MIT
Design Standards

DIVISION 23 —— HVAC

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Department of Facilities

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1. MIT HVAC SYSTEM GOALS

It is the intent of the HVAC these design standards to provide guidance for consultants and contractors to follow, and to stimulate discussions, questions, and exchange of information. Present ideas for HVAC design innovations which reduce cost and maintenance and improve safety and sustainability.

Presume an operating life of 40 years. In cases where access is difficult, longer lasting equipment is appropriate.

Provide easy access for maintenance, repair, replacement and day-to-day operations of equipment.

Provide an acceptable level of air quality and comfort, minimize energy use, and be manufactured of materials that are safe for the environment.

Design teams are expected to review project requirements with any existing master planning, in particular differences between new building systems and existing building systems. Systems presented in this document are suggested and should be tailored to meet specific project requirements.

1.1 List of Common HVAC Design Issues

1. Coordinate with all trades including but not be limited to the following:

    a. Confirm that systems will fit and provides appropriate capacities.
    b. Confirm that make-up water is supplied to humidifiers, cooling towers, closed systems, and similar systems.
    c. Confirm that electrical power is supplied to HVAC equipment that requires power including:

        1) Appropriate electrical power voltage and phase are supplied and listed correctly in HVAC and electrical schedules.
        2) Disconnects are provided, fused or otherwise, as appropriate to HVAC equipment.
        3) Emergency power or optional standby power as appropriate

2. Confirm required plumbing system components are supplied to HVAC equipment including:

        1) Appropriate plumbing devices are supplied and listed correctly in HVAC and plumbing schedules.

        2) Provide piping and isolation shut-off valves with unions or flanges at all equipment connections arrange piping to allow removal of equipment without dismantling piping.

3) Flow balancing control valves cannot be used as isolation shut-off valves.
4) Appropriate drains are provided.
5) Make-up water connections required.
6) Condensate drains are directed to the storm system not sanitary drainage.
7) Gas service is provided where required.
8) Auxiliary contacts are supplied for MIT Building Automation Systems control interfaces.

3. Confirm projects documents and comments are received and reviewed from all consultants and sub-consultants.
4. Provide a complete code review confirming all required provisions including, but not limited to:

a. Fire dampers, smoke dampers, smoke detectors, etc.
b. Hi-rise/smoke proof enclosures.
c. Elevator and stairwell pressurization.
d. Atria including requirements for exhausting atria.
e. Electrical rooms including any ductwork or piping conflicts.
f. Hazardous Exhaust (Fume Hoods) including:

1) Ducts must remain inside defined fire zone or laboratory unit.
2) A fire-rated dedicated shaft to roof is provided.

g. Sprinklers are provided above CPVC ducts and at tops of duct shafts. No sprinkler heads may be provided inside fume hood exhaust ductwork.
h. Grease/commercial kitchen exhaust.
i. Laundry facility dryer exhaust (dormitories).
j. Ventilation.
k. Energy Code and if applicable, the Stretch Energy Code.
l. Elevator cooling and venting.

5. Undertake a complete review of engineering calculations and assumptions including but not limited to the following:

a. Outside air/ventilation.
b. Steam.
c. Chilled water.
d. Power demand.
e. Campus medium temperature hot water demand (if applicable)
f. Required Engineering Documents in Division 01 – General Requirements

6. Review MEP space layouts and service access including:

a. Shaft space.

b. Mechanical/electrical rooms and penthouses.
c. Areas with large ductwork.
d. Public spaces.
e. Ceiling spaces and wall cavities.
f. IS&T rooms including space necessary to locate cooling equipment outside but adjacent to the room.
g. Service and Code mandated clearances.
h. Valve, damper, cleanout access.
i. Provide guardrails or enclosures around equipment and paths with proper fall restraint to equipment when 4 feet or more above roof decks or when roof decks as a whole do not meet OSHA fall protection with parapet walls or perimeter rail systems.

7. Undertake a complete review of control sequences conforming with controls section included on this document required for new equipment including:

   a. "Safeties" including freeze protection.
   b. Smoke control and smoke evacuation.
   c. Fume hood exhaust sequences for air side balance.
   d. Smoke dampers and actuation including integration with fire alarm systems.
   e. Interface with MIT Building Automation Systems.
   f. Alarm points.
   g. Interface with pneumatic and electric actuation. Use pneumatic actuation only where absolutely necessary because of harsh environments, (proximity to very hot steam piping) speed of response (fast opening or closing) or force requirements.

8. Undertake a complete review of riser and flow diagrams including:

   a. Air flow diagrams.
   b. Chilled water system.
   c. Steam systems and hot water systems flow diagrams and valve locations.

9. Verify new equipment is accessible and provides adequate clearance for maintenance. This includes drains, power supplies and all components which must be accessed for preventive maintenance or repair. If lifts are required for maintenance there must be a clear pathway to move them into position and a flat location available so they can be deployed for maintenance. In some cases hoisting beams may be required within air handlers or mounted to structure above other equipment to allow for the use of chain falls. In some areas hatches may be necessary to remove and replace equipment if no other access is available.
10. Verify utilities and infrastructure including:

   a. Chilled water systems:

      1) Appropriate building pump station capacity and differential pressure are

available. See section 3.4 for additional guidance.

2) Appropriate pump operation schedule and sequence.
3) Differential pressure without pumps. Evaluate possible energy savings and opportunities to improve system operation.
4) Confirm a check valve bypass assembly is between the suction and discharge sides of automated pump stations.

b. Steam systems:

1) Be certain that year-round steam sources are available for hot water reheat systems and central station air handling systems.
2) Confirm operating pressures and temperatures.
3) Building perimeter steam heating systems may be low cycled off above a certain outdoor temperature.

c. Heating hot water systems:

1) Operating temperatures including reset schedules based on outside temperature.
2) Operating schedules.
3) Capacities.

d. Ventilation systems:

1) Operating schedules.
2) Capacities for expansion.

e. Fume hood supply and exhaust air handling systems:

1) Fume hood types and requirements.
2) Capacities for expansion.

f. Compressed air system for temperature controls:

1) Operating pressure.
2) Capacity.

11. Undertake a complete review of compliance and design within MIT departments including:

a. Equipment will be appropriately labeled and nomenclature conforms to MIT standards including:

1) Pipe and duct identification.
2) Equipment identification.

3) Valve tags.

b. Systems engineering: Automatic temperature controls.

c. Central utilities (see Division 33000 for additional guidance.
   1) Utility operations.
   2) Utility metering (includes building level consumption of power, chilled water, campus steam, and campus heating hot water).

d. SEMO and insurance underwriter.
e. The Industrial Hygiene Office within EHS.
f. Repair and Maintenance or CSG as appropriate.
g. Facility Information Systems.
h. Department, Lab, or Center client team.

1.2 MEP Equipment Naming Standards

Comply with the MEP Equipment Naming Standard in Division 22 - Plumbing, Par 4.3.

2. DESIGN REVIEW REQUIREMENTS

The Design Consultant is responsible for filling out, and submitting this information at each phase of design as a guide for review by MIT Facilities. The following sections outline the items which are to be submitted at each phase of the design process. If project phases are consolidated, for example skipping DD phase, then the requirements are submitted in the earlier phase (SD in this example).

2.1 Schematic Design (SD) Phase

MIT will use this submittal to develop comprehensive cost scoping for project budget development. In addition to information noted below, the documents shall include statements of conditions, known and unknown, that could affect project cost (i.e. This portion of the ceiling is extremely tight and may require relocation of some existing services, etc.)

It is the intent of MIT that these documents identify areas of cost implication that the contractor can use to identify scope and cost that can be tracked through future phases of development.

Provide the following information in the Schematic Design submittal:

1. Review of applicable code, regulations, and standards.

2. State applicable codes on the cover drawing.

3. Verify energy code compliance and provide supporting calculations.

4. Specifications/schedules of performance, for pricing and installation of components.

5. Identify major equipment with physical sizes shown on drawings.
6. Space requirements, architectural and related building systems coordination including:
    a. Major shaft sizes and locations.
    b. Louver sizes and locations.
    c. Mechanical room block layouts and services.
7. Alternative design concepts.
8. Equipment cut sheets for proposed manufacturers.
9. Incorporation of pre-design contingencies, design charrettes, and owner's program requirements.
10. System descriptions (Basis of Design) which must include:
    a. Preliminary drawings (layout and riser diagrams).
    b. Lab Equipment lists or schedules available at the time.
    c. Full description of each system and the project requirements that are satisfied by these systems.
    d. Intended Control sequences including system diagrams.
    e. Include any additional information that can form the basis of inspection and test acceptance criteria.
11. Outline specifications.
12. Statement of probable costs contingency areas, (vendor/contractor/site issues, should be identified).
13. Submit preliminary calculations for:
    a. Cooling loads.
    b. Heating loads.
    c. Ventilation loads.
    d. Air system pressure drop and flow.
    e. Chilled water and steam.

f. Hydronic system pressure drop and flow.
g. Outside air.
h. Supply air.
i. Annual load profiles

14. Systems considered include:

    a. All air.
    b. Combination systems.
    c. Types of heating systems.
    d. Energy recovery options.
    e. Written narrative of systems proposed.

15. Obtain approval of design comfort level (heating and cooling operating standards) from MIT Systems Engineer.
16. Energy Analysis: A thorough energy analysis of the complete HVAC system including associated electricity, chilled water, and steam utilities is required for all projects. For large capital projects and major renovations MIT retains a specialty consultant to study sustainability and energy performance. For smaller scale projects the MEP Design Engineer is expected to use MIT's "Energy and Emissions Impact Calculator" to estimate the net change in energy and GHG performance. See "Sustainability " thematic folder elsewhere in the Standards. System recommendations must be submitted to MIT and their Energy/Sustainability consultants for review prior to design development drawings.

17. The proposed ventilation air change rate and other aspects of the ventilation system must be reviewed with MIT Systems Engineer, Project Management, and EHS during the schematic design phase.

2.2 Design Development (DD) Phase

1. Finalize system selection.
2. Equipment schedules and sizes.
3. Agree on basis of design and acceptable manufacturers.
4. Finalize space requirements, architectural and related building systems coordination including:

    a. Major shaft sizes and locations.
    b. Louver sizes and locations.
    c. Mechanical room block layouts and services.

5. Flow diagrams of major air and water systems including quantities and sizes.
6. Control sequences/descriptions including diagrams.
7. Verification of energy code compliance.
8. Bound copy of updated engineering calculations.

9. Bound copy of specifications unless otherwise indicated in Division 01.

2.3 90% Construction Documents and Construction Documents (CD) Phase

1. General:
    a. List of changes and deviations from Design Development.
    b. Drawing List and Specifications Table of Contents.
    c. Drawings coordinated with project specifications.
    d. Drawings marked for Progress, GMP, Bid or Construction.
    e. Final drawings (prints) sealed and embossed per State requirements.
    f. All HVAC components shown on the drawings.
    g. Existing and new work clearly labeled and easily identifiable.

2. Calculations:
    a. Complete calculations for pumps, fans etc. including the following:
        1. Flow rates, pressures, and consumption rates.
        2. Pressure drop calculations which align with pipe and ductwork sizes and fittings indicated on the floor plans. Include pressure drop for control valves, isolation valves, dampers, louvers, equipment and similar items as indicated on the schedules.
        3. Marked up floor plans associated with the pressure drop calculations included as a diagram.
    b. Cooling and heating load calculations associated with scheduled equipment.
    c. Pipe expansion and anchor load calculations.

3. Flow Diagrams:
    a. Diagrams depict engineering of all the HVAC air and water system.
    b. Arrangement of equipment is similar to actual conditions in a schematic format.
    c. All major equipment shown, identified and coordinated with scheduled sheets.
    d. Airflows show room by room balance and room totals against flow shown on air handling units and fans.

4. Floor Plans:
    a. Ductwork and piping sizes as well as fittings indicated on plans which align with pressure drop calculations.
    b. Control valves and major isolation valves indicated on plans.
    c. Drawings shall include complete chilled water, steam or hot water systems to HVAC equipment.
    d. Drawings shall include complete ductwork system drawings including supply, exhaust, return, and specialty exhaust from the distribution point to the air entry/exit point.

e. All areas heated, ventilated or air conditioned as required.
f. Supply, return and exhaust air balance.
g. Location of thermostats, humidistats, duct smoke detectors, CO_2 sensors and firestats.
h. Access provided where needed including:

    1) Controls (including all field devices such as air flow measuring stations, etc)
    2) Coils.
    3) Fans.
    4) Dampers.
    5) Valves.
    6) Filters.
    7) Cleanouts.

i. Heat trace is indicated where necessary and coordinated with electrical drawings In some applications optional standby power may be appropriate. Critical heat trace applications must be alarmed for loss of power and low temperature.
j. Labels indicated on all ductwork, piping, equipment etc.
k. Confirmation that pipes will fit into the available space and do not interfere with ducts, lights, or structural members. Take into account any piping that is required to be sloped for coordination with other trades. Coordination should include runouts to room terminal units. Routing to conform to accepted design practices.
l. Piping system to have adequate expansion loops and anchors. Locations and sizes should be detailed on plans.
m. Confirmation that ductwork will fit into the available space and does not interfere with piping, lights, or structural members. Routing to conform to accepted design practices and minimize system pressure drop. Space coordination should also account for any duct sloping requirements (grease exhaust etc.).
n. Architectural door schedule coordinated with the HVAC plans. Door schedule to indicate doors requiring ventilation openings with adequate undercut or louvered free area. If doors do not have undercuts/louvers transfer ducts should be provided as needed.
o. HVAC drawings to include all room names and numbers and column numbers.
p. Air outlets are indicated and do not interfere with lights or other devices.
q. Coordination of headroom available for ceiling hung units such as unit heaters with architectural plans.
r. Fire dampers, smoke dampers, and fire-smoke dampers clearly shown in accordance with relevant codes and ordinances, floor-by-floor where required. Access doors are provided and coordinated with fire alarm drawings.
s. Sound traps have been provided to meet required sound attenuation as required to meet the project acoustical requirements.
t. Volume dampers located.

5. Mechanical Equipment Rooms Plans:

    a. Equipment locations and layout allows for access and maintenance, coil removal, heat exchanger (steam-water converters) tube bundle pulls, damper, valves, controls, future equipment replacement etc.
    b. Floor drain locations are coordinated with plumbing plans for coils and plenums.
    c. Pumps:

        1) Drains and vents are properly located.
        2) Flexible connections, vibration isolation, and sound isolation connections are indicated where needed (expansion joints, equipment on isolators).

    d. Piping unions at unit, thermometer wells, pressure gauges, trap drainage, and traps on cooling coil condensate drains.
    e. Outside air intake and exhaust opening sizes including:
        1) Proper velocity to prevent snow carryover.
        2) Height above ground and recessed from building wall to prevent snow intrusion.
        3) Plenums should be drained.

    f. Building service connections coordinate with HVAC equipment.
    g. Freeze protection has been provided for cooling coils, cooling tower sump, etc.
    h. Adequate combustion air openings have been provided for boiler rooms, boilers, hot water heaters and other fuel burning equipment.
    i. Flue sizes and heights are properly sized for adequate draft and suitable discharge considering the effect of adjacent building.
    j. Insulate ductwork between fans and condensate areas.
    k. Ceiling clearances in adjacent areas have been coordinated with the architect for duct connection between mechanical rooms and floors served.
    l. Provide at least one section of each mechanical room.
    m. Control dampers are indicated on plans.
    n. Mechanical rooms are properly ventilated.

6. Schedules:
    a. Schedules to be project specific. Notes provided on schedules should align with information in project specifications.
    b. Electrical data is complete and coordinated with electrical department and electrical engineering including coordination of all emergency and standby power requirements.
    c. All equipment is scheduled, properly labeled and coordinated with the floor plans.
    d. Scheduled data for major equipment including AHUs, pumps, chillers, expansion tanks, etc. align with the load calculations and static pressure calculations.
    e. Verify equipment pressure ratings are adequate for the static height of each building.
    f. Acoustical information provided for review by an acoustical consultant. Acoustical

review should be completed prior to CD issue.

g. Air devices selected for appropriate airflow, pressure drop, noise level, throw and neck velocity.

7. Standard Details:

    a. Provide details that only apply to each specific project.
    b. Provide details which are customized for each specific project.
    c. Provide custom AHU are details with components, dimensions, plans, and elevations.
    d. Details to be properly cross referenced on detail sheet and plans.
    e. Equipment hook-ups to be detailed but not dimensioned.

8. Controls:

    a. Confirm electrical control requirements coordinated with other departments and disciplines included but not limited to fire alarm and BMS.
    b. Confirm equipment is covered under a sequence of operation.
    c. Confirm system operations for start-up, shutdown, summer, winter, and intermediate seasons.
    d. Review needs of special equipment, dampers, heaters, and etc.
    e. Review control points for adequate control and monitoring.
    f. Confirm control points are defined and adjustable.

2.4 Shop Drawing Phase

HVAC design documents must include a requirement for HVAC contractors to provide information regarding refrigerant quantities and types in the systems they install. This requirement will enable MIT to maintain a database of refrigerant types and quantities on campus in order to support compliance with environmental regulations. If portions of systems come from the manufacturer in a pre-charged condition, the contractor must include those quantities as well as the amount (in pounds) added to the completed system before operation. The refrigerant type shall be noted. This shall be a required submittal.

2.5 Record Drawing Phase

Record drawings must be high-quality, easily-readable, produced by carefully and accurately revising the Contract Documents to show clearly deviations from the original Contract Drawings, precise location of each item of work, and field changes. Record Drawings must be submitted to and approved by MIT as a prerequisite to final payment. Please refer to the thematic folder "BIM/CAD Standards" elsewhere in the MIT Design Standards.

3. HVAC SYSTEMS DESIGN STRATEGIES

3.1 MIT Facilities Drawings and Standard Details

MIT CAD Documents
MIT may have CAD documents, depending on the project location and scope, of facility related information and standard details, which may be of value to the designer for integration into project Construction Documents. To determine the availability of these documents, contact MIT's Facility Information Systems (FIS) group through the MIT Project Manager. The designer shall be responsible for determining the usability and appropriateness of MIT documents to a particular project.

3.2 MEP Equipment Naming Standards

Design drawings should include equipment designations in their schedules and plan views which are unique and do not duplicate existing equipment. Contact the MIT Systems Engineering Group to determine which equipment names are available.

Equipment names should conform to the following standard:
XXX_XXXXXX

Examples:
Building 76, Air Handling Unit 12A would be:
M76_AHU12A

Buildings which have no letter prefix assigned in the MIT naming convention (Buildings 1, 2, 3, etc.) will be preceded with an "M".

Building E17 , Chilled Water Pump 2 would be:
E17_CHWPMP02

Note that system, equipment, and number are combined as one text string.
The following is the standardized list of system, equipment, and other abbreviations:

Air Handling Unit	AHU
Exhaust Air Handling Unit	EAHU
Exhaust Fan	EF
Return Fan	RF
Pump	PMP
Air Cooled Condensing Unit	ACCU
Heat Exchanger	HX
Heating Converter (shell and tube)	CV
Chilled Water	CHW

Process Chilled Cooling Water	PCHW
Hot Water	HW
Condenser Water	CND
Domestic Hot Water	DHW
Domestic Cold Water	DCW
Supply	S
Return	R
Temperature	TEMP
Pressure	PRESS
Flow	FLOW

For example, Domestic Hot Water Return Temperature in Building 2 would be:
M02_DHWRTEMP

3.3 Design Criteria for HVAC Systems

Temperature Standards
Basic comfort temperature standards are 70 deg F for heating and 74 deg F for cooling. Specific uses and applications may require different comfort guidelines. Proposed design temperature and humidity must be agreed upon by the project design team early in the design phase.

Critical Environments:

When designing air systems for critical environments, (such as vivaria, and other places where stable controlled humidity is critical) follow ASHRAE 99.6% guidelines or better for outdoor heating conditions and 0.4% or better dehumidification peak loads - 0.4% dehumidification dewpoint with mean coincident drybulb (MCDB) condition.

1. Heating:
    a. Outside Temperature: 8 deg F
2. Cooling:
    a. Outside Dewpoint Temperature: 73 deg F.
    b. Outside MCDB Temperature: 81 deg F.

Typical Environments:

For typical office environments, follow ASHRAE 99.0% guidelines or better for outdoor heating conditions and 1% or better dehumidification peak loads - 1% dehumidification dewpoint with Mean Coincident Dry Bulb (MCDB) condition.

1. Heating:

    a. Outside Temperature: 13 deg F.

2. Cooling:

    a. Outside Dewpoint Temperature: 72 deg F.
    b. Outside MCDB Temperature: 79 deg F.

Campus Chilled Water

Design around a winter peak chilled water supply temperature of 50 deg F. During summer, the CUP will strive to deliver chilled water at 42 deg F utilizing mechanical cooling. The following wet bulb and dry bulb conditions are the control points utilized for chilled water reset:

Wet Bulb		Outside Air Temperature	Chilled Water Supply Temperature
Less than 42 F		Does not control	50 F or less
42 F to 55 F		Does not control	45 F or less
Above 55 F	OR	Higher than 70 F	42 F or less

For critical applications, use a summer chilled water design supply temperature of 43 deg F or higher.

Ventilation Air

Ventilation rates should be maintained within acceptable parameters established by ASHRAE 62.1 and building codes. For dense occupancies within office environments (conference rooms, meeting rooms) space CO_2 sensing and VAV box override may be an effective control strategy. For laboratory applications, refer to section 3.12 below.

3.4 Design Strategies for Ventilation Systems

Ventilation rates should be maintained within acceptable parameters established by ASHRAE 62.1 and building codes. For non-laboratory spaces care should be given to reduce the number of zones controlling to the heating set-point minimum in the summer months. This is a common undesirable occurrence caused by excessive VAV minimum airflow rates that are overcooling the zone first, and then requiring reheat to maintain zone set point minimum flow capacity. This constitutes simultaneous cooling and heating. By allowing the control systems to decrease the VAV flows sufficiently below the current design-minimum limits, the zones will start controlling to their cooling temperature set-points and reheat will not be required in the summer months. As an example, sequences for exterior VAV zones without perimeter radiation should include reheat coils and require modulating the discharge air temperature set-point before increasing the air volume to meet the heating set-point.

VAV boxes may operate below their flow-sensing point when there is no demand as long as CO_2 rates remain below 800 ppm. Since controls cannot measure these low flows, system cannot modulate at low flows and so the box tends to operate more as 2-position rather than modulating control in this region. For dense occupancies spaces such as conference and meeting rooms, VAV with reheat coils and space CO_2 override is an effective control strategy. For laboratory applications, refer to section 3.13 below.

3.5 Design Strategies for Areas without Active Mechanical Ventilation Systems

There are a number of buildings and areas on campus without active ventilation systems. Some systems have older, inoperable components, both moving and static; other areas were never provided with mechanical ventilation systems because they were not required.

1. Recommendations:
    a. A workable approach for renovating spaces without active ventilation should be reviewed with the project manager and facility engineer during the schematic phase of design to price out alternative solutions as appropriate
    b. Spaces with operable windows may no longer technically comply with code ventilation requirements without mechanical ventilation systems. Installing small total heat recovery ventilators has been an effective strategy for specific locations.
2. Often when a ventilation system is included for this reason, it is extended to serve additional or future spaces on campus:
    a. This strategy should be reviewed with project team and presented as alternates in pricing.
    b. this strategy should be presented and reviewed prior to the schematic phase of the project.

3.6 Design Strategies for Chilled Water Piping Systems

Various arrangements of chilled water systems within MIT buildings:

1. No pumps (Building E14 as an example).
2. One or more pumps and no check valve bypass (Buildings 3, 5, and 10 for example).
3. One or more pumps and a check valve bypass (E60, Building 13 for example).
4. Pumps, when present, are usually controlled to make a constant differential pressure available from pump discharge to building return (across the building loads).
5. Some pumps in a multiple pump station may be constant speed “backup” pumps intended to only run during repairs to the controlled pump(s).
6. Some buildings, especially on the East Campus, may only have control valves at the building entrance which are controlled to make a constant differential pressure available for the

building loads.

7. Some buildings have control valves at the building entrance and pumps to boost differential when necessary. These are a product of history and the control valves are not operable in some cases (Building 37 for example) or they may still be part of the published sequence of pressure control in the building (Building 35 for example). Whether they are truly active or not should be challenged.

Many buildings on campus have chilled water pumping stations with two or three pumps. These pumps are in parallel with each other and in series with plant pumps. These pumps may also be in parallel with other pumping stations in the same building that provide service to other buildings (Building 13 for example). If a pump station is required to provide differential to a campus building, the station must include a bypass line from suction to discharge with a check valve. This allows water to flow past the pump station when there is adequate differential for the building with the pumps off. Without this bypass, the water must flow through the pump body which causes a loss of available differential pressure. Also, when transitioning to pump minimum speed (15 hz), there is a large increase in the differential available to the building as the pumps go from being a restriction to assisting with flow.

If chilled water pumps are required, they must be fitted with VFD’s for controllability. The campus chilled water distribution system at times can have low differential as a result of heavy demand. Building pumps can adversely affect campus return pressures if operated inappropriately or not equipped with check valve bypasses. Campus practice has been to enable the building pumps, only when absolutely necessary, to provide adequate differential for the building load. This must be accomplished by using the balancing process to measure the actual differential required at the point of differential pressure sensing to achieve design flow through the building. Buildings which are closer to the chilled water plant will have a higher differential pressure available than those buildings which are further away. When designing a chilled water distribution system for an existing or new building verify with MIT Systems Engineer and the Utilities Group if there is a true need for a building pumping station at the project location. It is important to make this determination early in the design process, preferably before schematic design is started.

Most loads on the chilled water system can be adequately served by the differential available from the central plant and additional pumps are unnecessary. Always design new systems with low pressure drop in mind.

Whenever a secondary loop is used (either with a heat exchanger or a bleed-in valve and recirc pump) it is beneficial to elevate the loop temperature as much as practically possible. This increases the return water temperature to the CUP and helps campus delta T. Applications include process cooling, chilled beams and valence units. Future consideration should be given to fan coil and air handler circuits.

Generally, chilled water distribution piping within buildings shall be sized for an average pressure drop of 1.5 feet of head per 100 feet of pipe. Where applicable, design and size the piping distribution systems with consideration for future expansion.

Properly selected pressure independent flow control valves with fixed upper limits shall be used to prevent excess flow during times of strong or rapidly increasing pressure differentials. As a result, these valves keep the whole building delta T from being eroded by excess flow through coils and heat exchangers. Use of this valve type shall be reviewed with the MIT Systems Engineer. This type of valve eliminates the need for balancing valve at the individual piece of equipment, as manufacturer's literature advises against using a separate balancing valve with these products.

Typically, strainers shall be provided at water pumps. Do not provide strainers at terminal equipment

Automatic air vents can be beneficial for system start-up. The installation must include an isolation ball valve and contractors must be instructed to close the isolation valve after system start-up. The auto air vent should be installed at an elbow and the piping extended to a fitting "looking down" with a hose bib and chained cap. The cap shall be heavy brass rated for 75 psig.

At start-up (during cleaning and flushing) systems shall be filled using city water.

A cleaning solution should be circulated through the piping to remove debris and mill scale. The cleaning solution should be provided by the same company that provides water treatment services for the MIT heating hot water system in that building. R&M personnel assigned to that building can provide the contact information.

General Procedure - Circulate the cleaning solution with the control valves fully open. Flush with fresh water and take water sample(s) to prove the cleaning solution is adequately removed from the piping system. Then drain the system and remove the baskets from each strainer. You can then fill the chilled water with water from the building system. Be sure to coordinate this step with the building's R&M supervisor as they need to communicate with the CUP. The reason for this is that the chilled water filling the system will seem like a "leak" to the CUP if that's where the water will be made up from.

3.7 Design Strategies for Steam and Hot Water Systems

MIT does not use steam as the perimeter heating medium for newer buildings due to limited controllability. For new buildings or fully renovated buildings, hot water heating systems are used as the heating distribution in the building, including the AHU's. Steam should be used at AHU's only in small renovations and replacement in kind projects. Other process loads such as autoclaves always require steam. The type of system to be provided should be reviewed with the MIT Systems Engineer early in the design. Hot water heating systems should be selected at the lowest temperature possible, and enabled to operate at the lowest temperature necessary based on outdoor air temperature. We have been able to reduce the peak design heating water temperature to 140 degrees F in recent projects.

Steam from the campus CUP is distributed at 200 psig from the CUP. It is in a superheated condition at that point. Some degree of superheat is desirable within the plant, as it ensures a dry supply of steam to the turbines at the plant. Additionally, the heat recovery steam generator (HRSG) operation also contributes superheat. Superheat keeps the mains dry, and manhole traps cycle less frequently. Almost all steam used on campus originates from this 200 psig superheated source. This requires some special considerations with regard to control valve selection, as many vendors simple assume that 2 to 15 psig steam is from a local boiler producing saturated steam at 15 psi or less.

During the summer of 2021 this question was studied in some detail. What is a reasonable condition to expect at buildings? A representative location on campus for the hottest steam (with a good temperature sensor on the PI platform) to a building is the supply to Building 9. The steam main travels in a tunnel to the basement of 13 and then through a corridor to Building 9. As this feed never travels underground, it is likely the hottest steam available to any campus building. The peak condition noted is 200 psig at 409 degrees F. As the corresponding saturation temperature is 388 degrees F, it can be said that there is 21 degrees of superheat at that point, and the corresponding enthalpy is calculated at 1,214 btu/lbm. If this source is expanded to 15 psi (enthalpy remains the same) the resulting temperature is 350 degrees F. If this source is expanded down to 1 psi, the resulting temperature is 345 degrees F. If utilization is in the 60 psi range, as is common for domestic water heaters, the resulting temperature is 366 degrees F.

Control valves operating at 15psi and lower are typically rated for 250 degrees F. This is the saturated condition for 15 psig steam. Valves are commonly rated for a temperature which corresponds to the steam saturation condition in their operating range. What this means on our campus is that valves should be selected for a higher pressure rating in order to truly have the tolerance for temperature.

60 psig steam at 366 degrees F requires valves rated at 150 psig / 366 degrees F or better to meet the temperature requirement.

15 psig steam at 350 degrees F can be accommodated by valves rated at 125 psig / 353 degrees F or better to meet the temperature requirement.

Low pressure systems operating in the range of 1-5 psig also require valves rated at 125 psig / 353 degrees F or better to meet the temperature requirement. 5 psig steam at 1,214 btu/lbm enthalpy would be superheated at 347 degrees F.

Many older buildings at MIT have existing low pressure perimeter steam heating systems which are cycled on and off throughout the heating season. Where perimeter radiation lacks control, it is the strategy of MIT to provide DDC control or self-contained control valves. Where possible, shut off valves on steam supply and return lines to radiators, within renovation area, should be provided for routine maintenance and to avoid building wide shut downs. For larger renovation projects, we strongly prefer removing the perimeter steam heating system and replacing it with a hot water system. The long range strategy of MIT is to replace perimeter steam systems with hot water systems.

Campus steam distribution supply pressures to buildings are either 200 psig or 60 psig. At times of high load, these distribution pressures can be lower at the building entrance due to system losses. Please discuss your requirements with the Systems Engineering Group (SEG).

When connecting to these steam systems for renovations which might include air handling units, year round hot water reheat systems, or domestic hot water heaters, a firm (year round) steam source must be confirmed early in the design process. Review the requirements for steam with the MIT Systems Engineer. Provide pressure reducing stations and specialties per the MIT standards.

Steam supply to heating coils for air handling units shall not be tied into perimeter house steam heating system which may cycle on and off during the heating season. Check with MIT personnel and connect to year round steam source. Provide pressure reducing station as required. Steam pressure to coils shall be minimum 10 psig.

Determine whether condensate return system within the building is or shall be a wet return, dry return or vacuum return system. Use the appropriate steam coil detail for wet / dry or vacuum return. Verify that the vacuum return has proper water seal or equalizing line and eliminate vacuum breaker.

In condensate return systems, do not specify or detail bypass piping and valves to bypass flow around steam traps. These bypasses are not necessary. They can only result in unregulated steam flow into the condensate system, where it can damage traps, condensate pumps, and other building components.

Condensate piping must always be designed to drain by gravity through steam traps to the downstream piping.

Condensate pumps, where required, should be sized to overcome system back pressures. Review required discharge pressure with the MIT Systems Engineer and perform an Engineering study as required. It is preferred to pump to existing vented large receivers on campus where possible.

There is an existing medium temperature hot water (MTHW) circuit on campus which originates in NW14 and serves a few buildings nearby. In the future, additional heating hot water circuits may be available from the CUP as additional heat is scavenged from the gas turbine flue gas and supply/return lines are extended into additional campus areas. This source may be available for building heat as well as domestic hot water production. In winter the projected supply temperature is 200 F and building heat exchange equipment should be selected to provide a 170 F return water temperature. We expect that the lowest temperature for this system (summer) is likely to be 180 F, with the system designed for a 30 degree delta T. It is therefore desirable to design hydronic heating systems and domestic hot water systems which can provide summer design capacity with 180 deg. F supply water and return water to the plant at 150 F. The building heat exchangers and associated primary piping must be designed to tolerate temperatures as high as 230 F. These parameters are also valid for connection to the existing campus MTHW system.

Typically, strainers shall be provided at water pumps. Do not provide strainers at terminal equipment.

If hot water heating coils are used in a 100% outside air application (i.e. heat recovery preheat coils) they must be served with glycol protected water. Hot water heating coils in mixed air systems must have a local circulating pump and check valve in the bypass between coil supply and return. This pump must run when the outside air temperature is 35 or lower to protect the coil from freezing by assuring flow and even distribution through the coil. A 2-way modulating valve can be used to return water to the heating plant downstream from the branch that connects to the pumped bypass. If the pump is commanded to run by the BMS systems or the outside air temp is below 35 and the pump status is ”off” then the entire air handling unit shall trip off and dampers /valves will go to the same positions as they would if the hard wired freeze stat had tripped.

At start-up (during cleaning and flushing) systems shall be filled using city water. Thereafter, closed and independent piping systems requiring make-up water typically shall be designed to have water made up automatically from the chilled water distribution system, which in turn is made up at the CUP. This avoids the need for an additional building back flow preventer and the associated testing and maintenance. If chilled water is used for make up this must be reviewed by the water treatment vender servicing this system.

A cleaning solution should be circulated through the piping to remove debris and mill scale. The cleaning solution should be provided by the same company that provides water treatment services for the MIT heating hot water system in that building. R&M personnel assigned to that building can provide the contact information.

General Procedure - Circulate the cleaning solution with the control valves fully open. Flush with fresh water and take water sample(s) to prove the cleaning solution is adequately removed from the piping system. Then drain the system and remove the baskets from each strainer. You can then fill the heating water with water from the building systems. Be sure to coordinate this step with the building’s R&M supervisor as they need to communicate with the CUP. The reason for this is that the chilled water filling the system will seem like a “leak” to the CUP if that’s where the water will be made up from. On the heating side the building heating circuit most likely has water make up from the chilled water system as described above, but it is possible that it may be made up from domestic water system. It’s also very important to be sure that the source of makeup water for the closed circuit heating system is not isolated (valved off). If it is isolated you will fill your new piping from the rest of the system and the system operating pressure will be reduced.

3.8 Design Strategies for Air Handling Units

The entire air handling system, including without limitation, air handlers, ductwork, coils, filters and other components must be designed for appropriate static pressures, optimum operating efficiency, and other considerations.

The merits of heat recovery shall be considered for 100 percent outdoor air applications and where required by Code. These shall be carefully studied and reviewed with MIT facilities staff. See section on “Strategies for Heat Recovery” below in this document.

Housekeeping pads for AHU's shall be designed with adequate height to accommodate a correctly sized P trap considering the maximum anticipated operating static pressure of the drain pan section. Maximum filter loading must be considered for draw-through units.

When belt driven fans are used, fixed pitched sheaves shall be installed. Adjustable pitch shall be used at start-up only, then replaced with fixed pitch. Provide multiple belt-type sheaves.

Direct drive fans are preferred for most (non lab exhaust) applications on campus. Individual drives shall be provided for each fan motor See Division 26 for additional guidance on approved VFD manufacturers and harmonic mitigation strategies.

Carefully design the entire air handler to meet the project's noise and vibration requirements. The unit shall have a vibration analysis performed at the factory and any corrective action shall be taken as necessary to meet project requirements.

If air handling units are on emergency power, the glycol circulating system and heating source must also be supported by emergency generators. The current practice in Facilities (circa 2016) is that ethylene glycol is the appropriate freeze protection additive. Pay attention to and design for the heat transfer penalty and pump de-rating imposed by using a glycol solution.

100% outside air units which utilize hot water heating coils shall be served by glycol protected water and the design must include circulating pumps for good heat transfer and even coil temperature distribution. These preheat coil circulating pumps are generally only required to run if the outside air temperature is above 40 F.

100% outside air units with heat wheels and hot water coils and all other hot water heating coils in air handlers must have a local circulating pump and check valve in the bypass between coil supply and return. This pump must run when the outside air temperature (OAT) is lower than 40 degrees F to protect the coil from freezing by assuring flow. It also establishes even distribution through the coil under low load to prevent stratification. A 2-way modulating valve can be used to return water to the heating system downstream from the branch that connects to the pumped bypass. Once the valve has been signaled to greater than a 60% open value, the pump shall be commanded off. If the valve modulates below 50% (and the OAT remains below 40 degrees F), the pump shall be commanded on until the OAT rises to 40. If the pump is commanded to run by the BMS system and the pump status is "off" then an alarm shall be generated. Chilled water cooling coils shall be sized for five foot maximum pressure drop and 16 deg. F water temperature rise. Multiple coils shall be used as required. Campus chilled supply water temperatures are 42 deg. F summer, 50 deg. F winter. See section 3.2 for more detail on the transition from free cooling to mechanical cooling.

Cooling coil connections must be detailed so that coils can be drained and winterized by the following procedure:

1. Close isolation valves.

2. Open vent.
3. Open drain and drain chilled water.
4. Connect barrel of glycol/water solution to coil and circulate solution through coil from bottom to top, returning solution to barrel.
5. Stop pump.
6. Disconnect upper connection and leave connection open.
7. Allow water to drain back to barrel by gravity.
8. Connect compressed air line to top coil connection and blow remaining residue back to barrel.
9. Disconnect compressed air hose and barrel drain line.
10. Leave upper and lower valves for vents and drains open during winter operation. Residual solution at low points in coil will help protect the tubes from freezing.

Humidification is typically not included. See section elsewhere “Design Strategies for Humidification”.

Filters may be provided in various locations within air handlers for differing reasons.

ASHRAE Standard 52.2, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size” (ASHRAE, 2007) provides complex testing and rating procedures for filters. Test results are reported as the minimum efficiency reporting value (MERV) in 20 grades grouped into four categories. Tested filters are referred to by MERV number, MERV 1 being the least efficient.

Fresh air intakes should have adequate filtration to protect the downstream coils and equipment from heavy particulates in the outdoor air. This is often accomplished with a 2 stage filter bank consisting of MERV 8 and MERV 13 filters in series. Provide access doors on both sides of casing unless the filter compartment is a walk-in or the unit is small enough to be serviced from one side.

A V-bank arrangement should be used for pre-filters where space is available. This will increase filter surface area, decrease pressure drop, and increase filter life (250 feet per minute maximum recommended velocity). Final-filters shall have maximum velocity of 500 feet per minute.

When a heat wheel(s) or an energy recovery coil is in an AHU, the return air stream must be filtered to protect the wheel(s) or coil. These filters must meet or exceed the heat wheel manufacturer’s recommendations. MERV 8 would be typical.

Requirements for sprinklers and smoke detection within the units must be carefully examined and coordinated to meet MIT requirements. Dry sprinkler systems in the filter section and VESDA detection systems are often required.

Condensate drains shall be piped to clear water drains, storm or grade to meet MWRA requirements.

Vertical or horizontal steam coils with integral face and bypass dampers may be used. For variable air volume systems allow increased distance between these heating coils and cooling coils to allow for full mixing of bypass air and heated air during low turndown. During lower airflows, air may still be de-stratified causing nuisance tripping by freeze-stat mounted on face of cooling coil. In these cases, provide turbulators or mixing baffles down stream of steam coils to increase mixing.

A spacer section must be provided between steam preheat coil and cooling coils for service access, installation of freeze stats and proper mixing of air before cooling coil. Provide an access door on both sides if possible.

When designing 100% outside air system for ventilation only with steam heat (typically lab ventilation), use vertically oriented steam coil tubes with integral face and bypass control. The engineer must specify manufacturers that accept the use of modulating steam valves with their equipment (Control Air and AeroFin are examples of this. Wing does not warranty installations with modulating valves and recommends against it) . Integrated face and bypass assemblies must be fitted with mixing baffles and a perforated mesh screen downstream of the coil/damper assembly to enhance mixing.

For mixed air systems when steam is the appropriate heating medium a full face steam heating coil can provide some level of freeze protection for a chilled water coil located downstream. However, malfunctioning steam traps can put both coils at risk of freezing. Vertical tube orientation is generally better than horizontal, but in some AHU configurations this is not possible. If a full face heating coil is necessary, the best freeze protection for both coils is to use a glycol protected hydronic heating loop with adequate distance between heating and cooling coils.

3.9 Design Strategies for Airside Heat Recovery

Air to Air Energy Recovering Equipment: The following systems are considered in general, however, the list below should not be restrictive. The design team is encouraged to exceed minimum energy recovery effectiveness as required by code and submit new concepts for MIT project teams and EHS for consideration:

Run Around Loops

MIT has decades of experience with glycol run-around heat recovery loops in laboratory systems. These systems have the desirable feature in lab applications of having no risk of air side cross-contamination. The energy penalties include the pump energy and pressure drop across the coils. The coils must be constructed to suit the environment and operating conditions to which they are exposed. The effects of condensable and corrosives may require specialized materials or coatings. MIT Facilities and EHS consultation is needed for construction materials and coatings.

Heat Wheels

To allow maximum heat recovery potential, heat wheels should be installed before a cooling coil in the air-handling system and installed in a “blow through” mode, i.e., the supply fan blows air through the heat wheel and the return fan draws through the heat wheel. This allows any air leakage around the heat wheel to be only from uncontaminated supply air to the exhaust side. Heat wheels can be successfully applied to 100% outside air systems and the ventilation component of economizer systems, but only where the exhaust stream is not contaminated or hazardous. Fume hood exhaust is not acceptable for heat wheel recovery.

A heat wheel is a rotating mechanical piece of equipment, which means components such as the electric motor, wheel deflection, bearings, belt, and drives require careful selection and maintenance. The air seal design should be carefully evaluated to meet the design criteria. See “products” section for recommended manufacturers.

Heat Pipes

The heat-pipe heat-exchanger device, also called a thermosiphon, provides a full separation of exhaust and supply air stream. This is an approved concept at MIT for 100% outside air lab systems. Care must be taken that appropriate refrigerant is used in the heat pipe otherwise heat recovery potential is lost. The choice between “tilting” and “fixed coil” designs should be carefully considered.

An additional heat pipe application is a “wrap around” coil which has the chilled water coil between the two sections of refrigerant coils. This provides reheat downstream of the cooling coil by moving heat from upstream to downstream of the coil. The airside pressure penalty is present at all times, and should be considered in the design. Space needs to be made available between the refrigerant coils and the chilled water coils for maintenance and repair access. If there are active controls for the refrigerant coil they should be provided by the BMS vendor, not by the coil manufacturer. This also assures that the coil can be deactivated by the BMS when conditions are unfavorable.

Static Plate Total Energy Recovery Heat Exchangers

We are beginning to use heat exchangers with a corrugated resin core for office and general ventilation applications. The primary advantage of this device is the elimination of many moving parts and complexity of control required for heat wheels. Fume hood exhaust is not acceptable for static plate energy recovery.

Chemical Regenerators

This system consists of chemical spray headers installed in both supply and exhaust air streams. The chemical (the heat-transfer medium) is usually lithium bromide (LiBr). It is very maintenance intensive due to the corrosive nature of the chemical and is not recommended for MIT applications.

3.10 Design Strategies for Air Intakes

Outside air intakes must be located so as to avoid bringing contaminated air into the building air-supply systems. Examination of likely contaminant sources, such as air exhaust stacks, should be conducted before outside air intake locations are selected. The ANSI Z9.5 standard on laboratory ventilation recommends that a risk assessment of exhaust discharge location in relation to the air intake be conducted.

MIT prefers a minimum distance of 30 ft (9 m) from specialty exhaust discharge (including diesel generators, vacuum discharges, etc.) to air intakes (or greater if required by code) to reduce re-entry problems. It is good practice to design for the maximum feasible separation. The plumbing code requires a minimum of 25 feet of separation from air intakes to plumbing stack vents.

MIT has experienced that outside air intakes located at ground level are subject to contamination from automobile , truck fumes, dust, landscaping activities and leaves, whereas air intakes at roof level are susceptible to contamination from laboratory exhaust stacks or high stacks serving off-site facilities in the vicinity. Such design is to be avoided.

If a building contains more than 10 stories, A/E team should consider locating the air intakes at the midpoint of the building. In addition, the AHU entry should be separated from the building face by a horizontal distance of 10 feet or more. This will minimize snow buildup on the pre-filters and subsequent structural failure of the filter rack and/or unit trip on low static at fan suction.

Air intakes located at the face of a building shall be designed for a maximum velocity of 300 fpm.

When outside air intakes are in a “drywell”, A/E team shall ensure that the bottom of the air intakes are set at a minimum of 24 inches above the floor of the areaway.

For difficult project locations such as those surrounded by higher buildings A/E team should consider wind tunnel tests to investigate the fume reentry problem under simulated conditions. Alternatively, with permission of MIT PM and MIT EHS office, A/E team may use computer-modeling programs to assist in stack-discharge design and air-intake location. A/E team should perform this study for all new buildings constructed as well as those undergoing major renovations.

3.11 Design Strategies for Humidification

Typically, humidification is not provided for spaces at MIT. If humidification is required for specific program needs, do not use chemically treated CUP boiler steam directly for humidification unless approval in writing is obtained from the facilities engineer assigned to your project. The types of spaces which may be humidified on campus include animal facilities, cleanrooms, archival storage of valuable cellulose-based materials (rare books and artworks), musical instrument storage, and certain art galleries.

Where humidification is required, create a clean steam source for the project by using CUP steam and a steam-to-steam heat exchanger. The heat exchangers create a separation from chemically treated and non-chemically treated steam. The separation is required by DCM design standards for vivarium spaces and their support equipment, and is desirable for other applications as well. Certain applications may require that the clean steam is generated from purified water.

The following discussion is to help the design engineer understand why the clean steam carbon steel condensate return piping becomes severely corroded while plant steam carbon steel condensate return piping lasts much longer.

Deionized water is very aggressive and should not be used for clean steam generation. For clean steam generation use RO water as the feedstock to the heat exchanger. This water which produces the clean steam is not chemically treated and will corrode carbon steel piping. Plant steam is brought to the heat exchanger from the CUP on the primary side and RO water is provided on the secondary side to create the steam used for humidification. The Clean steam return condensate essentially becomes pure distilled water and eventually mixes with other plant steam condensate (which contains some level of boiler chemical treatment) prior to returning. Clean steam/condensate for humidification is made intermittently (seasonally) while clean steam for autoclaves runs year-round.

The clean steam condensate water contains no alkalinity and thus has no capacity to neutralize acidic content; mainly from carbonate and bicarbonate ions. When in contact with air, the pure condensate water readily absorbs both oxygen and carbon dioxide. The dissolved oxygen attacks steel through oxidation. The carbon dioxide dissociates into carbonic acid, creates a low pH condition, and attacks steel through a pitting corrosion mechanism. The source of air may be as dissolved gas in the make-up water (which is 100% make-up with no condensate return to the heat exchanger) as well as air introduced into the condensate piping system during shut-downs. Typical plant steam condensate piping is not subject to this level of corrosion due to the presence of some treatment chemicals used in the boiler (i.e. “carry-over”) as well as the absence of dissolved gases like oxygen and carbon dioxide through deaerators in the steam cycle.

In all cases pay special attention to the materials of construction in the system and the makeup water for the clean side of the heat exchanger. The heat exchanger must have appropriate materials of construction.

Typically CuNi tube bundles and stainless steel shell heat exchanger construction is best when softened water is used as the feedstock. For applications using RO water only, a stainless tube bundle may be used as the CuNi is not required. Stainless steel piping must be used as the piping material for the feed to the steam dispersion tubes. Stainless steel ductwork shall be used 2 feet upstream and 10 feet downstream of the dispersion tube. The stainless steel section shall be pitched to a drain located just downstream of the dispersion tube. The steam condensate piping which returns the condensate to the generator must be threaded 316 stainless steel pipe. Steam condensate piping which returns a mixture of plant steam (such as the trapped returns from CUP grade steam wand heater jacket) and clean steam (like the trapped returns from the clean steam feed to the humidifier wand) that are piped together must be 316 stainless steel.

Central systems are recommended for entire buildings or large laboratories. Special humidity control systems with additional dispersion tubes in duct branches may be needed for very precise humidity regulation within individual spaces. As these systems are costly, complex and difficult to maintain, the performance characteristics need to be carefully examined with the Project Manager and the representative of the Department, Lab or Center.

Typically, clean steam at atmospheric pressure is introduced directly into the air to be humidified. Duct-installed humidifiers need to be carefully designed to avoid condensation and carryover inside ducts. The persistent or intermittent presence of liquid water can initiate and sustain the growth of fungi and bacteria that degrade air quality. When condensation is persistent, water may drip from air outlets. The location of the dispersion tube is critical for optimum safe performance and effective maintenance. In addition to the manufacturers' recommendations, the dispersion tubes must be installed so they can be easily accessed for removal and replacement without disturbing the lab or otherwise occupied space. EHS office review is needed for all installations.

Atomizing humidifiers introduce a fine mist of water directly into the air, where the water evaporates. The ability of air to evaporate all the mist depends on air temperature, air velocity, and entering RH. A major problem with water atomization is the potential risk of bacteria growth in the supply water reservoir and the nozzle itself. MIT does not accept atomizing humidifiers for these reasons.

A wet pad and fan system where air flow evaporates water from the pad is prohibited for several reasons including poor control and the potential for growth of fungi and bacteria. MIT does not accept wet pad systems for these reasons.

Small humidifiers installed in or near the occupied spaces may be able to provide humidification for small areas of application. Care must be taken in their selection and placement because uniform dispersion of water vapor is often difficult to achieve. The unit may discharge direct to the room or may have a duct mounted dispersion tube. In this application, MIT prefers the self-contained, wall mounted disposable cartridge style of unit.

3.12 Design Strategies for Air Handling System Zones

Air handling systems (supply and exhaust) should be zoned to serve areas of similar use and occupancy schedules where possible. If this is not possible, occupied/unoccupied VAV terminals should be provided to shut down areas not in use.

In new building designs, air handling systems and duct distribution should not cross building lines. Air handling systems shall be dedicated only to the building they serve.

Unfortunately, there are a number of areas on campus where air handling units serve more than one building and cross building demising walls. During system shut downs, this makes it very difficult to notify user groups in advance of shut downs due to the difficulty of defining all of the areas the unit serves. This results in a user group not being notified and a potential valuable loss of research time. In these areas, it is the strategy of MIT to separate building systems, utilities and services. These systems, which do cross building demising walls and are within the project renovation area and beyond, must be evaluated and reviewed with the MIT Systems Engineer. The systems should be separated by dedicating the air handling unit to one building only, and if necessary, adding an air handling unit and distribution system to the other building. In order to facilitate shutdowns and reduce complexity, the utility services to the AHU (power, steam, chilled water etc.) should come from the building it serves. Cost implications may limit the feasibility of this approach and design. Be aware that if an AHU is NOT located in the building is serves, the normal power service (per NEC) must come from the building it is located in or on. This allows firefighting personnel to open the building's normal power disconnect and be confident that all normal power in the building is de-energized.

For roof mounted equipment, provide guardrails or enclosures around the equipment including the path of travel to the equipment which will satisfy OSHA requirements unless high parapets are provided. Provide lighting and service outlets. Maintain proper clearances to permit space to service and replace equipment.

3.13 Design Strategies for Terminal Units

MIT believes that all "waste water" cooling units (units which use domestic water for condenser heat removal) have been eliminated from the campus. However, if a renovation project has a waste water unit, the unit should be removed and its capacity replaced as necessary with alternate equipment by the project.

Verify that adequate spare capacity is available when tying into existing heating, cooling, and process cooling systems.

When considering chilled beam for project applications the engineer shall consider min flow rates (passive chilled beam) vs min ventilation air flow rate and temperatures. This strategy shall be reviewed with the design team prior to development of the schematic design.

A design should include how to address min flow during heating mode and information on achieving temp and comfort levels as noted in this document.

Where heating is required by fan coil units, design for a 4-pipe cooling and heating system. Use of two-pipe changeover systems will not be considered for new projects. Projects with small footprints in existing buildings with changeover systems may be permitted. See the project Systems Engineering Group (SEG) engineer for guidance.

Fan coils concealed above ceilings must be provided with a water-level detection device conforming to UL 508. The fan coil controls must be configured to shut off the equipment served in the event that the primary drain is blocked. The water-level detection device shall also generate an alarm to the building automation system. The water-level detection device shall be installed by the manufacturer in the primary drain pan, located at a point higher than the primary drain line connection and below the overflow rim of the pan. The design engineer must be sure any auxiliary components (such as transformers and fan relays) are properly coordinated with the BMS subcontractor specification.

Fan coils of all sizes shall have a switch lock bracket and MIT padlock to allow the switch to be locked in the on or off position; equal to Garvin Industries Item TOGLOK.

Low profile horizontal or vertical fan coil unit sizes can range from 200 to 1200 CFM. Unit sizes should be limited to 800 CFM nominal if possible, as 1200 cfm units are difficult to service due to their size.

Condensate drains shall be piped to clear water drains, storm or grade, to meet MWRA requirements.

3.14 Design Strategies for Laboratories

In laboratories, excellent air circulation and ventilation is needed to create the correct environment for research and for safety. Location of supply air relative to hazardous exhaust should be reviewed. Recirculation of laboratory air between lab units is not acceptable. Recirculating fan-coil units and induction units serving labs individually are acceptable. Air from offices, conference rooms, classrooms and similar spaces can and should be recirculated, and may be used for make-up air for lab exhaust and fume hoods. For all the topics addressed below, please also refer to the EHS Thematic Folder regarding Lab Design.

Cooling Laboratory Areas

Generally, it is the philosophy of MIT to provide for energy-efficient design. In laboratories where hood density is high the make-up air required for the fume hoods result in air change rates as high as 30 to 45 per hour. With a variable volume fume hood exhaust and lab supply air system, the turn down can be significant, resulting in reduced operating cost and installed cost since central systems can be down sized by diversity. In some cases, the minimum air flow at maximum turndown may result in insufficient cooling. Thermal override of minimum airflow is required in this case.

If a thermal override sequence would be required due to internal equipment loads (as described above), consider locating heat producing equipment outside of the ventilated lab if possible. Once removed from the ventilated lab, this load can be served by recirculating fan coils.

Chemical Laboratories

The volume of exhaust ventilation should be sufficient minimize hazards at all times. During non-use, volume of air exhausted may be reduced for energy conservation but a user override must be provided to accommodate after hours work. Typically, occupancy sensors (used to sense vacancy) would be preferred over a clock/schedule approach.

The volume of ventilation and ventilation systems proposed must be reviewed with the MIT Systems Engineer and MIT Industrial Hygiene Office (EHS-IHO) early in the design phase. Minimum design rates may range from 6 to 12 air changes per hour as a minimum. Labs may be operated at lower minimum rates at times as permitted by EHS. Coordinate special exhaust requirements including equipment enclosures, local snorkel exhaust, (ovens, vacuum pumps), bench exhaust, chemical storage cabinets, flammable storage cabinets, glove box, etc.

Animal Housing Areas

Provide ventilation, temperature, relative humidity and filtration to comply with National Institute of Health laboratory design criteria and standards and to comply with MIT EHS requirements, energy conservation; use airside energy recovery heat exchangers. 100% outside air is used for these areas and typically is circulated at a rate of 10 to 16 air changes per hour to meet AALAC Standards.

Heat Recovery

For animal areas and other lab applications heat wheels are not acceptable due to cross contamination risks. Use glycol based pumped heat recovery coils, or, if supply and exhaust are side-by-side, passive refrigerant circuits and coils may be used. Include appropriate filtration on the exhaust air side to protect the heat recovery coil. The heat recovery coil on the fresh air only requires a filter during pollen season. Tack pad blankets are used from March-June and replaced multiple times. From July-October tack pad exchanges are usually not necessary. For additional guidance see "Heat Recovery" elsewhere in this document.

Enclosed work spaces such as laminar flow exhaust hoods or bio-safety cabinets may also have to satisfy containment criteria if hazardous substances are being used. Be sure to consult EHS on any type of hood application. Refer to the Lab Design thematic chapter in the Design Standards and strategies for airside heat recover above.

Operable Windows

Operable windows shall not be used in laboratories or spaces where differential pressure and air flow is critical to the design and safety. In existing buildings, operable windows shall be permanently secured.

Positive Pressure or Clean Laboratories

The requirements and approval for a positive pressure laboratory containing chemicals shall be reviewed with MIT EHS. Often these rooms will require the need for a negative pressure ante-room. These requirements should be reviewed early in the design. Refer to the thematic folder “Lab Design” elsewhere.

Heat Rejecting Equipment

Verify heat rejecting equipment to be used and loads to be created early in the HVAC design phase.

Lab Exhaust Control

If pressure-independent spring balanced cone valves are used in lab exhaust systems, be aware that in the event that makeup air to the lab is down when the exhaust system is operating, the lab will be under a severe negative pressure. This is due to the fact that with tight building construction, leakage alone will not provide adequate makeup air. As the air flowing past the cone is reduced, the spring will open against the reduced airflow and slide the cone away from the venturi. This creates a suction in the lab even though there is inadequate air flow. The effect is so “transfer” the static pressure maintained by the exhaust fan VFD within the duct riser into the room. Remember that under normal operation the valve creates a pressure drop in the range of 0.6 to 3.0 inches of static. With no makeup air, the lab will approach the static pressure setpoint in the duct. Buildings with high fume hood density may become severely negative in the event supply air is lost while exhaust remains active. The negative can be so strong as to make it difficult to open doors and can cause an egress issue.

Fume Hoods

Use only fume hoods identified in the Lab Design thematic chapter in the Design Standards. Do not provide automatically controlled discharge dampers for single fume hoods or single fans. Do not use back draft dampers. Refer to the Lab Design thematic chapter in the Design Standards for information regarding face velocity and other fume hood design issues.

Constant-volume-exhaust fume hoods:

1. Shall be used where constant dilution is required (i.e., radioactive isotopes, perchloric acid and other acid digestion processes, etc.).
2. May be used when minimum room ventilation is satisfied by the hood airflow alone.
3. May be necessary when existing building systems do not allow for variable volume exhaust and variable volume make-up air.
4. May be of the combination sash type as opposed to vertical sash to reduce air flow and energy usage.

Variable-air-volume exhaust fume hoods and make-up air

1. Consider variable volume exhaust and supply make-up air with lab air controls where the type, use and dilution does not require constant volume exhaust.
2. Consider use of horizontal sash operation if hood is greater than six feet in length. If required by end user, consider the use of a combination vertical sash and horizontal sash type fume hood.
3. Refer to Lab Design Thematic Chapter for guidance regarding fume hood face velocities.
4. Variable volume fume hood minimum exhaust air flow rate shall be not less than 50 CFM per linear foot of fume hood unless a lower rate has been approved by EHS

Fume Hood Air Balancing

Testing, adjusting and balancing of the fume hood exhaust air, general exhaust air and variable volume supply air with reheat coils shall be tested, recorded and reported at minimum, intermediate and maximum air flows. Eliminate adverse conditions such as air drafts caused by supply registers and transfer air grilles. Balancing reports shall be forwarded to MIT EHS for final review and approval of fume hood and laboratory exhaust air requirements. Refer to Lab Design Thematic Chapter for guidance regarding fume hood face velocities.

Fume Hood Commissioning

Commissioning of fume hoods shall be an independent qualified agency and shall not be performed by the manufacturer or installer. New or remodeled fume hoods must have ASHRAE 110 testing conducted at the design opening or installed openings as directed by MIT. The HVAC designer of record must write their specification division and coordinate with other divisions such that the responsibility for corrective actions necessary to pass the ASHRAE 110 test is clearly defined. The sash movement effect test must be conducted on variable air volume hoods as well as all other requirements of AHRAE 110. In general, once face velocity and smoke tests have been passed, the five-minute average test results for tracer gas testing must be less than or equal to 0.1 PPM for all operating conditions tested. Forward failed reports to MIT-EHS immediately if any fume hood fails any portion of any test. Submit successful results through the project commissioning process.

Fume Hood Ductwork

Preferred fume hood ductwork material is 316L stainless steel. If CPVC is used for ducts, it must comply with the requirements outlined in Section 4.10 below. Do not provide discharge dampers for single fume hoods or single fans. Do not use backdraft dampers on fume hood or specialized local exhaust systems. For systems with redundant fans, use blast gates for fan isolation. Butterfly dampers may be used as balancing dampers for fume hood and specialized exhaust systems. Evaluate fire-stopping issues and details on a project specific basis.

When conventional CPVC is exposed to UV radiation there may be a slight decrease in impact strength and a color change of the material. UV radiation will not penetrate even thin shields such as paint. CPVC duct exposed to the direct effects of UV radiation should be painted with a light colored acrylic or latex paint that is chemically compatible with the CPVC. Compatibility information should be confirmed with the paint and CPVC manufacturer. The use of oil-based paints is not recommended. When painted the effects of exposure to sunlight are significantly reduced, however, consideration should be given to the effects of expansion/contraction of the system caused by heat absorption in outdoor applications. The use of a light colored, reflective paint coating will reduce this affect, however, the system must also be designed and installed in such a manner to reduce the effects of movement due to thermal expansion. Consider cost savings to use stainless steel if applicable in these exposed applications.

Venturi style air valves shall be connected to adjacent ductwork with the manufacturer's drawband kit of appropriate materials, paying particular attention to the sealant tape. The ductwork on either side of the valve must be well supported with hanger stock within 12 inches of the connection to the valve. Follow the manufacturer's instructions explicitly. Self - tapping sheet metal screws and duct sealant are NOT acceptable.

Exhaust Fans and Exhaust

Fume hood exhaust fan motors and belts should not be in the air stream so they can be maintained without exposure to the hazardous exhaust airstream. Use backwardly inclined fan wheels with airfoil blades to assure stable operation. For safety, fans are typically "always on". Variable volume air systems should be considered to reduce exhaust air volume as fume hood sash is lowered. The recapture of energy by use of a heat exchanger should be evaluated, but safe discharge must not be compromised. Achieve at least 3,000 fpm discharge velocity under all operating conditions. The top of the discharge stack must be at least 10 feet above general roof level and away from large rooftop structures such as penthouses. Additional code restrictions may apply to specific cases. Fume hood exhaust fans should be located on a roof or in a roof pent- house with the fewest positive pressure parts within the penthouse. If the fans are located in a penthouse, all positive pressure ductwork must be welded construction or the joints must be sealed with Hardcast mastic (or equivalent). If a penthouse is used, additional space may be needed for scrubbers, filters and other pollution control equipment which may be needed in the future. Exhaust ducts from humidified spaces may require external insulation to prevent condensation. Obtain MIT EHS design review and approval of fume hood exhaust system designs.

Manifold Exhaust Air Systems

1. Generally, fume hoods are not required to be individually exhausted by a dedicated exhaust air fan.
2. Fume hoods may be manifolded into an exhaust air system combined with a lab exhaust air providing manifolding is performed per the BOCA 1993 Mechanical Code and NFPA 45. When manifolding fume hoods, careful considerations should be given to labs with same type use, defining a laboratory unit and fire zone, fire separation in shafts and horizontally. Typically manifolded systems provide for increased dilution of chemicals. Manifolded systems should be reviewed with MIT EHS.

3. Systems which are manifolded on the roof outdoors should be designed with careful consideration for pitch and drainage of condensation, expansion and contraction, insulated duct if it will be part of a heat recovery system.
4. Larger manifolded systems should be welded stainless steel duct as opposed to CPVC duct. CPVC duct is subject to cracking due to expansion and contraction extremes, is brittle in cold weather, is UV sensitive and heat sensitive.
5. Type II CPVC duct should be used outdoors.
6. Chemical Storage Cabinets (chemical storage/flammable storage): When exhaust is required, chemical storage cabinets shall be exhausted using materials which have the same fire rating as the wall of the cabinet.. Cabinets shall be exhausted in accordance with MIT-EHS requirements. Follow NFPA 45.
7. Vacuum Pumps: A means shall be provided to exhaust pump discharge (indirect connection) at a minimum rate of 50 CFM. Confirm with end user pump discharge rates and increase air volume as required for multiple discharges into one snorkel exhaust. Review with MIT EHS.
8. Coordinate sprinkler head locations to be installed above CPVC duct and at top of the shafts. Do not install sprinkler heads inside CPVC duct.
9. Manifolded exhaust systems shall have redundant fan capacity.
10. If energy recovery is provided, a means of servicing coils and changing filters must also be provided either by use of multiple fans, filters and coils with diversity or redundancy. Shutting down one fan during off-peak periods or in systems which have redundant fans, filters and coils allow for routine maintenance to be performed without a system wide shut down if properly dampered. If this is not possible, a means must be provided for a dampered bypass duct around air filters and coils to allow for routine maintenance without system shutdown.

Perchloric Acid Fume Hood Exhaust Systems should be provided with a dedicated fan and duct and wash-down system that meets the following requirements:

1. Design to provide a complete system wash down.
2. Provide drain locations in the duct system as required to completely drain the duct.
3. At a minimum, fan casings and the hood work surface behind baffle shall have drain connections.
4. Wash down shall be activated by a manual valve located at the fume hood.
5. Prior to acceptance, testing of the wash down system must be witnessed and approved by appropriate MIT EHS Office representatives.

Heavy Acid / Heated Acid Hoods shall be designed to withstand reactions from strong acid and may be specially designed for performing acid digestion applications.

1. Depending upon the application, acid digestion fume hoods may feature wash-down systems similar to perchloric acid hoods. Some hoods may also require internal scrubbers.
2. The exhaust duct shall be welded 16 gauge 316L stainless steel or CPVC. A fluoropolymer

coated ductwork (trade named PSP) is also acceptable.

3. Note: This type of fume hood is not meant for perchloric acid applications. This hood is made of very high chemical resistant surfaces and the sash is designed to prevent fogging or etching. If a non-ferrous hood is selected for the application, all duct and fan materials should be non-ferrous.

Radiation Exhaust

In radiation lab exhausts, the welded ducts should be round and installed with the longitudinal seam within 45° of top center, to prevent radionuclides from accumulating at a weld bead. If carbon or HEPA filters are required for individual hood exhausts, space shall be provided in a mechanical room where maintenance (filter changes) can be performed while standing on the floor. If radiation hoods are connected to a building manifold and filtration is required, then the filter housing must be installed near the hood and access must be provided.

Duct Sizing and Manifolds

Exhaust ducts should be sized and designed to provide the necessary velocity to prevent material accumulation. See the latest version of the ACGIH Industrial Ventilation Manual for detailed guidance. The following hood exhausts should NOT be manifolded together:

1. Perchloric acid/hot acid hoods.
2. Any hoods with wash-down equipment.
3. Hoods that could deposit highly hazardous residues on the ductwork.
4. Exhaust requiring HEPA filtration or other special air cleaning.
5. Where the mixing of exhaust stream may create chemical reactions, causing fire or explosion, in the duct system.

For all applications the project team must determine laboratory air change rates. Review with MIT EHS. 6 air changes per hour minimum when the space is occupied.. 10-12 air changes per hour is typical for many special conditions.

Environmental Controlled Temperature Rooms

Cold rooms, warm rooms and freezer rooms often have equipment such as condensing units which can significantly affect the HVAC design loads of nearby spaces. Verify equipment to be used and loads to be created early in the HVAC design phase. Environmental Controlled Temperature Rooms may also need exhaust. The preferred method of heat rejection is to use a local recirculated loop of chilled water at an elevated temperature (mimicking a condenser water loop) to carry the heat away with head pressure controls on the refrigerant circuit. Otherwise, utilize air cooled condensers. The preferred location for the condensers is within the building mechanical space. Environmentally controlled temperature rooms may also require exhaust and associated makeup air.

Lab Equipment Cooling

Many research labs have requirements for water cooling of equipment. The type of system (open versus closed system or local versus central system) and the advantages and disadvantages of each, should be evaluated and documented early in the design and reviewed with the design team and the end user. Some systems used for cooling lab equipment will require a relatively clean source of makeup water. These systems shall use the appropriate water both at start-up and to automatically make-up water. A backflow preventer must be provided when city water makeup is required. Typically, these systems may require:

1. Tight temperature tolerances.
2. Glycol due to low operating temperatures.
3. High or very low operating pressures.
4. Special water filtration.
5. Use of non-ferrous piping materials.
6. User control and adjustability.
7. Reliability (redundancy and city water backup).
8. Dew point control of space temperature to prevent condensation on research equipment (will dictate leaving cooling coil conditions).
9. Chemical treatment.

For piping systems where the end user periodically connects and disconnects lab equipment, automatic air vents are required to remove air. Manual air vents will not provide a practical means of air removal when it is introduced frequently into the system.

Typically, strainers shall be provided at water pumps. Do not provide strainers at terminal equipment.

Review requirements with MIT Systems Engineer.

3.15 Design Strategies for Special Filtration Requirements

High-efficiency filters typically have a minimum retention of 99.97% for a monodisperse test aerosol containing 0.3-µm particles (HEPA). Ultra-low penetration air (ULPA) filters used for 0.1-µm particles are known as to have efficiencies of 99.99–100%. Certain environments will require these types of filters to achieve the space performance requirements.

ISO 14644-1 classifies a space based on the size and number of airborne particles per cubic meter of air (see chart below).

Prior to the implementation of ISO 14644-1, US Federal Standard 209E set the industry guidelines for cleanroom classification, and denoted the number of particles 0.5µm or larger per cubic foot of air. For instance, under FED-STD-209E, a "class 1,000 cleanroom" would indicate 1,000 particles 0.5 µm or smaller in each cubic foot of air. FED-STD-209E was officially cancelled on November 29th, 2001, though both standards are still widely used.

Clean Room Standards

ISO 14644-1 Cleanroom Standards							
Class	**maximum particles / m^3**						**FED STD 209E equivalent**
	≥0.1 µm	**≥0.2 µm**	**≥0.3 µm**	**≥0.5 µm**	**≥1 µm**	**≥5 µm**	
ISO 1	10	2.37	1.02	0.35	0.083	0.0029	
ISO 2	100	23.7	10.2	3.5	0.83	0.029	
ISO 3	1,000	237	102	35	8.3	0.29	Class 1 Cleanroom
ISO 4	10,000	2,370	1,020	352	83	2.9	Class 10 Cleanroom
ISO 5	100,000	23,700	10,200	3,520	832	29	Class 100 Cleanroom
ISO 6	1.0×10^{6}	237,000	102,000	35,200	8,320	293	Class 1,000 Cleanroom
ISO 7	1.0×10^{7}	2.37×10^{6}	1,020,000	352,000	83,200	2,930	Class 10,000 Cleanroom
ISO 8	1.0×10^{8}	2.37×10^{7}	1.02×10^{7}	3,520,000	832,000	29,300	Class 100,000 Cleanroom
ISO 9	1.0×10^{9}	2.37×10^{8}	1.02×10^{8}	35,200,000	8,320,000	293,000	Room air

(µm denotes micron particle size)

The HVAC engineer shall review space cleanliness requirements for lab design with the user and with the MIT EHS office. It is important to decide early in the design process if a project requires high-efficiency air cleaning devices because these design requirements will be difficult and costly to implement late in the design process.

Biosafety cabinets are equipped with HEPA filters to protect the work surface from room contaminants and to protect the room from contaminants in the hood. These are commonly deployed as a containment device for biological work such as tissue culture.

Microorganisms, including virus particles, are of sizes that are captured effectively by HEPA filters. ULPA filters are especially useful for microelectronics laboratories where elimination of inert particles smaller than airborne microorganisms is of critical importance. For critical laboratory operations it is important to specify “certified filters” that conform to all of the size, construction, and sturdiness criteria contained in a code such as ASME AG-1, and have efficiency and pressure drop measurement results noted on the side of the filter case. HEPA and ULPA filter testing requirements must be included in project specifications.

Clean rooms may be required for some research applications and are designed and built to the cleanliness standards described in the table above. Special micro environments may be required within a clean space in order to create a higher level of cleanliness.

For duct mounted filtration system designs must allow easy access to ducts upstream and downstream of the filters. There should be straight duct runs of at least six duct diameters on each side of the filters. The design shall include testing ports. An entry port at least six duct diameters upstream of the filters is required to introduce the challenge aerosol for the leak test and a second port is needed close to the downstream face of the filters is recommended to measure the uniformity of the challenge aerosol.

The design team must include in the project specifications that a leak test is not another filter efficiency test; it is designed to detect the presence of a damaged filter as well as leaky mounting racks and poorly installed filter cartridges.

The design team should review any user requirement for exhaust adsorbent vapor phase filtration with MIT EHS office. Activated carbon is the usual adsorbent used in ventilation air systems to remove organic vapors, sulfur dioxide, nitrogen oxides, and ozone. It can also be used for filtering radio nuclides in Radiation Labs. Activated carbon, as well as other adsorbents, gives no discernible signal when it reaches the breakpoint or saturation. The air coming out of the carbon bed can be monitored for unacceptable gas penetration. For critical applications, the design team shall include sampling provisions in their design.

Electronic air cleaners are generally not recommended for MIT facilities.

3.16 Design Strategies for Transformer Rooms

Provide ventilation to comply with requirements of guideline Division 26 Section "Electrical Service and Distribution". Evaluate cooling versus ventilation. Coordinate load with Electrical documents and MIT electrical department.

MIT's experience has been that cooling transformer rooms with chilled water fan coil units is able to maintain superior cleanliness in compared to typical exhaust air fan/intake air damper and duct arrangements. Fan coils should be located outside of conditioned spaces, cooling air and return air should be ducted to fan coil units from rooms.

3.17 Design Strategies for IS&T Spaces

There are two types of spaces in buildings which house IS&T support equipment, Building Distribution Frames (BDF) and Intermediate Distribution Frames (IDF). Refer to MIT Design Standards Division 27 – Communications for more information.

The design team shall provide dedicated DX cooling equipment to remove heat from IS&T rooms. MIT's preference is for DX cooling as we have found that when chilled water based cooling is utilized it is not practical to be able to obtain chilled water system shutdowns for the building. The loads are generally small, but constant cooling support is required as they are critical loads.

If the equipment in IS&T rooms will continue to operate and generate heat on a loss of normal power in the building, then the DX cooling shall be supported by the building's optional standby electric system.

IS&T rooms should be provided with cooling that will control the room drybulb to a set-point of 75 deg. F and the dewpoint should not exceed 59 deg. F to conform with TIA -942 requirements.

3.18 Design Strategies for Kitchen Exhaust

Categories of Kitchen Exhaust Systems at MIT

1. Type 1: Residential applications where exhaust hoods are installed over stoves. The requirements are described in International Mechanical Code (IMC) section 505.
2. Type 2: Commercial applications where hoods are installed in large kitchens or food preparation and service areas. IMC section 507 defines commercial kitchen hoods to be two types requiring exhaust:

    a. Type 1 Kitchen Exhaust Hoods:

        1) Installed "where cooking appliances produce grease or smoke, such as griddles, fryers, boilers, ovens, ranges, smokers and wok ranges", which may include conveyer and deck-style pizza ovens.
        2) Conform to NFPA 96 in design of all Type 1 hoods.
        3) The design team should ensure exhaust duct from Type 1 hoods to be a minimum of 16 gauge black iron, or 18 gauge stainless steel.
        4) To prevent liquid leakage all seams must be welded liquid-tight. No screws will be permitted.
        5) Clearances are 18 inch from combustible materials and 3 inch from gypsum board.

    b. Type 2 Kitchen Exhaust Hoods:

        1) Installed over cooking or dishwashing appliances that produce heat, steam or products of combustion and do not produce grease or smoke such as steamers, kettles, pasta cookers, and dishwashing machines.
        2) The design team should ensure exhaust duct from Type 2 to be welded aluminum or stainless steel not less than 18 gauge.
        3) Supports must be noncombustible and capable of supporting the hood, adjacent

ductwork, effluent load and weight of personnel working in or on the hood.

4) Joints, seams, and penetrations shall be shall be sealed on the interior of the hood and provide a smooth surface that is readily cleanable and water tight.

Kitchen Exhaust System Layouts

Design teams shall provide a separate duct system for each Type I hood, unless the following exceptions are noted:

1. Interconnected hoods are located within the same story.
2. Interconnected hoods are located within the same room or in adjoining rooms.
3. Interconnecting ducts do not penetrate assemblies required to be fire-resistance rated.
4. The exhaust duct system does not serve solid-fuel-fired appliances.

If multiple hoods are on a single duct, the design must naturally provide the relative flows required without dampers.

The design team will locate kitchen exhaust fan termination to be a minimum 10 feet above grade and a minimum 40 inch above the roof. One side of the fan will be hinged with a flexible electrical connector for inspection and cleaning of the interior. The location must not be a public nuisance or create problems in general due to the location, direction, or nature of the wind.

Exhaust velocity shall comply with NFPA and IMC.

Kitchen Exhaust System Clean Outs

The design team must provide duct cleanouts and openings to remove accumulated grease. The cleanout design must be complete and reviewed by MIT’s duct cleaning vendor before the design development is considered complete.

1. Cleanouts openings shall be equipped with tight-fitting bolted doors constructed of steel with same or more thickness as the duct. Doors shall bolt tight to the stand-off flange which is provided to clear the insulation thickness.
2. Cleanout doors shall be installed liquid tight.
3. Door assemblies including any frames and gaskets shall be approved for the application and shall not have fasteners that penetrate the duct.
4. Gasket and sealing materials shall be rated for not less than 1500°F (816°C).

Duct Wrapping

The design team will specify a kitchen duct wrap system that extends from 18 inches below any combustible truss or wood joist to a point 18 inch above the surface of roof coverings or; provide 18 inch clearance to combustible material for the same distance or; provide noncombustible 1-hour fire-rated shaft with a gypsum board and 3 inch minimum clearance. Comply with NFPA and IMC requirements.

Testing

The design team will specify a system to check leak test kitchen exhaust ducts. A “light test” for duct leak testing in accordance with the IMC prior to enclosing or concealing will be a minimum requirement.

Fire Extinguishing Systems

The design team will consult with MIT SEG on the type of Fire extinguishing system to be provided in kitchen hoods and exhaust ducts. Every Type 1 kitchen exhaust hood and duct system shall be protected with an approved automatic fire-extinguishing system installed per latest codes, including UL 300, developed by Underwriters Laboratories, Inc. (UL) entitled 'Fire Extinguishing Systems for Protection of Restaurant Cooking Areas'.

Although other types of extinguishing may be approved by UL, MIT’s experience is that wet-chemical extinguishing systems per NFPA 17A are preferred. Foam-water sprinkler system or foam-water spray systems per NFPA 16 may be considered as an alternative.

Fans must be provided and installed in accordance with the IMC.

Controls

The design team will provide heat sensor or other device to ensure automatic operation of both kitchen hoods and make-up air systems upon activation of cooking operations. Airflow shall be modulated to meet the demand of each hood. Be aware that optical sensing devices require close coordination with the installation of the fire protection package. It has been MIT’s experience that including a manual “on” switch which enables the automatic controls and allows for complete shutdown in the “off” position can yield the best combined result for energy conservation and operational integrity. Adequate regular training for the cooking staff and instructional signs must be provided.

Residential Kitchen Exhaust

For domestic range hoods and domestic appliances equipped with downdraft exhaust located within dwelling units, such hoods and appliances A/E design team will provide an exhaust system discharging to the outdoors through code compliant sheet metal ducts. Such ducts shall have smooth inner walls and shall be air tight and equipped with a backdraft damper.

4. PRODUCTS

The following is a list of equipment products which should be reviewed and discussed with the MIT Project Engineer. The manufacturers listed here represent the current acceptable products for use on the MIT campus.

4.1 Lab Exhaust and Airflow Control Systems

When airflow control is a critical design parameter, use Phoenix or Price venture style laboratory airflow control components. Variable flow fume hood exhaust applications always require critical airflow control.

The manufacturer’s controller shall regulate the supply and exhaust valves to obtain rapid rate of response and maintain appropriate airflow offsets. In some applications speed of response on the air supply may not be critical, and typical VAV boxes may be used in conjunction with venturi valves on the exhaust.

Hood exhaust shall be modulated to meet face velocity criteria.

Pressure independent valves shall be provided for each fume hood on manifolded exhaust systems.

Control range 20-100 percent air flow.

Response time shall be one second or less after reaching 90 percent of sash height or change in system static pressure.

Room pressure shall be maintained using a volumetric offset. This is typically 10% of the minimum room exhaust flow or 100 cfm per door leaf.

Provide a fume hood monitor.

Air flow supply and exhaust valves shall include the following features:

1. Venturi control type.
2. Pressure independent.
3. Turn down 8 to 1 with +/-5 percent accuracy.
4. Air supply valves: 16-gauge aluminum assembly with type 316 stainless steel hardware.
5. Fume hood and general exhaust valves shall coatings and materials appropriate for the application. See section 3.12 for installation and application guidance. Shaft and hardware shall be type 316 L and shall have phenolic coating when appropriate.
6. Exhaust valves generally shall fail open, supply valves generally shall fail to minimum air flow.
7. Valves shall be individually factory calibrated and supplied with a permanently attached calibration chart.

Provide one lab controller per lab. Control supply, exhaust and reheat coils for air flow and room temperature control.

Coordinate interface to building automation systems for remote monitoring and alarm including:

1. Exhaust air flow quantity.
2. Emergency override and flow alarm.
3. Room supply air quantity.

Sound Attenuators: Review noise requirements with acoustical consultant to determine is an attenuator is required to be provided with the exhaust valve.

4.2 Building Automation Systems

Provide Schneider or Automated Logic building automation systems. See the BAS section of the Design Standards for detailed information regarding automatic temperature controls.

4.3 Electric Motors and Variable Frequency Drives

Refer to the electrical section of the Design Standards for information on motors and variable frequency drives.

4.4 Automated Dampers

Outdoor air applications are best served by the installation of TAMCO dampers with the SW (saltwater) construction features. These features are also important where a damper is located downstream of the cooling coil and sees nearly 100% RH conditions during the cooling season.

For applications requiring unit smoke/fire isolation, Ruskin isolation dampers FSD-60 or FSD-60LP have been used successfully. For floor level smoke/fire dampers we use only Greenheck's product, as we have had issues with Ruskin in this application.

4.5 Central Station Air Conditioning Units

General: Double wall construction with solid inner liner.

Fans: Higher efficiency and generally quieter wheels shall be used where possible.

Bearings selected for fatigue life rating L10 of 200,000 hour operation.

Specify statically and dynamically balanced fan wheels to 0.10 inch/second at peak velocity.

All steam coils shall be ARI certified.

Chilled Water Cooling Coils:

1. Each coil row or each coil shall have its own aluminum or stainless drain pan and that condensate shall be piped within the unit to a location near the drain base's outlet
2. The floor of the section downstream of the cooling coils shall have a recessed, integral stainless or aluminum drain pan pitched in 2 directions with adequate drain points to provide positive flow to the outlet.
3. The dimension in the direction of airflow shall be adequate to capture all coil carryover at maximum design velocities.
4. All coils shall be ARI certified.
5. Cooling coil construction shall be 304L stainless steel casings with copper tubes, aluminum fins and steel headers.

Starters, Variable Frequency Drives and Motors: Motors shall be premium efficiency conforming to NEMA Standard 31, MG1.31. Motors shall be suitable for use with variable frequency drives where applicable. Coordinate all requirements with design electrical engineer. Also see Electrical Section of the Design Standards for additional guidance.

Starters and variable frequency drives shall be specified to be furnished and installed under the electrical section.

4.6 Horizontal Propeller Unit Heaters

Steam coils shall be rated at 150 psig.

OSHA compliant fan guard shall be provided.

The fan/motor assembly shall be provided with vibration isolation.

Provide an ECM motor with fan speed modulation to meet room set-point. No steam control valve is required.

4.7 Fancoils

Manufacturer: Airtherm, Price or MIT approved equal.

Four-way adjustable discharge grilles shall be provided for units located below ceilings.

Provide an EC motor to permit fan speed modulation.

Provide internal vibration isolation.

Drain pan shall be of sufficient size to cover end pocket piping and control valve.

Provide a drain pain configuration to comply with the IMC requirements.

High capacity cooling coil shall be provided to meet MIT delta T chilled water performance requirements.

The manufacturer shall provide a local disconnect switch, with a permanent lockable means (switch lock bracket), mounted to the unit.

4.8 Hot Water Reheat Coils

Provide ARI certified coils.

All coils shall be pressure tested at the factory.

Hot water reheat coils shall be selected to operate successfully in the future when fed from the future campus hot water loop. See section 3.6 for more information.

4.9 VAV Terminal Units

Units shall be internally insulated. The insulation material shall have a non-porous surface.

Damper air leakage shall not exceed 2 percent of rated air quantity at 1 inch static pressure. Casing leakage shall not exceed 2 percent of rated air quantity at 1 inch static pressure.

Units shall be provided with multi-port averaging flow sensors.

Boxes shall be shipped with the actuator from the factory. Controls shall be provided by the controls subcontractor, not the box manufacturer.

Sound performance shall be per ARI Standard 880, radiated and discharge NC less than 30 at 1 inch water gauge.

4.10 Laboratory Ductwork

Laboratory exhaust ducts should be preferably round, non-combustible, inert to agents to be used, nonabsorbent, and free of any organic impregnation.

Duct Material: Galvanized duct is not acceptable for laboratory exhaust systems. Ducts in shaft are recommended to be stainless steel. In new installations round 18 gauge minimum thickness Type 316L stainless steel is recommended. For most lab exhaust applications, 316L stainless or CPVC are suitable materials.

CPVC fume hood ductwork must be low flame spread CPVC with a flame spread rating of 5 or less, a smoke developed index of less than 25, (both in accordance with ULC S102.2) and meet FM 4910 Clean Room Materials Flammability Test. The material shall be Type IV, Grade I with a Cell Classification of 23437 as defined in ASTM D1784.

Duct Connections: ANSI Z9.5-2012 Section 5.4.2.1 states: "Longitudinal sections of a duct shall be a continuous seamless tube or of a continuously welded formed sheet. Longitudinal seams that are formed mechanically shall be utilized only for light duty systems with no condensation or accretion inside the duct." and "Traverse joints shall be continuously welded or flanged with welded or Van Stone flanges."

1. Clarification: The process of manufacturing a pipe spool with both flanges rotating without the use of conventionally welded or screw threaded collars is known as the "Conrac" or more properly the "Van Stone" system. The process essentially forms a lap collar by spinning over the parent tube at right angles to the original tube axis.
2. NFPA 45-2015 Chapter 7 contains: "7.4.5 Positive pressure portions of the lab hood exhaust systems (e.g., fans, coils, flexible connections, and ductwork) located within the laboratory building shall be sealed airtight or located in a continuously mechanically ventilated room."
3. These codes require duct connections to be tight. As the exhaust is under negative pressure, air leakage will be into the ductwork, not out of it. If the pressure differential is not too great it is possible that condensing liquids could possibly drip out of an open seam at the bottom of the duct.
4. Connections at the fan intake can be made with coated glass fiber cloth. Be sure that the cloth coating (neoprene, vinyl, silicone, Teflon, etc.) is compatible with chemicals used in the hoods connected to the upstream ductwork. In general, the MIT EHS office recommends that the transition joint from duct to fan shall be made of inert, corrosion and UV-resistant materials. The duct alignment offset shall not exceed 1.2 inch at the fan.
5. For welded duct work a continuous "butt" weld (use appropriate filler rod of same material as duct) for joint construction is required for both stainless and CPVC duct. CPVC duct welding shall be by the hot gas method only. Solvent welding shall not be used.
6. A flanged removable spool piece at each fume hood connection shall be provided. This spool sections can be used for leak tests, inspection, and to facilitate removal of equipment. Acceptable gaskets at flanged joint connections should be installed.

4.11 Flexible Duct Connections

Flexible connections generally be installed between fans and the connected duct system.

Hard duct all fume hood exhaust fans. No flexible connections should be used in this case.

Variable Volume Terminals: Generally, hard ducted where exposed to view.

4.12 Manual Dampers and Splitters

Ruskin and Greenheck are also acceptable products.

Provide manual opposed blade volume damper in each supply, return and exhaust branch duct from associated main duct and in each run-out to supply or return diffuser or register.

For scavenger or snorkel exhaust use blast gate damper.

4.13 Fire Dampers

Fire dampers shall be UL labeled in accordance with UL-555.

Fire dampers shall be installed per SMACNA standards.

For accordion-style fire dampers, the blades should be completely out of air stream when in the open position.

Provide access panel in duct and in ceiling or wall.

Use static type for systems that shut down on fire and dynamic type on systems that continue to operate.

Do not install on hazardous exhaust systems.

Greenheck or Ruskin combination fire/smoke dampers with Belimo actuators are preferred for fire/smoke applications.

4.14 Belt Guards

Provide for all belt driven equipment, OSHA approved guards designed for easy removal and hinged arrangement.

4.15 Diffusers, Registers and Grilles

Provide vaned diffusers, registers and grilles to reduce drafts and slow outlet velocities.

For high volume areas, provide round or flat oval perforated duct diffusion equal to United type SP. Constructed and engineered in accordance with United Corporation's Engineering Report No. 153 "Designing SP Duct Diffuser Systems". Maximum pressure drop .1 inch static pressure. For user comfort avoid downward flow of air. In certain conditions the bottom portion of the perforated duct may require a sheet metal (shroud) blank-off piece.

Location and types of diffusers must be carefully determined to avoid drafts, fogging windows, disruption of air flow at fume hoods, etc. In rooms without ceilings, consider use of lay-in panel type diffusers to avoid "dumping".

4.16 Exhaust Fans

AMCA certified for sound and air performance.

Exhaust fans shall be statically and dynamically balanced to no greater than 0 .1 inch per second. Vibration shall be tested and documented at factory.

Provide centrifugal, general purpose, Class II, fans for supply, exhaust and transfer with backward inclined or air foil type fan wheel. All fans should be Class II construction as a minimum level of quality.

Centrifugal used for fume hood exhaust installed indoors shall be up blast with weather hood and drain.

Fan shall be tested per AMCA 210-85. Fan sound tests shall be per AMCA 300.

UL listed per UL 705.

Fans shall meet NFPA-45.

Spark resistant construction per AMCA "C" shall be specified when appropriate.

4.17 Gravity Roof Ventilators

Spun aluminum with bird screen and insulated roof curb.

4.18 Motors, Drives and Starters

Premium efficiency motors, conform to utility company standards for rebate if available.

Starters and VFD's provided by electrical unless part of packaged equipment.

Motors driven by VFDs shall be equipped with motor shaft grounding rings at both ends.

Motors for VFD shall be VFD inverter duty rated.

4.19 Variable Speed Controllers

VFD's shall be provided under electrical section. Coordinate with electric design.

4.20 Access Panels and Doors in Ductwork

Access doors and panels must be appropriate size for intended purpose.

Show location and sizes of access doors and panels on Contract Documents and do not assume Contractor will provide the correct size or the correct locations.

Provide access doors and panels for all valves, dampers, fire dampers, at both sides of booster coils, at VAV boxes, at all control devices, and elsewhere needed.

4.21 Humidifiers

Specify Nortec, Armstrong, and Dri-Steem for small wall mount canister units.

Dri-Steem or Armstrong wands in duct shall be provided for large systems.

4.22 Acoustical Duct Lining

If at all possible, do not use duct lining anywhere on the air supply system. Use silencers or double wall ductwork constructed with a perforated steel liner to achieve sound attenuation.

If silencers will not achieve the desired result and the extent of double wall duct required is cost prohibitive, use flexible closed cell engineered polymer foam insulation duct lining. Emphasize compliance with the manufacturer's installation standards in the specification.

4.23 Insulation

Insulate ducts on the exterior for condensation control. Duct-board is more durable and neater in appearance than duct-wrap. Do not use internal insulation on fans. If ductwork insulation is to be exposed, review the requirements, durability and appearance of externally mounted insulation with MIT Project Manager and Architect.

4.24 Sound Attenuators

The designer shall schedule acoustic performance requirements for all relevant equipment. Coordinate these requirements with the client's goals and the acoustical consultant's advice.

Verify self-generated noise does not exceed noise criteria.

Test silencer per ASTM E477.

Attenuation material must be protected from erosion. Perforated covers should be used, but may not be adequate to prevent fibers from entering the air stream. Erosion coatings may not be long lasting and durable. Use mylar film for critical areas. Review special coatings which may be required for fume hood exhaust systems.

4.25 Fan Drives

Adjustable speed sheaves are not permitted. Provide fixed sheaves once balancing is complete.

4.26 Heat Wheels

We have had good results with the Thermotech heat wheel which has a number of robust design features, including the rim construction and design, the spoke arrangement, and the seal mechanism. The Thermotech wheel is our preferred product, but we have had success with products from SG America. We exclude the Trane OEM wheels as sold by AirExchange and wheels from SEMCO for reasons of durability and performance.

4.27 Static Plate Total Energy Recovery Devices

Static plate ERD's shall be by RenewAire or SEG approved equal. Static plate ERD's must insure no contaminants pass from the exhaust airstream into the supply airstream. They must transfer latent heat as well as sensible heat energy.

4.28 DX Split Systems

These are typically provided to reliably support BDF rooms, IDF rooms and elevator equipment rooms. They may also be used for other applications where building chilled water is not available. DX single or multi-split systems shall be by Mitsubishi or Facilities Engineering approved equal. Daikin systems are excluded.

4.29 Outdoor Condensing Units

Outdoor condensing units shall be specified with hail guards to reduce weather related damage.

4.30 Valve Tags

Comply with requirements in Division 22 - Plumbing, Par. 4.2.

5. GREEN DESIGN

5.1 Opportunities

Sustainable, green building design opportunities include, but are not limited to the following:

1. Fume hood design, including facilitation of hood hibernation program.
2. Ventilation design.
3. Cleaning water treatment systems.
4. CFC Reduction in HVAC and R Equipment Renewable Energy: Solar or Wind Power Elimination of HCFC's and Halons.
5. Green Power: Purchased from "Green" Utilities.
6. Thermal Comfort: Comply with ASHRAE 55-2013 and provide permanent monitoring system.
7. Heat Recovery.
8. Economizers on water or air side.
9. Efficient Control Schemes.
10. VAV Systems.
11. IAQ Monitoring, including CO2.
12. Commissioning.

13. Design for Ventilation Effectiveness.
14. Model Design to Optimize Energy Consumption.
15. Review the impact of green design on indoor air quality.
16. Receive design input and comments from the "Green Building Task Force" or similar.

5.2 Energy Conservation

Since the conditioning and movement of air is a major component of energy conservation management systems, MIT has generally used off-hour "temperature drift" and shut-down techniques. HVAC energy conservation is generally implemented through the building automation system. HVAC systems must be designed to permit transition from off-hour to peak-hour conditions within a reasonable period of time. It is expected that systems with adequate capacity be able to transition from off-hour to peak-hour conditions within 90 minutes or less.

1. Zoning: Zoning of building HVAC system into subsystems serving areas with common environmental and occupancy requirements is typically required. Give consideration to zoning techniques which accommodate individual after hour occupants with minimum operation of areas not in use. Buildings with fan coil units shall have those units controlled (on/off) in blocks by a time clock or building automation control point occupancy schedule. After hours occupant override shall be provided through occupied/unoccupied button on thermostat.
2. Ventilation: Ventilation rates should be minimized, but always maintained within the acceptable parameters established by the IMC, ASHRAE, MIT EHS, and the project requirements.

Refer to the Design Guidelines thematic folder "Sustainability" for additional requirements.

6. OPERATIONS

6.1 Operations Requirements

Provide adequate space around equipment for maintenance.

Provide proper clearance for panels, tube pull, etc.

For critical applications, lube oil lines for fans may be extended to outside the unit to permit lubrication without requiring a shutdown.

For contaminated exhaust place the motors outside of the air stream.

Provide adequate valves, dampers, etc., to isolate equipment and major system branches during maintenance.

6.2 Integrated Pest Management

Depending on the design of the cooling and heating system, these systems can at times serve as dark, quiet, and sheltered walkways for pests.

Prior to starting work a pest inspection of the space should be conducted, by the Pest Management Vendor and Design team, to control or eliminate any pest and to seal any pest access points in to the space.

After the work is concluded a follow up a pest inspection of the space should be conducted, by the Pest management Vendor and Design team to ensure all pest access points have been blocked with suitable materials.

Focus for both inspections should be the perimeter of the room, closets, electrical systems, drop ceilings, sewer systems, heating and cooling systems.

7. TESTING, ADJUSTING, BALANCING AND COMMISSIONING

7.1 Preliminary Installation Tests

The Construction Contractor and its subcontractors shall make the following preliminary mechanical system tests and obtain approval and acceptance of MIT and the Project Engineer and Architect, as applicable.

Certifications

Require the Contractor to provide test certifications showing the test has been made and is approved by local authorities and the MIT Project Manager.

Steam, Condensate and Water Piping Testing

Make hydrostatic pressure tests for 2 hours at not less than 150% of operating pressure, but never less than 50 psi. For large projects, test system in sections. X-ray of welds where required by piping spec.

Medium and High Pressure Ductwork Testing

Test duct risers and branches individually with a blower, orifice section and U-tube gauge board. Isolate each riser and branch under test with seals, plugs and caps. Maintain 8" pressure with maximum loss of 1" pressure difference across the orifice plate. Repair leaks with loss of more than 1" and all noisy or whistling leaks and retest until accepted.

Horizontal Mains

Test horizontal mains in the mechanical room after all risers have been accepted, after horizontal mains have been connected to the risers and before branches have been connected to the risers. Make tests as indicated above for duct risers and branches.

Final Connections

Only after work has been tested and accepted, connect branches to the risers and begin insulation work.

7.2 Custom AHU Factory Tests

Makeup Air Handling Units (MAHUs) and Exhaust Air Handling Units (EAHUs) Factory Testing

Scope of testing:

1. Airflow delivery at static (with duct traverse), 100 to 110% of design is acceptable. Also manufacturer to test at 50% of design flow.
2. Leakage and deflection with dial micrometers (positive & negative). 1/2% at 12" w.c. for leakage, L/250 for deflection.
3. Vibration test on fans to BV-5 (0.08 in/s).
4. Sound pressure readings by octave band at inlet, outlet, and adjacent to fan section.
5. Filter rack deflection test. L/250 at 3 inch water column.
6. Motor hi pot test.
7. All test plates for leakage testing to be in place for field re-testing by others.

Witnessing and video recording of testing:

1. Customer will be witnessing testing of AHU
2. Manufacturer to video record and distribute as directed all tests that the customer does not witness – all the tests on other units in under the same order
3. Manufacturer's Submittal Engineer/Project Engineer will act as surrogate witness for the testing for any units customer will not be here to witness.

Following is a narrative and explanation of each of the tests listed in the summary above.

Airflow Delivery at Static

1. Related standards: AMCA 203 Field Performance Measurement of Fan Systems
2. Basic Methodology:

   a. Unit to be connected to a test duct that follows the intent of AMCA 210, the standard for generating published fan ratings.

b. Round ducts will be used, approximately 10 duct diameters long with a straightener section in the middle.

c. Readings are taken toward the air leaving end of the duct, where the flow is best developed and there is the best opportunity to obtain a useable set of readings from a duct traverse.

d. Static pressure is simulated using an adjustable cone at the end of the test duct, partial blocking off of coils and filter racks, or a combination thereof.

3. Readings taken are:

a. Duct traverse for airflow.

b. Static pressure across the fan(s).

c. Fan power consumed is taken as the output power of the VFD used in the test stand, read directly from the VFD display.

4. Acceptance Criterion:

a. Per job specification, 110 to 100% on flow. This is more stringent than the AMCA ratings program or the reference standard on field testing, AMCA 203.

5. Details:

a. Instruments: Shortridge AirData Multimeter ADM – 870C (manometer functionality) ASME / AMCA Stainless Steel Pitot Tube 60" Dwyer 160-60.

b. Under the current AMCA ratings program, a fan manufacturer is entitled to apply the AMCA sticker to a fan if it can achieve a given operating point with a 3% speed variation or less from that published. In the testing at hand, we expect to adjust the VFD Hz and hence the fan speed until we reach 100% flow or more at the design static pressure. AMCA 203 states the uncertainty of the method as 2 to 10%, so it would not be unusual to see a fan speed higher than predicted under the ratings program as the speed needed to reach the acceptance criterion per the job specifications.

c. For the MAHU's, the discharge opening on the 45 degree angle face of the discharge plenum will be blocked and sealed. A removable plug panel will be built in to the end wall, to allow the test duct to connect in a direct fashion, on a common horizontal line with the unit, without transition ductwork out of the 45 degree discharge opening.

d. For the EAHUs, units will be tested without the attenuating round stacks installed, owing to height constraints within the factory. The fan inlet pressure will be measured and the other side of the manometer will be left open to atmosphere, just as the discharge of the fan is open to atmosphere in the test set up. The test duct will be connected to the inlet openings of the units via suitable transitions.

e. For the 50% airflow test, all fans will be running and turned down 50%.

Leakage and Deflection Tests

1. Related standards: ASHRAE 111, AHRI 1350
2. Basic Methodology:

   a. Unit openings are sealed. Test pressure is generated using an external test fan. Positive pressure sections are tested at positive pressure; negative pressure sections are tested at negative pressure. Fan isolation dampers are removed so that fan wall openings can be properly sealed to separate positive from negative sections. Leakage is determined using a calibrated orifice. Deflection is read from digital plunger-type micrometers during the leakage test.

3. Acceptance Criterion:

   a. Leakage: 1/2% of design unit cfm at +/-12" w.c test pressure.
   b. Deflection: L/250 at +/-12" w.c test pressure.

4. Details:

   a. Instruments:

      1) Shortridge AirData Multimeter ADM – 870C (manometer functionality) Internal tube #5202-5 which has a 3.25" calibrated orifice mounted in a tube of suitable length.
      2) B&K Vibrotest 60 kit with included accelerometers.
      3) Fowler Digital Indicator 0-1", manufacturers part # 54-520-250 (micrometer, plunger type).

   b. Tube is mounted between the test blower and the unit being tested.
   c. Measured pressure drop across calibrated orifice is used with calibration curve or equation for orifice to infer cfm of leakage.
   d. Measured pressure within unit is recorded as test pressure.

Vibration Tests on Fans

1. Related standards: AMCA 204
2. Basic Methodology:

   a. Motors are powered to design speed and sensor is placed at appropriate points for analyzer to take readings. Isolators are locked down. Readings are filter-in. Per job specification, all three axes are to be checked.

3. Acceptance Criterion: BV-5 (0.08 in/s vibration velocity)

Sound Pressure Readings

1. Related standards: None
2. Basic Methodology:

   a. A hand-held B&K 2238 sound analyzer/filter will be used to take 8 octave band readings at these locations during the airflow test (i.e., fan running at design conditions): 5 feet from end of test duct, 5 feet outside fan section casing, 5 feet from unit inlet for MAHUs, as near fan discharge as we can physically get with the personnel lifts we have for the EAHUs

3. Acceptance Criterion: None. Information only.

Filter Rack Deflection Tests

1. Related standards: None
2. Basic Methodology:

   a. Rack will be covered with shrink wrap so that shrink wrap will be sucked against rack when pressure is applied. Deflection will be measured with a micrometer at mid-point of rack.

3. Acceptance Criterion: L/250, where L is the greater of rack height or rack width
4. Details: Deflection will be read using same digital micrometers as used in casing deflection test.

Motor Hi Pot Test (High Potential)

1. Related standards: UL1995.
2. Instrument: 02925 – 5kV 12mA AC Tester.
3. Basic Methodology: Each motor wire is subject to 2.1kVA voltage, to verify integrity of winding insulation at voltage substantially higher than operating.
4. Acceptance Criterion: Pass/Fail.
5. Details: This test is a standard part of procedures we are obligated to follow under our ETL listing.

7.3 Operating Tests and Balancing

MIT may employ a separate balancing contractor, independent of contractors employed for other mechanical work on a project, to test and balance mechanical system piping and air handling systems. Discuss particular project requirements with the MIT Systems Engineer before developing operating test and balancing specifications.

Balancing Contractor’s Responsibilities During Original Installation: The Balancing Contractor shall make regular visits to the job site during installation of mechanical systems to ensure that work is being installed in a manner and with accessories which will permit satisfactory balancing of the systems.

Balancing Contractor’s Responsibilities During Pressure Testing: The Balancing Contractor shall observe pressure testing of medium and high pressure ductwork to the extent that the Balancing Contractor can ensure that the completed system will be sufficiently air tight to permit proper air balancing.

Notification Required: The Balancing Contractor shall immediately notify the MIT Project Manager and the Architect in writing with specific information if the Balancing Contractor believes that additional accessories such as dampers and valves are necessary for proper balancing, and if the Balancing Contractor believes that any work is being installed in a manner, which adversely affects proper balancing.

Test Policies and Procedures: The Balancing Contractor employed by MIT will make operation and balancing tests only after pressure tests and system cleaning is completed by the Project Contractor and its Mechanical Subcontractor. Make tests in the presence of MIT Project Man- ager and Project Engineers and Architect. Make CFM and static pressure tests.

1. Test Equipment: The Balancing Contractor shall provide all test equipment, gauges, instruments and personnel needed to properly complete the tests performed by the Balancing Contractor.
2. Construction Contractor’s Responsibilities: The Construction Contractor and its subcontractors shall cooperate with the Balancing Contractor and shall make all necessary adjustments as recommended by the Balancing Contractor. At no additional cost to MIT, the Construction Contractor and its subcontractors shall adjust or replace all impellers, pulleys, sheaves, belts, dampers and other work, and shall add dampers as needed for correct system operation and balance. After balancing is complete, the Construction Contractor and its subcontractors shall replace adjustable sheaves with fixed sheaves and check total system airflow to be sure it remains within specification.
3. Test Evaluation and Acceptance: The Balancing Contractor shall provide a detailed Balancing Report. The Balancing Report shall not be a copy of the design documents. The Balancing Report shall be a new report with tables having columns for Room Name and Number, Design Requirement, Measured Value and Deviation. The Balancing Contractor shall also provide typewritten opinions and evaluation as to whether the installed systems meet design requirements. Acceptance and approval of the installed work, however, shall remain with the Project Engineer, Project Architect and MIT Project Manager, and not the Balancing Contractor.

Acceptance Criteria: To be acceptable, design requirements must be met within +/-10%. In addition to meeting design requirements, the installed work shall operate with the least possible and no objectionable noise or vibration. Quiet and vibration free operation is a Contract requirement. Work, which does not meet this requirement, shall be repaired or replaced at no additional cost to MIT.

Acceptance by Authorities: A Contract requirement shall be to provide systems, which are acceptable to authorities having jurisdiction. Work, which does not meet this requirement, shall be repaired or replaced at no additional cost to MIT.

APPENDIX A: PIPE CLASS INDEX TABLE

CLASS	SERVICE	MATERIALS
125 CHW-C	Chilled Water in Buildings	Copper and Bronze
125 HHW-C	Heating Hot Water in Buildings	Copper and Bronze
125 CHW-S	Chilled Water in Buildings	Carbon Steel
125 HHW-S	Heating Hot Water in Buildings	Carbon Steel
300	High Pressure Steam in Buildings	Carbon Steel
300C	High Pressure Condensate in Buildings	Carbon Steel
150	Medium Pressure Steam in Buildings	Carbon Steel
150C	Medium Pressure Condensate in Buildings	Carbon Steel
150L	Low Pressure Steam in Buildings	Steel, Cast Iron, and Bronze
125C	Low Pressure Condensate in Buildings	Steel, Cast Iron, and Bronze
150F	Generator Fuel Oil in Buildings	Steel , Malleable Iron, and Bronze

APPENDIX B: HEATING AND COOLING PIPE CLASSES

Pipe Class:	125CHW-C 125HHW-C						**Material:**	Copper	
Primary ANSI Class:	125						**Primary Material Use:** Chilled Water/Heating Hot Water within buildings		
							Date: September, 2016		
Service Limits	Temperature, °F	150	200	250	300	350	406		Corrosion Allowance 0.05 inch
	Pressure, psig	200	185	170	155	140	125		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Tubing	4" – Under	Type L		Seamless Hard Copper Tubing ASTM B-88
Unions	1/2" – 2"		ANSI B16.22	Bronze, 150# Soldered type
	2 1/2" – 4"			Bronze, Use flanges or Victaulic couplings where possible instead of unions
Flanges	4" and Under		ANSI B16.5	Cast Bronze, 125#, ASTM B62, solder joint
Couplings	2" – 4"		ASTM A536	Ductile iron housings, ASTM A536, cast with offsetting, angle-pattern bolt pads (no torque requirement). Installation Ready similar to Victaulic Style 607.
Soldered Fittings	1/2" - 4"		ANSI B16.18	Soldered type, wrought copper brass or cast bronze, ASTM AB75 or B62
Grooved Fittings	2" – 4"		ANSI B16.18 ANSI B16.22	Bronze casting or wrought copper fittings with copper tube dimensioned grooved ends by Victaulic
Pressed fittings	1/2" - 4"		ASME B16.18 ASME B16.22 ASME B16.26	Copper and copper alloy, ProPress by Viega
Soldered Joints	1/2" – 4"		ANSI B16.18	95-5, tin-antimony, solder

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Ball	Block/Isolation	1/2" – 4"	ANSI B2.1	Bronze ASTM B-62, 125# WSP rating, Solder joint, (Hammond 8311, Apollo 7-200 or equal) or Forged brass, 300 psig CWP, pressure-sealed ends (Similar to Victaulic Series 589)
Butterfly	Block/Isolation	2 ½" – 4"	MSS-SP67	Brass (conforming to UNS C87850), copper tube dimensioned grooved ends, offset aluminum-bronze disc, integrally cast steel stem, pressure responsive elastomer seat. Similar to Victaulic Series 608N.
Check / Swing Type	Prevent Reverse Flow	1/2" – 2"	MSS-SP80-2 ANSI 16.18	Bronze ASTM B-62, 125# WSP rating, Solder joint
		2 1/2" and Larger	MSS-SP70-1 ANSI B16.10	Cast Iron A-126, 125#, flanged ends, swing or piston check
Check/ Silent Type	Pump Discharge	1/2" – 2"		Spring loaded, Center guided, Manufactured by Williams-Hager, Miller, Mueller, or Combination Pump Valve
		2 1/2" and Larger		Spring loaded, Center guided, Manufactured by Williams-Hager, Miller, Mueller, or Combination Pump Valve

BOLTING AND GASKETS			
Bolting:	Studs: Square or hex head, ASTM A307, Grade B, 2A threads	Nuts: Heavy Hex , ANSI B18, 2B threads, ASTM A-194 or A-307	
	Track-head heat-treated carbon steel per ASTM A449 and A183	Track-head heat-treated carbon steel per ASTM A449 and A183	
Gaskets	1/16” Red rubber, Full face		
Coupling Gaskets	Grade “EHP” EPDM with red and copper color code, suitable for water temperature range from -30 deg F to +250 deg F		
NOTES:	1. Viega ProPress and Victaulic valves may be considered as alternates. 2. Other equivalent pressed or grooved systems may be considered 3. Grooved couplings and fittings shall only be used in locations that are accessible for maintenance. 4. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. 5. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, verification of groove and installation of grooved piping products. Prior to the installation of Victaulic systems, a formal project-specific contractor kick-off meeting shall be performed by Victaulic with the appropriate subcontractor personnel who will be assigned to each project. A sign-in sheet and confirmation signatures shall be obtained by all attendees as documentation support that any personnel who will be grooving pipe and/or installing Victaulic products has obtained and understands the requirements as put forth by Victaulic installation instructions. . Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products. 6. Where possible, carbon steel grooved pipe 4” and larger shall be produced using the Victaulic RG5200i fully automated grooving tool that provides groove traceability documentation, corresponding identification marks on the pipe, and confirms all critical dimensions fall into the required tolerance range as listed by the tool manufacturer.		

Pipe Class:	125CHW-S	**Material:**	Steel
Primary ANSI Class:	125	**Primary Material Use:** Chilled Water within buildings	
		Date: Dec , 2016	

Service Limits	Temperature, °F	150	200	250	300	350	406		Corrosion Allowance 0.05 inch
	Pressure, psig	200	185	170	155	140	125		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½”-2”	Schedule 80	ANSI B36.10	Black steel pipe, ASTM A-53 Gr. B, ERW
	2 1/2" and Larger	Standard Wall		Black steel pipe, ASTM A-53 Gr. B, CW or ERW
Equipment Mating Flanges	1/2" – 2”	See Note 2	ANSI B16.5	Steel, 150 lb., socket weld or screwed, ASTM A-181, Gr 1, RF
	2 1/2" and larger			Steel, 150 lb., weld neck or slip-on, ASTM A181, Gr I, RF
Fittings (option) See note 3	2 1/2" and Larger			Grooved ductile iron, ASTM A-536 or A-395, or forged or fabricated from carbon steel pipe, ASTM A-53 or carbon steel ASTM 105, 106 or 235.
Couplings (option) See note 3	2 1/2" and Larger			Victaulic style 177, 107, W77, W07 as applicable; a minimum of three (3) Victaulic series 177 or W77 , flexible couplings must be used on pump suction and discharge, and other connections to rotating or vibrating equipment such as cooling towers, chillers. Proper joint assembly for non-tongue & recess couplings shall be verified by visual means (no coupling torque requirements as a primary means of obtaining joint rigidity).
Unions	1/2” – 2”			Malleable Iron, 250#, ASTM A197, Screwed, for ground joint use flanges
	2 1/2" and larger			Use flanges or Victaulic couplings.
Fittings	1/2" – 2”		ANSI B16.3	Malleable Iron, 250#, ASTM A126, Screwed
	2 1/2" and Larger	Wall thickness to match pipe	ANSI B16.9 or ASTM A536/395	Steel, Extra Strong, Butt Welded, ASTM A234, WPA or Victaulic grooved ended full-flow, as-cast ductile iron.

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Ball	Block/Isolation	1/2" – 2”	ASTM B62	Bronze, 125# WSP, Screwed (Hammond 8311, Apollo 70-200 or equal)
Check / Swing Type	Prevent Reverse Flow	1/2" – 2”	ANSI B62	Bronze, 125#, WSP, Screwed
		2 1/2" and larger	ANSI B16.1	Cast iron, 125#, Flanged, ASTM A-126 Class B, Renewable seat, Swing or piston type
		2” – 3”	AWWA C606	Ductile iron, ASTM A536, horizontal swing, grooved ends, 300 psi CWP, Victaulic Series 716H
		4"–12"		Ductile iron, ASTM A536, horizontal swing, grooved ends, 300 psi CWP, Victaulic Series 716

Check / Silent Type	Prevent Reverse Flow at Pump Discharge See note 4	1/2" – 2”	ASTM B62	Spring loaded, Center guided, Manufactured by Williams-Hager, Miller, Mueller, Bronze, 125# screwed ends
		2 1/2" and Larger	ASTM A126 CL B	Spring loaded, Center guided, Manufactured by Williams- Hager, Miller, Mueller, with Cast iron flanged ends, or Victaulic Tri-Service valve assembly.
Y-Pattern Globe	Manual Balancing	½” and larger		Multi-turn globe, ductile-iron or bronze body, with screwed, soldered, flanged or grooved ends. Digital handwheel with concealed/tamperproof locking device to permit full valve closure and re-opening to set position.
Butterfly See note 5	Block Isolation	2 1/2" and Larger		For main line isolation valves which separate the building from the campus system and other critical locations, provide high performance valves designed for bubble tight shut-off at a minimum of 200 psig differential pressure with water at 150°F. For installations between flanges, provide lug type or flanged valves. Provide steel body, worm gear operated, SS shaft, bronze or Ni-Resist disc, and Buna-N seat. Victaulic 300 MasterSeal (2”-12”) or Vic-300 AGS (14” – 24) are acceptable. For general purpose block and isolation functions within buildings, provide Bray Series 31H or Centerline Series 200 with ductile iron body and aluminum bronze discs. These valves shall be designed for use w/ 150# standard flange. For grooved end application use Victaulic 300 MasterSeal (2”-12”) or Vic-300 AGS (14” – 24). For Butterfly valves 4” and larger, specify the valve manufacturer’s gear operator.
BOLTING AND GASKETS				
Bolting:	Studs: Square or Hex head, ASTM A307, Grade B, 2A threads			Nuts: Heavy Hex , ASTM A194- or A-307, ANSI B18, 2B threads
	Track-head heat-treated carbon steel per ASTM A449 and A183			Track-head heat-treated carbon steel per ASTM A449 and A183
Gaskets	1/16” Red Rubber or EPDM for grooved fittings; Ring for raised face joints, full face or flat flanges			
Grooved Coupling Gaskets	Grade “EHP” EPDM with red and green color code suitable for water and oil-free compressed air with operating temperatures from -30 deg F to +250 deg F, available with Installation-Ready couplings 2” through 12”..			
	Grade “E Flushseal” EPDM with green color code suitable for water and oil-free compressed air with operating temperatures from -30 deg F to +230 deg F, available with standard and AGS couplings 14” and Larger			
NOTES:	1. All welds shall comply with requirements of B31.1 2. Flange bore to match pipe. 3. Grooved couplings and fittings shall only be used in locations that are accessible for maintenance. 4. Triple duty valves shall not be used. 5. Wafer style butterfly valves shall not be used. 6. Other equivalent grooved systems may be considered 7. Grooved couplings and fittings shall only be used in locations that are accessible for maintenance. 8. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. 9. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, verification of groove and installation of grooved piping products. Prior to the installation of Victaulic systems, a formal project-specific contractor kick-off meeting shall be performed by Victaulic with the appropriate subcontractor personnel who will be assigned to each project. A sign-in sheet and confirmation signatures shall be obtained by all attendees as documentation support that any personnel who will be grooving pipe and/or installing Victaulic products has obtained and understands the requirements in the Victaulic installation instructions. . Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products. 10. Where possible, carbon steel grooved pipe 4” and larger shall be produced using the Victaulic RG5200i fully automated grooving tool that provides groove traceability docs, corresponding identification marks on the pipe, and confirms all critical dimensions fall into the required tolerance range as listed by the tool manuf.			

Pipe Class:	125HHW-S	Material: Steel
Primary ANSI Class:	125	Primary Material Use: Heating Water within buildings
		Date: Dec, 2016

Service Limits	Temperature, °F	150	200	250	300	350	406		Corrosion Allowance 0.05 inch
	Pressure, psig	200	185	170	155	140	125		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½"-2"	Schedule 80	ANSI B36.10	Black steel pipe, ASTM A-53 Gr. B, ERW
	2 1/2" and Larger	Standard Wall		Black steel pipe, ASTM A-53 Gr. B, CW or ERW
Equipment Mating Flanges	1/2" – 2"	See Note 2	ANSI B16.5	Steel, 150 lb., socket weld or screwed, ASTM A-181, Gr 1, RF
	2 1/2" and larger			Steel, 150 lb., weld neck or slip-on, ASTM A181, Gr I, RF
Fittings (option) See note 3	2 1/2" and Larger			Grooved ductile iron, ASTM A-536 or A-395, or forged or fabricated from carbon steel pipe, ASTM A-53 or carbon steel ASTM 105, 106 or 235.
Couplings (option) See note 3	2 1/2" and Larger			Victaulic style 177, 107, W77, W07 as applicable; a minimum of three (3) Victaulic series 177 or W77 , flexible couplings must be used on pump suction and discharge, and other connections to rotating or vibrating equipment such as cooling towers, chillers. Proper joint assembly for non-tongue & recess couplings shall be verified by visual means (no coupling torque requirements as a primary means of obtaining joint rigidity).
Unions	1/2" – 2"			Malleable Iron, 250#, ASTM A197, Screwed, for ground joint use flanges
	2 1/2" and larger			Use flanges or Victaulic couplings.
Fittings	1/2" – 2"		ANSI B16.3	Malleable Iron, 250#, ASTM A126, Screwed
	2 1/2" and Larger	Wall thickness to match pipe	ANSI B16.9 or ASTM A536/395	Steel, Extra Strong, Butt Welded, ASTM A234, WPA or Victaulic grooved ended full-flow, as-cast ductile iron.

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Ball	Block/Isolation	1/2" – 2"	ASTM B62	Bronze, 125# WSP, Screwed (Hammond 8311, Apollo 70-200 or equal)
Check / Swing Type	Prevent Reverse Flow	1/2" – 2"	ASTM B62	Bronze, 125#, WSP, Screwed
		2 1/2" and larger	ANSI B16.1	Cast iron, 125#, Flanged, ASTM A-126 Class B, Renewable seat, Swing or piston type
		2" – 3" 4" – 12"	AWWA C606	Ductile iron, ASTM A536, horizontal swing, grooved ends, 300 psi CWP, Victaulic Series 716H Ductile iron, ASTM A536, horizontal swing, grooved ends, 300 psi CWP, Victaulic Series 716

Check / Silent Type	Prevent Reverse Flow at Pump Discharge See note 4	1/2" – 2”	ASTM B62	Spring loaded, Center guided, Manufactured by Williams-Hager, Miller, Mueller, Bronze, 125# screwed ends
		2 1/2" and Larger	ASTM A126 CL B	Spring loaded, Center guided, Manufactured by Williams- Hager, Miller, Mueller, with Cast iron, flanged ends, or Victaulic Tri-Service valve assembly.
Y-Pattern Globe	Manual Balancing	½” and larger		Multi-turn globe, ductile-iron or bronze body, with screwed, soldered, flanged or grooved ends. Digital handwheel with concealed/tamperproof locking device to permit full valve closure and re-opening to set position.
Butterfly See note 5	Block Isolation	2 1/2" and Larger		For main line isolation valves which separate the building from the campus system and other critical locations, provide high performance valves designed for bubble tight shut-off at a minimum of 200 psig differential pressure with water at 150°F. For installations between flanges, provide lug type or flanged valves. Provide steel body, worm gear operated, SS shaft, bronze or Ni-Resist disc, and Buna-N seat. Victaulic 300 MasterSeal (2”-12”) or Vic-300 AGS (14” – 24) are acceptable. ---For general purpose block and isolation functions within buildings, provide Bray Series 31H or Centerline Series 200 with ductile iron body and aluminum bronze discs. These valves shall be designed for use w/ 150# standard flange. For grooved end application use Victaulic 300 MasterSeal (2”-12”) or Vic-300 AGS (14” – 24). For Butterfly valves 4” and larger, specify the valve manufacturer’s gear operator.

BOLTING AND GASKETS		
Bolting:	Studs: Square or Hex head, ASTM A307, Grade B, 2A threads	Nuts: Heavy Hex , ASTM A194- or A-307, ANSI B18, 2B threads
	Track-head heat-treated carbon steel per ASTM A449 and A183	Track-head heat-treated carbon steel per ASTM A449 and A183
Gaskets	1/16” Red Rubber or EPDM for grooved fittings; Ring for raised face joints, full face or flat flanges	
Grooved Coupling Gaskets	Grade “EHP” EPDM with red color code suitable for water and oil-free compressed air with operating temperatures from -30 deg F to +250 deg F, available with Installation-Ready couplings 2” through 12”..	
	Grade “E Flushseal” EPDM with green color code suitable for water and oil-free compressed air with operating temperatures from -30 deg F to +230 deg F, available with standard and AGS couplings 14” and Larger	
NOTES:	1. All welds shall comply with requirements of B31.1 2. Flange bore to match pipe. 3. Grooved couplings and fittings shall only be used in locations that are accessible for maintenance. 4. Triple duty valves shall not be used. 5. Wafer style butterfly valves shall not be used. 6. Other equivalent grooved systems may be considered 7. Grooved couplings and fittings shall only be used in locations that are accessible for maintenance. 8. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. 9. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, verification of groove and installation of grooved piping products. Prior to the installation of Victaulic systems, a formal project-specific contractor kick-off meeting shall be performed by	

Victaulic with the appropriate subcontractor personnel who will be assigned to each project. A sign-in sheet and confirmation signatures shall be obtained by all attendees as documentation support that any personnel who will be grooving pipe and/or installing Victaulic products has obtained and understands the requirements as put forth by Victaulic installation instructions. . Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

10. Where possible, carbon steel grooved pipe 4” and larger shall be produced using the Victaulic RG5200i fully automated grooving tool that provides groove traceability documentation, corresponding identification marks on the pipe, and confirms all critical dimensions fall into the required tolerance range as listed by the tool manufacturer.

APPENDIX C: PIPE CLASS 150L AND 125C (LOW PRESSURE STEAM AND CONDENSATE)

Pipe Class:	150L	**Material:**	Carbon Steel
Primary ANSI Class:	150 and 125	**Primary Material Use:**	Low Pressure Steam
		Date:	Dec, 2016

Service Limits	Temperature, °F	150	200	250	300	350	406	Limits established by ASTM B-62, pressure Class 125	Corrosion Allowance 0.05 inch
	Pressure, psig	200	185	170	155	155	125		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½" – 2"	Schedule 80	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
	2 ½" and larger	Schedule 40 or std. wall		ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 150 lb. raised face flange, ASTM A-181, Gr. I
	2 ½" and larger			Weld neck 150 lb. raised face flange, ASTM A-181, Gr. I
Threaded Fittings	½" – 2"	250 lb.	ANSI B16.4	Screwed, Cast Iron, ASTM A-126 Class B
Weld Fittings	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Butt weld, steel, ASTM A-234 WPB
Unions	½"-2"	300 lb.	ANSI B16.3	Screwed, malleable iron ASTM A-197

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/ Isolation	½" – 2"		Screwed end with bronze ASTM B-62 body, bonnet, and disc holder. PTFE composite disc and copper silicon steel stem Stockham Fig B-13T or MIT approved equal
		2 1/2"- 24"		Cast iron ASTM A-126 Class B, 125 lb, bolted bonnet, OS&Y, bronze trim, flanged ends, Crane Fig. 465 ½ or MIT approved equal
Globe	Throttling	½" – 2"		Screwed end with bronze ASTM B-62 body, bonnet, and disc holder. PTFE composite disc and copper silicon steel stem similar to Stockham Fig B-16 or MIT approved equal
		2 ½" and larger	ANSI B16.34	Cast iron ASTM A-126 Class B, 125 lb, bolted bonnet, OS&Y, bronze trim. flanged ends, Crane Fig. 351 or MIT approved equal
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Screwed end with bronze ASTM B-62 body, and bronze or brass disc holder. PTFE composite similar to Stockham Fig B-320TY or MIT approved equal
		2 ½" and larger		Cast iron ASTM A-126 Class B, 125 lb, bolted cap, bronze trim. flanged ends, Crane Fig. 373 or MIT approved equal
Traps		All		Cast steel or forged steel, 150 lb. bucket type

BOLTING AND GASKETS

Bolting:	Studs: ASTM A-193, Square or hex head, 2A threads	Hex Nuts: Heavy hex, ASTM A-194, ANSI B18, 2B threads
Gaskets	1/16" Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 150 lb. ring for steel to steel, full face for flat flange	

NOTES:

1. Use flanges for equipment connections 2 ½" and larger
2. All welds shall comply with the requirements of B31.1

Pipe Class:	125C	**Material:**	Carbon Steel
Primary ANSI Class:	150 and 125	**Primary Material Use:**	Low Pressure Condensate
		Date:	Dec, 2016

Service Limits	Temperature, °F	150	200	250	300	350	406	Limits established by ASTM B-62, pressure Class 125	Corrosion Allowance 0.05 inch
	Pressure, psig	200	185	170	155	155	125		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½" and larger	Schedule 160	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 150 lb. raised face flange, ASTM A-181, Gr. I
	2 ½" and larger			Weld neck 150 lb. raised face flange, ASTM A-181, Gr. I
Threaded Fittings	½" – 2"	250 lb.	ANSI B16.4	Screwed, Cast Iron, ASTM A-126 Class B
Weld Fittings	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Butt weld, steel, ASTM A-234 WPB
Unions	½"-2"	300 lb.	ANSI B16.3	Screwed, malleable iron ASTM A-197

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/ Isolation	½" – 2"		Screwed end with bronze ASTM B-62 body, bonnet, and disc holder. PTFE composite disc and copper silicon steel stem Stockham Fig B-13T or MIT approved equal
		2 ½"- 24"	ANSI B16.34	Cast iron ASTM A-126 Class B, 125 lb, bolted bonnet, OS&Y, bronze trim, flanged ends, Crane Fig. 465 ½ or MIT approved equal
Globe	Throttling	½" – 2"		Screwed end with bronze ASTM B-62 body, bonnet, and disc holder. PTFE composite disc and copper silicon steel stem similar to Stockham Fig B-16 or MIT approved equal
		2 ½" and larger	ANSI B16.34	Cast iron ASTM A-126 Class B, 125 lb, bolted bonnet, OS&Y, bronze trim. flanged ends, Crane Fig. 351 or MIT approved equal
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Screwed end with bronze ASTM B-62 body, and bronze or brass disc holder. PTFE composite similar to Stockham Fig B-320TY or MIT approved equal
		2 ½" and larger		Cast iron ASTM A-126 Class B, 125 lb, bolted cap, bronze trim. flanged ends, Crane Fig. 373 or MIT approved equal
Traps		All		Cast steel or forged steel, 150 lb. bucket type

BOLTING AND GASKETS

Bolting:	Studs: ASTM A-193, Square or hex head, 2A threads	Hex Nuts: Heavy hex, ASTM A-194, ANSI B18, 2B threads
Gaskets	1/16" Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 150 lb. ring for steel to steel, full face for flat flange	

NOTES:

1. Use flanges for equipment connections 2 ½" and larger
2. All welds shall comply with the requirements of B31.1

APPENDIX D: PIPE CLASS 150 AND 150C (MEDIUM PRESSURE STEAM AND CONDENSATE)

Pipe Class:	150	**Material:**	Carbon Steel
Primary ANSI Class:	150	**Primary Material Use:**	Medium Pressure Steam
		Date:	Dec, 2016

Service Limits									
Temperature, °F	100	200	300	400	500	600		Corrosion Allowance 0.05 inch
Pressure, psig	285	260	230	200	170	140		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½” – 2”	Schedule 80	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
	2 ½” and larger	Schedule 40 or std. wall		ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½” – 2”	Bore to match pipe diam.	ANSI B16.5	Socket weld 150 lb. raised face flange, ASTM A-181, Gr. I
	2 ½” and larger			Weld neck 150 lb. raised face flange, ASTM A-181, Gr. I
Fittings	½” – 2”	3,000 lb.	ANSI B16.11	Socket welded forged carbon steel, ASTM A-105, Gr. II
	2 ½” and larger	Standard	ANSI B16.9	Carbon steel, standard butt weld ASTM A-234 WPB
Unions	½”-2”	3,000 lb.	ANSI B16.11	Socket welded forged carbon steel, ASTM A-105, Gr. II, ground joint
	2 ½” and larger	See Note 1	ANSI B16.5	

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/ Isolation	½” – 2”		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends ANSI Class 800. Velan 2054B or MIT approved equal.
		2 ½” and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 47 ½ , or MIT approved equal.
Globe	Throttling	½” – 2”		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2074B or MIT approved equal.
		2 ½” and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 143 ½ , or MIT approved equal.
Check/ Swing Type	Prevent Reverse Flow	½” – 2”	ANSI B16.34	Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800.. Velan 114B or MIT approved equal.
		2 ½” and larger		Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 147 ½ , or MIT approved equal.
Traps		All		Cast steel or forged steel, 300 lb. bucket type

BOLTING AND GASKETS			
Bolting:	Studs: ASTM A-193, Grade B7, heavy hex	Hex Nuts: ASTM A-194, Class 2H, heavy hex	Cap Screws: ASTM A-325
Gaskets	1/16" Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 300 lb. for steel on steel, full face for flat flange		
NOTES:	1. Use flanges for equipment connections 2 ½" and larger 2. All welds shall comply with the requirements of B31.1 3. Valve packing for 150 class and 800 class steam service valves shall be non-hardening PTFE impregnated packing yarn similar to Chesterton style 1724.		

Pipe Class:	150C	**Material:**	Carbon Steel
Primary ANSI Class:	150	**Primary Material Use:**	Medium Pressure Condensate
		Date:	Dec, 2016

Service Limits	Temperature, °F	100	200	300	400	500	600		Corrosion Allowance 0.05 inch
	Pressure, psig	285	260	230	200	170	140		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
	1/2" and larger	Schedule 160	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 150 lb. raised face flange, ASTM A-181, Gr. I
	2 ½" and larger			Weld neck 150 lb. raised face flange, ASTM A-181, Gr. I
Fittings	½" – 2"	3,000 lb.	ANSI B16.11	Socket welded forged CS steel, ASTM A-105, Gr. II
	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Carbon steel, standard butt weld ASTM A-234 WPB
Unions	½"-2"	3,000 lb.	ANSI B16.11	Socket welded forged carbon steel, ASTM A-105, Gr. II, ground joint
	2 ½" and larger	See Note 1	ANSI B16.5	

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/Isolation	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends ANSI Class 800. Velan 2054B or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 47 ½ , or MIT approved equal.
Globe	Throttling	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2074B or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 143 ½ , or MIT approved equal.
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800.. Velan 114B or MIT approved equal.
		2 ½" and larger		Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 150. Velan API 600, Crane Fig. 147 ½ , or MIT approved equal.
Traps		All		Cast steel or forged steel, 300 lb. bucket type

BOLTING AND GASKETS			
Bolting:	Studs: ASTM A-193, Grade B7, heavy hex	Hex Nuts: ASTM A-194, Class 2H, heavy hex	Cap Screws: ASTM A-325
Gaskets	1/16" Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 300 lb. for steel on steel, full face for flat flange		
NOTES:	1. Use flanges for equipment connections 2 ½" and larger 2. All welds shall comply with the requirements of B31.1 3. Valve packing for 150 class and 800 class steam condensate service valves shall be non-hardening PTFE impregnated packing yarn similar to Chesterton style 1724.		

APPENDIX E: PIPE CLASS 300 AND 300C (HIGH PRESSURE STEAM AND CONDENSATE)

Pipe Class: 300								Material: Carbon Steel	
Primary ANSI Class: 300								**Primary Material Use:** High Pressure Campus Steam	
								Date: Dec, 2016	
Service Limits	Temperature, °F	100	200	300	400	500	600		Corrosion Allowance 0.05 inch
	Pressure, psig	740	675	655	635	600	550		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½" – 2"	Schedule 80	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
	2 ½" and larger	Schedule 40		ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 300 lb. raised face flange, ASTM A-105, Gr. II
	2 ½" and larger			Weld neck 300 lb. raised face flange, ASTM A-105, Gr. II
Fittings	½" – 2"	3,000 lb.	ANSI B16.11	Socket welded forged carbon steel, ASTM A-105, Gr. II
	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Butt weld seamless ASTM A-234 WPB

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/Isolation	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2054B, or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends. ANSI Class 300. Velan API 600, Crane Fig. 33 ½ , or MIT approved equal.
				For valves located at the service branch to the building, division valves on the campus steam loop, or the individual feed valve to any pressure reducing station, use Adams Class 300 rotary tight shut-off valve, MAK type, with manual gear operator or MIT approved equal.
Globe	Throttling	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2074B or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 300. Velan API 600, Crane Fig. 151 ½ , or MIT approved equal.
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 114B or MIT approved equal.
		2 ½" and larger		Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 300. Velan API 600, Crane Fig. 159 ½ or MIT approved equal.
Traps		All		Cast steel or forged steel, 300 lb. bucket type

BOLTING AND GASKETS			
Bolting:	Studs: ASTM A-193, Grade B7, heavy hex	Hex Nuts: ASTM A-194, Class 2H, heavy hex	Cap Screws: ASTM A-325
Gaskets	1/16” Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 300 lb. for steel on steel, full face for flat flange		
NOTES:	7. All welds shall comply with the requirements of B31.1 8. Valve packing for 300 class and 800 class steam service valves shall be non-hardening PTFE impregnated packing yarn similar to Chesterton style 1724.		

Pipe Class: 300C				Material: Carbon Steel
Primary ANSI Class: 300				Primary Material Use: High Pressure Campus Condensate
				Date: Dec, 2016

Service Limits									
Service Limits	Temperature, °F	100	200	300	400	500	600		Corrosion Allowance 0.05 inch
	Pressure, psig	740	675	655	635	600	550		

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½" and larger	Schedule XXS	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 300 lb. raised face flange, ASTM A-105, Gr. II
	2 ½" and larger			Weld neck 300 lb. raised face flange, ASTM A-105, Gr. II
Fittings	½" – 2"	3,000 lb.	ANSI B16.11	Socket welded forged carbon steel, ASTM A-105, Gr. II
	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Butt weld seamless ASTM A-234 WPB

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/ Isolation	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2054B Class 800 or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends. ANSI Class 300. Velan API 600, Crane Fig. 33 ½ , or MIT approved equal.
Globe	Throttling	½" – 2"		Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 2074B or MIT approved equal.
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 300. Velan API 600, Crane Fig. 151 ½ , or MIT approved equal.
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Forged carbon steel ASTM A-105, bolted bonnet, OS&Y, stainless steel trim, socket welded ends, ANSI Class 800. Velan 114B or MIT approved equal.
		2 ½" and larger		Cast carbon steel ASTM A-216 Gr. WCB, bolted bonnet, OS&Y, stainless steel trim, butt welded ends, ANSI Class 300. Velan API 600, Crane Fig. 159 ½ or MIT approved equal.
Traps		All		Cast steel or forged steel, 300 lb. bucket type

BOLTING AND GASKETS

Bolting:	Studs: ASTM A-193, Grade B7, heavy hex	Hex Nuts: ASTM A-194, Class 2H, heavy hex	Cap Screws: ASTM A-325
Gaskets	1/16" Anchor Packing 443A, Flexitallic, Remantite, or Garlock Blueguard, 300 lb. for steel on steel, full face for flat flange		

NOTES:

1. All welds shall comply with the requirements of B31.1
2. Valve packing for 300 class and 800 class steam condensate service valves shall be non-hardening PTFE impregnated packing yarn similar to Chesterton style 1724.

APPENDIX F: PIPE CLASS 150F (FUEL OIL)

Pipe Class:	150F								Material:	Carbon Steel
Primary ANSI Class:	150								Primary Material Use:	Fuel Oil
									Date:	Sept, 2016
Service Limits	Temperature, °F	150	200	250	300	350	406		Corrosion Allowance 0.05 inch	
	Pressure, psig	225	210	195	180	165	150			

PIPE AND FITTINGS

ITEM	SIZE	THICKNESS	STANDARD	MATERIAL SPECIFICATION
Pipe	½" – 2"	Schedule 80	ANSI B36.10	ASTM A-106 Gr. B or ASTM A-53 Gr. B
	2 ½" and larger	Schedule 40 or std. wall		ASTM A-106 Gr. B or ASTM A-53 Gr. B
Flanges	½" – 2"	Bore to match pipe diam.	ANSI B16.5	Socket weld 150 lb. raised face flange, ASTM A-181, Gr. I
	2 ½" and larger			Weld neck 150 lb. raised face flange, ASTM A-181, Gr. I or A-105 Gr I
Fittings	½" – 2"	150 lb.	ANSI B16.3	Malleable iron, screwed ASTM A-197
	2 ½" and larger	Wall thickness to match pipe	ANSI B16.9	Carbon steel, standard butt weld ASTM A-234 WPA
Unions	½"-2"	300 lb.	ANSI B16.3	Malleable iron, screwed ASTM A-197

VALVES

TYPE	USE	SIZE	STANDARD	SPECIFICATION
Gate	Block/Isolation	½" – 2"		Screwed end, rising stem with bronze ASTM B-62 body, bonnet, and disc. Crane 431 UB or MIT approved equal
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, 150 lb. ANSI rating, bolted bonnet, OS&Y, stainless steel trim, butt welded ends. Crane Fig. 47 ½, or MIT approved equal.
Globe	Throttling	½" – 2"		Screwed end, rising stem with bronze ASTM B-62 body, bonnet, and disc. Crane 7TF or MIT approved equal
		2 ½" and larger	ANSI B16.34	Cast carbon steel ASTM A-216 Gr. WCB, 150 lb. ANSI rating, bolted bonnet, OS&Y, stainless steel trim, butt welded ends. Crane Fig. 143 ½, or MIT approved equal.
Check/ Swing Type	Prevent Reverse Flow	½" – 2"	ANSI B16.34	Screwed end, with bronze ASTM B-62 body, and disc. Crane 137 or MIT approved equal
		2 ½" and larger		Cast carbon steel ASTM A-216 Gr. WCB, 150 lb. ANSI rating, bolted bonnet, OS&Y, stainless steel trim, butt welded ends. Crane Fig. 147 ½, or MIT approved equal.

BOLTING AND GASKETS

Bolting:	Studs: ASTM A-307, square or hex head, 2A threads	Nuts :heavy hex, ASTM A-194 or A-307, ANSI B18, 2B threads
Gaskets	1/16" Anchor Packing 445, Flexitallic, Remantite, or Garlock Blueguard	

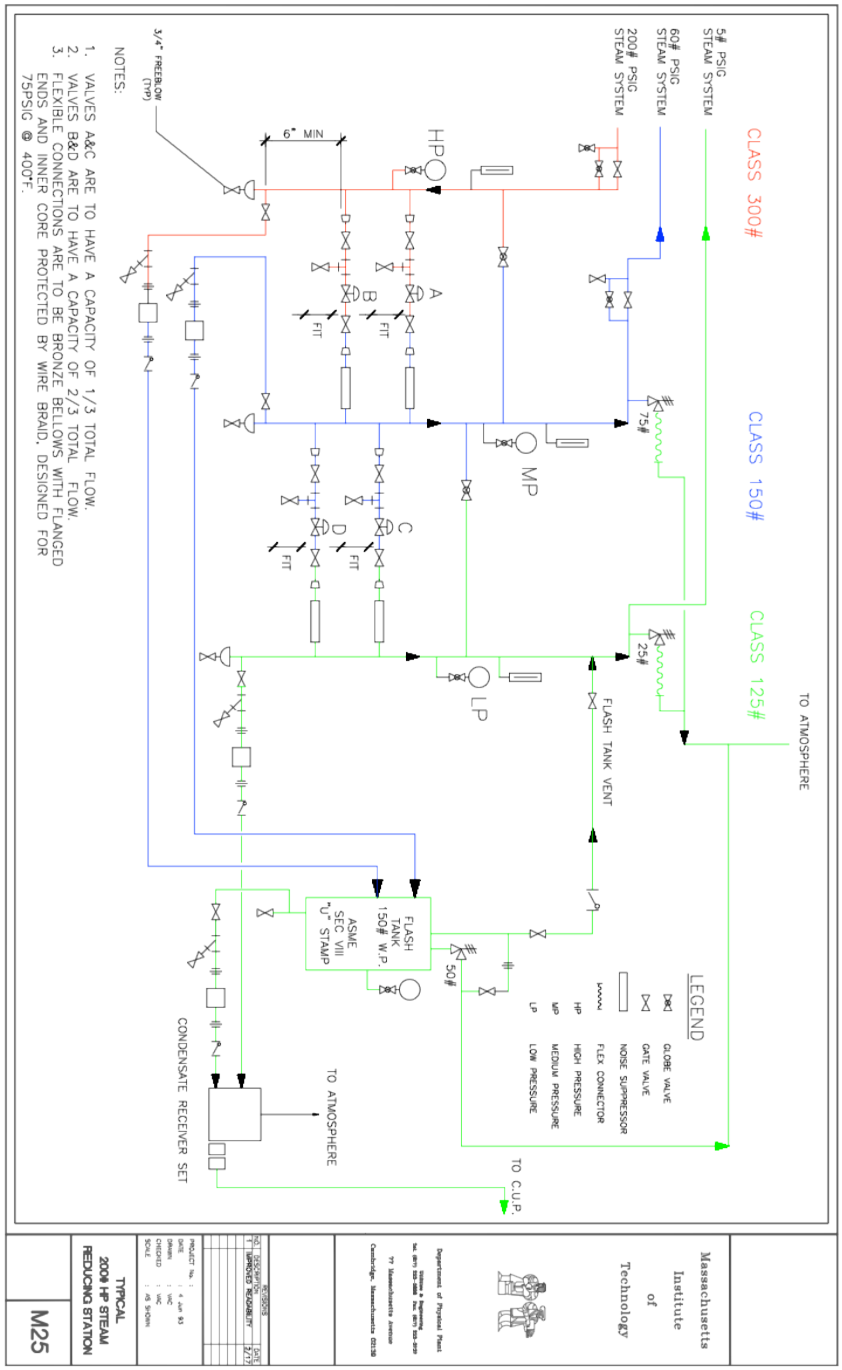
NOTES:

1. All welds shall comply with the requirements of B31.1

APPENDIX G: STRAINER TABLE

CLASS	SIZE	SPECIFICATION
125 CHW-C, 125 HHW-C 125 CHW-S, 125 CHW-S	½”-2”	Cast bronze body 125# rating, threaded ends, Y-type with 20 mesh (maximum) stainless steel screen openings, Mueller Steam Specialty #351M
	2 ½” to 4”	Cast bronze body 125# rating, threaded ends, Y-type with 1/16 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #351M
125 CHW-C, 125 HHW-C	3” and 4”	Cast bronze body 125# rating, flanged ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #851M.
125 CHW-S, 125 HHW-S	4”	Cast iron body 125# rating, flanged ends, Y-type with 1/16 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #758
	5” and up	Cast iron body 125# rating, flanged ends, Y-type with 1/8 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #758
300 and 300C	½” -2”	Cast steel body 600# rating, socket weld ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #582
300	2 1/2”- 4”	Cast steel body 300# rating, butt weld ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #782-WE
	5”-12”	Cast steel body 300# rating, butt weld ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #782-WE
300C	2 1/2”- 4”	Cast steel body 300# rating, flanged ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #782
	5”-12”	Cast steel body 300# rating, flanged ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #782
150 and 150C	½” -2”	Cast steel body 600# rating, socket weld ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #582
150	2 1/2”- 4”	Cast steel body 150# rating, butt weld ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #781-WE
	5”-12”	Cast steel body 150# rating, butt weld ends, Y-type with 1/16 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #781-WE
150C	2 1/2”- 4”	Cast steel body 150# rating, flanged ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #781
	5”-12”	Cast steel body 150# rating, flanged ends, Y-type with 1/16 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #781
150L and 125C	½” -2”	Cast bronze body 125# rating, threaded ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #351
	2 ½ -10”	Cast iron body 125# rating, flanged ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #758
150F Note: Strainers may need to exceed line size for acceptable pressure drop	½” -2”	Cast bronze body 125# rating, threaded ends, Y-type with 1/32 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #351
	2 ½ -10”	Cast iron body 125# rating, flanged ends, Y-type with 3/64 inch (maximum) stainless steel screen openings, Mueller Steam Specialty #758

APPENDIX H: STEAM PRV DETAIL



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