from the test well; indicating the undisturbed ground temperature, ground conductivity, etc.
      2) The well depth and spacing calculations and the field loop layout showing the anticipated number of wells.
      3) The modeling report for the well field over a 30-year time duration; indicating the monthly heat exchanged, monthly minimum and maximum field leaving water temperatures; monthly well field temperatures, and graph of time vs. well field temperature indicating seasonal swings.
      4) Identify any unusual subsurface conditions and assess their impact on well field installation, constructability, cost, and other risks associated with subsurface conditions.
   b. The Construction Document phase submission shall include on the drawings or the specifications the following information but not limited to.
      1) Heat Pump performance at actual conditions
      2) Design operating conditions: entering and leaving ground loop temperatures, return air temperatures, airflow, and liquid flow rates.
      3) Design operating conditions; entering leaving fluid temperatures and flow rates.

4) Bore depth, bore diameter, bore spacing and grout/fill specifications.
5) Piping material specifications, visual inspection and testing requirements.
6) Pipe header and well field layout with pipe sizing.
7) Casing allowance regardless of the test well findings.
8) Submit final design load calculations separately.

Section 9 – LABORATORIES

A. GENERAL

1. Design a Pressure Independent Variable Volume system that satisfies the airflow demand of the fume hoods, room minimum air change rates (ACH) and HVAC loads.
   a. When airflow quantities are dictated by the cooling loads consider decoupling portions of the load from the airside system using fan coil units, or inductions units (chilled beams).
2. Perform a risk and hazard assessment of operations in laboratories to determine the appropriate room air change rates during occupied and unoccupied periods.
   a. Lab ventilation shall be sufficient to maintain harmful contaminants below their threshold limit value (TLV-TWA).
   b. Provide a minimum of 6 ACH during a laboratory's occupied periods and a minimum of 2 ACH during unoccupied periods unless the risk and hazard assessment concludes higher ACH are necessary.
   c. Design air change rates are to be discussed and agreed upon by the Campus Environmental Health and Safety Office.
3. Standby power for laboratory ventilation systems is not required by code, except for specific locations of code defined Higher Education Laboratories. Confirm with the campus the requirements for optional- standby power for laboratory systems including utilities, laboratory exhaust fans, make-up air units, environmental rooms, refrigerators, space heating/cooling, laboratory plug loads and other systems which the campus has requested.
4. Confirm with the campus requirements for redundancy in building utilities such as space heating, space cooling, laboratory exhaust systems, make-up air units, etc. Facilities conducting research are expected to have a higher concern for redundancy than facilities performing primarily teaching activities.
5. See Section 2 "General Requirements" for noise control criteria in laboratories.
   a. Sound attenuators are acceptable though not preferred. When used, sound attenuators must be constructed the same materials as the ducts, be suitable for the intended uses and be pack-less.

B. AIR RE-ENTRAINMENT ANAYLSIS

1. To assess the impacts of the exhaust airflow on the project building and surrounding buildings an airflow re-entrainment study using either computational fluid dynamics modeling and or physical (wind tunnel) modeling will be required for laboratory projects.
   a. Select exhaust locations that minimize the potential for exhaust re-entrainment at the building intakes, operable windows, entryways, and prevent accumulation on roof areas and at exterior gathering areas.

b. The laboratory fan(s) performance shall be assessed by the airflow modeling consultant based on a fan selection from the laboratory exhaust system designer.

C. PRESSURIZATION CONTROLS

1. Provide the ability to switch the ventilation in a space to and from occupied/unoccupied mode independent of the buildings occupied/unoccupied status with room occupancy and fume hood sash position sensors. The space shall be considered unoccupied if the occupancy sensors for a predetermined set amount of time do not sense occupancy and the sash position sensors detect all the hoods are closed. If people are sensed in the space or any of the hoods are open it shall remain or switch to the occupied mode.
2. Volumetric offset shall be used for space pressurization control to maintain the laboratory slightly negative to corridors and adjacent non-laboratory spaces. Offset shall be a minimum of 100 cfm. The maximum transfer air through a door undercut shall be limited to 100 cfm.

D. SUPPLY SYSTEM

1. Provide non-aspirating supply diffusers separated to the greatest extent possible from the fume hood. Disturbance velocities caused by supply diffusers should not exceed 20% of the hood face velocity.
2. Utilize airflow control devices with a maximum required operating static pressure of 0.3" W.G.

E. EXHAUST SYSTEM

1. General
    a. The fume hood exhaust system can be either independent or it can be combined with the general laboratory exhaust system.
2. Utilize airflow control devices with a maximum required operating static pressure of 0.3" W.G.
3. Energy recovery
    a. Exhaust air from fume hoods, storage cabinets or rooms shall utilize energy recovery equipment with zero cross contamination potential.
    b. General laboratory exhaust which is independent of fume hood, storage cabinet or room exhaust air may utilize an energy recovery wheel.
    c. Exhaust airstream shall be at a negative pressure relative to the outside airstream.
    d. For runaround coil loop system and fixed plate air-to-air heat exchanger provide coils and heat exchanger of appropriate material or with appropriate coating for the application.
    e. Either external or internal bypasses are required for outside air and exhaust airstreams for a fixed plate air-to-air heat exchanger allowing for inspection and maintenance of heat exchanger while maintaining system operation.
4. Exhaust Fans
    a. Utilize a laboratory exhaust fan with integral pressure-controlled bypass.
    b. Fans shall be AMCA Type B spark resistant and constructed of materials or coated with corrosion resistant materials suitable for the application.
    c. Locate fans outside the building at the point of final discharge. Fans shall be the last element of the system so that all ductwork within the building is under negative pressure.
    d. Provide an N+1 arrangement for fans.

   e. Equip fans with variable frequency drives to provide soft start and aid in smooth transitioning in lead/lag changeover and starting or stopping fans. Variable frequency drives are not to be used for capacity control to meet varying exhaust demands. They are only to be used to gradually bring up fans to the respective constant speed operation.
   f. Discharge stack shall be directed vertically upwards.
5. Ductwork
   a. Utilize the materials listed below for ductwork connected to the following types of hoods, unless it is determined it is not appropriate for the chemicals being utilized.
      1) Standard chemical fume hoods - Type 316L Stainless Steel with welded joints for all horizontal ductwork until it transitions to a riser where it can transition to G90 galvanized
         a) Manifolded exhaust ductwork may transition to G90 galvanized steel downstream of a general exhaust connection.
      2) Radioisotope fume hoods - Type 316L Stainless Steel with welded joints.
      3) Perchloric Acid fume hoods - Type 316L Stainless Steel with welded joints or Type 1 uPVC (unplasticized polyvinyl chloride).
      4) Acid Digestion fume hoods - Type 1 uPVC unless a higher level of acid resistance is necessary which will dictate the use of PVDC (polyvinylidene chloride).
   b. Round ductwork for exhaust systems is to be used to the greatest extent possible.
   c. Exhaust ductwork connected to fume hoods; storage cabinets/rooms should be labeled to differentiate it from other exhausts systems.

F. FUME HOODS

1. Acceptable fume hood types are constant volume, variable volume, or high performance. Provide explanation/justification for each constant volume hood used.
2. Unacceptable fume hood types are auxiliary make-up air hoods and ductless fume hoods.
3. Design face velocity for standard fume hoods shall be a minimum of 60 feet per minute based upon a releasable sash stop position of 18 inches.
   a. Design face velocities are to be discussed and agreed upon by the Campus Environmental Health and Safety Office.
4. Confirm with the campus if any of the following special-purpose hoods are required: Radioisotope Hoods, Perchloric Acid Hoods, Acid Digestion Hoods, or others.
   a. Perchloric Acid Hoods - Follow the specific code requirements in the section labeled “Perchloric Acid Hoods” in NFPA 45.
   b. Radioisotope hood shall meet the requirements listed in Scientific Equipment and Furniture Association Recommended Practices (SEFA)-1 Laboratory Fume Hoods. High efficiency particulate air (HEPA) and/or charcoal filters may be needed in the exhaust system. These filters should be contained within a bag in bag out filtration system.
   c. Acid digestion hood shall be designed and rated for the application.
5. Special-purpose hoods shall be completely independent from all other exhaust systems.
6. Fume hood airflow monitor shall include digital face velocity display with audible and visual alarm, manual alarm silence, and contact for remote alarm notification. Flow alarm shall occur when face velocity falls below 80% of design face velocity.

7. Fume hoods shall be field tested per ASHRAE Standard 110 “Method of Testing Performance Laboratory Fume Hoods” Velocity Measurement and Smoke Visualization tests.
   a. Testing shall be done in the field for 100% of standard fume hoods with design face velocity less than 100 feet per minute and for 25% of hoods with the minimum design face velocities of 100 feet per minute. The standard hoods to be tested will be selected during construction.
   b. For special-purpose hoods field testing shall be done on 100% of the hoods.
   c. Successfully passing the containment performance testing will be achieved with the control level for 5-minute average tests at each location of 0.10 ppm or less for “as installed” (AI) when conducted at a generation rate of 4L/m.

G. SPECIALTY LABORATORIES

1. Animal laboratories and housing: Animal labs and housing shall be designed in accordance with the latest edition of the:
   a. National Resource Council’s, “Guide for the Care and Use of Laboratory Animals.”
2. Other Specialty labs: For labs with specialized equipment (NMRs or other large equipment with special spatial, structural, mechanical, and electrical needs) that will be provided by the campus, provide clear documentation of the equipment used as the basis of design. Since the purchase of equipment will most likely occur after construction of the lab begins, review contingencies with the campus during design for addressing the impact (if any) of purchasing equipment that is different from the models used as the basis for design.

Section 10 – CENTRAL PLANTS -RESERVED