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Northeastern University
Boston, MA

Statement of Work
Basis of Design

Rev 2 – 10/14

Contents

1 Heating, Ventilating and Air Conditioning (HVAC)

2 Plumbing

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1. Heating, Ventilating and Air Conditioning (HVAC)

1.1 General

1.1.1 Standards

Scope of work shall include all labor, materials, tools, equipment, transportation, hoisting, rigging, insurance, etc., to perform the work as indicated on the drawings and herein specified for a complete installation

The general contractor and the HVAC contractor shall make all provisions for protection and safety of all construction employees and all other occupants of the building as they may be affected by the construction process, including but not limited to the ventilation systems, duct control, noise control, etc.

All work shall be in accordance with national, state, and local codes and ordinances.

All substitutions are to be approved by the Northeastern Design / Project Team.

Provide all hangers and supports as required to support all new piping, ductwork, and equipment.

Pay for all permits and fees, obtain all approvals

All work shall be guaranteed for a period of one (1) year after completion date. Date to be determined by the owner.

Shop drawings of pertinent HVAC equipment shall be submitted for review by the architect. Record shop drawings shall be submitted for architect use as well, in the form of three (3) electronic and three (3) paper copies

Any utility outages or system shutdowns for construction shall be scheduled at least three days in advance with the owner prior to commencing of work.

It shall be the responsibility of the HVAC contractor to study all drawings and details so that the installation of all new work can be fully coordinated. The HVAC contractor shall visit the site to satisfy himself that all provisions have been made for all aspects of the project. If discrepancies exist between drawings and/or site conditions, the HVAC contractor shall notify the architect prior to signing of contract.

All demolition of inactive HVAC systems within the contract limits shall be by coordinated by the general contractor and performed by the HVAC contractor.

All cutting, core drilling, etc., required for the installation of the new HVAC systems shall be by the HVAC contractor.

HVAC work is indicated diagrammatically. Location of diffusers, registers, and grilles shall be as indicated on the architect's reflected ceiling plan.

Piping and ductwork shall be concealed unless otherwise noted. Exposed piping and ductwork shall be arranged for neat appearance and shall be shown on shop drawings for approval before installation.

Provide access doors located so that fusible links and other damper components may be inspected, replaced, and/or serviced and so that reheat coils and ductwork may be cleaned.

Provide volume dampers or acceptable air balancing devices at each low pressure branch from main duct and at each duct runout to an individual diffuser, register, or grille in supply and exhaust ducts.

All mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators.

Install room thermostats 4'-0" above finished floor in accordance with ADA requirements except in corridors.

All MEP/FP services exposed within spaces without ceiling shall be painted. Architect/NU shall determine if duct is to be painted based on project type and location.

1.2 Materials and Equipment

1.2.1 Ductwork Materials

Provide new supply and exhaust air ductwork per SMACNA "HVAC Duct Construction Standards – Metal and Flexible." All supply ductwork shall be constructed of G90 galvanized sheet metal unless otherwise noted. All new supply ductwork shall be externally insulated with 1 ½" wall, 1.5 pcf density flexible duct insulation with FSK vapor barrier. All ducts shall be sealed to SMACNA seal class A and leakage class 4. All exposed ductwork within program space without ceilings to be painted to match existing or per direction of architect.

Supply ductwork to have a pressure class of +6"W.G. from AHU to air terminal boxes and +2"W.G. from boxes to diffusers.

Exhaust ductwork to have pressure class of -4"W.G. from EAHU to air terminal boxes/air valves and -2"W.G. from air boxes/air valves to diffusers.

Provide stainless steel W/ -6"W.G. pressure class for fume hood and BSC's exhaust up to medium pressure ganged exhaust main. Provide welded stainless steel on roof systems.

1.2.2 Laboratory System (Phoenix)

Provide a laboratory airflow control system, furnished and installed to control the airflow into and out of laboratory rooms. The exhaust volume of a laboratory fume hood shall be constant volume, based on the Northeastern standard dynamic barrier fume hood. The BMS shall control the laboratory space temperature and occupancy status. Fume hood air flow control valves could be selected as a 2 position valve, based on occupancy sensor status. The laboratory control unit shall maintain temperature control, minimum ventilation, airflow balance, and laboratory pressurization in relation to adjacent spaces (positive or negative). All laboratory airflow control system devices shall be by a single manufacturer.

The airflow control device shall be a Venturi valve equal to the Phoenix controls Accell II model.

The airflow control device shall be pressure independent over its specified differential static pressure operating range.

The airflow control device shall maintain accuracy within +/- 5%

The airflow control device shall be class B. The airflow control device, for corrosive airstreams such as fume hoods, shall have baked-on corrosion resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts, and rivets shall be stainless steel. All shaft bearing surfaces shall be made of Teflon or PPS composite.

Constant volume valves for fume hoods shall maintain position constant volume pressure independent, adjustable, volume setpoint. It shall be factory calibrated and set for desired airflow rate. It shall also be capable of field adjustment for future changes of desired airflow rate.

Each airflow control valve shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least +1% of signal over the entire range of measurement. Electron valves shall be further calibrated and their accuracy verified to +5% of signal at eight different airflows per valve.

All airflow valves shall be individually marked with valve specific and factory calibration data, as a minimum.

1.2.3 Piping and Pipe Insulation

New piping shall be steel or copper pipe to ASTM standards, and Northeastern University standards.

Hot water and/or chilled water piping shall be Type L copper (all sizes) or steel: - All sizes soldered with Silvabrite solder. Vic fittings are acceptable only on chilled water piping.

All new piping systems shall be insulated with 1 ½" thick fiberglass with ASJ.

1.2.4 Air Distribution Devices

Provide diffusers, registers, and grilles as shown and schedule on the drawings and herein specified by Tuttle & Bailey or Metalaire.

All air distribution devices shall be aluminum construction unless otherwise specified herein or schedule on drawings.

All diffusers, registers, and grilles must be compatible with the design ceiling/wall type.

Hang and support air distribution devices independently of the ceiling construction

Ceiling Supply Diffusers

Ceiling or sidewall supply air diffusers shall be of the restricted multi-orifice jet induction and air mixing type, consisting of louvered sections with build-in diffusing vanes, as manufactured by Tuttle & Bailer Type RCTC or Metalaire Series 5000 IV

The vanes shall be arranged to discharge air from adjacent channels at a 45° angle in opposite directions to the plane of discharge to ensure rapid mixing of primary and room air. Each individual diffusing vane shall be welded in two places to the adjacent louver sections to make a rigid integral unit. The vanes shall extend to the discharge edges of the louvers. Where louver sections abut core frame, the louver ends shall be welded to core frame. The louver ends shall be rounded and hemmed before welding to core frames.

Diffusers shall be constructed with an integral collar extending at least 1” above the core to accommodate an internal duct connection. Collar corners shall have welded angles on the outside to prevent leakage and ensure that internal duct connection can be made secure.

Research labs shall utilize low velocity type diffusers. Tritek shall be acceptable for perforated duct, duct socks, etc.

Where dampers are provided, the raised mounting frame shall be sufficiently high enough to accommodate the installation of the damper with the frame and extend 1” above the damper to permit the internal duct connection.

Return and Exhaust Register

Lab return/exhaust registers shall be equal to Tuttle & Bailey Model T77D or Metalaire Model RHD, and shall be made of steel or aluminum with one set of fixed blades, 42” deflection.

All return and exhaust registers installed in all toilet rooms, locker rooms, and showers, and other areas subject to moisture shall be similar to above except constructed of all aluminum, including opposed blade dampers, equal to Tuttle & Bailey Model A77D.

Sidewall Adjustable Supply

Sidewall supply registers shall be equal to Tuttle & Bailer

Model T547 or Metalaire Model H4004SD, and shall be made of steel or aluminum, with mitered corners, double adjustable deflection core, and horizontal front louvers.

High Capacity Radial Ceiling Diffuser

Diffuser intended to disperse supply air at low velocity without induction. The diffuser shall incorporate a flat, non-aspirating face flush to the ceiling or mounting surface and deep back pan plenum with perforated dispersion grid standing off diffuser face. Equal to Anemostat Model HCR, Tuttle & Bailey Vector, or Tritek.

The diffuser air discharge shall be a radial, outward contiguous air stream that forms and fills a 90° arc in continuous planes, perpendicular to the longitudinal axis of the diffuser. The air discharge stream shall allow installation of continuous rows of diffusers that abut each other without air steam interference between adjacent diffusers. Each diffuser shall incorporate a manual patter controller to trim adjust the pattern.

Multi-blade, grille-like assemblies requiring field adjustment of each individual blade to obtain desired pattern are not acceptable.

The radial diffusers shall be constructed from steel or aluminum, the finish of the face assembly shall be baked-on epoxy. The finish of the back pan assembly shall be arctic white baked-on epoxy.

1.2.5 Conduit and Piping Runs

When surface mounted conduit/piping run-outs are required to points of connections, they shall be dropped vertically in corners and offset horizontally to noted locations. Intent is to keep wall surface areas clear of verticals drops.

1.2.6 In-Duct Hot Water Heating Coils

In-duct hot water heating coils shall be manufactured by:

- Trane
- Aerofin
- Heat Craft
- TSI
- Precision

Water heating coil shall be of the extended surface type, constructed of copper tubing minimum 5/8” O.D., 0.035” thick, and having plate fins of aluminum extending at right angles to the tubes.

Tubes shall be pressure bonded into the fin collars by expanding the tubes. No solder bonding shall be used. All copper-to-copper joints shall be made with high temperature silver brazing material.

Plate fins shall be corrugated. Fins shall be spaced no closer than twelve per inch integral spacing collars that cover the tube surface. Minimum fin thickness shall be 0.095”.

Hot water coils shall be tested for 250 psig, maximum 300°F, and 400 psig air pressure under water. All coils shall be performance certified in accordance with ARI 410

1.2.7 Fume Hoods

Fume hoods installed shall be Kewaunee Dynamic Barrier.

Hoods shall have the following piping routed to each one:

- Water
- Compressed Air
- Vacuum
- High Vacuum
- Nitrogen
- Natural Gas

As specified by client

1.2.8 Automatic Temperature Controls

The temperature control system shall be directed by Northeastern University, consisting of DDC controls to fill the intent of the design and provide for a complete and operable system.

Room Sensor/Controls

- Room thermostats shall have occupant adjustment of +/- 2°F
- Thermostat locations and type shall be reviewed by architect and owner prior to installation

Hot Water Re-Heat

- Update graphics at existing BMS to reflect CFM values & fan systems supporting specific rooms.

1.2.9 Air Testing Balancing and Adjusting

The HVAC contractor shall procure the services of the balancing and testing contractor approved by Northeastern University, who specializes in the balancing and testing of heating, ventilating, and air conditioning systems, to balance and adjust all moving equipment, air distribution/exhaust systems and test all water systems.

Balance supply air and return/exhaust air terminal boxes, diffusers, grilles, and reheat coils service the project area to within 5% of specified values, and to maintain correct directional room air migration.

Test calibration of thermostat and environmental monitoring sensors.

Provide all testing instruments used for balancing air and water systems. All instruments shall have been calibrated within a period of six (6) months prior to balancing. Types, serial number, and dates of calibration of all instruments shall be listed in the final air and water balance reports.

Provide all manpower, instruments, temporary connections, and all other materials required to accomplish the balancing and testing specified.

In the event the HVAC contractor fails to balance the systems for correct directional airflow and within 5% of the capacities or quantities indicated on the drawings, and it becomes necessary for the owner to balance them correctly, the cost of this work will be backcharged to the HVAC contractor.

Test forms used by balancing engineers and technicians shall be set up to include the following information:

- Each sheet shall have the job name and address, the name of the balancing contractor, owner, architect, engineer, the instruments used to perform the test, and the test date.
- All of the specified design parameters as well as actual balanced values.

1.3 Basis of Design

Fume hood venturi valves should be 2-position constant volume (occupied/unoccupied) based on detection of an associated occupancy sensor. This is to be confirmed with Northeastern prior to design. When the sensor detects movement, the fume hood exhaust valve shall be indexed to occupied mode. Sensor is indexed to unoccupied when no movement is sensed for 10 minutes.

Make-up supply Phoenix valves shall modulate based on the occupied hood exhaust valves. The supply valves shall modulate proportional to the exhaust valves to maintain a negative CFM offset with relation to additional lab spaces, offices, and corridors.

Supporting lab space Phoenix valves shall be indexed to occupied mode based on an associated occupancy sensor. The valves shall modulate in proportion in order to maintain a positive CFM offset.

Associated reheat coils shall modulate to maintain a room setpoint of 70°F. For cooling mode of supporting lab spaces, the phoenix valves shall increase supply and exhaust airflow and maintain the set CFM offset.

Fail positions for associated equipment, per Northeastern standards, are as follows:

- Supply Air Valve – Fail Last Position
- Exhaust Air Valve – Fail Open
- Supply Air Reheat Valve – Fail in place

2. Plumbing

2.1 Materials and Equipment

2.1.1 Piping, Fittings, Joints, and Valves

Laboratory Waste and Laboratory Vent System
Schedule 40 fire retardant polypropylene, ASTM D4101, 2" and smaller to be mechanical joint system. Larger than 2" shall be fused joints as manufactured by Orion, Enfield, R.G. Sloan, or Asahi.

Natural Gas Pipe and Fittings
Black steel pipe schedule 40 and conforming to ASTM A120-74 (Seamless Type). Fittings shall be black malleable screwed type conforming to ANSI B16.3-71.

Valves 3" and small shall be Apollo Series 70-100-07 threaded bronze valve, 600 PSI WOG, or approved equal by Northeastern University.

Nitrogen and Argon Pipe and Fittings
All piping shall be welded, drawn, and annealed Type 304 Stainless Steel tubing 16 gauge thickness to 2-1/2" size. Based on user purity of the lab gases, copper could be used. If used, piping must be brazed and purged during installation.

Fittings shall be Type 316 stainless steel conforming to ASTM B31.1 and B31.2 or Swage-Lock, Gyrolock, or Parter tube fittings. Fittings and pipe to be one manufacturer to assure proper fit and total system conformance.

Joints shall be either flanged or swage connections to valves, equipment, and where indicated on the contract drawings

Laboratory Vacuum & Laboratory Air
Tubing to be Type L hard temper with wrought copper fittings conforming to ASTM B88 and ASTM B16.22. All joints shall be brazed and purged with inert gas (N_2).

Isolation/Shut-off valves 2" and small shall be all bronze ball valves Watts Series B-6000 or Apollo 77-200, full port Teflon seated ball and 2-piece valve body designed for 600 PSI water and shall have threaded ends with sweat adapters. 3-piece valves shall be utilized for brazed applications. Substitutes must be approved by Northeastern University.

Non-Potable Water & Tempered Water Systems
Hard drawn Type L copper with wrought copper or cast brass fittings with 95-5 lead-free solder joints. Pro Press

mechanical fittings are acceptable on non-potable & tempered water systems.

Isolation/Shut-off valves 2” and smaller shall be all bronze ball valves Watts Series B-6000 or Apollo 77-200, full port Teflon seated ball and 2-piece valve body designed for 600 PSI water and shall have threaded ends with sweat adapters. Pro Press shall be acceptable on domestic, non-potable, and tempered water systems.

RODI Water Piping
Piping shall be SRD11 Series polypropylene with a wall thickness conforming to ASTM-2837 with butt fusion joints rated for 150 PSI at 68°F as manufactured by George Fischer, ASAHI, or SIMTECH.

Valves shall be diaphragm type, ½” to 2”. Polypropylene with an allowable working pressure of 150 PSI at 68°F water, spigot ends, EPDM diaphragm, position indicator, George Fischer type 315PPM, ASAHI, or SIMTECH

2.1.2 Pipe Hangers and Supports

Drainage Piping
Horizontal Supports: Provide B-Line Systems INC. Figure B3100 clevis hangers with supporting rods and adjustable turnbuckles.

Insulation Shields: Provide oversized hangers with 12-inch long galvanized insulation shields on rainwater piping

Structure Attachments
Clamps: B-Line Systems, Globe, Grinnell, and Michigan

Inserts: Empire, Grinnell, Michigan and Unistrut, or Carpenter & Patterson 650 UL-Listed

Ceiling Bolts: For installation in metal decks, Carpenter & Patterson Figure 143

Insulation Shields: Carpenter & Patterson Figure 265P

Insulation
Insulation thickness shall be as follows:

- Cold Water Piping: ½ inch
- Hot Water Piping: 1 inch
- Hot Water Return Piping: 1 inch

2.1.3 Testing of Systems

Pressure Test
Before attachment of system components, such as pressure actuating switches for alarms, manifolds, pressure gauges, relief valves, etc., but after installation of the laboratory gas termination and vacuum outlets, with

rest caps in place, and before closing of the walls and ceilings, each piping system shall be subject to a minimum test pressure of 150 psig with oil free dry air or nitrogen.

This test shall be maintain until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection safe for use with oxygen.

Leaks, if any, shall be repaired and the section retested.

Final Pressure Test
After testing each individual system as specified above, the assembled stations outlet valves and all other system components such as pressure actuating switches for alarms, manifolds, pressure gauges, relief valves, shall be installed and all laboratory gas piping systems shall be subject to a 24 hour standing pressure test at 20% above normal line pressure

3. Electrical

3.1 General

3.1.1 Scope of work

- Lighting fixtures and lamps
- Conduit and cable
- Wiring devices and plates
- Connection to existing panel boards
- Outlet, pull and junction boards
- Branch circuit breakers
- Panelboards
- Grounding
- Multi-outlet assembly
- Hangers, supports, inserts, sleeves
- Firestopping, smokeproofing, waterproofing
- Demolition and removal of existing electrical equipment
- Fire Alarm devices
- Furnishing of access panels (as required)
- Testing, cleaning, and adjusting
- Fees, permits, royalties, guarantees.
- Shop drawings
- Record drawings
- Empty conduit system for telephone and data
- Cutting, coring through walls and floors.

3.1.2 Grounding

Provide grounding for all electrical equipment and devices in accordance with applicable requirements of the National Electrical Code (NEC) and IEEE Standards, as indicated on drawings.

Bonding jumpers shall be installed at all locations required by NEC

A green grounding conductor of proper size shall be installed and connected with the feeder circuit conductors, to wiring devices, circuits, and lighting fixtures. Connections to the equipment may be bolted or screwed using corrosion resisting bolts or screws.

3.2 Materials

3.2.1 Lighting Fixtures

Existing lighting fixtures to be removed. Fixtures to be retained at Northeastern's discretion.

All fixtures shall be furnished complete with sockets, wiring trims, hangers, frames, lamps, ballasts, etc.

Mounting height and locations of all lighting fixtures shall be determined from architectural ceiling plans and elevations

All lighting fixtures to be re-lamped and ballasts shall be of the energy saving type, to match existing building standards

Existing lighting fixtures to be cleaned and verify proper operation before re-installation

3.2.2 Branch Circuit Wiring

All branch circuits signal wiring shall be copper rated at 600 volts, installed in conduit or EMT

Minimum size for branch circuit and power wiring shall be #12 AWG for remote control signal circuit and interlock wiring may be #14 AWG.

Insulation types shall be wiring, THHN for lighting branch circuit and THWN for remote control, signal circuits and fire alarm wiring. THWH shall be used for underground and wet locations.

Color coding for identification shall match existing color coding

Number associated with each branch circuit outlet identifies the branch circuit to which the device served by the outlet is to be connected. The circuit numbers indicated are utilized to denote limits of branch circuits only, and are not intended to limit the panelboard circuitry.

For branch circuit homeruns, MC cable shall transition to conduit/wireways and wire before entering the panelboard

3.2.3 Conduit

All wiring, unless otherwise noted, shall be installed in rigid metal conduit, EMT, or flexible metal conduit, subject to restriction of NEC. Minimum size ¾ inches.

EMT fittings shall be cold-rolled steel compression or mechanical fastened. Die cast filling shall not be used.

When surface mounted conduit run-outs are required to points of connections, they shall be dropped vertically in corners and offset to noted locations. Intent is to keep wall surface clear of vertical drops

3.2.4 Outlet Boxes

Outlet boxes shall be one piece galvanized construction meeting NEC requirements, or proper size and suitable for location indicated on the drawings.

Outlet boxes in wall partitions shall not be installed back-to-back, unless properly firestopped.

Outlet boxes shall be 4' square with 1 gang or 2 gang plaster extension rings as required and manufactured by the following:

- Crouse-Hinds Company: Appleton
- Steel City Electric Company: RACO

3.2.5 Pull and Junction Boxes

Pull boxes and junction boxes shall be constructed of Code gauge galvanized steel and shall be installed at points required by code whether indicated on the drawings or not. Minimum dimension shall not be less than NEC requirements.

Provide flat plain covers with suitable flat head machine screws or slotted truss head bolts

3.2.6 Wiring Devices

Furnish and install wiring devices to match base building standards. Devices shall be specification grade, complete with all accessories indicated in contract documents.

Catalog numbers specified for this section are Hubbell. Other manufacturers are acceptable at Northeastern's approval.

Duplex receptacles shall be U-ground, rated for 125V, 20 amperes, specification grade. All device plates shall be marked as to panel and circuit location.

Duplex receptacles with ground fault interrupter characteristics shall be U-ground, rated for 125V, 20 amperes, specification grade, feed-through type. Ground fault receptacles shall meet the requirements of UL 943, 2006. All receptacles in toilets or bathrooms within 6'-0" of sink locations, exterior outlets, utility vault, in wet areas shall be ground fault type. Hubbell #HBL GF5362, or approved equal by Northeastern University.

Switches shall be full size, heavy duty, AC type, rated for 20 amperes – 120/277 Volts

Duplex receptacles with ground fault interrupter characteristics shall be Hubbell #HBL GF8300 or approved equal.

Color of all wiring devices shall be as selected by the architect, except for receptacles on emergency systems shall be red and standby systems shall be orange.

3.2.7 Surface Mounted Raceway System

Manufacturer for multi-outlet assembly shall be as follows:

- Wiremold Prewired Systems – Series 4000
- Steel with epoxy coated factory finish

Raceway
Raceway shall have 2 wiring compartments with field removable cover. Raceway shall have a nominal wall thickness of 0.078"

Raceway covers shall be a minimum of 18" in length to facilitate future modification. Covers must be removable with a standard straight blade screwdriver without marring.

Raceway shall be manufacturer of steel factory applied epoxy finish.

Raceway covers shall have holecut provision for telecommunications outlets, voice and data/LAN outlets.

3.2.8 Telephone/Data System

An empty telephone/data conduit and outlet system shall be provided for connection to the existing building communications. From each designated outlet, an empty box and conduit with pull string shall be extended above ceiling

Conduits and sleeves shall be based on number of cables possible to each telecommunication outlet. Each single gang device plate may be supplied by two cables and each double gang device plate may be supplied by four cables, conduits, and sleeves shall be provided as follows:

- Two cables – ¾"
- Four cables – 1"
- Eight cables – 1 ¼"
- Ten cables – 1 ½"
- Fourteen cables – 2"

The intent is to provide a fully accessibly empty conduit system for future installation of communications wiring

3.2.9 Panelboards

Bus
Main bus bars shall be copper sized in accordance

with UL standards to limit temperature rise on any current carrying part to a maximum of 65°C above an ambient of 40°C maximum.

A bolted copper ground bus shall be included in all panels

Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices

Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection

Branch Circuit Panelboards
Bolt-on type, heavy duty, quick-make, quick-break, single and multi-pole circuit breakers of specified types shall be provided for each circuit with toggle handles that indicate when unit has tripped. All Panelboards shall be marked with engraved ID as well as feeder location. All branch circuit Panelboards shall be clearly marked as to the circuit's purpose and location.

Circuit breakers shall be thermal magnetic type with common tie handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100 ampere frame and through 100 ampere trip sizes shall take up the same pole spacing. 20 ampere, single pole circuit breakers shall be UL listed as type SWD for lighting circuits.

Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management and control system (EMCS) panels and fire alarm panels.

Enclosure
Enclosures shall be at least 20 inches wide and 5 ¾ inches deep made from galvanized steel. Provide minimum gutter space in accordance with the National Electric Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, an auxiliary gutter shall be provided, sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided. All panelboard covers shall be door in door type.

Enclosures shall be provided with removable blank ends.

All Panelboards shall have NEMA 1 general purpose enclosures unless otherwise noted.

Finish
Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 49

or 61 paint applied

Acceptable Manufacturers
General Electric
Approved equal by Northeastern University

3.2.10 Busway Plug-in Units

Plug-in units shall be factory pre-assembled, and shall be of the types and ratings indicated on plans

Plug-in units shall be mechanically interlocked with the busway housing to prevent their installation or removal while the switch is in the ON position. The enclosure of any plug-in unit shall make positive ground connection to the duct housing before the stabs make contact with the bus bars. All plug-in units shall be equipped with a defeatable interlock to prevent the cover from being opened while the switch is in the ON position and to prevent accidental closing of the switch while cover is open. The plugs shall be provided with a means for padlocking the cover closed and padlocking the disconnect device in the OFF position.

The operating handle and mechanism of the plug-in unit shall remain in control of the disconnect device at all times permitting its easy operation from the floor by means of a hookstick or chain. Plug-in units shall be equipped with a means for direct positioning or hanging, so that the weight is borne by the duct before the stabs make contact with the bus bards. For safety reasons, no projections shall extend into the busway housing other than the plug-in stabs. All plug-in units shall be interchangeable without alteration or modification of plug-in duct.

Plug-in units shall be circuit breaker type with integral time delay/thermal trip protection in one assembly and shall meet all requirements of UL Standard 489. Circuit breakers connected to normal power busways shall be solid state type with ground fault protection

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General Design Conditions

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains general system and architectural design and performance requirements, equipment installation guidelines, disposal guidelines, and design team coordination requirements.

B. System and Architectural Design and Performance Requirements

In addition to the design, performance, and coordination requirements contained in this section, the designer must design Northeastern University facilities to applicable codes and industry standards.

1. General

a. Cut at least one section in every mechanical room.

b. For continuity of critical services, design in redundancy and provide sufficient isolation for maintenance.

c. Architect and engineers to communicate proposed redundancy with Northeastern prior to design drawings

2. Vibration Control

a. Carefully evaluate each installation of vibration producing equipment for transmission of vibrations to the building structure. In some cases, special equipment and techniques are required due to the presence of extremely sensitive laboratory devices in the building Determine the need for special equipment and techniques in all locations.

b. Be aware that some of the buildings are of very light construction and require special treatment for any vibration-producing equipment. To reduce transmission problems, flexible duct connectors should be at least 6" long and fire resistant.

c. Give special attention to the need for pipe and conduit isolation from vibration sources.

3. Seismic Design – Where Applicable, Based on Project

a. The design of seismic controls must be performed by a professional engineer licensed to practice in the State of Massachusetts. The engineer is responsible for the complete design, the verification of seismic zone classification, and the selection of all seismic restraint systems and components, including all vibration isolation elements.

b. Design piping, hangers, and braces to meet State of Massachusetts building codes. The hanger supplier is not responsible for seismic design. The design of anchors, thrust restraints, guides, and other similar components is the responsibility of the engineer.

4. Noise Control

a. See Table 1 for room background noise guidelines. Selection criteria depend on user or space sound quality needs. Higher or lower values might be appropriate and should be based on an analysis of space use, economics, and user needs. An experienced acoustical consultant should be retained for guidance on acoustical criteria spaces below RC30 and on all performing arts spaces. Verify sound criteria with local codes.

b. Engineer systems to achieve specified sound levels, and use sound attenuation, as necessary. The noise from cooling towers might require special consideration. Consult local codes for maximum ambient noise. See Table 1 for maximum ambient sound guidelines.

Table 1. Room Background Noise Design Guidelines

Space	Noise Criteria (NC)	Room Criteria (RC)	Maximum dbA
Mechanical rooms			85
Primary electrical rooms			85
Stairs	45		
Toilet rooms	40		
Telecom data rooms		30–40	
Elevator machine rooms			85
Laboratory storage spaces		45–55	
Shipping & receiving spaces	45–55		
Breakout rooms		30–40	
Multi-purpose rooms		40–50	
Laboratories		40–45	
Laboratory work spaces		40–45	
Laboratory support spaces		40–50	
Laboratory equipment rooms		45–55	
Private offices		30	
Open-plan offices		30–40	
Corridors		40–45	
Conference & seminar rooms		25–35	
Instrumentation rooms		30–40	
Classrooms		30	
Large lecture rooms		25–30	
Gymnasiums & natatoriums	40–50		
Music practice rooms		30–35	
Drama theaters		25	
Outdoor ambient			60 (1)

(1) At 120 feet.

5. *Space Efficiency*

Minimize the floor area required while providing specified spaces, space relationships, and required circulation and services areas.

6. Energy Efficiency

Minimize energy consumption while providing the specified function, amenity, and comfort requirements. See Section 01352: Sustainable Design Requirements.

7. Water Consumption

Minimize water consumption. See Section 01352: Sustainable Design Requirements.

8. Waste (Trash/Rubbish) Removal

See the project program and Section 01352: Sustainable Design Requirements.

9. Ease of Operation

Provide facilities, equipment, and systems that personnel can operate easily with a reasonable level of training. Minimize the need for specialized training in the operation of specific systems or equipment. Identify all equipment and systems for which the manufacturer recommends or provides training. See Section 01810: Commissioning and Section 01820: Demonstration and Training.

10. Ease of Maintenance

- Minimize the amount of required maintenance.
- For new buildings, provide a means of washing exterior windows.

11. Ease of Repair

Elements that do not meet the specified requirements for ease of repair may be used under the following conditions:

- They meet the specified ease of replacement requirements for elements not required to have a service life span equal to that specified for the project
- The service life expectancy analysis and life-cycle cost substantiation for the specified service life are provided
- Northeastern University accepts them

12. Ease of Replacement

Design provisions for replacement without undue disruption of building operations for elements not required to have a service life span equal to that specified for the project

13. *Acoustical Performance*

Limit sound transmission through the substructure as follows.

a. Maintain ambient sound levels in enclosed, occupied, substructure spaces within the noise criteria ranges indicated in Tables 2 and 3.

b. Maintain the maximum average daytime and nighttime exterior noise levels from sound sources at building entrances and exists in accordance with City of Boston acoustical requirements.

c. Achieve the outdoor–indoor airborne sound level reductions for perimeter spaces indicated in Table 3 and when tested in accordance with ASTM E 966 and classified in accordance with ASTM E 413 (R94).

d. Use substructure elements that will not resonate at frequencies that are characteristic of ambient underground sound and vibration sources at the project site. Isolate the structure from internal and external sources of vibration adjacent to and on the site.

e. Design and select materials that dampen and maintain the sound of precipitation on the roof and of water flowing down building sanitary and storm risers to the interior ambient sound levels in Table 3.

Table 2. Airborne Sound Design Guidelines—Interior Space to Interior Space

Space	Noise Criteria	Space	Noise Criteria	Minimum Noise Isolation Class
Similar Function		Similar Function		36
Quiet Space	20-30	Moderate	30-40	39
Quiet Space	20-30	Noisy	40-50	42
Quiet Space	20-30	Very Noisy	50-60	48
Moderately Noisy Space	30-40	Noisy	40-50	36
Moderately Noisy Space	30-40	Very Noisy	50-60	42
Adjacent Music Practice Rooms				55
Adjacent Theatres				45
Adjacent Offices Requiring High Speech Confidentiality				50

14. Appearance

Design and select materials to provide the following exterior appearance requirements and characteristics.

a. The materials must be compatible with adjacent buildings on campus.

b. The materials must match the materials on the existing building.

c. Comply with the requirements of the federal historic district in which the project is located.

d. Comply with requirements of the local architectural control or review commission regulating the area in which the project is located.

e. Glazing appearance.

(1) Tint—use as little tint as possible while complying with other requirements.

(2) Reflectivity—do not use glass that has been treated to increase its natural reflectivity.

f. Cleanliness of exterior surfaces.

(1) Prevent the attraction and adherence of dust and airborne dirt and soot.

Minimize the appearance of settled dust and dirt.

(2) Exterior surfaces must be washed reasonably clean by normal precipitation.

(3) Prevent precipitation from washing settled dust and dirt over surfaces exposed to view.

g. Conceal mechanical equipment, plumbing equipment, electrical equipment, piping, conduit, and ducts from view from the street, from windows in the project that overlook the roof, and where possible, from windows in adjacent buildings overlooking the roof. Design permanent concealments for rooftop items using substantial construction other than screens. Coordinate with the HVAC design engineer on concealments for lab fans or duct discharges.

h. Roof color must be compatible with energy efficiency design. Use materials on roofing surfaces exposed to view that will conceal dirt. Arrange roof drainage to eliminate ponding.

15. Health and Safety

a. Design and select materials that provide fire resistance in accordance with code.

(1) All exterior enclosure materials must be non-combustible, without exception.

(2) Facades enclosing stairs must have a fire resistance rating of two hours, unless applicable laws require a higher rating.

(3) Facades exposing stairs or stair enclosures must have a fire resistance rating of one hour within 10 ft (3 m)—horizontally and vertically—of a stair enclosure.

b. Prevent the accumulation and subsequent penetration into occupied spaces of harmful chemicals and gases, such as radon and methane, in spaces below the substructure.

c. Provide permanent protection against the infestation of construction by ground dwelling termites and other vermin.

d. Design and select materials to protect pedestrians and building occupants in accordance with code and with the following additional requirements.

(1) Prevent ice and snow from falling off building elements onto pedestrians, building occupants, and vehicles.

(2) Protect pedestrians, building occupants, and vehicles from objects accidentally dropped from elevated observation decks, balconies, or plazas.

e. Design and construct to provide physical security in accordance with the following requirements.

(1) For ground-level opaque elements, use materials that give the impression of strength to discourage opportunistic attempts at intrusion. At a minimum, such materials must meet ASTM F 1233 Class I and ASTM F 476 (R96) Grade 10 forced entry resistance requirements, adapted to suit the element.

(2) Minimize the size of ground-level glazed elements, and locate them in areas under surveillance by Northeastern University staff at their normal workstations.

(3) Ground-level glazing must have a UL 972 burglary resistant rating.

(4) Doors must meet ASTM F 476 (R96) or ASTM F 842 requirements, Grade 10, as appropriate.

(5) Provide window protection adequate for the conditions or location.

f. Design and select materials to provide natural ventilation in accordance with code and with the following additional requirements.

(1) The ventilation opening area must be at least four percent of the total floor area for each room. This ventilation requirement is not applicable to bathrooms, toilet compartments, closets, halls, and storage or utility spaces.

(2) The ventilation area must be at least 10 percent of the wall area for each floor, equally distributed on two elevations.

(3) Where possible, design to provide cross ventilation.

(4) Design in accordance with the requirements of Section 01352: Sustainable Design Requirements.

g. Design and construct the shell to minimize the potential effects of an explosion on building occupants and structural members.

h. Design to prevent the growth of fungus, mold, and bacteria on surfaces and in concealed spaces.

i. Design to prevent damage to occupants, structure, services, and contents from lightning strikes.

(1) Provide protection equivalent to that specified in NFPA 780-1997. Supplementary strike termination devices, ground conductors, and grounding electrodes are required only where the integral portions of the structure cannot perform those functions.

(2) Prevent lightning strikes from damaging or traveling along landscape features within 10 ft (3 m) of a structure.

j. Design and construct to comply with code and with the following additional requirements for hazardous construction materials.

(1) All existing friable asbestos and materials containing asbestos must be removed or abated to the extent required by federal, state, and local regulations, using the specified procedures.

(2) All existing lead-based paint must be removed or abated to the extent required by federal, state, and local regulations, using the specified procedures.

(3) All existing equipment containing PCBs and materials contaminated with PCBs must be removed using the procedures specified by federal, state, and local regulations.

k. Design and construct to comply with local, state, and national indoor air quality codes, with ANSI/ASHRAE 62 and applicable addendums, and with Section 01352: Sustainable Design Requirements.

16. Physical Security

In addition to any provisions that may be required by law or code, design and construct both exterior and interior spaces to incorporate accepted principles of crime prevention through environmental design, using natural (as opposed to technological) methods of providing surveillance, access control, and territorial reinforcement, wherever possible.

a. For purposes of physical security, elements at ground level are defined as any elements within 20 feet (6 m) of the ground, grade, or adjacent paving.

b. Security zones are defined as follows.

(1) Public access zone—an area to which the public has free access, including public corridors, grounds, and parking lots.

(2) Reception zone—an area to which the general public has access but beyond which access is restricted at all times.

(3) Operations zone—an area to which only employees (and visitors with a legitimate reason to be there) have access.

(4) Secure zone—an area to which access is always controlled and which is monitored continuously.

(5) High-security zone—an area indicated in project program and an area named "vault", "secure file room," or "cash room."

C. Installation Guidelines

1. Access to Equipment

Select and locate all equipment and accessories with due consideration for easy routine servicing and feasibility of major servicing, including removal and replacement of equipment.

a. Provide direct elevator access to mechanical spaces on the lower and upper floors and roof for maintenance purposes where applicable in existing buildings.

b. Provide a fixed ladder and/or catwalk for any equipment that requires maintenance access (including valves) and is not readily accessible from a 6-foot high portable ladder. To the extent possible, place valves and equipment so that a ladder is not needed.

c. Provide access to equipment and pull spaces and a means for removing and replacing the largest and/or heaviest equipment. Consider adding a beam attached to the structure to move or replace large motors, compressors, and other equipment.

d. Avoid roof-mounted equipment for critical applications. Access to roof-mounted equipment is difficult, and rooftop working conditions for maintenance personnel are not as safe as working conditions for indoor installations.

e. Provide at least OSHA and NEC clearance requirements at all mechanical equipment service points for personnel access and working space. For switchgear and other electrical equipment, follow National Electrical Code recommendations for required clearances.

f. Automatic control valves and damper operators must be exposed or equipped, with access doors or panels. The minimum access door or panel size is 12" x 12" clear.

g. Fans and similar components located above hung ceilings must have adequate access for such services as lubrication and filter changes. “Lay- in” ceiling boards are not satisfactory because of difficulty with smudging and breaking. Coordinate unit placement with the ceiling grid, walls, and doorways. Fan coil units can be placed above the ceiling with pre-approval from the Northeastern staff. Installation of air handling units above ceilings require prior Northeastern approval.

h. Locate thermometers and gauges, as well as thermometer wells and gauge taps, for easy reading (and changing).

i. Where necessary, provide extended grease fittings for concealed or hard-to-reach bearings.

j. Provide adequate branch valving to allow for servicing without major shutdowns.

k. Equip branch piping serving each floor with shut-off valves.

l. Equip branch mains serving fan-coil units, reheat boxes, induction units, convectors, and similar units with flow-measuring devices and balancing valves.

m. Avoid routing piping through rooms containing electrical or communications equipment. Where there is no other choice for routing, provide stainless steel drain pans under pipes that pass overhead and within 2' of any switchboard, motor, or controller. Drain pans must be 20 oz, copper pans at least 4" wider than the outside edge of the pipes. Drain pans must be properly stiffened and braced with brass angles and supported to prevent sagging. Provide a turned-up edge rolled over stiff brass wire on each side. Seams must be soldered and watertight. Provide 1" diameter drip pipe from the pan down to the nearest drain.

n. Locate equipment to allow the necessary clearance for removing coils and other sub-assemblies.

o. Provide conveniently-located access doors to all enclosed areas housing mechanical equipment.

p. Provide lighting and power for servicing equipment.

2. Access to Piping Risers

Where required by the building design, access to valves and/or traps should be easy and practical. Access doors should be sectionalized, as necessary, for ease of removal and replacement. Install Lamicore name plates on access doors to identify the services available in pipe chases.

3. Mechanical Room Layout

a. Design mechanical rooms to provide a minimum clearance of 3' clear around all units, boilers, heat exchangers, pumps, fans, and similar equipment. Provide a minimum clearance of 4' in front of electrical panels.

b. Provide the manufacturer's recommended minimum service areas around all equipment.

c. Provide a full-length coil pull space. Show all coil pull spaces and access ways on the drawings.

d. Arrange mechanical rooms so that any piece of equipment within the room can be removed in one piece, without removing or disassembling any other piece of equipment within the room. On drawings, outline areas required for coil, shaft and blower removals.

e. Access to mechanical rooms must be from public spaces. Access through program spaces is not permitted. Access must be safe and easy (normal stairs, not ladders) and allow for easy movement of equipment and maintenance supplies (elevators or hoistways).

f. Sections or profiles of underground piping must show elevation (with respect to grade), roads, and possible conflicting utilities.

D. Disposal Guidelines

1. Review the project with the Northeastern University Project Manager during the design- development phase to identify salvageable equipment and hazardous waste.

2. Drawings must identify salvageable equipment and include the requirement that such equipment be delivered to the facilities department or other designated location. The following materials are considered salvageable, unless refused by Northeastern University:
   - Meters, meter sockets, and test switches
   - Transformers (10 kva and larger)
   - Fire alarm equipment
   - Other equipment designated by the Northeastern University Project Manager

3. Ensure that hazardous waste disposal is in accordance with Division 1 standards.
4. All removed equipment that will not be reinstalled becomes the property of the contractor, and must be removed from the site and disposed of legally.

E. Coordination Requirements

1. Refer to Northeastern University's Guidelines for New and Remodeled Buildings, Specification Sections 01051 and 01052, for the coordination of items to be included in the contract documents.
2. The design team is responsible for coordinating materials and equipment locations to ensure that adequate space is available in the general location of each component.
3. Coordinate equipment emergency power requirements with the electrical engineer. Equipment requiring emergency power includes life safety equipment, the control compressor, and the DDC controls system.
4. Verify that adequate clearances have been allowed for expansion, and coordinate space requirements with engineers from all disciplines.
5. Coordinate control and electrical systems wiring requirements with the electrical engineer.
6. Coordinate access space and door requirements with engineers from all disciplines.
7. Verify that electrical outlets have been provided for servicing remote and rooftop equipment.
8. Coordinate the requirements for motor starters, disconnects, and variable-frequency drives with the electrical engineer.
9. Verify that drain line sizes for backflow preventers are adequate to handle the flow if the reduced-pressure backflow preventer should fail and flow through the emergency drain port.
10. Verify with the plumbing engineer that make-up water is available at sufficient flow and pressure.
11. Verify that expansion joints have been coordinated with building expansion joint location, the structural engineer, and the structural requirements for anchoring.
12. Verify that there are accessible drains available to serve automatic vents.
13. Provide sufficient ventilation in mechanical and utility rooms to accommodate heat

loads and noxious gases.

14. Ensure that adequate space is available for piping that must pitch.
15. Do not route piping through electrical rooms; mount the heating coil outside the space and duct heated air in.
16. Do not route piping above electrical switchgear. If there is no other alternative, provide drain pans with drain lines while maintaining maximum space for conduits.
17. Provide hose bibs in mechanical rooms and at rooftop equipment.
18. Coordinate freeze protection electrical heat tracing requirements with the electrical engineer.
19. Coordinate metering requirements with the plumbing and electrical engineers.
20. Coordinate gas train requirements with Northeastern University’s insurance carrier.
21. Coordinate electrical service requirements for fire system tamper and flow switches, fire pumps, and control panel with the electrical engineer.
22. Provide a ball valve with 3/4" hose thread and a cap at all low points to drain equipment and piping.

-END-

00703

General Plumbing Design Conditions

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains general design guidelines for plumbing systems.

B. System Design and Performance Requirements

1. Install drains at all interior water faucets.
2. Install equipment that uses large volumes of water at an elevation that does not require pumping of effluent to the city sewer.
3. Coordinate with the HVAC engineer to ensure that equipment temperatures, pressures, setpoint deviations, and monitoring points are included in the building automation system controls.
4. Provide hose bibs at all mechanical equipment that requires water for wash down.
5. Include all pumped drain high-level alarms in the controls points list.
6. Plumbing fixtures installed shall be “low flow type

-END-

00704

General Fire Protection Design Conditions

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A. Summary

This section contains general design criteria for fire protection systems.

B. System Design and Performance Requirements

1. Include hydraulic calculations for all systems, equipment, and piping systems in the as-built documents. As-built drawings and documentation required of the mechanical engineer or contractor must be reviewed by the mechanical engineer.
2. Revise as-built drawings and documentation to reflect modifications made to any part of the facility or mechanical systems.
3. Carefully monitor and document any change in usage, installed equipment, loads, or occupancy.
4. Sprinkler spacing must allow for future growth in the following types of facilities by providing the flexibility to move partitions without relocating sprinkler heads:
   - Laboratories: 15%, to allow for additional ductwork for new fume hoods.
   - Open storage: 20%, to allow for new walled-off areas.
   - Laboratory support spaces: 25%, to allow for new cold room boxes.
   - Very large classrooms may be divided. Add three heads per room to allow for a new wall.
   - Allow at least a 10 psi safety factor on hydraulic calculations for each building.
5. Electrical spaces must be sprinklered.
6. Locate sprinkler heads at the center of tiles.
7. Plastic pipe is prohibited for use in sprinkler systems.

-END-

00705

General HVAC Design Conditions

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains general design criteria for Heating, Ventilation, and Air Conditioning (HVAC) Systems.

B. System Design and Performance Requirements

1. Air Conditioning Design

a. Base system sizing on project-specific load calculations and rule-of-thumb cfm/sq ft.

b. Specify crankcase heaters for all refrigeration compressors, except window units, unless specifically waived by Northeastern University.

c. Specify that all refrigeration systems be equipped with the necessary controls for low ambient temperature operation. In most cases, this means 20°F. However, before specifying equipment, discuss with Northeastern University the need for operation at lower temperatures.

d. Give special consideration to possible noise problems resulting from the locations of fan equipment, particularly in existing buildings, and of outdoor, air-cooled condensing units.

2. Design Conditions

In the absence of project-specific information, use the design conditions in Table 1 for load calculations.

Table 1. Design Conditions

Space	Summer Occupied	Summer Unoccupied	Winter Occupied	Winter Unoccupied	Winter Recess	Relative Humidity	Air Supply
Offices and conference rooms	73–78°F	HVAC off Temp Uncontrolled	70–73°F	65°F Night Setback	60°F T-Setback	N/A	Summer Unoccupied OFF
Labs and lab support spaces (as required)	73–78°F		70–73°F	65°F Night Setback	60°F T-Setback	50%	Summer/ Winter Unoccupied Setback
Equipment rooms							
Animal rooms (each independent)							
Assembly/DH, etc.	73–78°F	HVAC off Temp Uncontrolled	70–73°F	65°F Night Setback	60°F T-Setback	N/A	Summer Unoccupied OFF
Classroom	73–78°F	HVAC off Temp Uncontrolled	70–73°F	65°F Night Setback	60°F T-Setback	N/A	Summer Unoccupied OFF
Dormitory	N/A	N/A	70–73°F	65-68°F Night Setback	60°F T-Setback	N/A	N/A
Libraries (common and non-stack areas)	73–78°F	68°F Night Setback	70°F	65°F Night Setback	N/A	30–50%	Summer/ Winter Unoccupied Setback
Libraries (dedicated stack areas)	70°F	70°F	68°F	68°F	68°F	50%	ON
Computer rooms							Project-specific
Museums							Project-specific
Specialty areas							Project-specific

3. *Equipment Sizing*

Use the following outside design temperatures for sizing mechanical equipment:

- Critical or 100% outside air systems: 0.4% DB, 0.4% WB
- Non-critical systems: 1.0% DB, 1.0% WB
- Critical air-cooled condensers: 0.4% DB +5°F

- Non-critical air-cooled condensers: 0.4% DB

4. Heat Gain and Loss Estimates

a. Follow the most current ASHRAE guidelines when estimating heat gains and losses. The design team must conduct an economic life-cycle analysis for insulation values per the most current ASHRAE Fundamentals Handbook. Where it is impractical or impossible to conduct such an analysis, use the following data or code-required values, whichever have the more stringent requirements:
    - Roof: R-30
    - Walls: R-19
    - Floors: R-11

5. Chilled Water System Design Temperatures

a. The nominal chilled water supply temperature is 42°F at the central chilled water at the building level. Expect a temperature rise of 1°F to 2°F during distribution.

b. The chilled water supply temperature is allowed to rise during periods of low load (winter) to as much as 46°F. During these periods, comfort cooling systems are generally able to meet the demand with this higher supply water temperature.

c. Comfort cooling systems should be designed based on the lowest expected supply water temperature and highest expected load. Cooling systems for process loads that are independent of climatic conditions should be designed based on the highest expected supply water temperature.

d. Design building chilled water systems for a minimum 18°F rise at full load. There is no maximum limit.

e. See Section 15625: Water Chillers for chilled water system design criteria.

6. Heating and Humidification Design

a. *Applications*

(1) Steam is used to transport heat into and indirectly humidify the buildings. Use glycol for pre-heat in mechanical rooms only. Pre-heat coils for 100 percent air make-up units must be steam or glycol-hot water.

(2) Use hot water heating for reheat, fin-tube radiation, cabinet unit heaters, unit heaters, and similar equipment outside of the mechanical room. Systems should be two-pipe, with utilization of the reverse return arrangement to facilitate system balancing.

b. *Terminal Heating*

(1) Two types of heating terminal units are generally employed at Northeastern University: perimeter radiation and terminal reheat. Paragraphs a and b below describe the appropriate system application and operating requirements.

(a) Some existing buildings do not have perimeter radiation. In these cases, heating is done via air side reheats.

(b) If required by the system design, constant- and variable-volume terminal boxes must have a reheat system. The system must be hot water, unless project requirements dictate otherwise.

(2) Heating, ventilation, and air conditioning is not required in stairs, except to prevent piping installed in the stairway from freezing. Provide cabinet unit heaters or convectors at principal building entrances and landings, as necessary, to maintain a minimum temperature of 50°F.

7. Air Handling System Design

Provide air handling systems to support cooling in the following areas.

a. *Offices and Conference Rooms*

(1) System Description

(a) Offices and conference rooms must be supported by a variable-volume system.

(b) The system may use return air from office areas or 100 percent outside air. The system shall be capable of delivering 100 percent outside air for free cooling.

(c) The amount of fresh outside air must not drop below 20 cfm per person in the occupied mode. During occupied operation, the system must vary the volume of supply and return or exhaust air to meet the cooling needs of the space. During unoccupied operation, the system must reduce the air volume to some pre-set minimum (two air changes per hour) to maintain the temperature within an acceptable range of ±10°F.

(d) The use of fan coil units is discouraged. Fan coil units should only be used in areas with heavy, concentrated, sensible heat loads.

(2) Pressure Relationships

Design offices, reception areas, and conference rooms to be pressure-positive relative to adjacent areas and pressure-negative with respect to the corridor.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 10 percent growth anywhere in the system.

b. *Laboratories and Laboratory-Support Areas*

(1) System Description

(a) Laboratories and laboratory-support areas must be supported by a variable-volume system.

(b) The system may use return air from office areas or 100 percent outside air. The system shall be capable of delivering 100 percent outside air for free cooling. One hundred percent of the air removed from the laboratory and laboratory-support areas must be exhausted and not be returned to any HVAC system. The exhaust system for laboratory and laboratory-support areas must be separate from other building exhaust systems.

(c) The amount of fresh outside air must not drop below 20 cfm per person in the occupied mode. Nominally, the system must be sized to provide 6 air changes per hour to laboratories and 4 air changes per hour for laboratory-support areas. The exhaust must be 10 percent greater than the supply so that the laboratory and laboratory-support areas are pressure-negative relative to the adjacent area.

(d) During occupied operation, the system must vary the volume of supply and return or exhaust air, above some pre-set minimum (approximately six air changes per hour) to satisfy the hood requirements and to meet the cooling needs of the space. During unoccupied operation, the system must reduce the air volume to some pre-set minimum (approximately two air changes per hour) to satisfy the hood requirements and to maintain the temperature within an acceptable range of ±10°F.

(e) The laboratory supply air system must not be interlocked with the laboratory general exhaust systems to balance temperature, pressure, and flow requirements. The laboratory controls must be based primarily on air volume to avoid contamination of the laboratory areas.

(f) The use of fan coil units is discouraged. Fan coil units should only be used in areas with heavy, concentrated, sensible heat loads.

(2) Pressure Relationships

Design laboratory and laboratory-support areas to be pressure-negative relative to adjacent areas and the corridor.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support growth anywhere in the system. Specific sizing to be determined by Northeastern.

(4) Redundancy and Diversity

Equip the supply and exhaust air systems with twin fans, each sized at 65 percent of the exhaust requirements. Fan system diversity may be applied, but must not be greater than 30 percent. Discussion with Northeastern to occur prior to design.

c. *Classrooms*

(1) System Description

(a) Classroom areas must be supported by a variable-volume system/fan coils

(b) The system may use return air from office areas or 100 percent outside air. The system shall be capable of delivering 100 percent outside air for free cooling.

(c) The amount of fresh outside air must not drop below 20 cfm per person in the occupied mode. During occupied operation, the system must vary the volume of supply and return or exhaust air, above some pre-set minimum (approximately two air changes per hour) to satisfy the cooling needs of the space. During unoccupied operation, The system must reduce the air volume to some pre-set minimum (approximately one air changes per hour) to maintain the temperature within an acceptable range of ±10°F.

(d) The supply air system should be interlocked with the return or exhaust system to balance temperature, pressure, and flow requirements.

(2) Pressure Relationships

Design classroom areas are to be pressure-positive relative to adjacent areas and the corridor.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 10 percent growth anywhere in the system.

d. *Toilet, Locker, and Shower Rooms*

(1) System Description

(a) Toilet, locker, janitor's closets, and shower room areas must be supported by a constant-volume system.

(b) The system may use return air from classroom and office areas or use 100 percent outside air, with 100 percent exhaust at all times. The supply air system must be capable of delivering 100 percent outside air for free cooling. The exhaust system for toilet, locker, and shower rooms must be separate from other building exhaust systems.

(c) The amount of fresh outside air must not drop below 25 cfm per person, based on the maximum projected occupancy.

(d) Janitor's closets and similar areas must be exhausted at a rate of not less than 10 air changes per hour.

(e) The use of fan coil units is discouraged in these areas.

(2) Pressure Relationships

Design toilet, locker, and shower room areas to be pressure-negative relative to adjacent areas and the corridor.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 10 percent growth anywhere in the system.

e. *Residential Facilities*

(1) All new residience facilities shall be equipped with air conditioning. For offices, bathrooms, cafeterias, and other specific areas within the dormitory, refer to the applicable paragraphs in this document.

(2) Because of heavy traffic and the possibility of damage, do not use fan coil units in hallways. Consider using panel-type radiators.

f. *Animal Quarters*

(1) System Description

(a) Animal areas must be supported by a dedicated, constant-volume system.

(b) The system must be a 100-percent outside air supply system, with 100 percent exhaust at all times. The exhaust system for animal areas must be separate from other building exhaust systems.

(c) Size all system components and design the system to meet American Association for Accreditation of Laboratory Animal Care (AAALAC) requirements.

(d) The use of fan coil units is not allowed in these areas.

(2) Pressure Relationships

Design animal areas to be pressure-negative relative to adjacent areas and the corridor. Pressurize surgery to meet AAALAC requirements.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 6-12 air changes per hour, based on occupancy.

g. *Cafeterias, Lounges, and Photocopy Rooms*

(1) System Description

(a) Cafeterias, lounges, and photocopy rooms may be supported by either a constant- or variable air volume (VAV) system; a VAV system is preferred.

(b) The system may use return air from office areas or 100 percent outside air. The system must be capable of delivering 100 percent outside air for free cooling. All of the air removed from these areas must be exhausted. Do not return the air to any other system.

(c) The amount of fresh outside air in the occupied mode must not drop below 10-15 cfm per person or code requirements, whichever is greater.

(d) During occupied operation, the system must vary the volume of supply and return or exhaust air to meet the cooling needs of the space. Minimum air change rate shall be 4 air changes per hour. During unoccupied operation, the system must reduce the air volume to some pre-set minimum (two air changes per hour, or as permitted by code) to maintain the temperature within an acceptable range of ±10°F.

(e) The use of fan coil units is discouraged. Fan coil units should only be used in areas with heavy, concentrated, sensible heat loads.

(2) Pressure Relationships

Design cafeterias, lounges, and photocopy rooms to be pressure-negative relative to adjacent areas and the corridor.

(3) Excess Capacity

Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 10 percent growth anywhere in the system.

(4) Redundancy and Diversity

The supply and exhaust air systems may be equipped with a single fan, or twin fans, each sized at 50 percent of the exhaust requirements. Do not assume any fan system diversity.

h. *Elevator Machine Rooms*

Equip elevator machine rooms with unit heaters to maintain a minimum temperature of 60°F, if they are located in areas where the temperature is expected to fall below 60°F. These rooms must also be equipped with a mechanical ventilation system capable of offsetting heat gain, both internal and external, and maintaining an ambient temperature of not more that 104°F. Use of ductless split A/C is encouraged.

i. *Garages, Enclosed Driveways, and Loading Platforms*

Equip garages, enclosed driveways, and loading platforms with a mechanical ventilation system per NFPA 88. Approximately two-thirds of the exhaust must be taken near the floor or below the loading platform. Consider loading dock heating.

j. *Other Spaces*

Design al other spaces per appropriate ASHRAE guidelines. The system design must also be consistent with the design philosophy for the types of spaces identified above.

8. Heat Recovery

Heat energy recovery of constantly-operated exhaust air may be done with air-to-air plate-type heat exchangers, heat pipes, desiccant wheels, or coil run-around cycles, for a ducted exhaust of 3000 cfm, or more, for 100-percent outside air units. Design controls for heat recovery systems to avoid defeating any required "free cooling" (economizer cycle) operation. Avoid overheating the outside air during mild or warm weather.

9. Ventilation

a. Provide ventilation systems that have a minimum of six air changes per hour.

b. Do not cool the following areas, which must be heated, as necessary, and ventilated with supply and exhaust air:

- Motor vehicle storage areas
- Electrical equipment rooms
- Mechanical equipment rooms
- Transformer rooms
- Emergency generator rooms
- Elevator machine rooms
- Trash rooms
- Supply service warehouse areas, except specialized storage requiring mechanical cooling

10. Exhaust Systems

a. The following areas shall be 100-percent exhausted:

- Animal research areas
- Bathing facilities
- Dark rooms
- Janitor's closets
- Kitchens
- Laboratories
- Storage rooms
- Gas storage rooms
- Flammable storage rooms
- Toilet facilities
- Trash collection areas
- Confined spaces

b. Provide separate exhaust systems for:

- Animal wards
- Autopsy suites

- Laboratories
- Each radioisotope hood
- Each bacteriological cabinet
- Each perchloric fume hood
- Each cartwasher or cagewasher
- Kitchen grease hoods
- Toilet rooms (Provide separate exhaust when proximity to general exhaust grilles would allow toilet room odors to enter spaces that are normally occupied when the general exhaust fan is off.)
- Mechanical and electrical rooms
- Parking garages

11. Pipe Sizing

Base pipe sizes, pressure loss, and other calculations for circulating water systems on Cameron Hydraulic Data, with C=100 for open (cooling tower) systems and C=130 for closed systems. See Section 15181: Hydronic Piping for recommended velocities in piping.

-END-

01010

Scope of Work

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains general scope of work requirements owner-consultant architectural and engineering services agreements. The scope of work may vary according to the project requirements. See Section 01330: Designer Submittals, for detailed engineer submittals to Northeastern University.

1. Design/Enhanced Schematic Design

The engineering consultant must work with Northeastern University to define the best applicable systems based on performance, operation and ease of repairs, quality, first cost, operating cost, maintenance cost, and aesthetics. At the end of this phase, submit drawings, one-line diagrams, and a report to Northeastern University that address the following requirements. Include photographs and illustrations in the report, as necessary.

a. General

1. Survey and assess existing building systems.
2. Review applicable building codes, and identify requirements for the given building type and occupancy.
3. Identify energy sources and other utilities available or feasible at the site, and determine the most desirable sources that meet the needs of the project.
4. Identify or recommend the required degree of mechanical system flexibility to accommodate building expansion and changes in space usage or occupancy.
5. Identify special needs and/or Northeastern University requirements pertaining to mechanical systems, such as:
   - Special aesthetic treatment
   - Special safety or security requirements

- Special acoustical requirements
- Special temperature or humidity requirements, or control strategies
- Indoor air quality levels
- Special scheduling or sequencing of construction work
- Special equipment

6. Propose recommended systems or equipment.
7. Provide information for the preparation of a detailed estimate of construction cost based on a preliminary system concept. Include a preliminary life-cycle cost analysis.
8. Determine the applicability of utility company or other energy conservation incentive programs.
9. Identify site conditions affecting construction.
10. Identify long lead-time items.
11. Provide the information necessary to develop a construction schedule.
12. Attend meetings, as requested, with Northeastern University, building committees, governmental agencies, and other groups.
13. Work with Northeastern University to determine energy management system requirements for all building systems.
14. Provide outline specifications in a system-type format.

b. Mechanical

1. Provide preliminary load calculations.
2. Select generic heating or cooling equipment.
3. Review or propose alternate types of systems and analyze them for first cost and life-cycle cost comparisons.
4. Review space requirements and service accessibility for all systems and equipment.
5. Provide flow diagrams for major systems.
6. Provide a one-line diagram showing major equipment and the proposed piping and ductwork layout.
7. Provide a systems description and sequence of operation.

c. Electrical

1. Provide one-line system diagrams.
2. Review or propose alternate types of systems and analyze them for first cost and life-cycle cost comparisons.
3. For renovation projects, submit copies of documentation generated during field investigations, including field notes, sketches, and photographs of all pertinent portions of the existing installation.
4. Provide preliminary load calculations based on loads shown in panelboard and switchboard schedules. Provide breakdowns of power consumption per square foot for lighting, air conditioning, and other major categories of utilization, together with total consumption.
5. Review space requirements, and service accessibility for all systems and equipment. Plan space requirements to meet the most demanding operations and maintenance required.
6. Provide a design intent document based on load requirements and design parameters.
7. Provide lighting calculations for each type of space in accordance with IES standards. Calculations must clearly indicate assumptions of reflectances, maintenance factors, and ballast factors. Present results in footcandles and in watts per square foot.

2. Design Development

Provide drawings and a report that addresses the following requirements:

a. General

1. Provide an updated estimate of construction cost indicating scope changes and including cost implications and updated life-cycle costing.
2. Provide lead-times for ordering equipment.
3. Attend agency reviews as requested by Northeastern University (for example, owner representatives, building inspector).
4. Identify demolition requirements.
5. Attend utility company reviews.

6. Identify bidding alternatives.
7. Provide an updated code analysis as a result of the design process.
8. Provide outline specifications in CSI format.

b. Mechanical

1. Provide preliminary detailed drawings showing equipment, piping and ductwork locations.
2. Determine space requirements for equipment, ductwork, and piping, including chases and mechanical rooms. Coordinate with structural members and other trades.
3. Define seismic requirements for mechanical systems.
4. Identify site utility locations.
5. Define equipment control strategies.
6. Update flow diagrams.

c. Electrical

1. Provide updated one-line diagrams.
2. Provide updated electrical load calculations.
3. Provide harmonics calculations in accordance with standard IEEE 519.
4. Provide short-circuit calculations showing contributions from each source, the characteristics of each circuit element, and the short-circuit energy available at each bus. Calculations must indicate the selection criteria for conductors, in addition to overcurrent devices.
5. Submit coordination analyses or all types of overcurrent devices in series.

3. Construction Documents

a. General

1. Provide final load calculations (mechanical and electrical).
2. Provide code compliance calculations.
3. Coordinate with other trades.
4. Provide a final estimate of construction cost.

5. Attend the final review and coordination meeting with Northeastern University representatives.
6. Formulate a submittals list along with a list of proprietary or non-University standard equipment.

b. Drawings

See Section 01330: Designer Submittals.

4. Bidding

a. General

1. Prepare or assist in the preparation of bid documents.
2. Review bid documents.
3. Assist in the selection of bidders.
4. Review bidder qualifications.
5. Attend pre-bid meetings with contractors.
6. Provide Northeastern University with a written analysis or comparison of submitted bids.
7. Review proposed substitutions or alternates.
8. Attend the bid opening meeting.

5. Construction

a. General

1. Assist with the preparation and filing of permits.
2. Attend the pre-construction meeting.
3. Review shop drawings.
4. Inspect installed work (roughing and finished work).
5. Attend job meetings as requested by Northeastern University.
6. Assist in the approval of payments to contractors.
7. Initiate requests for change orders, and/or review change orders.

8. Prepare punch lists.
9. Prepare record drawings (as-built).
10. Prepare or review system operation and maintenance manuals.
11. Assist with turnover and building commissioning.

b. Mechanical

1. Review testing or balancing reports.
2. Review emissions compliance studies.
3. Witness on-site tests of all mechanical systems. Provide a written report to Northeastern University.

c. Electrical

1. Review contractor submittals and shop drawings.
2. Witness on-site tests of all electrical systems. Provide a written report to Northeastern University.

6. Post Construction

- Verify system performance. (mechanical & electrical)
- Review as-built drawings.
- Review operation and maintenance manuals.
- Provide record drawings on 24” by 34” paper copies and diskettes.

-END-

01060

General Regulatory and Directive Standards

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

1. This section identifies general plumbing, fire protection, HVAC, and electrical design regulatory and directive standards, codes, and references. It also contains general project documentation and occupational and environmental health guidelines, and identifies the desired quality, type, and characteristics of certain materials and facilities and the regulations and standards to be followed for the design of building systems.
2. The items contained in this section should be discussed during the development of each project. Use of this section and the other relevant sections listed in the following paragraph is intended to save time and help produce high-quality construction documents and buildings that provide a safe and healthy environment, are accessible to handicapped persons, are efficient to operate, and are compatible with existing operating and maintenance procedures.

B. Project Documentation Requirements

1. Specifications

Comply with the following specification requirements. Deviation from these requirements is not permitted without formal notice and Northeastern University's written approval.

a. Format

Arrange project specifications per the Construction Specifications Institute (CSI) MasterFormat,™ which arranges subjects in numbered sections within 16 established divisions. Precede these specifications with the general documents containing bidding documents and general conditions. Use of the CSI MasterFormat™ saves all users time and effort. This feature is important to an institutional owner. Therefore, the arrangement of specifications on

Northeastern University projects by CSI division is mandatory, unless there is a valid reason for not doing so and that reason is approved by the University. Use of E-Builder is required for budgets, RFIs, bidding, submittals, etc.

b. *Practice*

Unless policy is dictated by a funding agency, Northeastern University favors the following practices.

(1) Submit performance specifications, or specify acceptable manufacturers (usually a minimum of three) and omit the term “or equal.”

(2) Insert specific product approval standards under General Requirements, covering the following items:

(a) Where performance specifications are used, the Contractor is obligated, on request of the architect, to present an affidavit from the manufacturer certifying compliance prior to incorporation in the project.

(b) For approval of products other than those specified, a bidding contractor must submit a request in writing at least 10 calendar days prior to the bid date. Such requests must be accompanied by all of the data necessary to completely describe the item for conformance. The architect’s approval, after consultation with Northeastern University, must be in the form of a specification addendum to all prime contract bidders of record. Submitted via E-Builder.

(c) The substitution of products will be approved after bids are opened only for such reasons as unavailability beyond the control of the contractor. Requests must be in writing, and substitutions must be accompanied by all of the data necessary to completely describe the item for conformance and by added cost or credit data. The architect’s approval, after consultation with Northeastern University, must be in writing.

(d) Except in the instance of items beyond the control of the contractor, the contractor is be responsible for the space and fit requirements of approved substitutions.

(e) Comments leading to revisions should be routed to the Northeastern Design / Project Team. The Design / Project Team will record the names of all persons or firms to whom issue is made and will attempt to inform the recipients about changes. Users, however, should check periodically to be sure they have all revisions.

c. *Language and Technology*

When reviewing specifications, Northeastern University uses the CSI Manual of Practice and Specification Series. As an owner concerned with avoiding the defense of contingent liability lawsuits, the University expects the architect to pay particular attention to the language used in, and technology described by, the specifications.

d. *Reproduction*

Make single-sided reproductions of specifications to allow use of the blank side for attaching addenda and bulletin items and for annotations by users.

e. *Shop Drawings and Samples*

Each specification section should state if shop drawings and samples are required. If required, state the required quantities if not spelled out in the general documents.

2. **As-Built Drawings and Documentation**

As-built drawings and documentation required of the mechanical engineer or contractor must be reviewed by the engineer.

a. Revise as-built drawings and documentation to reflect modifications made to any part of the facility or mechanical systems.

b. Carefully monitor and document any change in usage, installed equipment, loads, or occupancy.

c. Drawings must be compatible with the CADD platform specified in *CADD Requirements for Outside Consultants*. Each mechanical drawing must contain all layers listed therein, whether or not actually used.

d. Operation and maintenance manuals shall include a copy of the Testing and Balancing Report.

3. **Working Drawings**

All persons using the drawings are sensibly interested in using them easily and with the least waste of time and effort. Obviously, good drafting and lettering are a requisite quality, but the arrangement of information is just as important. Some desired arrangement features that should be incorporated in the drawings are described in the following paragraphs.

a. *Size and Scale*

Sheets should not be larger than 30" H x 42" L. The preferred scale for all overall plans and sections, except where very limited work is shown, is 1/4" - l'-0". To avoid a conflict in these requirements for larger buildings, use multiple sheets with suitable match lines.

b. *Numbering*

An attempt should be made to have drawing numbers, such as SB, B, 1, 2, 3, 4, 5, show plans for sub-basement, basement, lst, 2nd, 3rd, 4th, and 5th floors. A logical extension of this scheme involves P, M, and E prefixes to these numbers for the appropriate mechanical and electrical floor plans. Drawing numbers should be located in the lower right-hand corner of a title block appearing in the lower right hand corner of each drawing.

c. *Room Designation*

Rooms should be designated on plans by name, as well as room number, per Northeastern University Standards and Guidelines. Room numbers are important. They should be approved before the design development phase and remain unchanged. Northeastern to provide room numbers.

d. *Room Finish and Painting Schedules*

Locate individual floor schedules on the same sheet as the associated floor plan.

e. *Drawing Index*

In addition to the complete face sheet index, repeat a partial index on other drawings. For example, on plan drawings the local index should refer to sheet locations for items most wanted when looking at the plans.

Example:

Item	Dwg. No.
Equipment schedules	10
Plumbing details	14
Lab. equipment details	35

f. *Standard Abbreviations List*

The face sheet should include a list of all standard abbreviations.

4. **Project Document Inclusions**

a. Place the following note in bold type on each MEP sheet:

All control boxes, valves, control valves (of every type, shape, and function), and DDC control boxes must be installed in such a manner as to be fully and reasonably accessible and free from insulation or other construction components. Fully and reasonably accessible is defined as capable of being accessible for repair or replacement by an average-size individual, on a ladder if necessary, and capable of being removed without removing other components of the work.

b. Statements similar to the following should be included on drawings or in a specification section on special requirements for mechanical and electrical work:

(1) *Mechanical and electrical drawings show pipe, duct, and conduit runs, and the locations of equipment, valves, panels, and other components. Dimensions not shown must be obtained from the architect, and not scaled from the drawings. Lay out routing and locations to meet field conditions, to provide easy access for service and maintenance, and to avoid conflict between the work of all trades. Submit proposed routings and locations to the architect for approval, and modified or relocate them within reasonable limits, as directed, without extra cost.*

(2) *Provide equipment and apparatus complete with all the usual and necessary fittings and accessories not normally shown or specified, but which are required for proper installation and operation. Place gauges, thermostats, thermometers, and other accessories, not specifically located on the drawings, where directed by the architect.*

(3) *Provide written operating and maintenance instructions for all equipment and systems, in approved form, to the architect before final acceptance of the work.*

c. The architect is expected to design spaces housing equipment so that the actual layout, when complete, will allow Northeastern University to service the equipment. Include a statement similar to the following so the contractor is cautioned about this feature:

Locate all equipment and accessories to provide easy access for proper service and maintenance. Install equipment and accessories to enable the removal of any part without the need to remove other components.

C. Occupational and Environmental Health

Northeastern University Environmental Health and Safety has responsibility for all occupational health and safety provisions in and around Northeastern University buildings. Through the Facilities Department, make arrangements for conferences and consultation with the NU EHS Director and such section directors as indicated by the nature, contents, and occupancy of the particular project.

1. General

Northeastern University Environmental Health and Safety is responsible for the formulation of safety guidelines and conduct of other such activities as to promote the general health and well-being of the University community. The department is concerned with matters pertaining to exposures to potentially hazardous biological, chemical or radiological agents; to the establishment of a relatively safe work environment; and to provide health services for conditions arising as a result of employment.

2. Consultation Services

The department provides consultation services through its several sections for specific questions or problems dealing with health and safety issues. These consultations, considered essential components of any construction project, should be requested and completed at the schematic design stage of the project. The nature of the project should lead to the forwarding of consultation requests to one of the following DOEHS sections:

a. Biological Safety

The following principal areas impact biological safety. Projects that include these areas should be reviewed by the Biological Safety department

- Any other area where work with infectious agents is conducted
- Any area where animal experiments are conducted

b. Environmental Health

The following principal areas impact environmental health and sanitation. Projects that include these areas should be reviewed by the Environmental

Health department

- Food service, storage and/or processing facilities
- Swimming pools
- Potable water systems
- Solid waste handling (garbage and rubbish)
- Dormitory facilities
- Sewage disposal at off-campus sites

c. *Occupational Safety*

The Safety Department is concerned with the establishment and maintenance of a safe work environment, and is responsible for ensuring compliance with OSHA regulations. The following list of areas of interest is not all-inclusive, but serves as an example of the areas covered by OSHA for which construction plans should be reviewed. Questions concerning other areas not on this list that might also be covered by OSHA should be directed to the department's Occupational Safety section.

- All laboratory facilities
- Walking and working surfaces
- Ventilation systems
- Fume hood systems
- Stairways
- Shop facilities
- Storage facilities
- Electrical services
- Plumbing services

d. *Radiation Safety*

New construction or renovations to any of the following facilities, systems, or components should be reviewed to ensure incorporation, during the early design stages, of sufficient engineering controls for radiation protection purposes. The list is not all-inclusive, but serves as an example of the types of plans that might need review. Coordinate with Northeastern University Environmental Health and Safety

- Research laboratories

- Clinical laboratories
- Patient care facilities (including radiation services)
- X-ray facilities
- Accelerator laboratories
- Laser facilities
- Microwave facilities
- Ventilation systems
- Drainage systems
- Shielding
- Shielded facilities

D. Stairs, Steps, and Ramps

In addition to conformance with the State of Massachusetts Building Code or other code requirements, consider the following:

- Facilities for the handicapped
- Adequate exterior lighting, as well as interior features
- Barriers at changes in levels (exterior and interior) where persons, including children, can fall from one level to another

E. Exterior Lighting

In addition to lighting at exterior stairs and steps, consider the amount and type of other exterior lighting. Discuss with Northeastern University the need to coordinate design with the University master plan for lighting of exterior spaces.

F. Design, Construction, and Alteration for the Handicapped

1. Under Section 504 of the Rehabilitation Act of 1973 all new construction must be barrier free and, in the case of additions and/or alterations, the renovated or added areas must be made accessible “to the maximum extent feasible.”
2. Design, construction, and alteration must meet the guidelines in ANSI A117.1, Specifications for Making Buildings and Facilities Accessible to, and Usable by, Physically Handicapped People, published by the American National Standards Institute, unless other methods clearly provide equivalent access.

G. Submittals

1. Contract documents are often produced at the last minute. If the contract award is based on competitive bidding, document review and coordination often occurs during the bidding period, which generates numerous bidding period addenda and costly errors. This last-minute document review and coordination results from a document completion target date that is usually the out-to-bid or bid-due date.
   - Out-to-bid date, if the award is based on bidding
   - Contract signing date, if the award is based on negotiation
   - Coordinate with facilities fiscal affairs contract administrator

H. Project Document Inclusions

1. Include under General Requirements in the specifications, such statements as the following:
   a. *Until construction is complete, protect all equipment from water, dirt, and physical damage.*
   b. *Cover pumps, fans and similar equipment with tarpaulins or heavy plastic to protect bearings, motors, couplings, and other such components from weather and dust.*
   c. *Do not use mechanical equipment as scaffolding or working platforms for other trades (painters, plasterers).*
   d. *Upon completion of construction, chipped or scratched factory-finished equipment must be "touch-up" painted by the painting contractor at mechanical contractor's expense.*
2. Place the following note in bold type on each MEP sheet:

   All control boxes, valves, control valves (of every type, shape, and function), and DDC control boxes must be installed in such a manner as to be fully and reasonably accessible and free from insulation or other construction components. Fully and reasonably accessible is defined as capable of being accessible for repair or replacement by an average-size individual, on a ladder if necessary, and capable of being removed without removing other components of the work.

-END-

01061

Plumbing Regulatory and Directive Standards

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section identifies applicable plumbing design standards, codes, references, and project document inclusions, and describes broad system concepts that address a number of sub-systems. These sub-systems are generally described here, but might be further described and specified in a separate section of the Northeastern University Design Standards. This and all other applicable sections should be read carefully and understood before designing or specifying any system or piece of equipment.

B. System Design and Performance Requirements

1. Design the HVAC system for longevity, durability and flexibility. Include redundant equipment in the design to provide Northeastern University with the capability to maintain the plumbing system without disturbing normal building operation.
2. Several options are available when selecting systems and equipment for a given type of building. To best serve Northeastern University's facility management strategies and for ease of maintenance, use proven central-type systems. For example, use central storage or instantaneous domestic hot water heaters, instead of local hot water heaters on each floor.
3. See the Division 15 sections of these standards, as well as Section 00703: General Plumbing Design Conditions, for further detailed design requirements.
4. The design team is responsible for coordinating the construction drawings to ensure that adequate space is available in the general location of each component. The general contractor or construction manager is responsible for coordinating the construction to ensure compliance with this space requirement. Any corrective work is at the expense of the general contractor or construction manager.

C. Submittals

See Section 01330: Designer Submittals and the Division 15 mechanical sections of these standards for submittals requirements.

-END-

01062

Fire Protection Regulatory and Directive Standards

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section identifies applicable fire protection design standards, codes, and references, and describes broad system concepts that address a number of sub-systems. These sub-systems are generally described here, but might be further described and specified in a separate section of the Northeastern University Design Standards. This and all other applicable sections should be read carefully and understood before designing or specifying any system or piece of equipment.

B. System Design and Performance Requirements

1. The insurers will review an early printing of the contract documents. Arrange for a conference, through the Northeastern University Facilities group, with the University Fire Marshal and with the City Fire Marshal having jurisdiction.
2. The design team is responsible for coordinating the construction drawings to ensure that adequate space is available in the general location of each component. The general contractor or construction manager is responsible for coordinating the construction to ensure compliance with this space requirement. Any corrective work is at the expense of the general contractor or construction manager.
3. See Section 00704: General Fire Protection Design Conditions and Section 13915: Fire Suppression and for further, detailed design requirements.

C. Project Document Inclusions

1. Include under General Requirements in the specifications, such statements as the following:
   - *a. Until construction is complete, protect all equipment from water, dirt, and physical damage.*
   - *b. Cover pumps, fans and similar equipment with tarpaulins or heavy plastic to protect bearings, motors, couplings, and other such components from weather*

and dust.

c. *Do not use mechanical equipment as scaffolding or working platforms for other trades (painters, plasterers).*

d. *Upon completion of construction, chipped or scratched factory-finished equipment must be "touch-up" painted by the painting contractor at mechanical contractor's expense.*

2. Place the following note in bold type on each MEP sheet:

   All control boxes, control valves (of every type, shape, and function), and DDC control boxes must be installed in such a manner as to be fully and reasonably accessible and free from insulation or other construction components. Fully and reasonably accessible is defined as capable of being accessible for repair or replacement by an average-size individual, on a ladder if necessary, and capable of being removed without removing other components of the work.

D. Submittals

See Section 01330: Designer Submittals and Section 13915: Fire Suppression for submittals requirements.

-END-

01063

HVAC Regulatory and Directive Standards

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section identifies applicable HVAC design standards, codes, and references, and describes broad system concepts that address a number of sub-systems. These sub-systems are generally described here, but might be further described and specified in a separate section of the Northeastern University Design Standards. This and all other applicable sections should be read carefully and understood before designing or specifying any system or piece of equipment.

B. System Design and Performance Requirements

Design the HVAC system for longevity, durability and flexibility. Include redundant equipment in the design to provide Northeastern University with the capability to maintain the HVAC system without disturbing normal building operation. See Section 00705: General HVAC Design Conditions and the Division 15 mechanical sections of these standards for further, detailed design requirements.

The design team is responsible for coordinating the construction drawings to ensure that adequate space is available in the general location of each component. The general contractor or construction manager is responsible for coordinating the construction to ensure compliance with this space requirement. Any corrective work is at the expense of the general contractor or construction manager.

C. Project Document Inclusions

1. Include under General Requirements in the specifications, such statements as the following:

   a. Until construction is complete, protect all equipment from water, dirt, and physical damage.

   b. Cover pumps, fans and similar equipment with tarpaulins or heavy plastic to protect bearings, motors, couplings, and other such components from weather *and dust.*

c. *Do not use mechanical equipment as scaffolding or working platforms for other trades (painters, plasterers).*

d. *Upon completion of construction, chipped or scratched factory-finished equipment must be "touch-up" painted by the painting contractor at mechanical contractor's expense.*

2. Place the following note in bold type on each MEP sheet:

   All control boxes, control valves (of every type, shape, and function), and DDC control boxes must be installed in such a manner as to be fully and reasonably accessible and free from insulation or other construction components. Fully and reasonably accessible is defined as capable of being accessible for repair or replacement by an average-size individual, on a ladder if necessary, and capable of being removed without removing other components of the work.

D. Memos

Include any memos issued that affect changes and updates to the design standards.

E. Submittals

See Section 01330: Designer Submittals and the Division 15 mechanical sections of these standards for submittals requirements.

-END-

01064

Electrical Regulatory and Directive Standards

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section lists general electrical standards, codes, and guidelines.

B. Northeastern University Electrical Design Standards and Schedules

1. 1600-1: Electrical Plans Standard Symbols
2. 1600-2: Electrical Diagrams Standard Symbols
3. 1600-3: Electrical Abbreviations
4. 16123-1: Feeder Schedule
5. 16500-1: Lighting Fixture Schedule
6. 16530: Walkway Lighting Details

-END-

01330

Designer Submittals

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains detailed mechanical and electrical submission requirements applicable to engineers performing design services under Divisions 15000 and 16000.

All submittals shall be submitted through E-Builder. All contractors involved in the project shall be trained in E-Builder at the start of the pertinent project.

B. Submittals

Table 1 identifies the submittal requirements for mechanical and electrical engineers.

Table 1. Submittal Requirements for Mechanical and Electrical Engineers

Item	PD*	CD*	CA* & Closeout
Title Sheet	X	X	
Demolition Plans(if necessary)	X	X	
Site Plan	X	X	
Utility Plans	X	X	
Engineer Floor Plans	X	X	
Details and Schedules	X	X	
MEP Design Progress Report	X		
MEP Plans	X	X	
MEP Schedules	X	X	
MEP Riser Diagrams	X	X	
Mechanical Flow Diagrams	X	X	
Equipment Sequence of Operation	X	X	
Electrical One-Line Diagrams	X	X	
Outline Specifications (systems format)	X	X	

Component Specifications (16-division CSI format)	X	X	
Project Manual		X	
Construction Cost Estimate	X	X	
Life-Cycle Cost Analysis	X		
Code Review or Analysis	X		
Code Compliance Calculations		X	
Block Heating & Cooling Loads	X		
Mechanical Load Calculations	X	X	
Control Points List	X	X	
Controls Location Plan	X	X	
Electrical Load Calculations	X	X	
Submittal List		X	
List of Proprietary or Non-University Standard Items	X	X	
Archive Documents		X	X

* PD = Preliminary/Enhanced Schematic Design
* CD = Construction Documents
* CA & Closeout = Construction Administration and Closeout

Table 1. Submittal Requirements for Mechanical and Electrical Engineers – Continued

Item	PD*	CD*	CA* & Closeout
Record Product Data and Samples			X
Operations and Maintenance Data			X
Warrantees and Bonds			X
Spare Parts/Maintenance Materials			X
Progress Photographs			X
As-Built Documents (if required)			X

* PD = Preliminary/Enhanced Schematic Design
* CD = Construction Documents
* CA & Closeout = Construction Administration and Closeout

C. Information Requirements

1. Drawings

a. General

(1) Ensure that all drawings are neat, clear, and of appropriate scale and

completeness to easily determine the intended work.

(2) Draw floor plans on 24" x 36" sheets at a minimum scale of 1/4" = 1'0". Draw site plans on 24" x 36" sheets at an appropriate scale.

(3) Show demolition on separate drawings.

(4) Drawings must be compatible with the CADD platform specified in *CADD Requirements for Outside Consultants*. Each drawing must contain all layers listed in the CADD requirements document, whether or not they are actually used.

(5) Where ductwork, piping, conduit, and bus bars interface with the systems or equipment of other divisions, make a clear distinction between division 15 and 16 work and the work of other divisions. Do not make references by subcontractor or trade.

(6) Show the key plan, North arrow, and room locations**.**

(7) Provide separate floor plans for removals and demolition. Show all existing equipment, piping, ductwork, and electrical components within the area of work. Clearly identify all of the equipment, piping, ductwork, and electrical components that will remain or be removed.

(8) Provide floor plans for new work.

(9) All new systems should clearly show connections to the existing systems (ductwork, piping, reused equipment electrical parts, and portions of mechanical and electrical rooms). Remove piping, ductwork, and electrical wiring and conduit back to the first "live" branch or main. Cap off mechanical components with a valve and live cap electrical conductors. If the complete circuit is removed, lock and tag the circuit breaker.

(10) Equipment locations must show work access spaces, filter removal areas, coil pull areas, clearance in front of switchgear, motor control centers, and code required work space.

(11) For renovation projects, coordinate the new equipment numbers and operation with the existing equipment. Use Northeastern University acronyms for all equipment shown on the drawings.

(12) Provide record drawings on 24” by 34” paper and on diskettes upon completion of construction.

(13) Ensure that symbols and abbreviations used on drawings are in accordance with the latest Northeastern University standards for symbols and abbreviations.

b. Mechanical

(1) Draw ductwork double-lined, and clearly indicate the direction of air flow. Show supply, return, and exhaust ductwork with a different intensity of shading. Clearly indicate all rises and drops. If ductwork is not shown in section, indicate the height of the bottom of the duct.

(2) Draw all piping larger than 2-1/2" double lined, and clearly indicate the direction of flow and use. When piping of different usage is shown on the same drawing, show each group of piping with a different intensity of shading. Clearly indicate all rises and drops. If piping is not shown in section, indicate the height of the bottom of the pipe. Show floor plans, building sections, isometric diagrams, and details. Plumbing and fire protection may be included on the same drawings unless they are extensive enough to warrant separate floor plans.

(3) Draw all equipment to scale. Clearly indicate service and pull spaces. Use shading to distinguish new equipment from existing equipment. Identify equipment according to the designation on the drawing schedule. Duct work and equipment may be included on the same drawing with HVAC piping unless they are extensive enough to warrant separate floor plans. Ductwork and equipment drawings should include the proper designation for all air handling equipment and show all local exhaust, general exhaust, fume hoods, VAV boxes, VVE boxes, and other similar equipment.

(4) Controls drawings must contain control and wiring diagrams, point lists, graphics, and a written sequence of operation. Associated electrical work must be shown clearly on electrical drawings and referenced on mechanical and/or controls drawings. Engineering consultants must work with Northeastern University and controls vendors selected by the University to define control systems and strategies.

(5) Riser diagrams must include air flow, gpm, cfm, and direction of flow arrows. Provide riser diagrams for such systems as:

- Cold and hot water piping supply and return
- DI water piping

- Watering systems for animals
- Sanitary or waste drainage, including pumps
- Vent piping
- Acid waste piping
- Storm drainage, including pumps
- Process piping: natural gas, vacuum, nitrogen, CO_2, compressed air, and oxygen
- Fire suppression systems: wet and dry sprinkler piping systems
- Special systems
- HVAC air flow for HVAC systems, including fume hood and general exhaust
- Toilet exhaust
- Animal room exhaust
- Radioactive exhaust with HEPA filters
- Chilled water flow for HVAC systems
- Hot water flow for HVAC systems, including heat exchangers
- High, medium, and low-pressure steam
- High, medium, and low-pressure condensate
- PRV stations, condensate pumps, and condensate receivers
- Refrigerant piping

(6) Provide block or one-line diagrams for HVAC control diagrams. Show all interlock equipment, such as fans, VAV boxes, and motorized dampers. Show all interlocks for fume hood exhaust VVE boxes, general exhaust VVE boxes, and supply air VAV boxes. State how room pressurization is maintained as the fume hood sash is opened, and show how air locks are used.

(7) Provide sections or elevations for:

- Air handling units
- Cooling towers
- Main mechanical rooms
- Floor plans for main distribution

c. *Electrical*

Where wiring interfaces with equipment or systems of other divisions, clear distinction shall be made between work of division 16 and work of other divisions; Do not make references by subcontractor or trade.

(1) Provide separate floor plans or removals and demolition, and for power, lighting, and fire alarm systems.

  (a) Equipment locations for other systems, such as intrusion detection and telecommunications systems, may be included on power plans, unless the other systems are extensive enough to warrant separate floor plans.

  (b) Include relevant building information, such as ceiling heights and slopes, exposed joists, beam and girder locations, and fan CFMs, on fire alarm system floor plans.

(2) Provide one-line diagrams for power distribution systems.

  (a) Indicate on the diagram the short-circuit energy available at each bus or tabulate it on the drawing.

  (b) Indicate grounding methods and locations for all separately-derived systems. Where extensive or complex grounding arrangements are required (including ground-fault protection systems), provide separate grounding diagrams.

(3) Provide riser diagrams for such systems as fire alarm, intrusion detection, and telecommunications. Include the locations of vertical chases.

(4) Equipment schedules for feeders, switchboards, panelboards, and lighting fixtures must be in accordance with standard details shown in the relevant standards.

(5) Calculate demands for the following loads:

- Loads operating at 120 volts
- Lighting loads
- All other normal loads
- Emergency loads, excluding fire pumps (include itemized list)
- Fire pump, with horsepower rating
- Standby loads (include itemized list)
- Maximum coincident demand expected on the normal source and the

alternate source

(6) Where multiple buildings are fed from a load center, list the following information for each building:

- The expected power factor prior to power factor improvement measures
- Duty cycles for each category of equipment
- Sizing calculations for switches over 100 amperes
- Calculations for selection and sizing of all transformers, including connected load, future loads, harmonics, and temperature considerations
- Calculations for sizing bus ducts
- Lighting fixtures catalog cuts
- Lighting calculations or isofootcandle layouts demonstrating that required illumination levels will be achieved throughout all egress routes

2. Specifications

Write specifications in accordance with current CSI guidelines for section titles and numbering, section format, and page format.

3. Cost Estimates

a. Arrange cost estimates according to major project divisions. Present costs within each major division according to the CSI broad-scope section number.

4. Supporting Information

Provide Northeastern University with supporting information that clearly shows the basis for the design of each part of the project. Where applicable, supporting information must include the following, and may include additional information described elsewhere in these standards or requested by Northeastern University when individual equipment or installation conditions require special attention.

a. When calculations are performed by computer, include input values in the submittal, and indicate program title and version number. Calculations must highlight all assumptions made.

b. For renovation projects, submit copies of documentation generated during field investigations. Such documentation includes field notes, sketches, and photographs of all pertinent portions of the existing installation. Develop a list of all existing equipment to coordinate the new equipment numbers.

c. Provide heating and cooling load calculations based on Northeastern University design standards and the latest codes. Compare the results with the applicable energy requirements of the State Building Code.

d. Provide hydraulic calculations for fire protection piping.

e. Submit load calculations based on loads shown in panelboard and switchboard schedules. Provide breakdowns of power consumption per square foot for lighting, air conditioning, and other major categories of utilization, together with total consumption. Separate analyses may be required for various building areas. Compare the results with the applicable energy requirements of the State Building Code.

f. Submit harmonics calculations in accordance with standard IEEE 519. The calculations must indicate the basis for neutral conductor sizing and selection of transformer k rating.

g. Submit short-circuit calculations showing contributions from each source, the characteristics of each circuit element, and the short-circuit energy available at each bus. The calculations must indicate the selection criteria for conductors in addition to overcurrent devices.

h. Submit coordination analyses for all types of overcurrent devices in series. The equipment manufacturer will complete a short-circuit and coordination study.

i. Submit lighting calculations for each type of space in accordance with IES standards and based on the zonal cavity method for interior lighting and on manufacturers' isofootcandle curves for exterior lighting. The calculations must clearly indicate assumptions of reflectances, maintenance factors, and ballast factors and present the results in footcandles and in watts per square foot.

5. Design Intent

a. Basic commissioning includes the design intent documentation, one-line diagrams, and operating descriptions for full and part-load conditions to help communicate design intentions to current and future building operators. The description of the mechanical system and its intended operation and performance must include the following information, which must also be included on the drawings:

- Design intent
- Assumptions
- Noise criteria
- Facility occupation and utilization
- Basic system type
- Major components
- Interrelationship of components
- Capacity and sizing criteria
- Equipment selection and redundancy criteria
- Control strategies (The intended operation under all loads, changeover procedures, part-load operational strategies, design setpoints with permissible adjustments, operation of system components in life-safety modes, energy conservation procedures, and any other engineered operational mode of each system.)

b. Submit a design intent document for indoor air quality that includes:
- Method of ventilation, occupancy times, and number of people
- Method and equipment for fume hood exhaust systems
- Chemicals proposed in tabs for use in fume hoods
- Expected noise level in occupied spaces
- Design temperature in the space
- Design relative humidity (summer and winter)
- Type of HVAC system and selection criteria
- Kitchen hood exhaust methods
- Air distribution zoning
- Filter types and efficiency
- Method of room pressurization for labs

c. Submit a design intent document for energy conservation methods that includes:
- Methods of free cooling using outside an air economizer and condenser water economizer
- Methods of heat recovery using runaround coils, Zduct, heat wheel, or other similar equipment.
- Energy-saving methods for semester break in December and January

d. Submit a design intent document for heating of spaces using:
- Perimeter radiation
- Warm air
- Panel units
- Unit heaters

e. Submit a design intent document for equipment sizing criteria and calculations for chillers, boilers, VAV boxes, VVE boxes, VFDs, mixing boxes for existing dual duct systems, and other similar equipment.

f. Submit a design intent document for specific spaces, such as animal rooms, and for kitchen hood exhaust methods.

g. Submit a design intent document for air distribution zoning.

h. Submit a design intent document for motion sensors to prove occupancy.

i. Submit a design intent document for pump selections. Provide Northeastern University with the following documentation:
- Total GPM complete with GPM by equipment type, such as air handlers, unit heaters, fan coil units, all coils, and fin tube radiation.
- Certified pump curves to indicate that pumps are non-overloading in parallel or individual operation, and operate within 25 percent of the mid-point of the published maximum efficiency curve. Plot the pump and system operating point. Include the NPSH curve when applicable.
- Electrical data: voltage, required horsepower, full-load amps, electric phases used.

6. Sequence of Operation

a. Submit a sequence of operation of the DDC system for all controlled equipment, including:
- The position of failed equipment, including provisions for freeze protection, normally closed, and normally open
- The method of maintaining minimum ventilation by code, for occupied spaces
- The anticipated close off pressures for both supply and return, including differential pressure, for chilled water systems

b. Provide a separate sequence of operations for the occupied, unoccupied, and warm-up cycle for each season of the year.

c. Describe the life safety operating modes for:

- Atrium systems
- Smoke pressurization systems
- Fire pumps
- Smoke detectors and automatic shut-off of supply and return air fans
- Smoke dampers and automatic shut-off of supply and return air fans

d. Provide a plan to integrate control of existing HVAC systems with new HVAC systems.

e. State whether pre-heat coils for 100% air make-up units are to be steam or glycol hot water.

f. Describe humidification methods and show psychometric calculations.

7. Control Points List

Important! Provide a points list with Northeastern university acronyms. Coordinate new numbers with existing equipment. Obtain approval for acronyms before starting drawings.

D. Mechanical Design Requirements

Design criteria and assumptions should include the following design conditions for each space:

- Indoor dry bulb temperature
- Indoor relative humidity
- Outdoor dry bulb temperature
- Outdoor wet bulb temperature
- Occupancy, hours, and degree of activity
- Lighting and miscellaneous power
- Ventilation – recirculation and outside air
- Internal loads
- Special loads
- R-values for roof, wall, glass, and other insulating materials
- Percentage of glass – fenestration
- Type of glass, including coatings and solar coefficient

- Building pressurization and infiltration
- Zone control
- Air changes
- Smoke control
- Air movement
- Control responses of the ATS
- Freeze protection of steam, hot water, and chilled water coils
- IAQ
- Noise

E. Electrical Design Requirements

Where wiring interfaces with equipment or systems of other divisions, clear distinction shall be made between work of division 16 and work of other divisions; Do not make references by subcontractor or trade.

1. Provide separate floor plans or removals and demolition, and for power, lighting, and fire alarm systems.
   a. Equipment locations for other systems, such as intrusion detection and telecommunications systems, may be included on power plans, unless the other systems are extensive enough to warrant separate floor plans.
   b. Include relevant building information, such as ceiling heights and slopes, exposed joists, beam and girder locations, and fan CFMs, on fire alarm system floor plans.
2. Provide one-line diagrams for power distribution systems.
   a. Indicate on the diagram the short-circuit energy available at each bus or tabulate it on the drawing.
   b. Indicate grounding methods and locations for all separately-derived systems. Where extensive or complex grounding arrangements are required (including ground-fault protection systems), provide separate grounding diagrams.
3. Provide riser diagrams for such systems as fire alarm, intrusion detection, and telecommunications. Include the locations of vertical chases.
4. Equipment schedules for feeders, switchboards, panelboards, and lighting fixtures must be in accordance with standard details shown in the relevant standards.

5. Provide design and engineering criteria, as well as space and ambient conditions. Specify the system under the designed intent to perform.
6. Calculate demands for the following loads:
   - Loads operating at 120 volts
   - Lighting loads
   - All other normal loads
   - Emergency loads, excluding fire pumps (include itemized list)
   - Fire pump, with horsepower rating
   - Standby loads (include itemized list)
   - Maximum coincident demand expected on the normal source and the alternate source
7. Where multiple buildings are fed from a load center, list the following information for each building:
   - The expected power factor prior to power factor improvement measures
   - Duty cycles for each category of equipment
   - Sizing calculations for switches over 100 amperes
   - Calculations for selection and sizing of all transformers, including connected load, future loads, harmonics, and temperature considerations
   - Calculations for sizing bus ducts
   - Lighting fixtures catalog cuts
   - Lighting calculations or isofootcandle layouts demonstrating that required illumination levels will be achieved throughout all egress routes
8. The building electrical service and distribution should be based on following criteria or conditions:
   - Service entrance configuration
   - Connected load estimate: receptacles, lighting, motors, special loads
   - Demand load estimate
   - Provision for future load growth
   - Level of redundancy or reliability requirement
   - Basis for equipment sizing: connected or demand load, load factor, non-linear load, future load growth, overload criteria
   - Automatic scheme and interlock

- Over-current protection criteria and degree of selectivity at each voltage level
- Required metering and accuracy
- Provision for testing and maintenance
- Grounding system requirement: safety, instrumentation, lightning protection
- Special protection requirement: transient voltage surge suppression, under-voltage or loss of phase protection, EMI or RFI

9. The emergency power system should be based on following criteria or conditions:

- Connected load estimate: receptacles, lighting, motors, special loads
- Demand load estimate
- Provision for future load growth
- Motor starting capability
- Non-linear loads
- Transient performance, block load, and unload criteria
- Generator auxiliary systems: starting, fuel supply and storage, cooling, combustion air supply, exhaust, sound attenuation, fire protection
- Configuration and mode of operation
- Required metering and accuracy
- Provision for testing and maintenance
- Over-current protection criteria and degree of selectivity
- Provision for monitoring, supervisory and alarm
- Interaction with other systems: fire protection, elevator, energy management, security, lighting control

10. The fire alarm system should be based on following criteria or conditions:

- System configuration and equipment
- Type of detection and signaling to be provided in each space
- Type of system, initiating device circuit, and signaling circuit per NFPA 72
- Standby power supply
- Interaction with other systems: fire protection, elevator, HVAC, security, fire door and fire curtain, lighting control and egress lighting
- Provision for signaling, monitoring, supervisory and alarm annunciation

11. The communication and paging system should be based on following criteria or conditions:

- System configuration and equipment

- Zone listing
- Audibility criteria
- Instrument type and functionality
- Reliability and redundancy
- Interaction with other systems: fire alarm, security
- Power supply: UPS, emergency power, DC battery

-END-

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Special Project Procedures

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section includes design criteria for equipment location and installation, working in confined spaces, emergency power, and central building utility metering systems.

B. Designing Safe Mechanical and Support Spaces

1. General

The purpose of these design guidelines is to aid the design, consulting, and contracting community working on Northeastern University projects to design and build mechanical and support spaces that are inherently safe for construction, operation, and maintenance. By designing safe mechanical and support spaces, the designer can eliminate or minimize confined spaces or design confined spaces that are more easily and safely accessed. These guidelines focus on the design of safe mechanical and support spaces by avoiding the hazards associated with such spaces. Such hazards include:

- Inadequate dimensions, entries, and exits
- Toxic atmosphere or oxygen deficiency
- Moving parts
- Electrical shock hazard
- Heat and chemical hazards
- Structural hazards that can cause injury
- Combustible dust
- Irritant or corrosive agents
- Moisture or water
- Noise and vibration
- Surface residues making the floor unsafe for walking

2. Design Guidelines

a. Allocate sufficient space within the building footprint for utilities and for mechanical, electrical, telecommunications, and other equipment, including mechanical rooms, rather than designing such features as vaults, hatches, and tunnels outside of buildings.

b. Design mechanical rooms large enough for the intended equipment, with:
   - sufficient distances and clearances for each piece of equipment,
   - sufficient work area around the equipment,
   - sufficient space for removal of equipment components for repair and replacement, and
   - sufficient space for removal of the entire unit for replacement.

c. Design access doors, corridors, ventilation, lighting, and other mechanical room components to meet applicable code requirements while also designing safe working conditions. Requirements for safe working conditions must apply to both normal and emergency operating conditions.

d. Design entries, exits, ventilation, and other mechanical room components with consideration for the conditions inside the room, as well as conditions inside adjacent spaces.

e. Design mechanical rooms with the proper penetrations and seals for cable and piping entries to prevent the penetration of such things as water, moisture, fumes, gases, and heat.

f. Design appropriate doors, rather than hatches, for mechanical rooms and support spaces.

g. Lay out equipment in the mechanical rooms and support spaces for safe service and repair under normal and emergency operating conditions. Ensure that there are sufficient distances and clearances for each piece of equipment, sufficient work area around the equipment, space for removal of equipment components for repair and replacement, and removal of the entire unit for replacement.

h. Design mechanical rooms and support spaces with adequate lighting, ventilation, insulation, noise attenuation, drainage, flood alarms, means of communication, and other safety measures to ensure safe working conditions under normal and emergency operating conditions.

i. Locate cable splicing and other items that require periodic inspection and service within the building, rather than outside of the building in a confined space.

j. Locate utilities distribution systems equipment that requires periodic inspection and service within the building rather than outside of the building in a confined space.

k. Provide adequate spacing of equipment, piping, and cables and a safe working environment for their installation, inspection, and service under normal and emergency working conditions. Provide coordination drawings in the design documentation; the coordination and layout of equipment in mechanical rooms and support spaces should not be left to the construction manager.

C. Designing Confined Spaces

1. General

a. Confined spaces can pose serious health and safety hazards to persons performing inspection, service, maintenance, or related activities. Use the following information about confined spaces in the building design, construction, and renovation process to eliminate such spaces or, where not feasible, to design confined spaces that are more easily and safely accessed. Also, follow OSHA standards.

b. OSHA's standard on confined spaces (29 CFR Part 1910.146) defines a confined space as one that meets all of the following criteria:

- Large enough and so configured that it can be entered to perform work
- Has a limited or restricted means of entry or exit
- Is not designed for continuous employee occupancy

c. Some common examples of confined spaces include below ground electrical vaults that are accessed by ladder, various tanks and pits, boiler interiors, and crawlspaces. For more information, refer to applicable OSHA publications and the OSHA web site: http://www.osha-slc.gov/SLTC/confinedspaces/.

2. Types of Confined Spaces and Basic Design Options

The following paragraphs describe the major types of confined spaces, including the type of space, typical hazards, and the means for minimizing or eliminating the hazards. One of the most frequent safety issues associated with confined spaces involves entry and exit (access). Additionally, the materials introduced into confined spaces and the operations performed with them can create unsafe conditions by releasing toxic materials (for example, welding, cleaning, and painting) or reducing oxygen levels below safe levels. Such hazards are possible within any confined space, as is the nearly ever-present danger of an oxygen-deficient environment.

a. *Telecommunication or Electrical Distribution Vaults*

(1) Telecommunication and electrical distribution vaults typically consist of a below-ground, poured-concrete vault, accessible by a grade-level access hatch. Depending upon inner depth, portable ladders or a fixed rung ladder is used to reach the base.

(2) Although telecommunication and electrical distribution vaults rarely contain hazardous processes (provided the electrical cabling is sheathed or is enclosed in conduits), their physical location below-grade carries the risk of oxygen deficiency, falls during entry or exiting, and water accumulation. Operations performed in, and materials introduced into, these spaces can also create unsafe conditions by releasing toxic materials (for example, welding, cleaning, painting) or by reducing the oxygen level below a safe level.

(3) Basic safety design options include:

- Incorporating new vaults as part of a building basement, providing a full-size door to eliminate the confined space (preferred).
- Ensuring an access or hatchway diameter of no less than 30" (36" or larger is preferred for equipment and materials transfer).
- Providing an OSHA-compliant fixed stairway or ladder with an extendable grab bar or rail.
- Grading the floor and including a small sump pit to collect any water seepage that accumulates within the space and permit easier pump-down before entry. The sump pit should be located away from the ladder base.

b. *Electrical Transformer Vaults*

(1) Electrical Transformer Vaults are very similar in structure to telecommunications or electrical distribution vaults, but with the added potential hazard from electricity during periodic manual interactions with switches.

(2) Basic safety design options include all those for telecommunications or electrical distribution vaults, plus:

- A minimum clearance of 36" from all breakers, switches, and other components
- Passive ventilation of space to avoid accumulations of ozone or an oxygen-deficient atmosphere
- Providing vaults with frequent need for access with permanent, moisture-protected lighting
- Placing transformers and switch gear away from access doors or hatches

c. Steam Distribution Systems

(1) Steam distribution systems include large horizontal and vertical pipe chases (some are tunnel sized), valve access vaults, and condensate return pits.

(2) The hazards associated with these steam distribution system components include all those for telecommunications or electrical distribution vaults, plus exposure to very high levels of heat and humidity and the potential for exposure to steam leaks and possible steam explosions.

(3) Basic safety design options include all those for telecommunications or electrical distribution vaults, plus:

- Maximizing clearances from all steam pipes and other obstructions, both to provide greater distance from hot surfaces and to reduce head and face injuries.
- Ventilating the space to reduce heat and humidity loads. For vaults, the preferred method is the use of a dual-pipe or duct system to induce convective airflows. For tunnels, provide outdoor access grilles or panels at regular tunnel intervals to enhance natural airflows through individual tunnel sections.
- Ensuring that all pipes that must be stepped over in order to reach a confined area have metal guards around the insulation, and/or steps and platforms.

d. Power Plants

(1) Power plants contain a large number and wide variety of confined spaces

due to their complex and interconnected operational systems. Some examples of confined spaces in the power plants include:

- Boilers
- Turbines or generators
- Liquid storage and other types of tanks
- Water and cooling towers
- Numerous pits and recessed floor or grade channel ways
- Large ventilation system components (for example, ductwork, filter houses, plenums)

(2) The hazards in specific power plant confined spaces vary by system. However, access in many power plant spaces is difficult due to elevated heights and narrow entry or exit ways, and should be designed with ease of access and safe maintenance in mind.

e. Elevator Systems

(1) Building elevator systems consist of a vertical elevator shaft, a motor or service room, and a pit at the bottom of the elevator shaft.

(2) Hazards associated with elevator systems include:

- Elevator shaft: access hazards, physical hazards from moving cables and counterweights, fall hazards.
- Motor or service room (those located in rooftop penthouses or other locations without an ordinary door entry): physical hazards from the cable winding, potentially exposed mechanical components on the motor and gear shafting, and electricity, including an accumulation of ozone in poorly ventilated rooms.
- Pit: access hazards, oxygen deficiency, falling objects, and possible drowning from engulfment in accumulated water.

(3) Basic safety design options include:

- The installation of a lockable door, rather than a hatch to both the shaft and pit
- Fall protection attachment points for shaft work
- Passive or active ventilation of the motor or service room
- Fixed permanent lighting for the motor or service room
- Machine and equipment guarding where possible on exposed moving

motor and gear or winding parts

f. Sump Pump and Sewage Ejector Pits

(1) Although the liquid materials to be pumped vary, sump pump and sewage ejector pits share many common features. Both consist of concrete or lined pits, often with a liquid holding tank and pump (either submersible or remote). These pits are generally located below-grade in a basement area or outdoors inside a vault. Access is typically made by either a metal grating cover, solid hatch, or manhole cover. Some of these systems possess a fixed ladder.

(2) Hazards include oxygen deficiency, the potential for accumulation of toxic vapors (including those from materials discharged to domestic waste lines), falls during entry or exit, and possible drowning from engulfment in liquid.

(3) Basic safety design options include:

- The installation of remote pumps, or pumps that can be easily retrieved without requiring pit entry (also requires means for pump retrieval or attachment of retrieval means)
- The installation of permanent fixed ladders
- A means of valving-off and locking-out water or wastewater inputs into the pit during entry
- Lockable access to prevent unauthorized entry

g. HVAC Systems

(1) Many larger HVAC systems contain remote supply air plenums, larger diameter ductwork, filter and coil "houses," mechanical rooms, and related components that qualify as confined spaces. These remote areas are often elevated in height with restrictive means of access.

(2) The most common hazards of HVAC confined spaces are restricted access, vertical shafts and plenums or ducts, and mechanical and electrical energy sources.

(3) Basic safety design options include:

- Providing fall protection for elevated walkways (preferably railings)
- Guarding exposed mechanical elements (for example, belts and drive shafts)

- Installing adequately-sized drains for condensate collection pans and basins
- Providing adequate clearance around all moving parts, electrical transformers, high voltage switches, and other similarly hazardous systems
- Providing adequate access space and clearance space for repairs and movement of new or replacement equipment
- Providing fixed ladders or stairs (preferred) for air supply intake plenums and related building "moats"
- Providing filter rooms and mechanical rooms with permanent, moisture-protected lighting
- Installing true doors rather than hatches, where possible
- Lockable access to prevent unauthorized entry

h. Crawlspaces and Chases

(1) Although not generally identified as confined spaces, a variety of crawlspaces, pipe chases, ceiling plenums, and related areas require periodic entry for inspection and repair. Difficult access to these spaces, coupled with their general layout, can create significant confined space hazards.

(2) The majority of hazards associated with crawlspaces and chases pertain to restricted access, entrapment, and head and face injuries from obstructions and falls, either directly to the individuals entering these areas or indirectly by dropping tools or other objects. In certain cases (for example, some pipe chases), high-pressure steam can also be a hazard if piping is leaking or a valve is damaged.

(3) Basic safety design options include:

- Eliminating crawlspaces wherever possible. Where crawlspaces are necessary, maximize their cross-sectional area and minimize obstructions.
- Installing floor gratings in large vertical pipe chases at each entry point or grade.
- Installing permanent, fixed ladders in large building-wide pipe chases.
- Providing designated access hatches for above-ceiling MEP system components that will likely require regular service (for example, VAV

mixing boxes).

i. Tanks and Vessels

(1) A wide variety of tanks and vessels are used for storage, collection, and distribution, including fuel tanks, boiler vessels, and wastewater neutralization tanks, as well as tanks used for the temporary retention of domestic water, chilled or cooling water, and those used in research applications. The confined nature of these kinds of spaces is generally well understood by service and maintenance staff. Those tanks that are located below-ground (for example, many fuel tanks) have limited or no direct means of entry, except after partial excavation.

(2) The hazards associated with tanks and vessels include their material contents or residue, atmospheric hazards (oxygen deficiency, toxicity, flammable or explosive) and access (including falls upon entry or exit).

(3) Basic safety design options include:

- Boltable or lockable access to prevent unauthorized entry
- A means of removing the contents prior to entry
- Fixed ladder and railing access systems for elevated tanks requiring regular entry or inspection
- A means for remote assessment of contents level
- A means for valving-off and locking-out inputs into the tank or vessel during entry

j. Miscellaneous Areas

Several other areas and locations present access problems that can create confined space and related hazards, including tunnels, platforms, and some attic areas where fall hazards can exist because of inadequate or non-existent railings, the absence of a fixed ladder or stairway, or very low clearance within the space. These kinds of issues are best addressed by providing standard means of access (preferably stairs), incorporating hand and toe rail protections, and installing larger entry ways or doors instead of hatches.

3. Basic Design Guidance

a. The most effective means of reducing the hazards associated with a confined space (as well as the long-term operational and procedural requirements associated with these spaces) is to eliminate the confined space from the start.

Depending upon the space, this can be accomplished by several means, including:

- incorporating the space as an element of a building,
- providing a true full-size door instead of a hatch or manhole for access, and
- installing a stair rather than a ladder.

b. Where these steps are not feasible, the following is a brief listing of good design practices that can significantly reduce the hazards associated with most confined spaces.

(1) Provide as-built drawings of all confined spaces, showing all penetrations and systems contained within them.

(2) Ensure space is sufficiently large to provide adequate clearances.

(3) Design the space to be linear in configuration, with a clear line of sight.

(4) Minimize obstructions and penetrations to provide clear and safe paths of travel.

(5) Adopt a standardized hinged and counterweighted cover in lieu of ordinary manhole covers or large grates.

(6) Ensure that access ways are sufficiently large to accommodate anticipated supplies and equipment transfers into and out of the space.

(7) Provide a means of fall protection, preferably through the use of railings and gratings.

(8) Provide a safe and easy means for collecting and removing accumulated water in below-grade vaults, using sloped flooring and small sump pits away from the ladder landing.

(9) Where possible, provide quality fixed ladders. Follow OSHA guidelines.

(10) Install moisture- or weather-protected fixed lighting in frequently-accessed spaces.

(11) Provide a means for passive or active ventilation for especially hot or humid locations and all other locations with anticipated atmospheric hazards.

(12) Provide an easily accessible means for locking or tagging out power supplies and liquid inputs to the space to prevent accidental engulfment, electrocution, or physical injury during entry.

4. Design Document Review and Approval

a. Northeastern University departments assigned to project reviews review all phases of the design documentation, giving special attention to safe design and the elimination of confined spaces.

b. If a confined space is unavoidable, the project manager must obtain approval of the design from the managers of the departments servicing the confined space —Northeastern University Facilities group and/or Telecommunications.

c. Submit the final design documentation to Northeastern University's Office of Environmental Health and Safety for review and approval to ensure the design of safe mechanical, support, and confined spaces.

D. Emergency Power

1. Usual Essential Plumbing System Power Requirements

a. Storm water pumping systems.

b. Sewage ejectors.

c. Laboratory waste lift station.

d. Booster water pumping systems.

2. Usual Essential Fire Protection System Power Requirements

a. Fire and jockey pumps and control panel.

b. Sprinkler system controls.

c. Smoke evacuation system.

3. Usual Essential HVAC System Power Requirements

a. Energy Management and Control System, each field cabinet (stand-alone control panel), the control air compressor and dryer, and any electric controls for systems on emergency power.

b. Laboratory hood exhaust fans and fume hood controllers.

c. Air handling supply and exhaust fans, and chilled water circulating pump and controls for servicing specialized HVAC equipment and systems.

d. Emergency power required to prevent crystallization in absorption water chillers during a power failure.

e. Central system heating equipment.

f. Ventilation equipment and controls for emergency generator rooms.

g. Refrigeration system and controls for food storage freezers.

4. Usual Essential Electrical System Power Requirements

a. Emergency lighting.

b. Fire alarm system.

c. Circuits for health care services and critical equipment support.

d. Security and emergency paging system.

e. Critical communication services.

5. System Design Considerations

a. Because of the odor, route generator exhaust to the roof whenever possible.

b. Locate louvers to provide unobstructed air intake and exhaust. Size them per the manufacturer's recommendations.

c. Verify code and facility fuel requirements for an extended run time.

E. Equipment Installation

1. The contractor is responsible for notifying all sections or individuals identified by the project manager at least three days before the disruption of utilities.
2. The contractor must provide the Northeastern University Facilities Department with a 24-hour emergency telephone number.
3. During installation, the contractor must have personnel who are available for immediate response in case of emergency (for example, broken pipes or interrupted electricity).

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Special Procedures for Historic Treatment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains general design guidelines associated with the treatment of historic buildings.

B. General Design Guidelines

1. The architect must review each project with Northeastern University for specific project conditions. Specific treatment is dependent on many factors, including building age, historic value, types of existing materials, and desired outcome.
2. Generally, the architect should refer to the Boston Redevelopment Authority, Boston Historical Society guidelines for preserving, rehabilitating, restoring and reconstructing historic buildings.
3. The Boston Redevelopment Authority, Boston Historical Society guidelines seek to minimize the impact of updates made to historic buildings. The publication contains guidelines for exterior and interior treatment of historic buildings, including such elements as stone, masonry, windows, and interior finishes. These guidelines also provide helpful definitions for preservation, rehabilitation, restoration, and reconstruction.

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Sustainable Design Requirements

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

Sustainable design seeks a balance between the environment, economics, occupant comfort and human health considerations. Sustainably-designed buildings aim to lessen their impact on our environment by using energy and environmental resources efficiently while providing for the present and future needs of Northeastern University. Northeastern University is committed to the incorporation of sustainable design practices in the design of construction of all size projects on campus. This section describes the goals, strategy and procedures for providing and meeting sustainable design requirements for projects designated by Northeastern Facilities as **Comprehensive, Limited or Small Scope** projects.

B. Comprehensive Scope Projects

1. System Design and Performance Requirements

a. Northeastern University has adopted the Leadership in Energy and Environmental Design (LEED-NC or LEED-CI) rating system, administered by the US Green Building Council (USGBC) as the method to help achieve a commitment to sustainable design.

b. All comprehensive new construction and renovation project designs must meet LEED status, as directed by Northeastern. Registration with USGBC may occur at any time in the design process, but must be transitioned to the version in effect at the end of the CD phase.

c. Northeastern University has outlined several "points," listed under **Special Requirements**, below as mandatory areas of compliance.

2. Submittals

Submit the LEED checklist in the pre-design phase, DD phase and 50% CD phase with those points proposed for project inclusion. Score all designs at each design phase for Northeastern University's information.

3. Materials & Product Standards

Designers shall provide product and materials specifications that preferentially select resource, energy saving and health building materials and design features.

4. Special Requirements

All sustainable design alternatives shall be presented to the University for their consideration with analyses as described herein. Designers are encouraged to reduce the energy loads, apply the most efficient systems, and look for synergies wherein all systems, building construction and components will work together to produce overall functionality and environmental performance.

a. Special Requirements

(1) Required Credits (Note: This currently references credits in LEED-NC v3 and LEED-CI v3. These references will be updated as new versions are published and adopted by Northeastern).

The following LEED NC and LEED CI points are required credits:

(a) Sustainable Sites

LEED NC: Must incorporate SS Credit 6.1, Storm Water Management. (LEED CI: Not Applicable)

LEED NC: Must incorporate SS Credit 6.2, Storm Water Design – Quality Control (LEED CI: Not Applicable)

(b) Water Efficiency

LEED NC: Must incorporate WE Credit 1: Water Efficient Landscaping.

(c) Energy and Atmosphere

LEED NC: Must incorporate EA Credit 1, Optimize Energy Performance, using detailed energy modeling.

- Lab building or other building with 100% OA requirements: 12 pts (34% new, 30% existing)
- All other building types: 7pts (24% new, 20% existing)
- Must incorporate EA Credit 3, Enhanced Commissioning.

- Although EA Credit 5 Measurement & Verification is not required, all projects shall incorporate metered building energy consumption and diagnostic tools to evaluate system operations. Northeastern Utilities & Engineering shall indicate criteria for Measurement & Verification for each project.

LEED CI:

- Must incorporate EA Credit 1.1 Lighting Power (3 pts). Reduce installed lighting power density to 25% below ANSI/ASHRAE/IESNA Standard 90.1-2007 as a minimum.
- Must incorporate EA Credit 1.2 Lighting Controls (2 pts). Provide daylight controls for regularly occupied day lit spaces within 15 feet of windows and under skylights. Install daylight controls for at least 50% of the connected lighting load –or- install occupancy sensors for at least 75% of the connected lighting load.
- Must incorporate EA c1.3 Option 1Appropriate Zoning/Controls (5 pts) and EAc1.3 Option 2 Performance Modeling (5 pts). For Option 1, zone each solar exposure and interior spaces separately, and provide active controls capable of sensing space use and modulating the HVAC systems in response to space demands of private offices and special occupancies. For Option 2, demonstrate that HVAC system performance criteria used for tenant space are 15% better than a system that is in minimum compliance with ANSI/ASHRAE/IESNA Standard 90.1-2007 using a whole building energy simulation. Note: Chilled water and steam shall be held cost neutral in energy simulations in accordance with the "Required Treatment of District Thermal Energy in LEED NC v2.2."

  In the case where a project does not have dedicated base building infrastructure, must incorporate EAc1.3 Option 1 Appropriate Zoning/Controls (5 pts) and EAc1.3

Option 1 Equipment Efficiency (5 pts). Zone each solar exposure and interior spaces separately, and provide active controls capable of sensing space use and modulating the HVAC systems in response to space demands of private offices and special occupancies, and also demonstrate that HVAC systems comply with the efficiency requirements outlined in the Advanced Buildings Core Performance Guide Sections, 1.4, 2.9, and 3.10 as applicable to project scope.

- Must incorporate EA Credit 1.4 (4 pts) Equipment & Appliances 90% (by rated power) of ENERGY STAR eligible equipment and appliances shall be qualified by EPA's ENERGY STAR program.
- Must incorporate EA Credit 2 Enhanced Commissioning (5 pts).
- Although EA Credit 3 Measurement & Verification is not required, all projects shall incorporate metered project area energy consumption and diagnostic tools to evaluate system operations. Northeastern Utilities & Engineering shall specify criteria for Measurement & Verification for each project.

(d) Materials and Resources

LEED-NC and LEED-CI

- Must incorporate MR Credit 2, Construction Waste Management; divert a minimum 90% of construction waste from landfills.

5. Salvageable Building Components

Design Consultant, with review by Facilities Project Manager and Planning Office to identify salvageable building components and determine their reuse by Northeastern or qualified salvage vendor.

6. Salvageable Furniture and Equipment

Facilities Project Manager to evaluate existing furniture and equipment for potential storage and re-use on other projects

7. Life-Cycle Cost and Life Cycle Assessment

a. Life Cycle Cost (LCC) evaluates the total lifetime cost of alternative building systems or construction options. Instead of focusing on the first cost, it incorporates the potential savings in energy and water, as well as ongoing costs of maintenance and service. It also recognizes that future dollars are not equivalent to present dollars, and converts future cash flows to present value for comparison.

(1) For all major sustainable design alternatives that have quantifiable economic impact over time (e.g. reduced cost for maintenance, energy or water use).

b. Life Cycle Assessment (LCA) is a method of evaluating sustainable attributes and environmental impacts of construction materials over the lifetime of the building. Published LCA reports should be referenced for alternative products, assemblies and systems to assist in selections. Sustainable attributes of specific interest to Northeastern should be emphasized in these selections, and the referenced LCAs submitted to Northeastern.

8. Sustainability and Energy Group

The Sustainability and Energy Group will serve as an advisory body for Comprehensive Scope Projects providing input and guidance as needed on projects' sustainable design attributes. Project team (or Northeastern Planner) will meet with the Sustainability and Energy Group to present proposed sustainable design strategies. The integration of recommendations into each project will be tracked on the Sustainability Supplement Recommendations Checklist. The checklist is a tool to assess the depth and range of sustainable attributes that are being integrated into each project.

9. Archive Sustainability Documents

After LEED certification has been awarded, provide a compilation of all LEED documentation that was submitted to USGBC on-line plus all supporting analyses in the form of a bookmarked PDF file. Provide the following:

a. LEED Submittal File: The full LEED documentation that was submitted to the USGBC for the project.

b. LEED Final Report: The final report from USGBC that states each credit and describes what was earned and the final rating achieved with commentary from the USGBC reviewer regarding the design team responses.

c. Energy Modeling Reports: Energy Modeling Reports that were prepared to analyze energy strategies for the project.

d. Additional Supplements: Additional information, reports, studies etc. that provide insight into why decisions were made.

C. Limited Scope Projects

No LEED certification is required but the following sustainable attributes are required if the category is applicable. In addition, and depending on the type of project, life cycle costing must be used for comparative analysis for all measures. (Note: This currently references credits in LEED-NC v3 and LEED-CI v3. These references will be updated as new versions are adopted by Northeastern.

1. Energy and Atmosphere

Optimize energy performance (e.g. –and not limited to- use of occupancy sensors, light fixture and lamp selections, controllability systems, HVAC system zoned and controlled for low energy consumption, use of energy star equipment, day lighting, thermal comfort, building insulation and reduced heat island effect roofing, etc.)

a. Lighting:

(1) LEED CI EA Credit 1.1: Optimize Energy Performance, Lighting, reduce lighting power density to 25% below the standard)

(2) LEED CI EA Credit 1.2: Optimize Energy Performance; lighting controls

b. HVAC:

(1) LEED CI EA Credit 1.3: Optimize Energy Performance, HVAC

(2) LEED CI EA Credit 2: Enhanced Commissioning (only if totally replacing HVAC system)

(3) LEED NC EA Credit 4, Enhanced Refrigerant Management, if

replacing or installing a chiller

(4) Include Metering to enable monitoring of systems performance (where possible connecting to existing DDC)

c. Plug Load:

(1) LEED CI EA Credit 1.4: Optimize Energy Performance, Equipment and Appliances (use energy star rated appliance)

d. Building Envelope:

(1) LEED NC SS Credit 7.2 Heat Island Effect: Roof

2. Materials and Resources

Specify high recycled content, low emitting materials, high content of rapidly renewable materials, use of regional materials (e.g. when specifying carpet, floor tiles, ceiling tiles, casework etc.).

a. Material Specifications:

(1) LEED CI MR Credit 4: Recycled content, 10%

(2) LEED CI MR Credit 5: Regional Materials, 20% Manufactured Regionally

(3) LEED CI MR Credit 6: Rapidly Renewable Materials

(4) LEED CI MR Credit 7: Certified Wood

(5) LEED CI IEQ Credit 4.1: Low Emitting Materials, Adhesives & Sealants

(6) LEED CI IEQ Credit 4.2: Low Emitting Materials, Paints and Coatings

(7) LEED CI IEQ Credit 4.3 Low Emitting Materials, Flooring Systems

(8) LEED CI IEQ Credit 4.4 Low Emitting Materials, Composite Wood and Agrifiber Products

(9) LEED CI MR Prerequisite 1: Storage and Collection of Recyclables

3. Water Use Reduction

Use e.g. dual flush toilets, water saver faucets, low flow lavatories, and where applicable reduce storm water runoff, reduce heat islands, and limit potable water irrigation.

a. Plumbing Fixtures:

(1) LEED CI WE Credit 1 Water Use Reduction, 30%

b. Landscape and Storm Water:

(1) LEED NC SS Credit 6.1 Storm Water Design Quantity Control
(2) LEED NC SS Credit 6.2 Storm Water Design Quality Control

(3) LEED NC SS Credit 7.1 Heat Island Effect, Non Roof

(4) LEED NC WE Credit 1 Water Efficient Landscaping, Reduce by 50%

4. Construction Methods

The following construction methods must be followed where applicable:

a. Construction and Demolition Debris:

(1) LEED CI MR Credit 2: Divert 75% of construction waste from landfill

b. Salvageable Building Components:

(1) Design Consultant, with review by Facilities Project Manager and Planning Office to identify salvageable building components and determine their reuse by Northeastern or qualified salvage vendor.

c. Salvageable Furniture and Equipment:

(1) Facilities Project Manager and TR&S to evaluate existing Furniture and Equipment for potential storage and reuse on other projects.

d. Air Quality:

(1) LEED CI IEQ Credit 3.1 Construction IAQ Management Plan, during Construction

(2) LEED CI IEQ Credit 3.2 Construction IAQ Management Plan, before Occupancy

e. Construction Activity Pollution Prevention

(1) LEED NC SS Prerequisite 1: Construction Activity Pollution Prevention

5. Salvageable Building Components

Design Consultant, with review by Facilities Project Manager and Planning Office to identify salvageable building components and determine their reuse by

Northeastern or qualified salvage vendor.

6. Salvageable Furniture and Equipment

Facilities Project Manager and to evaluate existing furniture and equipment for potential storage and re-use on other projects.

7. Sustainability Resource Group

The Sustainability Resource Group (SRG) will serve as an advisory body for Limited Scope Projects. The SRG will provide input and guidance as needed on projects' sustainable design attributes. The SRG will respond with comments, questions or suggestions. The SRG may also request a meeting with the project team for clarification.

D. Small Scope Projects

No LEED certification is required. Sustainable products and construction methods must be followed as per the Northeastern Sustainable Products List and the Construction Methods listed below. Substitutions may be made if approved by Northeastern Project Manager with products or methods that achieve the same or greater sustainable attributes.

1. Northeastern Sustainable Products List

The Northeastern Sustainable Products List provides information on approved products typically used on small scope projects. The Northeastern Sustainable Products List will be updated regularly.

2. Construction Methods

The following construction methods must be followed where applicable:

a. Construction and Demolition Debris:

(1) LEED CI MR Credit 2: Divert 75% of construction waste from landfill

b. Salvageable Building Components, Furniture and Equipment:

(1) Per project requirements if needed, similar to requirements for Limited Scope Projects

c. Air Quality

(1) LEED CI IEQ Credit 3.1 Construction IAQ Management Plan during Construction

(2) LEED CI IEQ Credit 3.2 Construction IAQ Management Plan, before Occupancy

d. Construction Activity Pollution Prevention:

(1) LEED NC SS Prerequisite 1: Construction Activity Pollution Prevention

3. Salvageable Building Components

Design Consultant, with review by Facilities Project Manager to identify salvageable building components and determine their reuse by Northeastern or qualified salvage vendor.

4. Salvageable Furniture and Equipment

Facilities Project Manager to evaluate existing furniture and equipment for potential storage and re-use on other projects

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Referenced (Non-Regulatory)

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A. Information Available to Designers

1. Central Campus Floor Numbering Standards
2. Central Campus Room Numbering Standards
3. Request for Extension of Utilities
4. Northeastern Accessibility Guidelines
5. Northeastern CAD Standards
6. Northeastern Security Standards
7. Northeastern University Electrical Acronyms
8. Northeastern Standard Detail 16000-1, Electrical Plans Standard Symbols
9. Northeastern Standard Detail 16000-2, Electrical Diagrams Standard Symbols
10. Northeastern Electrical Distribution Master Plan
11. Northeastern University Exterior Lighting Manual

B. General Regulatory and Directive Standards

1. Accessible Design Handbook (1991)
2. ADA Compliance Guide (1991) (Contains Minimum Guidelines and Requirements for Accessible Design, 1982, from Federal Register)
3. American Society of Mechanical Engineers (ASME)
4. ANSI/ASHRAE/IESNA, Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings
5. American National Standards Institute (ANSI)
6. American Society for Testing and Materials (ASTM)

7. Environmental Protection Agency (EPA)
8. Factory Mutual (FM)
9. National Electric Manufacturers Association (NEMA)
10. National Fire Protection Association (NFPA)
11. NFPA, Life Safety Code 101
12. Occupational Safety and Health Administration (OSHA)
13. Practical Guide to Seismic Restraint (ASHRAE)
14. Underwriters Laboratories (UL)

C. Site Construction

1. Water Distribution

a. ANSI A21.4
b. ANSI A21.10
c. ANSI A21.11
d. ANSI A21.51
e. ASTM D1556
f. AWWA C-205
g. AWWA C-600

2. Chilled Water Distribution

a. ASME
b. AWWA
c. ASTM A53
d. ASTM D1556

3. Steam Distribution

a. ANSI B31.1
b. ASME Section IX
c. ASTM A53 or A106
d. ASME B16.5

e. ASTM D1556

4. **Storm Sewerage Systems**
   a. AASHTO M294
   b. ASTM A48
   c. ASTM C76
   d. ASTM D1556
   e. ASTM D3034

5. **Sanitary Sewerage Systems**
   a. ASTM A48
   b. ASTM D3034
   c. ASTM D1556

D. Architectural Regulatory and Directive Standards

1. **Masonry**
   a. ASTM C67—Methods of Sampling and Testing Brick and Structural Clay Tile
   b. ASTM A82—Cold-Drawn Steel Wire for Concrete Reinforcement
   c. ASTM A153—Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   d. ASTM C90—Hollow Load-Bearing Concrete Masonry Units
   e. ASTM C144—Aggregate for Masonry Mortar
   f. ASTM C150—Portland Cement
   g. ASTM C207—Hydrated Lime for Masonry Purposes
   h. ASTM C216—Facing Brick
   i. ASTM C270—Mortar for Unit Masonry
   j. ASTM C476—Grout for Reinforced and Non-Reinforced Masonry
   k. ASTM C744—Prefaced Concrete and Calcium Silicate Masonry Units
   l. ASTM E119—Fire Tests of Building Construction and Materials

2. **Woods and Plastics**

a. AWI—Architectural Woodwork Institute Quality Standards and Guide Specifications
b. NWMA—National Wood Manufacturers Association
c. PS 20—American Softwood Lumber Standard
d. ANSI A156.9—American National Standard for Cabinet Hardware
e. NEMA LD3—High Pressure Decorative Laminates

3. **Thermal and Moisture Protection**
   a. ASTM C516—Vermiculite Loose Fill Insulation
   b. ASTM C578—Preformed, Cellular Polystyrene Thermal Insulation
   c. ASTM E84—Surface Burning Characteristics of Building Materials
   d. ASTM C764—Mineral Fiber Loose Fill Insulation
   e. FS HH-558—Insulation, Board, Blanket, Felt, Sleeving (Pipe and Tube Coverings) and Pipe Cover Insulation
   f. ASTM E605—Test Method for Thickness and Density of Sprayed Fire-Resistive Materials Applied to Structural Members
   g. ASTM E736—Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members
   h. ASTM E759—Test Method for Effect of Deflection on Sprayed Fire-Resistive Materials Applied to Structural Members
   i. ASTM E760—Test Method for Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members
   j. ASTM E859—Test Method for Air Erosion of Sprayed Fire-Resistive Materials Applied To Structural Members
   k. ASTM E937—Test Method for Corrosion of Steel by Sprayed Fire Resistive Material Applied to Structural Members
   l. ASTM E119—Method for Fire Tests of Building Construction and Materials
   m. ASTM E 814—Fire Tests of Through-Penetration Fire Stops
   n. UL 723—Test for Surface Burning Characteristics of Building Materials
   o. UL 1479—Fire Tests of Through-Penetration Firestops

p. ASTM A361—Sheet Steel, Zinc-Coated (Galvanized) by the Hot-Dip Process for Roofing and Siding
q. ASTM D225—Asphalt Shingles Surfaced with Mineral Granules
r. ASTM D226—Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
s. ASTM D2822—Asphalt Roof Cement
t. ASTM D3018—Class A Asphalt Shingles Surfaced with Mineral Granules
v. ASTM D3462—Asphalt Shingles Made From Glass Felt and Surfaced with Mineral Granules
w. ASTM D4586—Asphalt Roof Cement, Asbestos-Free
x. ASTM C728—Perlite Thermal Insulation Board
y. ASTM D41—Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
z. ASTM D312—Asphalt Used in Roofing
aa. ASTM D1863—Mineral Aggregate Used on Built-Up Roofs
ab. ASTM D2178—Asphalt Glass Felt Used in Roofing and Waterproofing
ac. ASTM D2626—Asphalt Saturated & Coated Organic Felt Base Sheet used in Roofing
ad. FS-HH-I-529—Insulation Board, Thermal (Mineral Aggregate)
ae. FS-HH-I-1972—Insulation Board, Thermal-Faced, Polyurethane or Polyisocyanurate
af. NRCA—The NRCA Roofing and Waterproofing Manual
ag. PIMA—Technical Bulletin 281-1, Conditioning Procedures
ah. ASTM D412—Rubber Properties in Tension
ai. ASTM D4637—Vulcanized Rubber Sheet used in Single Ply Roof Membrane
aj. ASTM D746—Brittleness Temperature of Plastics and Elastomers by Impact
ak. FM Approval Guide—Equipment, Materials, Services for Conservation of Property
al. FM Loss Prevention Data 1-28—Insulated Steel Deck

am. FM Loss Prevention Data 1-49—Perimeter Flashing

an. ASTM D746—Brittleness Temperatures of Plastics and Elastomers by Impact

ao. FM Approval Guide—Equipment, Materials, Services for Conservation of Property

ap. ASTM C177—Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate

aq. ASTM A526-90—Spec for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality

ar. ASTM D226-89—Spec for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

as. SMACNA—Architectural Sheet Metal Manual

at. ASTM B32—Solder Metal

au. ASTM A653-96—Spec for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

av. ASTM B209-93—Spec for Aluminum and Aluminum: Alloy Sheet and Plate

aw. ASTM B209-93—Spec for Aluminum and Aluminum: Alloy Sheet and Plate

ax. ASTM C790—Recommended Practices for Use of Latex Sealing Compounds

ay. ASTM C804—Recommended Practice for Use of Solvent-Release Type Sealants

az. ASTM C834—Latex Sealing Compounds

ba. ASTM C920—Elastomeric Sealants

bb. ASTM C1193—Standard Guide for Use of Joint Sealants

4. **Doors and Windows**

a. ANSI A224.1—Test Procedure and Acceptance Procedure for Prime Painted Steel Surfaces

b. ASTM A366—Steel Carbon, Cold-Rolled Sheet, Commercial Quality

c. ASTM A653—Spec for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

d. ASTM E152—Methods of Fire Tests of Door Assemblies

e. DHI (Door Hardware Institute)—The Installation of Commercial Steel Doors and Steel Frames, Insulated Steel Doors in Wood Frames and Builder's Hardware

f. SDI-100—Standard Steel Doors and Frames

g. SDI-105—Recommended Erection Instructions for Steel Frames

h. UBC 702 (1997)—Standard Methods of Testing Positive Pressure Fire Door Assemblies

i. UL 10B—Standard for Safety for Fire Tests of Door Assemblies

j. UL 10C—Standard for Positive Pressure Fire Tests of Door Assemblies

k. AWI—Quality Standards of Architectural Woodwork Institute

l. ITS (Warnock Hersey) —Certification Listings for Fire Doors

m. NFPA 80—Fire Doors and Windows

n. NFPA 252—Standard Methods of Fire Tests for Door Assemblies

o. FSC—Forest Stewardship Council guidelines for environmentally certified wood doors

p. ANSI A115 Series—American National Standards Institute: Door and Frame Preparation

q. ANSI A156 Series—American National Standards Institute: Specific hardware items

r. BHMA—Builder's Hardware Manufacturer's Association: Recommended Locations for Builder's Hardware

s. NFPA 80—National Fire Protection Association; Standard for Fire Doors and Windows

t. ANSI Z97.1—Safety Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings

u. ASTM C1036—Specification for Flat Glass

v. ASTM C1048—Specification for Heat Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated Glass

w. ASTM E773—Test Method for Seal Durability of Sealed Insulating Glass Units

x. ASTM E774—Specification for Sealed Insulating Glass Units

y. CPSC 16CFR-1201—Consumer Product Safety Commission, Safety Standard for Architectural Glazing Materials

z. FS DD-M-411—Mirrors, Plate Glass, Framed and Unframed

aa. Flat Glass Marketing Association (FGMA) Glazing Manual

ab. Insulated Glass Certification Council (IGCC)

5. **Finishes**

a. ASTM D2047—Static Coefficient of Friction of Polish-Coated Floor Surfaces

b. ASTM D16—Definitions of Terms Relating to Paint, Varnish, Lacquer, and Related Products

c. ASTM D4442—Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials

d. PDCA—Architectural Specifications Manual; Painting and Decorating Contractors of America

e. SSPC—Steel Structures Painting Manual; Steel Structures Painting Council

6. **Specialties (Toilet Accessories, Toilet Partitions)**

a. ASTM A167—Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

7. **Equipment**

a. ASTM A240—Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

b. ASTM A366—Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality

c. ASTM A167—Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

d. ASTM E84—Test Method for Surface Burning Characteristics of Building Materials

8. **Furnishings—None**

9. **Special Systems—None**

10. **Conveying Systems**
    a. ANSI/ASME A17.1—Elevators, Escalators, and Moving Walks
    b. NSI/ANSI/ASME A17.2—Inspectors' Manual for Elevators and Escalators
    c. AASME A17.3—Safety Code for Existing Elevators and Escalators
    d. ANSI A117.1—Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People
    e. ADAAG—Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities

E. Mechanical Regulatory and Directive Standards

1. **General Design References**
    a. AABC National Standards
    b. Air Conditioning and Refrigeration Institute (ARI) standards
    c. American Gas Association (AGA)
    d. American Society of Heating, Ventilating and Air Conditioning Engineers (ASHRAE) Handbook:
        - Applications
        - Equipment
        - Fundamentals
        - Systems and Equipment
    e. ASHRAE—A Practical Guide to Noise and Vibration Control for HVAC Systems, Schaffer, Mark E.
    f. ASHRAE Green Guide
    g. ASHRAE Humidification and Dehumidification Controls Strategies
    h. ASHRAE Humidity Control Design Guide for Commercial and Institutional Buildings
    i. ASHRAE HVAC Design Manual for Hospital and Clinics
    j. ASHRAE Standard 15, Safety Code for Mechanical Refrigeration
    k. ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality
    l. ASHRAE—Thermal Guidelines for Data Processing Environments

m. ASHRAE—The HVAC Commissioning Process

n. American Water Works Association (AWWA)

o. American Conference of Governmental Industrial Hygienists, latest edition of the Industrial Ventilation Guide

p. American Society of Plumbing Engineers (ASPE), Data Books

q. American Society of Sanitary Engineers (ASSE)

r. ASTM-E84—Fire Hazard Classifications

s. Cameron Hydraulic Data

t. Carrier Design Manual

u. “The Commissioning Design Intent Narrative,” Ronald J. Wilkinson, P.E.

v. Corrosion Control Handbook

w. CSA standards

x. Guidelines for Planning and Design of Biomedical Research Laboratories (published by ASHRAE)

y. Hydraulic Institute standards

z. Hydronic System Design and Operation, Erwin G. Hansen, New York: McGraw-Hill (1985)

aa. Manufacturer's Standardization Society (MSS) of the Valve & Fittings Industry

ab. MCAA(MSS) —Guideline for Quality Piping Installation

ac. MSS SP 58(MSS)—Pipe Hangers and Supports Materials, Design and Manufacture

ad. MSS SP 69—Pipe Hangers and Supports Selection and Application National Association of Plumbing/Heating/Cooling Contractors (PHCC)

ae. National Environmental Balancing Bureau (NEBB)

af. National Fire Protection Association (NFPA):

- 72—National Fire Alarm Code
- 90A—Installation of Air Conditioning and Ventilating Systems
- 90B—Installation of Warm Air Heating & Air-Conditioning Systems
- 92A—Recommended Practice for Smoke Control Systems

- 92B—Guide for Smoke Management Systems in Malls, Atria, and Large Areas
- 96—Ventilation Control and Fire Protection of Commercial Cooking Operations

ag. NCPWB, Welding Procedure Specifications

ah. Plumbing and Drainage Institute

ai. Roadmap for Integrating Sustainable Design into Site-Level Operations, US Department of Energy (March 2000)

aj. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) design guides

ak. Seismic Restraint Manual Guidelines for Mechanical Systems, 2nd edition SMACNA

al. Thermal Insulation Manufacturers Association (TIMA)

am. Trane Company:

- Air-to-Air Energy Recovery Manual
- Air Conditioning Manual
- Rooftop/VAV System Design Applications Manual
- Systems Design Manual
- Variable Air Volume Duct Design

an. "Understanding Owner Project Requirements Documentation (Design Intent)," Karl Stum, P.E., National Conference on Building Commissioning (2001)

ao. US Green Building Council, Leadership in Energy & Environmental Design

2. Basic Materials and Methods

a. ANSI Piping and Equipment Labeling Requirements

b. ANSI/UL 674—Electric Motors and Generators for Use in Division I Hazardous (Classified)

c. ASHRAE Standard C680—Standard Practice for Determining Heat Gain or Loss

d. ASME PTC 8.2 and 9

e. ASTM Standards for Thermal Insulation

f. ASTM C930—Classification of Potential Health and Safety Concerns Associated With Thermal Insulation Materials and Accessories

g. ASTM C1094—Standard Guide for Flexible, Removable Insulation Covers

h. ASTM E413—Classification for Rating Sound Insulation

i. CSA C22.2 No. 100-95—Motors and Generators

j. IEEE Standard 112 Method B

k. NEMA MG 10-2001—Energy Management Guide for Selection and Use of Fixed-Frequency Medium AC Squirrel-Cage Polyphase Industrial Motors

l. NEMA MG 11-1977—Energy Management Guide for Selection and Use of Single-Phase Motors

m. NEMA MG 1—Motors and Generators

n. NEMA Standard MG-1-12.53a

o. UL 1004—Electric Motors

p. Northeastern Specification Section 15930—Insulation Jackets

3. **Fire Protection Design References**

a. ANSI Elevator Code A17.1

b. ANSI B31.1—B31.9

c. NFPA Fire Prevention Handbook

d. NFPA 10—Portable Fire Extinguishers

e. NFPA 13—Installation of Sprinkler Systems

f. NFPA 14—Installation of Standpipe

g. NFPA 20—Installation of Centrifugal Fire Pumps

h. NFPA 24—Installation of Private Service Mains and Their Appurtenances

i. NFPA 25—Inspection, Testing and Maintenance of Water-Based Fire Protection Systems

j. NFPA 30—Flammable and Combustible Liquids Code

k. NFPA 45—Fire Protection for Laboratories Using Chemicals

l. NFPA 70—National Electric Code

m. NFPA 72D—Protective Signaling Systems

n. NFPA 72E—Automatic Fire Detectors

o. NFPA 75—Protection of Electronic Computer/Data Processing Equipment

p. NFPA 92A—Recommended Practice for Smoke Control Systems

q. NFPA 92B—Guide for Smoke Management Systems in Malls, Atria, and Large Areas

r. NFPA 96—Ventilation Control and Fire Protection of Commercial Cooking Operations

s. Northeastern Specification Section 15310—Fire Protection

4. **Piping**

a. ABMA, Boiler Water Limits and Steam Purity Recommendations for Water Tube Boilers

b. ACGIH Threshold Limit Values for Chemical Substances

c. ANSI/ASME B16.1—Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800

d. ANSI/ASME B16.24—Cast Copper Alloy Pipe Flanges and Flanged Fittings

e. ANSI/ASME B16.34—Valves-Flanged, Threaded, and Welding Ends

f. ANSI/ASME PTC 25—Pressure Relief Devices

g. ANSI/ASHRAE 41.2—Standard Methods for Laboratory Airflow Measurement

h. ANSI/ASHRAE 41.3—Standard Method for Pressure Measurement

i. ANSI/ASHRAE 41.1—Standard Method for Temperature Measurement

j. ANSI/ASHRAE 41.8—Standard Methods of Measurement of Flow of Liquids in Pipes Using Orifice Flowmeters

k. ANSI/Hydraulic Institute 8.1–8.5

l. API 6D—Specification for Pipeline Valves (Gate, Plug, Ball and Check)

m. API 598—Valve Inspection and Testing

n. ASHRAE—Legionellosis Position Paper (1998)

o. ASME PTC 19.5—Application of Fluid Meters

p. ASME MFC-10M—Method for Establishing Installation effects on Flowmeters

q. ASME Boiler and Pressure Code, Section VIII

r. ASME—Consensus on Operating Practices for the Control of Feedwater and Boiler Water Chemistry in Modern Industrial Boilers (1994)

s. ASME B31.1—Power Piping

t. ASME B31.5—Refrigeration Piping and Heat Transfer Components

u. ASME B31.9—Building Services Piping

v. ASSE/ASTM 6030

w. "The Analytical Control of Anticorrosion Water Treatment," W.F. Langelier, 1936

x. DOE—Non-Chemical Technologies for Scale and Hardness Control (1998)

y. Ingersoll-Rand Compressed Air and Gas Data Book

z. ISO 4126-1—Safety Valves, Part 1: General Requirements

aa. NFPA 99—Health Care Facilities

ab. Plumbing and Drainage Institute

5. **Plumbing Fixtures and Equipment**

a. ANSI/ASHRAE 18—Methods of Testing for Rating Drinking Water Coolers with Self Contained Mechanical Refrigeration Systems

b. ASME PTC 8.2 and 9

c. ANSI Z-358.1

d. ANSI/ASHRAE 118.1

e. ANSI/UL 399—Drinking Water Coolers

f. ARI-1010—Self Contained, Mechanically Refrigerated Drinking Water Coolers

g. American Society of Sanitary Engineers

h. ASSE 1016

i. ASSE 1017

j. CAN/CSA-C22.2 No. 110-94

k. NSF/ANSI 5

l. NSF/ANSI 61—Drinking Water System Components Health Effects
m. UL Motor-Operated Water Pumps Standard
n. UL 795
o. UL 1453

6. **Heat Generation Equipment**
   a. ABMA—Packaged Boiler Engineering Manual
   b. ABMA—Boiler Water Limits and Achievable Steam Purity for Watertube Boilers
   c. ABMA—Boiler Water Requirements and Associated Steam Purity—Commercial Boilers
   d. ABMA—Operation and Maintenance Safety Manual
   e. ABMA— (Selected) Codes and Standards of the Boiler Industry
   f. ABMA—Combustion Control Guidelines
   g. ABMA—Utility and Boiler Terms and Phrases
   h. ACCA Manual CS—Commercial Applications Systems and Equipment, 1st ed.
   i. ASME—Boiler and Pressure Vessel Code
   j. ASME CSD-1—Control and Safety Devices for Automatically Fired Boilers
   k. ANSI/UL 343—Pumps for Oil-Burning Appliances
   l. ANSI Z21.13/CSA 4.9—Gas-Fired, Low-Pressure Steam and Hot Water Boilers
   m. ANSI/NFPA 8501—Single Burner Boiler Operations
   n. ANSI/NFPA 8502—Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers
   o. ANSI/UL 834—Heating, Water Supply, and Power Boilers—Electric
   p. CSA ANSI Z83.3—Gas Utilization Equipment in Large Boilers
   q. CSA CAN 1-3—Industrial and Commercial Gas-Fired Package Boilers
   r. CSA B-51—Boiler, Pressure Vessel, and Pressure Piping Code
   s. CSA B 140.7.2—Oil-Fired Steam and Hot-Water Boilers for Commercial and Industrial Use

t. Hydronics Institute IBR—Testing and Rating Standard for Heating Boilers
u. UL 726—Oil-Fired Boiler Assemblies (1995)
v. UL 795—Commercial/Industrial Gas Heating Equipment (1999)

7. **Refrigeration Equipment**

a. AABC National Standards—Cooling Tower Testing
b. ACGIH—Bioaerosols: Assessment and Control
c. ACGIH—Threshold Limit Values for Chemical Substances
d. ACCA Manual CS—Commercial Applications, Systems, and Equipment, 1st ed.
e. ANSI/AHAM DH-1—Dehumidifiers
f. ANSI/ASHRAE 15—Safety Standard for Refrigeration Systems
g. ANSI/ASHRAE 30—Method of Testing Liquid-Chilling Packages
h. ANSI/ASHRAE 34—Designation and Safety Classification of Refrigerants
i. ANSI/UL 474—Dehumidifiers
j. CSA C22.2 No 92-1971—Dehumidifiers
k. ARI 365-94—Commercial and Industrial Unitary Air-Conditioning Condensing Units
l. ARI 410—Forced Circulation Air Cooling and Air Heating Coils
m. ARI-440—Room Fan Coils and Unit Ventilators
n. ARI 450—Water-Cooled Refrigerant Condensers, Remote Type
o. ARI 460—Remote Mechanical-Draft, Air-Cooled Refrigerant Condensers
p. ARI 560—Absorption Water-Chilling and Water-Heating Packages
q. ARI 550—Centrifugal and Rotary Screw Water-Chilling Packages
r. ARI 590—Positive-Displacement Compressor Water-Chilling Packages
s. ASHRAE Guideline 3—Reducing Emission of Halogenated Refrigerants in Refrigeration and Air Conditioning Equipment and Systems
t. ASME PTC 23—Atmospheric Water Cooling Equipment
u. CSA C743—Performance Standard for Rating Packaged Water Chillers

v. CTI ATC-128—Code for Measurement of Sound from Water Cooling Towers

w. CTI PFM-143—Recommended Practice for Airflow Testing of Cooling Towers

x. CTI STD-201—Certification Standard for Commercial Water Cooling Towers

y. ISO 6718—Bursting Discs and Bursting Disc Devices

z. NFPA 214—Water-Cooling Towers

aa. UL 1995/C22.2 No. 236-95—Heating and Cooling Equipment

ab. UL 2182—Refrigerants

8. **HVAC Equipment**

a. ACCA Manual CS—Commercial Applications Systems and Equipment, 1st ed.

b. ACCA Manual RS—Comfort, Air Quality, and Efficiency by Design

c. ANSI/ASHRAE 62—Ventilation for Acceptable Indoor Air Quality

d. ACCA Manual CS—Commercial Applications, Systems and Equipment, 1st ed.

e. ACGIH—Bioaerosols: Assessment and Control

f. ACGIH—Threshold Limit Values for Chemical Substances

g. ANSI/ARI 430—Central Station Air Handling Units

h. ASHRAE—A Practical Guide to Noise and Vibration Control for HVAC Systems," Schaffer, Mark E. (1992)

i. ANSI/ARI 640—Commercial and Industrial Humidifiers

j. ANSI/ASHRAE 127-2001—Method of Rating Computer and Data Processing Room Unitary Air Conditioners

k. ASME BPVC-2001—Boiler and Pressure Code, Section VIII, Division 1: Pressure Vessels

l. ARI Compliance for Units with Capacities Less Than 135,000 Btuh (39.6 kW): ARI 210/240, Commercial and Industrial Unitary Air-Conditioning and Air-Source Heat Pump Equipment

m. ARI Guideline B for Rooftop Unit Mounting

n. ARI 410—Forced Circulation Air Cooling and Air Heating Coils

o. CAN/CSA-C273.3-M91—Performance Standard for Split System Central Air Conditioners and Heat Pumps

p. Hydronic Institute IBR—Testing and Rating Standard for Baseboard Radiation, 6th ed.

q. Hydronic Institute IBR—Testing and Rating Standard for Finned-Tube (Commercial) Radiation

r. NRCA Low-Slope Membrane Roofing Construction Details Manual, Illustration—Raised Curb Detail for Rooftop Air Handling Units and Ducts

s. Sound Power Level Ratings: Comply with ARI 270, Sound Rating of Outdoor Unitary Equipment

t. TEMA—Standards of Tubular Exchanger Manufacturers Association, 8th ed. (1999)

u. UL/CSA 998/C22.2 No. 104—Humidifiers (2001)

v. UL/CSA 1995/C22.2 No. 236—Heating and Cooling Equipment

9. Air Distribution

a. ACCA Manual Q—Commercial Low Pressure, Low Velocity Duct System Design, 1st ed.

b. ACCA Manual Q—Pressure, Low Velocity Duct System Design, 1st ed.

c. ACGIH—Industrial Ventilation: A Manual of Recommended Practice, 24th ed.

d. ACGIH—Selection of Air Filtration Equipment

e. ADC-91—Flexible Duct Performance and Installation Standards, 3rd ed.

f. AMCA 99—Standards Handbook

g. AMCA 201—Fans and Systems

h. AMCA 211—Certified Ratings Program: Air Performance

i. AMCA-410—Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

j. AMCA-2404—Drive Arrangements for Centrifugal Fans

k. AMCA-2407—Motor Positions for Belt or Chain Drive Centrifugal Fans

l. AMCA-2406—Designation of Rotation and Discharge of Centrifugal Fans

m. AMCA-2410—Drive Arrangements for Tubular Centrifugal Fans
n. ANSI S12.11—Methods for the Measurement of Noise Emitted by Small Air-Moving Devices
o. ANSI/AMCA 210
p. ANSI/AMCA 330
q. ANSI/ASHRAE 51—Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
r. ANSI/ASHRAE 52.1—Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
s. ANSI/ASHRAE 52.2—Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
t. ANSI/ASHRAE 68—Laboratory Method of Testing to Determine the Sound Power in a Duct
u. ANSI/ASHRAE 70—Method of Testing for Rating the Performance of Air Outlets and Inlets
v. ANSI/ASHRAE 113—Method of Testing for Room Air Diffusion
w. ANSI/ASHRAE 120—Method of Testing to Determine Flow Resistance in HVAC Ducts and Fittings
x. ANSI/AWS D9.1-2000—Sheet Metal Welding Code
y. ANSI/UL 705—Power Ventilators
z. ANSI/UL 900—Air Filter Units
aa. ARI 670—Fans and Blowers
ab. ARI 850-93—Commercial and Industrial Air Filter Equipment
ac. ARI 880—Air Terminals
ad. ARI-885—Procedure for Estimating Occupied Sound Levels in the Application of Air Terminals and Air Outlets
ae. ASC-A-7001A—Adhesives Standard for Duct Liner Adhesive & Sealant
af. ASHRAE—A Practical Guide to Noise and Vibration Control for HVAC Systems, Schaffer, Mark E.
ag. ASHRAE Standard 129 Schaffer Measuring Air Change Effectiveness

ah. ASME PTC 11 Schaffer Fans

ai. ASHRAE 51-1999 Schaffer Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

aj. ASHRAE 52-1999 Schaffer Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ak. ASTM F1471 Schaffer Test Method for Air-Cleaning Performance of a High-Efficiency Particulate Air Filter System

al. CSA C22.2 No. 113-M Schaffer Fans and Ventilators

am. Industrial Ventilation: A Manual of Recommended Practice, 24th ed. (2001)

an. SMACNA 2002—Accepted Industry Practices for Sheet Metal Lagging, 1st ed.

ao. SMACNA—HVAC Air Duct Leakage Test Manual

ap. SMACNA—HVAC Duct Construction Standards, Metal and Flexible

aq. SMACNA—Rectangular Industrial Duct Construction Standards

ar. SMACNA—Duct Design

as. SMACNA—Round Industrial Duct Construction Standards

at. SMACNA—Duct Liner Applications

au. SMACNA—Mechanical Fasteners Standard

av. SMACNA—HVAC Air Duct Leakage Test Manual, 1st ed. aw.SMACNA—

HVAC Duct Systems Inspection Guide, 2nd ed.

ax. SMACNA—Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th ed.

ay. UL 181—Factory-Made Air Ducts and Air Connectors

az. UL 181A—Closure Systems for Use with Rigid Air Ducts and Air Connectors

ba. UL 181B—Closure Systems for Use with Flexible Air Ducts and Air Connectors

bb. UL 507—Electric Fans (1999)

bc. UL 555C—Ceiling Dampers

bd. UL 555S—Smoke Dampers

be. UL 585—High-Efficiency, Particulate, Air Filter Units bf. UL 710—Exhaust Hoods for Commercial Cooking Equipment

bg. UL1046—Grease Filters for Exhaust Ducts

10. **HVAC Instrumentation and Controls**

a. AABC National Standards, Chapter 12—Temperature Control Systems

b. AMBA—Guideline for the Integration of Boilers and Automated Control Systems in Heating Applications

c. ANSI/ASHRAE 111—Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems

d. ANSI/ASHRAE 114-1986—Energy Management Control Systems Instrumentation

e. ANSI/Hydraulic Institute 1.6—Centrifugal Pump Test

f. ARI Guideline G—Mechanical Balance of Fans and Blowers

g. Buildings Controls Group of the UK—Control Sensor Installation website

h. Hydraulic Institute 9.1-9.6—Pumps: General Guidelines (including Measurement of Airborne Sound)

i. Johnson Controls—Metasys Design Manual

j. NEBB—Procedural Standards for Certified Testing of Cleanrooms, 2nd ed.

k. NEBB—Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 6th ed.

l. NEBB—Procedural Standards for Building Systems Commissioning, 1st ed. (1993)

m. SMACNA—HVAC Systems Testing, Adjusting and Balancing, 3rd ed.

F. Electrical Regulatory and Directive Standards

1. **General Design References**

a. ASHRAE 90.1—Energy-Efficient Design of New Buildings Except Low-Rise Residential Buildings

b. ANSI/IEEE C2-1993—National Electrical Safety Code

c. ANSI/IEEE 141-1986—Electric Power Distribution for Industrial Plants

(Red Book)

d. ANSI/IEEE 142-1991—Grounding of Industrial and Commercial Power Systems (Green Book)

e. ANSI/IEEE 241-1990—Electric Power Systems in Commercial Buildings (Gray Book)

f. ANSI/IEEE 242-1986—Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)

g. ANSI/IEEE 399-1990—Industrial and Commercial Power Systems Analysis (Brown Book)

h. ANSI/IEEE 493-1990—Design of Reliable Industrial and Commercial Power Systems (Gold Book)

i. ANSI/IEEE 602-1986—Electric Systems in Health Care Facilities (White Book)

j. ANSI/IEEE 739-1984—Energy Conservation and Cost-Effective Planning in Industrial Facilities (Bronze Book)

k. ANSI 117.1—Providing Accessibility and Usability for Physically Handicapped People

l. ANSI Z117.1—Safety Requirements for Confined Spaces

m. ANSI/IEEE 100-1988—Standard Dictionary of Electrical and Electronics Terms

n. ANSI/IEEE 519-1992—Harmonic Control in Electrical Systems

o. ANSI/IEEE 693-1984—Seismic Design of Substations

p. ANSI/IEEE 946-1992—DC Auxiliary Power Systems for Generating Stations

q. ANSI/IEEE 979-1984—Substation Fire Protection

r. ANSI/IEEE 980-1987—Containment and Control of Oil Spills in Substations

s. ANSI/IEEE 1001-1988—Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems

t. ARI Guideline G—Mechanical Balance of Fans and Blowers

u. ETL Directory (1987)

v. IEEE 666-1991—Electric Power Service Systems for Generating Stations

w. IEEE 1109-1990—Interconnection of User-Owned Substations to Electric Utilities

x. IEEE 1127-1990—Design, Construction, and Operation of Safe and Reliable Substations for Environmental Acceptance

y. Lineman's and Cableman's Handbook, 5th ed. (Bradley)

z. National Electrical Safety Code Handbook

aa. Switchgear and Control Handbook (Bradley)

ab. UL Directories:

- Electrical Appliance and Utilization Equipment (1990)
- Electrical Construction Materials (1990)
- Fire Protection Equipment (1990)
- Hazardous Location Equipment (1990)

ac. United Illuminating Company:

- Company Energy Blueprint Program
- Company Energy Opportunities Program
- Electric Service Guidelines
- Engineering and Construction Standards
- Electric Service Guidelines (1992)

2. Power and Distribution

a. Robert Shaw Controls—Electronics Products Master Catalog

b. ICEA S-19-81—Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

c. ICEA S-61-402—Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

d. NEMA OS1—Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports

e. NEMA RN1—Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing

f. NEMA TC2—Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

g. NEMA TC3—PVC Fittings for Use with Rigid PVC Conduit and Tubing

h. NEMA WD1—General-Purpose Wiring Devices

i. NEMA WD2—Semiconductor Dimmers for Incandescent Lamps

j. NEMA WD5—Specific-Purpose Wiring Devices

k. Underwriters Laboratories (UL):
   - 1—Flexible Metal Electrical Conduit
   - 5—Surface Metal Electrical Raceways and Fittings
   - 6—Rigid Metal Electrical Conduit
   - 20—General-Use Snap Switches
   - 50—Electrical Cabinets and Boxes
   - 62—Flexible Cord and Fixture Wire
   - 83—Thermoplastic-Insulated Wires and Cables
   - 310—Electric Quick-Connect Terminals
   - 360—Liquid-Tight Flexible Steel Conduit, Electrical
   - 486A—Wire Connectors and Soldering Lugs for Use with Copper Conductors
   - 486C—Splicing Wire Connectors
   - 486E—Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
   - 498—Electrical Attachment Plugs and Receptacles
   - 508—Electric Industrial Control Equipment
   - 510—Insulating Tape
   - 514A—Metallic Outlet Boxes, Electrical
   - 514B—Fittings for Conduit and Outlet Boxes
   - 651—Schedule 40 and 80 Rigid PVC Conduit
   - 651A—Type EB and A Rigid PVC Conduit and HDPE Conduit
   - 773A—Non-Industrial Photoelectric Switches for Lighting Control
   - 797—Electrical Metallic Tubing
   - 870—Electrical Wireways, Auxiliary Gutters, and Associated Fittings
   - 886—Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations

- 943—Ground-Fault Circuit Interrupters
- 1059—Electrical Terminal Blocks
- 1242—Intermediate Metal Conduit
- 1449—Transient Voltage Surge Suppressors

3. **Transmission and Distribution**
   a. ANSI C84.1—Voltage Ratings for Electric Power Systems and Equipment
   b. IEEE 739—Energy Conservation and Cost-Effective Planning in Industrial Facilities (Bronze Book)
   c. IEEE 980—Containment and Control of Oil Spills in Substations
   d. IEEE S-135—Power Cable Ampacities
   e. NEMA TC3 and TC6—PVC Conduit and Tubing
   f. ANSI/NEMA 70—National Electric Code
   g. ICEA/NEMA S-61-402/WC 5, S-66-524/WC, and S-68-516/WC 8—600 Volt or Less Conductors
   h. UL 44 and 83—600 Volt or Less Conductors
   i. ANSI/NEMA FB1—Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   j. NFPA 70—National Electrical Code
   k. NECA 5055—Standard of Installation

4. **Low-Voltage Distribution**
   a. IEEE 446—Emergency and Standby Power Systems for Industrial and Commercial Applications (Orange Book)
   b. NEMA:
      - AB1—Molded Case Circuit Breakers
      - BU1—Busways
      - FU1—Low-Voltage Cartridge Fuses
      - ICS 1—General Standards for Industrial Control and Systems
      - ICS 2—Industrial Control Devices, Controllers, and Assemblies
      - ICS 3—Industrial Systems

- KS1—Enclosed Switches
- PB1—Panelboards
- SG3—Low-Voltage Power Circuit Breakers
- ST20—Dry-Type Transformers, for General Applications
- TR27—Commercial, Institutional, and Industrial Dry-Type Transformers

c. Underwriters Laboratories (UL):

- 50—Electrical Cabinets and Boxes
- 67—Electric Panelboards
- 98—Enclosed Switches
- 198C—High-Interrupting-Capacity Fuses, Current-Limiting Types
- 198E—Class R Fuses
- 489—Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
- 506—Specialty Transformers
- 508—Electric Industrial Control Equipment
- 845—Electric Motor Control Centers
- 857—Busways and Associated Fittings
- 943—Ground-Fault Circuit Interrupters
- 1008—Automatic Transfer Switches
- 1561—Large General Purpose Transformers

5. **Lighting**

a. IES Lighting Handbook

b. ANSI C78.1 (with supplements)—Dimensional and Electrical Characteristics of Fluorescent Lamps, Rapid Start Types

c. ANSI C78.2 (with supplements)—Dimensional and Electrical Characteristics of Fluorescent Lamps, Preheat Start Types

d. ANSI C78.20—Characteristics of Incandescent Lamps of A, G, PS, and Similar Shapes with E26 Medium Screw Bases

e. ANSI C78.21—Characteristics of Incandescent Lamps of PAR and R Shapes

f. ANSI C78.1350 through C78.1359—High-Pressure Sodium Lamps

g. ANSI C78.1375 through C78.1381—Metal Halide Lamps

h. ANSI C82.1—Specifications for Fluorescent Lamp Ballasts
i. ANSI C82.2—Methods of Measurement of Fluorescent Lamp Ballasts
j. ANSI C82.3, Specifications for Fluorescent Lamp Reference Ballasts
k. ANSI C82.4 (with supplement) —Specifications for High-Intensity-Discharge and Low-Pressure Sodium Lamp Ballasts (Multiple-Supply Type)
l. ANSI C82.5 (with supplement)—Specification for High-Intensity Discharge Lamp Reference Ballasts
m. ANSI C82.6 (with supplement)—Methods of Measurement of High-Intensity Discharge Lamp Ballasts
n. NEMA FA1—Outdoor Floodlighting Equipment
o. NEMA LE1—Fluorescent Luminaires
p. UL 924—Emergency Lighting and Power Equipment
q. UL 935—Fluorescent-Lamp Ballasts
r. UL 1029—High-Intensity-Discharge-Lamp Ballasts
s. UL 1570—Fluorescent Lighting Fixtures
t. UL 1571—Incandescent Lighting Fixtures
u. UL 1572—High Intensity Discharge Lighting Fixtures

-END-

Project Execution and Closeout

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

Please contact the Northeastern University Department of Facilities Contract Administrator about project execution and closeout requirements.

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Warranty Procedures

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Time of Submittal

This section includes administrative and procedural requirements for preparing and submitting operation and maintenance manuals.

B. Partial Occupancy

Submit properly executed warranties within 21 days of completion of designated portions of the work completed and occupied or used by Owner during construction period by separate agreement with the contractor.

C. Submitting Procedure

Organize warranty documents into an orderly sequence based on the table of contents of the project manual.

1. Bind warranties and bonds in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of installer.
3. Identify each binder on the front and spine with the typed or printed title “WARRANTIES,” project name, and name of contractor.
4. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at the beginning of each document.

5. Provide additional copies of each warranty to include in operation and maintenance manuals specified under Section 01782: “Operation and Maintenance Data”

-END-

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Operation and Maintenance Data

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section includes administrative and procedural requirements for preparing and submitting operation and maintenance manuals.

B. Definitions

1. System—an organized collection of parts, equipment, or subsystems united by regular interaction.
2. Subsystem—a portion of a system with characteristics similar to a system.

C. Submittals

Submit operation and maintenance documentation in accordance with the following requirements.

1. Submittal Schedule

Submit three hard copies and three soft copies of each O&M manual in final form at least 15 days before final inspection. O&M documentation is required within 30 days after occupation of the building by Northeastern University. Retainage shall not be released until receipt of O&M manuals and final lien waivers are delivered to Northeastern University.

2. Coordination

Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, assemble and coordinate information furnished by the representatives, and prepare the manuals.

3. Binding

a. Bind each manual in a loose-leaf, three-ring binder of the following size and quality:

- Ring size (thickness): as necessary to accommodate the contents
- Dimensions: 8-1/2" x 11"
- Covering: vinyl
- Quality: heavy-duty, commercial-quality

b. The binder must include pockets inside the front and back covers to hold folded sheets.

c. The binder must include clear plastic sleeves on the front cover and spine to hold a cover sheet and label containing the following information:
   - Title: Operation and Maintenance Manual
   - Project name
   - System, subsystem, or equipment name
   - Volume number (as appropriate)

d. If necessary, separate the contents of the manual into two or more volumes to accommodate the data. Group the information in each volume by subsystem and related components. Provide appropriate cross-references to information contained in other volumes.

e. Provide heavy, paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate its contents. Include a description of the section contents on the front of each divider.

f. Use the manufacturer's standard printed material. If unavailable, print the required content on 8-1/2" x 11", 20 lb/sq ft, white bond paper.

g. Attach reinforced, punched binder tabs on drawings and bind them with the text. Fold oversize drawings to the same size as the text pages for use as fold-outs. If a drawing is too large for a fold-out, fold it neatly and place it in the front or back pocket of the binder. Insert a page at the appropriate place in the manual containing the drawing title, a description of the drawing, and its location (front or back pocket).

h. Place diagnostic software CDs for computerized electronic equipment inside protective, transparent, plastic sleeves.

D. Operation and Maintenance Documentation Directory

Provide an operation and maintenance documentation directory that includes the following elements.

1. **Organization**

   Include a section in the directory for each of the following:
   - List of documents
   - List of systems
   - List of equipment
   - Table of contents

2. **List of Systems and Subsystems**

   List systems alphabetically. Include references to O&M manuals that contain information about each system.

3. **List of Equipment**

   List equipment for each system, organized alphabetically by system. List pieces of equipment not part of a system alphabetically in separate list.

4. **Tables of Contents**

   Include a table of contents for each O&M manual.

5. **Identification**

   In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with the same designation used in the contract documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

E. O&M Manual Organization

Organize each manual into separate sections for each piece of related equipment. As a minimum, each manual must contain a title page; a table of contents; copies of product data supplemented by drawings and written text; and copies of each warranty, bond, and service contract issued.

1. **Title Page**

   Provide a title page in a transparent, plastic envelope as the first sheet of each manual. The title sheet must contain the following information.
   - Subject matter covered in the manual
   - Name and address of the project

- Date of submittal
- Name, address, and telephone number of the contractor
- Name and address of the architect/engineer

2. **Contractor List**

Provide contact information for the following project personnel:

- General Contractor
- Sub-contractors
- Primary Vendors
- Primary Suppliers

The contact information should include the following information.

- Company name
- Address
- Phone number
- Name and phone number for main contact person for project
- Company web address/URL

3. **Table of Contents**

Provide a table of contents for each volume, after the title page.

4. **General Information**

Provide a general information section immediately following the table of contents. List each product included in the manual, identified by product name. Under each product, list the name, address, and telephone number of the subcontractor or installer and the maintenance contractor. Clearly delineate the extent of their responsibility for the product. Include a local source for replacement parts and equipment.

5. **Product Data/Systems and Equipment**

Where the manuals include the manufacturer's standard printed data, include only sheets that are pertinent to the part or product installed. Mark each sheet to identify each part or product included in the installation. Where the project includes more than one item in a tabular format, identify each item, using appropriate references from the contract documents. Identify data that is applicable to the installation, and delete references to information that is not applicable. Provide the following information for each piece of equipment, each building operating system, and each electric or electronic system.

a. *Description*

Provide a complete description of each unit and related component parts, including:

- Name of manufacturer, model number, serial number, and equipment tag number
- General description of system or equipment function and its purpose
- Operating characteristics
- Limiting conditions
- Performance curves
- Engineering data and tests
- Complete nomenclature and number of replacement parts
- Design factors and assumptions

b. *Manufacturers' Information*

Provide the following information for each manufacturer of a component part or piece of equipment.

- Printed operation and maintenance instructions
- Assembly drawings, wiring diagrams, and diagrams required for maintenance
- List of items recommended to be stocked as spare parts
- Shop drawings, engineering data, and product data
- Warranty data and copies of warranties

c. *Maintenance Procedures*

Provide essential maintenance procedures, including:

- Routine operating procedures
- Troubleshooting procedures
- Calibration procedures
- Disassembly, repair, and reassembly procedures
- Alignment, adjusting, and checking procedures
- Inspection and testing procedures

d. *Operating Procedures*

Provide equipment and system operating procedures, including:

- Testing procedures
- Startup procedures
- Equipment or system break-in procedures
- Routine and normal operating procedures
- Regulation and control procedures
- Stopping procedures
- Shutdown and emergency procedures
- Summer and winter operating procedures
- Special operating procedures
- Required sequences for electric or electronic systems
- Precautions against improper use

e. *Servicing Schedule*

Provide a schedule of routine preventative maintenance and lubrication requirements, including a list of required lubricants for equipment with moving parts.

f. *Controls*

Provide a description of the sequence of operation and as-installed control diagrams by the control manufacturer for systems requiring controls. Refer to the requirements in specification section 15950, Energy Management and Controls System, and section 15960, Laboratory Airflow Control System.

g. *Coordination Drawings*

Provide each contractor’s coordination drawings.

(1) Provide as-installed, color-coded, piping diagrams, where required for identification.

(2) Provide charts of valve-tag numbers, with the location and function of each valve.

h. *Circuit Directories*

(1) Provide complete panel-board circuit directories for electric and electronic systems, including:

- Electric service

- Controls
- Communication

(2) Refer to the requirements in specification section 15950, Energy Management and Controls System, and section 15960, Laboratory Airflow Control System.

F. Special Control System O&M Manuals

See the content requirement in specification section 15950, Energy Management and Controls System, and section 15960, Laboratory Airflow Control System.

G. Product Safety/Data Manual

Provide three copies of a manual containing product safety/data sheets for all project products, arranged in accordance with CSI MasterFormat®

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01810

General Commissioning

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

1. When required by Northeastern University, follow the commissioning procedures contained in this section. For limited project scope, commissioning may be selectively applied by the University.
2. This section contains general requirements for commissioning building systems, subsystems, and equipment to ensure reliable, safe, and secure operation. The commissioning process verifies that systems are complete and functioning properly upon project completion and that the Northeastern University staff has received appropriate system documentation and training.
3. As part of the commissioning process, Northeastern University may choose to follow the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Program requirements, which require fundamental building systems commissioning, as well as additional commissioning. For further information related to Northeastern University's sustainable design guidelines, see Section 01352: Sustainable Design Requirements

B. System Design and Performance Requirements

1. Commissioning is a quality-focused process for enhancing the delivery of a project. Commissioning helps the project team to understand project goals and take logical steps along the way to ensure and document that those goals are met.
2. Northeastern University commissioning is a quality-focused process that targets:
   - Documentation
   - Testing
   - Training
3. Through documentation, commissioning ensures acceptance that all building or facility systems perform interactively. This interactive performance must be in

accordance with Northeastern University's design intent, the designer's documentation, and Northeastern University's operational needs for documentation and operating personnel training.

4. Commissioning may be performed by the design engineer, Northeastern University personnel, or a third-party commissioning consultant. For complex projects, Northeastern University prefers a third-party consultant contracted directly to the University.

5. The level of commissioning required will be determined by Northeastern University Energy and Sustainability Group during the design and development process. Each project will be assigned a level of commissioning required.

C. Extent of Commissioning

1. Ideally, commissioning activities begin during the design phase of the project and proceed through the warranty period. The four phases of commissioning at Northeastern University are design, construction, acceptance, and warranty.

2. Each project requires a customized approach. The Northeastern University project team develops a project-specific list of systems to be commissioned. Building systems that affect life safety, energy consumption, water usage, and indoor environmental quality should generally be commissioned. Table 1 lists general, mechanical, and electrical systems that are representative of systems that may be commissioned to verify full conformance with Northeastern University's project requirements and design intent.

Table 1. Representative Systems, Subsystems, and Equipment

General Systems Commissioning
• Mechanical room floor over critical spaces • Building thermal and moisture envelope • Equipment • Doors and windows • Life safety and personnel egress systems • Conveying systems (functional testing oversight by Northeastern University fire marshal and elevator consultant) • Telecommunications systems

Table 1. Representative Systems, Subsystems, and Equipment—Continued

Mechanical Systems Commissioning
• Chilled and condenser water systems • Process chilled water system • Utility metering (chilled water and condensate) • Air handling units, including glycol preheat/heat recovery systems • Humidification system • Exhaust air handling units • Fans—exhaust, return, and transfer • Terminal units, including VAV boxes, CV boxes, reheat coils, unit heaters, FCUs, baseboard radiation, and radiant panels • Heating hot water system • Steam system, including PRVs and condensate system • Building automation system • Laboratory air control sequences, including fume hood controls • Room pressurization • Plumbing system • RO/DI system • Lab Specialty Gases and Piping Systems • Vacuum systems • Lab neutralization system • Lab waste duplex lift station • Compressed air system • Domestic hot water heaters and pumps • Grey water system • Sanitary lift station • Backflow preventers • Fire protection/fire pumps

Table 1. Representative Systems, Subsystems, and Equipment—Continued

Electrical Systems Commissioning
• Building main electrical service switchgear, switchboard, or substation • Major switchboard with breakers rated 200 A or higher • Normal power double-ended substations • Outdoor, liquid type, pad-mounted transformers • Alternate power switchgear • Lighting control systems • Automatic transfer switches • Major switchboards or panelboards following ATS • Emergency power system MCC • Normal power outage simulation tests • Emergency switchgear or switchboard • Emergency panels, including emergency power outlets • Emergency lighting, exit sign and lighting control (testing oversight by the Northeastern University fire marshal) • Fire alarm system (tests are performed by Northeastern University personnel) • Security system (tests are performed by Northeastern University personnel)

D. General Commissioning Activities

The rest of this section provides supplementary information about the four phases of commissioning (design, construction, acceptance, and warranty) shown on the Northeastern University Commissioning Process flow chart. The general commissioning activities described in this paragraph apply to two or more phases of the Northeastern University commissioning process. These activities are not described again in the subsequent paragraphs associated with commissioning activities specific to each phase. The Northeastern University project manager determines which commissioning activities are required on a project-by-project basis.

1. Commissioning Scheduling Activities and Regular Reviews

a. Immediately following the commissioning kickoff meeting, the commissioning authority, in concert with the Northeastern University project manager, establishes regularly scheduled commissioning coordination meetings. The purpose of these meetings, in coordination with construction meetings, is to establish lines of communication, determine the routing of submittals and documents, facilitate maintenance of the schedule, and provide a forum for discussion of action items. Regular reviews are conducted throughout the project during construction team status meetings or commissioning coordination meetings.

b. The commissioning authority lends their expertise with respect to timing and duration of the various commissioning tasks and works with the construction manager to incorporate commissioning into the master schedule. The commissioning authority reviews the schedule periodically for information regarding progress for upcoming activities, submissions, and any issues that might impact the successful and timely completion of commissioning.

2. **Commissioning Action Item List**

The commissioning authority tracks scheduled commissioning-related issues and functional performance testing. The commissioning authority also develops and maintains an action item list and submits it to the commissioning team on a regular basis for information and appropriate responses.

3. **Change Order Reviews and other Construction Phase Documentation**

During the construction and acceptance periods, the commissioning authority reviews change orders, requests for information, supplemental instructions, and meeting minutes for equipment and/or systems that are to be commissioned. The commissioning authority reviews the documents for issues or directives that could impact a system's ability to comply with the design intent. In addition, the commissioning authority reviews maintainability issues and incorporates designer-approved changes into the system readiness checklists and final functional test procedures.

4. **Construction Team Status Meetings**

a. The commissioning authority attends the construction team status meetings periodically to obtain information on construction progress. These meetings are typically facilitated by the construction manager.

b. The commissioning authority and Northeastern University determine the number of meetings to be conducted and attended.

5. **Design Intent Document Update**

Due to the evolving nature of all design and construction projects, the design intent document is modified during the design process if budgeting and scheduling decisions necessitate a change in expected system performance. At that time, Northeastern University and the designers discuss and document an owner-approved change to the design intent document.

6. Commissioning Record Book Maintenance

The commissioning authority maintains a record of commissioning activities throughout the design, construction, and acceptance testing and training periods. Recorded information and issues aid in creating and tracking the documentation to be included in the commissioning report.

E. Design Phase Commissioning

1. Discovery Phase

Design phase commissioning involves completing a project-specific commissioning plan. Questions that must be asked of Northeastern University include:

- As a cost-saving measure, can the facility's operations and maintenance staff undertake some of the process management tasks, training oversight, or other activities, with the commissioning authority acting as a "coach"?
- Will the systems testing strategy be to test all systems or conduct random sampling?
- Will contractors be penalized for failed tests?
- What are the final deliverables?

2. Commissioning Plan

1. The commissioning plan defines the commissioning process and identifies the commissioning activities for a specific project. Among other things, the plan outlines the organization's structure, the allocation of resources, and the documentation requirements of the commissioning process. The plan also identifies the project phases and lists the commissioning team members, their commissioning-related responsibilities during each phase, and the expected deliverables from each team member.
2. The commissioning authority prepares the plan at the beginning of their involvement in the project—ideally during conceptual or schematic design—and develops it in greater detail as the project progresses through its various phases. The plan is strictly a process-roadmap for commissioning activities and does not include such items as detailed checklists, test procedures, and forms,

which are identified and developed during the commissioning activities defined in the plan.

3. See the sample Commissioning Plan.

3. Design Phase Commissioning Kickoff Meeting

The design phase commissioning kickoff meeting is an opportunity for the commissioning authority and Northeastern University to present the commissioning plan to the entire design phase project team (Northeastern University project manager, designers, O&M staff, construction manager, and other special consultants). During the meeting, project team members are given an overview of the commissioning process and informed of their roles and responsibilities, the purpose of the design intent document, future maintenance provisions, and design review protocols. Although the project team continues to learn about commissioning throughout the entire project, the overview serves to broaden their perspective and explains the benefits of participating in the commissioning process.

4. Design Intent Document

a. The design intent document describes Northeastern University's project requirements and identifies system performance goals in quantitative and verifiable terms. In addition, the document includes the university's vision for the facility, the facility's functional requirements, and the university's expectations regarding the facility's design, use, and operation.

b. The purpose of the design intent document is to focus all project activities on achieving the desired outcome. It also serves as the reference for evaluating success and quality in all phases of the project and becomes the benchmark for system maintenance and repair/replacement decisions. In addition, the design intent document serves as the basis for preparing system design narratives and design documents that contain the calculations, rationale, and assumptions necessary to achieve the design intent.

c. The Northeastern University project manager requests the design intent document from the design professional. The designer—in consultation with Northeastern University, and with input from facility users and operators—prepares the design intent document, based on an understanding of the project requirements. The commissioning authority reviews and approves the document.

d. The design intent document is updated periodically during the design and construction phases of the project to reflect changes in project requirements. A final update occurs during the acceptance phase. Northeastern University reviews and approves all changes, and the commissioning authority documents them.

5. Design Reviews

a. Design documents are reviewed by other Northeastern University and regulatory agency representatives at various project milestones, such as schematic design, design development and construction documents. Northeastern University determines the number of reviews, which depends on project type and scope.

b. The commissioning authority reviews the design documents to answer to the following questions.
   - If constructed as designed, will the systems meet the design intent?
   - Are the systems (as designed) "commissionable"? Have the designers included the features necessary to verify that the systems will meet the design intent at the end of construction?
   - Are the system components accessible and maintainable? Are the specified O&M documentation requirements adequate? Are the specified operator training requirements adequate?
   - Are the design documents unambiguous? Do the drawings and specifications clearly detail requirements, or do they leave a lot up to the imagination and creativity of the contractor?

c. The design engineers review the commissioning authority's comments and submit their responses, through the construction manager, to the commissioning authority and Northeastern University.

6. Technical Design Review

a. Technical design reviews are conducted at several stages in a project. The number and type of reviews are based on project scope, and reviews may not be required on some projects. An electrical load flow analysis review (described in the following paragraph) is one type of technical design review that may be conducted, as well as reviews for other engineering disciplines.

b. Under normal conditions, a load flow analysis determines real and reactive power flow in power system circuits. It also determines bus voltages in all possible operating conditions and provides solutions to potential system deficiencies. A review of the analysis by the commissioning authority confirms that the main electrical system components are included in the documentation used by the project team and by operations and maintenance personnel in making future system changes and in conducting system evaluations.

c. Northeastern University determines the extent of the commissioning authority's participation in technical design reviews. As a participant, the commissioning authority's role is to review and comment on the designs, focusing on the clarity of the design documents and on the designated system's ability to meet the design intent criteria.

7. Commissioning Specification

a. The commissioning authority, working with the design team specification authors, must develop a commissioning specification for each project for inclusion in Division 1 of the design team’s project specification books. The draft specification extracts the contractors’ responsibilities from the commissioning plan and converts them into standard specification language and format, thus binding the contractors to the commissioning process through their normal contracting document. The commissioning specification is updated with each issuance of the design documents.

b. The commissioning specification must reflect the bidding contractors’ commissioning responsibilities (scope, process, rigor of testing) that Northeastern University requires. Northeastern University may direct the commissioning authority to incorporate features that enhance the university's involvement and contribute to the scope of training requirements or processes that increase the value of the project. The final outcome is a commissioning specification that describes the preferred approach to commissioning and identifies:

- The systems to be commissioned
- The preferred approach to commissioning
- Required documents and forms
- Detailed testing procedures
- Training requirements
- Commissioning schedule sign-off requirements
- All other information needed to complete the commissioning process

c. In the sample commissioning specification, LEED (Leadership in Energy and Environmental Design) Certification is a requirement. Sustainable design, which LEED supports, is a Northeastern University project design requirement. The decision to pursue LEED certification depends on the unique requirements of each project. See Section 01352: Sustainable Design Requirements for additional information regarding sustainable design.

8. Commissioning Requirements in Technical Specifications

The commissioning authority reviews the design team's technical specifications and suggests inclusions that alert the contractor to specific commissioning requirements and document coordination requirements.

9. Training Plan Development

a. The commissioning authority reviews the training requirements included in the design team's technical specifications and meets with Northeastern University to understand the nature and extent of the necessary training. In addition, the commissioning authority customizes the commissioning specification and suggests modifications to the technical specifications that reflect the university's training preferences. The specification review and recommendations focus on making the training requirements measurable and enforceable.

b. See the sample commissioning specification for an example of the Operation and Maintenance Training Plan form used by contractors to submit their intentions for each training session and used by Northeastern University in reviewing, approving, and documenting the successful delivery of each training session.

10. Preventive Maintenance and Equipment Data Requirements

a. Researching preventive maintenance and data retrieval requirements ensures that they are included in the bid specifications. The installation contractors or equipment vendors supply all of the data required to populate Northeastern University's preventive maintenance system with information on new equipment. The commissioning authority and Northeastern University determine what data is needed and how it should be presented. See the sample Mechanical–Electrical Data Retrieval form in the sample commissioning specification.

b. During construction, the commissioning authority collects the data retrieval forms submitted by the contractors and reviews them for completeness.

11. System Readiness Checklists and Verification Test Procedures

a. The commissioning authority develops all required system readiness checklists. The checklists are used to demonstrate complete system installation and readiness for operational testing. At the end of construction, the contractor uses the checklists to certify that the work is complete and the system is ready for independent verification testing.

b. The commissioning authority also develops preliminary verification test procedures—the functional component of testing. The test procedures provide the contractors with repeatable, unambiguous acceptance criteria that clearly define the level of rigor necessary in demonstrating system performance.

c. The system readiness checklists and verification test procedures are incorporated into the commissioning specification. Sample of these documents are included in the sample commissioning specification.

12. 100-Percent Design Review Backcheck

During the backcheck, the commissioning authority reviews the final design documents for engineer responses and the inclusion of outstanding commissioning authority comments.

F. Construction Phase Commissioning

1. Pre-Bid Meeting

During the pre-bid meeting, Northeastern University introduces the design team to prospective bidders. The commissioning authority describes the benefits of the commissioning, and provides a 5–10 minute overview of the commissioning process. In addition, the commissioning authority presents the system readiness checklists to the group, reviews the required verification testing procedures, and answers any questions.

2. Pre-Construction Meeting

During the pre-construction meeting, Northeastern University introduces the design team and commissioning authority to the installation contractors. The commissioning authority briefly reviews the commissioning specification with the construction team, answers their questions, and is prepared to discuss how the contractors benefit from the commissioning process. In addition, the construction phase commissioning kickoff meeting is scheduled. The kickoff meeting should be held within two to six weeks of the pre-construction meeting.

3. **Construction Phase Commissioning Kickoff Meeting**

a. The commissioning authority chairs the construction phase commissioning kickoff meeting, which is attended by all commissioning team members, including all responsible contractors and subcontractors. The commissioning authority presents a detailed overview of the commissioning process described in the commissioning plan and in the commissioning specification section of the construction documents.

b. At this meeting the commissioning authority in concert with the Northeastern Project Manager would establish regularly scheduled commissioning coordination meetings. This meeting establishes lines of communication, routing of submittals and documents, maintenance of schedule, and discussion of action items.

4. **Shop Drawing Reviews**

a. The commissioning authority, concurrently with the designers, reviews the equipment and system shop drawing submittals for systems being commissioned. The commissioning authority submits their comments, which based primarily on the four design review areas defined under the design development review task, to the designers. If the designers agree with the commissioning authority, they incorporate these comments into their formal response back to the contractors.

b. An ATC submittal review is mandatory.

5. **Coordination Drawing Review**

The commissioning authority reviews coordination drawings and documents, such as ductwork and piping coordination drawings or over-current protection coordination studies, to verify that equipment installations conform to the design intent and are easily accessible for on-going maintenance.

6. **Equipment O&M Manual Review**

a. The commissioning specification must require that the contractors submit operations and maintenance (O&M) manuals within two to three months after approval of all equipment submittals. Within the scope of systems being commissioned, the commissioning authority reviews all O&M manuals for completeness, accuracy, clarity, and project-specific customization. The commissioning authority may also gather test parameter data for use during final functional testing. The O&M manuals are then available for use during training.

b. The O&M manual review is project-specific and cannot be completed until the coordination drawings and equipment submittals have been reviewed and accepted.

7. **Review Equipment Training Plan**

a. The commissioning authority works with the contractors and Northeastern University to establish training dates; review contractor training plans, agendas, and outlines for all equipment training sessions required by contract; and assist in customizing the training to meet the needs of the building's operations and maintenance staff. The equipment training sessions focus on the operation and maintenance of individual equipment.

b. Training is project-specific and depends on the scope of services. Commissioning authority participation in training activities must be discussed with Northeastern University.

c. Training cannot be completed until the coordination drawings and equipment submittals have been reviewed and accepted.

8. **Test, Adjust, and Balance Execution Plan Review**

a. The commissioning authority, concurrently with the designers, reviews the execution plan, calibration information, and documentation for the planned testing and balancing approach and the instruments to be used in performing the balancing work. The execution plan must be submitted before starting any balancing work.

b. In many cases, the designers specify that the test, adjust and balance (TAB) contractor submit a TAB execution plan for approval before starting their fieldwork. The commissioning authority reviews the final TAB report to finalize the functional performance test procedures.

c. The test and balance approach must address such questions as:

(1) Does the plan include the need for the balancer to obtain any equipment from the controls contractor in order to balance a system?

(2) Does the balancer know how to use the equipment provided by the controls contractor?

(3) Must the controls contractor be on-site while the test and balance process is occurring?

(4) Does the test and balance contractor understand the direct digital control (DDC) system know how to enter and override control setpoints?

(5) Does the test and balance contractor understand project phasing and the need to visit the project site multiple times in order to accommodate the phasing process?

9. **Electrical Test Agency Test Plan Review**

a. The commissioning authority reviews the electrical test agency test plan to confirm that electrical testing will meet the requirements of the design intent. The test plan review compares proposed tests to International Electrical Testing Association standards and other applicable standards as required by the design intent. In addition, the review helps confirm that required test results are documented properly for acceptance and as a baseline for future operations and maintenance needs.

b. Some steps in the functional performance tests developed by the commissioning authority may require special test instruments. The electrical subcontractor may be required to retain an electrical test agency. If one is retained, the electrical test plan is required to finalize functional performance tests procedures.

10. **Technical Design Review**

a. The commissioning authority reviews and comments on the designs at several stages. The reviews focus on the ability of the designated systems to achieve the design intent criteria. The commissioning authority also reviews the design documents for clarity.

b. Technical design reviews are specific, may be multi-disciplinary, and might not be required on all projects. The decision to a conduct a review should be based on the size of the commissioning project. Participation by the commissioning authority in technical design reviews must be discussed with Northeastern University.

c. The following three technical design reviews serve as representative examples of the types of reviews that may be conducted.

(1) Short-circuit and power coordination study review.

(2) Electrical system short-circuit analysis review.

(a) The commissioning authority confirms that the study reports include adequate detail and that the resulting documentation provides an adequate reference for system evaluation, operations, and maintenance. The commissioning authority confirms also confirms that the study includes a comparison between short circuit analysis results and equipment ratings, which ensures that the supplied distribution equipment meets specification requirements.

(b) Documentation in the reports should include one-line diagrams, explanation of assumptions, utility-provided data, computer analysis program data, manufacturer's time current curves, original equipment manufacturer cut sheets, a listing of all final settings, and an explanation for the final settings of each function.

(3) Electrical harmonic study.

(a) The commissioning authority reviews electrical harmonic studies when 50 kva or greater variable-frequency drives are proposed for the project. The studies must be based on IEEE 519-1992 standards.

(b) System one-line input data includes emergency generator and primary fault current data. The study must include:

- All input data and assumptions
- An explanation of the method used to perform the analysis
- All calculations and computer analysis printouts
- Each point of common coupling on the secondary side of the transformer that feeds that group of drives meeting the required limits
- A system impedance diagram based on the one-line diagrams
- A detailed description of the tests and procedures to support the calculations

11. **Preventive Maintenance Retrieval Forms**

  a. During construction, the commissioning authority collects and reviews the completeness of the data retrieval forms submitted by the contractors for each piece of equipment associated with the systems being commissioned.

  b. The commissioning authority tracks, receives, reviews, and accepts the equipment data retrieval forms submitted by the contractors. Acceptance is based on the contractors' forms being complete and meeting the specification requirements.

12. **Field Record Drawing Review**

  a. During construction, the commissioning authority must review field record drawings ("red-lines") periodically—typically monthly. These reviews confirm the accuracy and completeness of the red-line markups prior to concealment of system elements. Attention is given to the locations of critical O&M items, such as shutoff valves, fire/smoke dampers, disconnect switches, control system instrumentation, terminal units, and access panels. Except where gross deviations are obvious, attention is not focused on the actual pipe and duct locations, if the general routing is depicted accurately.

  b. At the completion of construction, the commissioning authority compares the final as-built documents to the red-lined drawings previously reviewed and approved in the field.

13. **Equipment Training Session Scheduling and Verification Testing**

  a. As construction of the systems approaches completion, the commissioning authority conducts a commissioning team meeting to develop a detailed verification testing schedule.

  b. The commissioning authority convenes a meeting with the contractors and O&M supervisors to schedule the equipment training sessions. The commissioning authority also assists ion coordinating training events to meet the needs of all participants and to ensure that resources are used effectively.

14. **Systems Training Planning**

In addition to assisting with training coordination, the commissioning authority, in conjunction with the design engineers, provides additional training for the O&M staff on the design intent of the systems being commissioned. The design intent training includes a detailed review of how the systems and sub-systems work together. The training also includes a walk-through of each building to ensure that O&M staff members are familiar with the systems and with the associated control devices.

15. **Final System Readiness Checklist Development**

    a. The commissioning authority makes any necessary revisions to the systems readiness checklists based on the final approved submittals and all project changes, such as change orders, architectural supplemental instructions, and proposal requests. The commissioning authority submits the final system readiness checklists to the contractor for use in performing final system checkouts.

    b. The commissioning authority finalizes the checklists based on comments received during preliminary development.

16. **Final Functional Performance Test Procedure Development**

    a. The commissioning authority, after having reviewed the approved project submittals and all project changes, such as change orders, architectural supplemental instructions, proposal requests, revises the preliminary functional test procedures to reflect the as-installed and as-programmed conditions. The contractors review their respective final functional test procedures before conducting the tests.

    b. The commissioning authority finalizes the functional test procedures and issues them for testing, based on comments received during preliminary development.

G. Acceptance Phase Commissioning

1. **Equipment Training Oversight**

    a. The contractors deliver their respective O&M equipment training sessions. The commissioning authority is not always asked to attend and witness all of the training. Northeastern University's trainee representative must formally accept each training session, in writing, as being in compliance with that session's training plan. The commissioning authority collects and compiles the training plan/ agenda forms.

    b. Training is project-specific, depending on the scope of services. The commissioning authority may not participate in training activities.

Commissioning authority participation must be discussed with Northeastern University.

2. **Systems Training**

The commissioning authority plans and leads the delivery of Systems Training to supplement the equipment training provided by the contractors. Systems training consists of an explanation of the Design Intent Documentation and how the Designers' systems achieve the stated criteria. The goal of this training is to convey how all of the individual pieces of equipment are uniquely configured to operate as a "system." Such training is best delivered before the functional testing is performed, because the operators can then witness the tests and get as close to "hands-on" systems training as possible before the systems are turned over to them.

3. **Contractor Test Report Tracking and Review**

a. The commissioning authority reviews the Contractors' Test Reports to verify that each test is within the acceptable parameters identified in the contract documents. The commissioning authority maintains a current status log of all Contractors' Test Reports required to be submitted as part of the project. System functional testing must not occur until the Contractor Test Reports have been submitted and approved by the commissioning authority.

b. This cannot be reviewed or accepted until completed Equipment Startup Reports have been submitted by the Contractor to the commissioning authority.

4. **Test, Adjust, and Balance Report Review**

a. The commissioning authority, concurrent with the Designers, reviews the Report(s) submitted by the TAB contractors as they complete their work on individual systems (not all systems need to be balanced before the reporting process begins). The commissioning authority verifies that all required data has been collected and that the measured results are in compliance with the specification and the Design Intent. The commissioning authority also verifies that all air and hydronic systems have been adjusted and are reported to be within the acceptable design values.

b. The test and balance report also identifies specific system deficiencies that prevent proper balancing of a system. As a result, the commissioning authority issues a Corrective Action Report (CAR) to track the deficiency to resolution. The test and balance contractor is responsible for revisiting the system balancing after the deficiencies have been resolved.

c. TAB completion is required before the contractor can complete the System Readiness Checklists.

5. **Test, Adjust, and Balance Field Verification/Spot Check**

a. Upon completion of testing and balancing, and the commissioning authority's review and approval of the test and balance report, the test and balance contractor re-measures a random sample of air flow values and hydronic flow rates documented in the test and balance report under the direction of, and witnessed by, the commissioning authority.

b. This is project specific and might not be included. Commissioning authority participation must be discussed with Northeastern University.

6. **System Readiness Checklist Tracking and Review**

a. The Commissioning Specification includes the Systems Readiness Checklists and must be completed by the contractors as formal notification that each system is ready for its respective verification test procedure. These checklists recognize that "systems" are usually a collaborative effort of more than one subcontractor. As such, all contractors who have a role in successfully completing a system sign-off on a single checklist that their part of the system is complete.

b. The commissioning authority reviews the checklists to verify that they are complete as they are submitted. The commissioning authority maintains a current status log of all System Readiness Checklists required. System functional testing cannot occur until the System Readiness Checklists have been submitted and commissioning authority has approved them.

c. System Readiness Checklists cannot be completed until TAB reports have been reviewed and accepted. Testing cannot commence until completed SRC's have been submitted and accepted.

7. **Direct and Document Functional Performance Testing**

a. The commissioning authority coordinates functional testing with the responsible contractors and Northeastern University's operations and maintenance staff. During the functional testing process, the contractors are responsible for performing the functional tests under the direction of the commissioning authority. Northeastern University O&M staff is encouraged to participate in the testing as the culmination of their training program. The commissioning authority documents the results of the all functional tests.

b. The witnessing of testing cannot begin until the contractor has submitted and the commissioning authority has approved all necessary information and documentation.

8. **Submit Daily Test Reports**

Upon completion of testing each day, the commissioning authority prepares a summary Verification Test Report for that day. This report lists the tests performed, describes the results, and provides immediate feedback to all commissioning team members.

9. **Corrective Action Reports and Logs and Correction of Deficiencies**

a. For each deficiency found during testing, the commissioning authority prepares a Corrective Action Report (CAR) for communicating, tracking, and documenting the status and correction of each deficiency. The commissioning authority maintains a Corrective Action Report log to track the status of each CAR.

b. The commissioning authority gives the CAR to the Contractor who, upon correction of the problem, returns the form to the commissioning authority with an explanation of steps taken resolve the issue. Upon receipt of the completed CAR, the commissioning authority schedules and coordinates retesting with the contractors and Northeastern University O&M staff. The commissioning authority issues a functional test report summarizing the retesting efforts, plus any new CAR after each day of retesting. See a sample CAR and CAR Log in the sample specification.

10. **Trend Log Evaluation**

a. The commissioning authority identifies specific systems that require trend logs. Trend logs provide four forms of documentation: two are measures of system evaluation and two provide long-term records.

b. Trend logs:

(1) Prove the functionality of the digital control system to collect regular and continuing real time values, and proves the selected sensors work as expected.

(2) Reflect the performance of the mechanical and electrical systems the

sensors represent. Comparing the data to similar units and to the DID affirms that the system is performing correctly.

(3) Establish a history of normal operations.

(4) Provide a detailed record of the test changes and resultant responses during functional testing.

c. This is project specific and might not be included for the commissioning authority to review. Commissioning authority participation must be discussed with Northeastern University.

11. LEED Recommissioning Management Manual – If Applicable

The commissioning authority gathers and assembles contributions from all commissioning team participants, organizes the information, prepares the recommissioning manual to meet LEED requirements, and presents the manual to Northeastern University.

12. Final Commissioning Report

The commissioning authority prepares the report and includes an executive summary followed by copies of the Commissioning Plan, Design Intent Document, Commissioning Specifications, O&M Training Record, Functional Performance Test Reports, and Corrective Action Report Log. In addition, the report incorporates appendices that include Design Reviews, System Readiness Checklists, Corrective Action Reports, and blank Functional Test Procedures for future recommissioning activities.

H. Warranty Phase Commissioning

1. Deferred Test Procedures and Associated Deficiency Tracking

The commissioning authority schedules and coordinates all system functional testing that could not be completed during the acceptance phase because of issues such as seasonal constraints, construction phasing, or tenant fit-out. Trend logs for deferred testing must be included. Similar to the initial functional testing, all deficiencies discovered during the deferred functional testing process must be tracked, logged, and brought to resolution.

2. 10-Month Checkup and Lessons Learned Facilitation

a. Ten months into the typical twelve-month warranty period, the commissioning authority convenes the commissioning team to meet with Northeastern University staff. At this meeting, the commissioning team s solicits operation and maintenance staff comments, suggestions, and areas of concern regarding the systems and systems operations. The meeting generates the following:
   - Warranty items to address
   - Requests for system modifications to better meet operator and building occupant needs.
   - lessons the team learned that can be applied to future projects.
   - Systems training review

b. This is project-specific and may not be included. Commissioning authority participation must be discussed with Northeastern University.

3. **Benefits of Commissioning Analysis**

a. The commissioning authority documents specific examples of how the project benefited from the commissioning process, including deficiencies discovered during the commissioning process. The analysis also documents how the commissioning process, including training, affected the ability of the building operators to control their building more efficiently.

b. This is project-specific and might not be included. Commissioning authority participation must be discussed with Northeastern University.

4. **Amendment to Final Commissioning Report**

The commissioning authority updates the final commissioning report to include the results of warranty period activities, including deferred testing. Recommendations made as a result of the 10-month checkup are summarized in the final commissioning report.

-END-

01820

Demonstration and Training

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains administrative and procedural requirements for conducting system, subsystem, and equipment demonstrations and training.

B. Training Requirements

Before occupying the building, the facilities staff must be trained and fully capable of operating and maintaining building systems, subsystems, and equipment in accordance with the design intent.

C. Submittals

Submit the following demonstration and training documents to Northeastern University and designers for review and approval.

- Training plan
- Training materials

1. Training Plan

Develop and submit a training plan four weeks before the start of scheduled training that addresses the proposed training content and scope, instructional strategies, scheduling, resource requirements, and contingencies. Northeastern University will review the plan and discuss it with the training provider during the pre-training conference.

a. Training Content and Scope

(1) Provide the learning objectives for each classroom and hands-on training session. The learning objectives must describe observable and measurable behaviors (knowledge and skills), written in terms of what the trainees will know and be able to do following training.

(2) Provide a topic outline identifying all systems and equipment and listing

the major topics and sub-topics in the order in which they will be presented during the training session.

b. Instructional Strategies

Describe the instructional methods planned for the training (classroom presentations, hands-on training, operational demonstrations, site walk-throughs, simulations and/or learning activities).

c. Scheduling

Provide a training schedule showing the proposed dates, times, location, and duration of the training session(s); the training session topic; and the name of the instructor.

d. Resource Requirements

Identify training resource needs, such as classroom space and training equipment (projectors, screens, whiteboards).

2. Training Materials

Prepare and submit an electronic version of all instructional materials, in native file format, for future use by Northeastern University. Develop the documents using Microsoft®-compatible software accessible through Windows-based operating systems.

D. Instructor Qualifications

Provide a qualified instructor for each training session. Qualified instructors must be subject matter experts with demonstrated training competence and recent, similar training experience.

E Instructional Design

1. Develop learner-centered, performance-oriented training based on the life-cycle operation and maintenance requirements of the system, subsystem, or equipment as described in the O&M manuals. Include in the training applicable O&M knowledge and skills listed in Table 1.
2. Design and develop training materials that Northeastern University can use to train/re-train their personnel in the future. The training materials shall include:
   - an instructional outline that reflects the sequence of instruction and that addresses the approved learning objectives,

- visual aids or other prepared presentation materials,
- trainee handouts, include the learning objectives, a topic outline, and appropriate drawings, diagrams, charts, tables, illustrations, and reference material.

Table 1. O&M Knowledge and Skills

System Description	• Design intent of new or modified systems, subsystems, equipment, and technology • System, subsystem, equipment, and component locations • Special design characteristics, construction features, and operational requirements • Theory and sequence of operations • Operating parameters, operating standards, regulatory requirements, limiting conditions, and performance curves • Materials and processes • Control systems, including control screens or devices; integrated sensors, switches, and other input devices • Safety hazards and precautions, including lockout/tagout procedures • Design features that mitigate safety hazards, such as guarding or other protective devices • Hazardous waste products and contaminants • Regulatory requirements and limitations, including special waste disposal and/or reclamation needs • Odors and other emissions • System, subsystem, and equipment interactions and interfaces, including utilities
Normal and Emergency Operation	• Normal operation, including startup, break-in, control, stopping, and normal shutdown • Automatic and manual control sequences • Routine, normal, seasonal, and weekend operation • Common failure modes and sudden power loss • Emergency operation, including trouble indications (error messages, warnings, alarms), emergency responses, stopping, shutdown, and abnormal or casualty operations • Required sequences for electric or electronic systems

Preventive and Predictive Maintenance	• Testing • Inspection • Adjustments, alignments, calibration, and balancing • Cleaning methods, surface care needs, and agents • Preventive and routine maintenance • Use of special tools and test equipment • Performance optimization, including how to maintain high operational reliability, economy, and efficiency; minimize noise and vibration transmission, and conduct seasonal changeover operations

Table 1. O&M Knowledge and Skills—Continued

Corrective Maintenance and Repair	• Troubleshooting • Diagnosis • Repair • Disassembly and disassembly
Consumables and Spare Parts	• Parts identification • Contractor-furnished spare parts and extra materials • Recommended critical spare parts for on-site inventory • Procurement information for replacement parts, repair kits, and materials • Contact information for local suppliers and factory representatives
Documentation	• Installation requirements • Identification systems • Format, content, and use of O&M data, manuals, and project record documents • Warranty and bond terms and conditions, points of contact, material return procedures, effective dates, expiration times, and extension options • Maintenance service agreements and other similar continuing commitments, except sales promotions

F. Instructional Delivery

Conduct training as outlined in the approved training plan. Provide an appropriate combination of classroom and hands-on instruction, using instructional methods and training materials that support the learning objectives.

1. General Requirements

a. State the purpose, and review the learning objectives at the start of each training session. Ensure that the trainees understand what they are expected to know and be able to do after completing the training session.

b. Promote active trainee involvement in discussions, and encourage them to share relevant knowledge and experiences.

c. Provide the trainees with opportunities to apply what they have learned.

d. Review and summarize the content at the conclusion of each training session.

2. Hands-On Demonstrations and Training

a. State the purpose of each operation and maintenance task; the expected outcome; the consequences of improper task performance; and the circumstances, frequency, and standards of task performance.

b. Demonstrate and describe each task step, using correct terminology and equipment nomenclature.

c. Demonstrate and explain proper use of all tools, equipment and materials.

d. Demonstrate and explain the proper use of all controls and instrumentation.

e. Provide the trainees with opportunities to learn operation and maintenance tasks by performing them, and to develop the necessary expertise through practice.

3. Safety

a. Ensure that the area is safe for training. Ensure adequate trainee supervision and strict adherence to all safety precautions to avoid injury to personnel or damage to the equipment.

b. Limit the size of the group in each training session to the number of trainees that can be safely supervised and who can hear the instructor over the background noise. Conduct additional training sessions, demonstrations, and walk-throughs, as necessary, to accommodate the total number of trainees.

c. Ensure that the trainees are wearing the appropriate attire and required personal protective equipment.

4. Session Documentation

Document the completion of each training session. Include the following information:

- Date
- Topic

- Instructor's name
- List of trainees
- Sign-off by Northeastern University or its designated representative

G. Training Coordination Meeting

Training providers may be required to participate in a pre-training coordination meeting to review the training plan, discuss training needs and expectations, and resolve potential problems, scheduling conflicts, and other logistic concerns.

-END-

15055

Common Motor Requirements for HVAC Equipment

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A. Summary

This section contains general HVAC design criteria for electric motors.

B. System Design and Performance Requirements

1. Unless otherwise specified, provide constant speed, self-ventilated, squirrel cage induction motors per NEMA Design B.
2. Unless totally enclosed, motors must have a 1.15 service factor.
3. Motors must have Class B insulation.
4. Unless otherwise specified, design motors under 1/2 hp for 120 V, 60 Hz, single-phase.
5. 1/2 hp motors and over must be as required in schedules.
6. See Northeastern specification 15950, Energy Management and Controls Systems, variable- frequency drives.
7. All motors must be high- or premium-efficiency. All motors over 5 hp must be premium-efficiency. Motors for variable-frequency drives must be high-efficiency.
8. For buildings with utility UI, the minimum nominal new motor efficiencies must be the UI incentive minimums.
9. Do not select motors to operate in their service factors.

10. Select all motors to be non-overloading throughout the fan or pump service requirements range.
11. Specify that all motors must be aligned with driven equipment.

C. Product Standards

Motors must conform to NEMA Standard MG-1-12.53a. Determine motor efficiencies in accordance with IEEE Standard 112 Method B. List the NEMA nominal efficiency on the motor nameplate.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Baldor
- Lincoln
- General Electric
- U.S. Motors

E. Installation Guidelines

Provide sufficient clearance for motor maintenance and removal upon completion of construction. Allow a minimum clearance of 2" 6" around the motors. In locations where a portable hoist cannot be maneuvered, such as within air handling units, install horizontal lift beams with hoists for motors over 100 pounds.

-END-

15075

Mechanical Identification

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for mechanical systems identification.

B. System Design and Performance Requirements

Ensure that identification systems are compatible with existing systems and are consistent throughout the project. Provide for future additions to the systems.

1. Plumbing Systems Identification

a. Provide color-coded pipe identification markers on piping installed per this section. Use snap-on, laminated, plastic pipe markers protected with a clear acrylic coating. Apply pipe markers after architectural painting where such painting is required.

b. Provide an arrow marker with each pipe content marker to indicate the direction of flow. If flow can be in either direction, use a double-headed arrow marker.

c. Pipe markers must have legends and color coding with black letters. Apply markers to all piping per Table 1, regardless of under-jacket colors.

Table 1. Pipe Marker Color Coding

Service	Legend	Background Color
Cold water	Cold water	Green
Hot water	Domestic hot water	Yellow
Hot water return	Domestic hot water return	Yellow
Protected cold water	Protected cold water	Yellow
Protected hot water	Protected hot water	Yellow
Protected hot water return	Protected hot water return	Yellow
Non-potable water	Non-potable	Yellow
Compressed air	Compressed air	Green
Sanitary	Sanitary Sewer	Green
Vent	Vent	Yellow
Rainwater	Storm Sewer	Green
Pump discharge	Pump discharge	Green
Pure water	Pure water	Green
Vacuum	Vacuum	Green
Central vacuum	Vacuum	Yellow
Lab waste	Lab waste	Yellow
Lab vent	Lab vent	Yellow
Gray water	Gray water	Green
Tempered water	Tempered water	Green
Tempered water return	Tempered water	Green

d. Use colored PVC jackets in penthouses, plumbing rooms, shipping docks, janitor's closets, and other areas without hung ceilings. Cover all insulated plumbing piping exposed in mechanical rooms with a Ceel-Co plastic jacket. The system identification and color pattern legend must be per Table 2.

Table 2. System Identification and Color Patterns

Piping System (and Legend)	Color
Potable Cold Water	Green, Blue, _______
Potable Hot Water	Green, Blue, _______
Non-Potable Cold Water	Yellow, Gray, ______
Non-Potable Hot Water	Yellow, Gray, ______
Storm Drain	Green, Blue, _______
RODI Water	Yellow, White, ______
Gray Water	Green, Blue _______
Tempered Water	Green, Blue _______

e. Plastic jackets include fitting and piping covers.

f. Insulate and finish the piping to be covered with plastic jackets, per this section, then apply the plastic jackets.

2. Tags, Valves, Equipment, and Instruments

a. Upon completion of work, attach engraved laminated plastic tags to all valves and instrumentation. In every mechanical space, tags must be seen when hung with valve/riser charts.

b. Equipment must bear stamped, stainless steel tags.

c. Tags must be numbered consecutively with black characters on a white face. Tags for general valves must be prefixed with the letter P. Tags must bear the number used in the P&IDs for those items so marked. Numerals must be at least 3/8" high.

d. Embossed or engraved aluminum or brass tags may be substituted for stainless steel or laminated tags, if desired.

e. Tags must be at least 1" in diameter, at least 1/8" thick, and attached by S-hooks and chains.

3. HVAC Systems Identification

a. Stencil ductwork at each junction or branch takeoff, at least once in each room, and at intervals not longer than 20 feet. Stencils must clearly identify the duct service area (S for supply, R for return, X for exhaust) served by the branch, and must include an arrow indicating the direction of flow.

b. Provide color-coded pipe identification markers on piping installed per this section. Use snap-on, laminated, plastic pipe markers protected with a clear acrylic coating. Apply pipe markers after architectural painting where such painting is required.

c. Provide an arrow marker with each pipe content marker to indicate the direction of flow. If flow can be in either direction, use a double-headed arrow marker.

d. Label mains:
   - At points of entrance and exit from mechanical rooms
   - Adjacent to each valve
   - On each riser
   - At each tee fitting
   - At points of entrance and exit from building
   - At least once in each room
   - At intervals no longer than 20 ft

e. The size of legend letters on markers and the length of the color field must be per the latest edition of ANSI.

f. Use the color-coding in Table 3, with names in black letters on a white background and white letters on a green background.

Table 3. Pipe Marker Color Coding

Service	Legend	Background Color
Chilled water supply	CHWS	Dk Blue
Chilled water return	CHWR	Lt Blue
Hot water supply	HWS	Yellow
Hot water return	HWR	Yellow
Cold water	Cold water supply	Green
Low pressure condensate return	LPR	Tan
Medium pressure condensate return	MPR	Tan
High pressure condensate return	HPR	Tan
High pressure steam	HPS	Orange
Low pressure steam	LPS	Orange
Medium pressure steam	MPS	Orange
Pumped condensate	PC	Tan
Steam	Steam	Orange
Glycol supply	GS	Yellow
Glycol return	GR	Yellow

C. Product Standards

Color banding must meet the latest ANSI and OSHA requirements.

D. Manufacturers

- Ceel-Co plastic jacket.
- Seton Name Plate Corporation
- Marking Services Incorporated
- Approved equal

E. Materials

Use Setmark markers by the Seton Name Plate Corporation, or approved equal.

F. Installation Guidelines

1. Mains shall be labeled at points of entrance and exit from mechanical room, adjacent to each valve, on each riser, at each tee fitting, at points of entrance and exit from building, at least once in each room, and at intervals no longer than 20'.
2. In general, use 2" high legends for 4" and larger diameter pipe lines, and 3/4" high legends for pipe lines 3" diameter and smaller pipe lines.
3. Use screws or rivets to securely attach nameplates, catalog numbers, and rating identifications to mechanical and electrical equipment. The use of adhesives or cements is not permitted.
4. Identify non-potable water outlets with permanently attached, yellow color-coding or 4" high triangle tags that read "Water unsafe."
5. Coordinate the numbering system with existing piping tags to avoid duplicate numbers.

-END-

15081

Duct Insulation

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A. Summary

This section contains duct insulation design criteria, including internal lining.

B. System Design and Performance Requirements

1. Kitchen Exhaust Ducts

Insulated kitchen exhaust ducts per NFPA, local code, and Fire Department requirements.

2. Concealed Rectangular, Flat Oval, and Circular Ductwork

Insulate supply and fresh air ducts and plena in concealed spaces and return ducts not in the ceiling plenum. Refer to the wrap requirements under Materials.

3. Exposed Rectangular Ductwork

Insulate supply and return exposed ducts. Insulation requirements to be determined at the design phase.

4. Exposed Round and Flat Oval Ductwork

Insulate exposed supply and fresh air ducts and exposed plena located in mechanical and electrical rooms, storage rooms, unoccupied areas, unconditioned areas, and/or as indicated on plans.

5. Internal Duct Insulation

Sound traps in ductwork are required over internal duct insulation. Use internal duct insulation only with the prior approval of Northeastern University Facilities Group. Duct lining of the first 15 feet of ductwork leaving the air handler is Not acceptable.

C. Manufacturers

1. Subject to compliance with the design requirements, provide products by one of the following manufacturers:
   - Owens-Corning
   - Certain-Teed
   - Manville
   - Knauf
2. Subject to compliance with the design requirements, provide unicellular, elastomeric, foam rubber sheet insulation by one of the following manufacturers:
   - Armstrong (Armaflex)
   - Manville
   - Owens Corning
   - Halstead-Nomaco
3. Provide kitchen exhaust duct wrap by Thermal Ceramics (or other comparable manufacturer).

D. Materials

- Materials must meet Adhesive and Sealant Council Standards and SMACNA requirements.
- ASTM E-84 minimum fire hazard ratings must be 25 flame spread, 50 fuel contributed, and 50 smoke developed.
- Transmission rates of vapor barriers cannot exceed 0.02 perms.

1. **Concealed Rectangular, Flat Oval, and Circular Ductwork**

   Use at least 1-1/2" thick, fibrous glass duct wrap with a foil-kraft flame-resistant vapor barrier. Insulation density must be 3/4 ib/cf. The maximum K-factor must be 0.3 at a mean temperature of 75°F.

2. **Exposed Rectangular Ductwork**

   Use semi-rigid fibrous glass boards with R valve of 6 with factory-applied fire retardant, foil-reinforced kraft vapor barrier facing. Insulation density must be 3 lb/cf. The maximum K-factor must be 0.23 at a mean temperature of 75°F.

3. **Exposed Round and Flat Oval Ductwork**

   Use 1-1/2" fibrous glass ductwrap with a foil-kraft flame-resistant vapor barrier. Insulation density must be 3/4 lb/cf. the maximum K-factor must be 0.30 at a mean temperature of 75°F.

4. **Outdoor Round or Rectangular Duct External Rubber Steel Insulation and Waterproofing**

   Use a 2" thickness of flexible unicellular elastomeric foam rubber sheet insulation with a maximum K-factor of 0.27

5. Any exposed ductwork subject to personnel traffic should be protected with an approved walking surface. Approval shall be on a case by case basis and Northeastern Facilities shall sign off.

E. Installation Guidelines

- Install insulation, mastics, adhesives, coatings, covers, weather-protection, and other materials exactly as required by the manufacturer's recommendations.
- Apply insulation after systems have been tested, proven tight, and approved by Northeastern University. Remove dirt, scale, oil, rust, and foreign matter prior to installing insulation.
- Insulation and vapor barrier must be continuous through wall and ceiling openings and in sleeves.

1. **Outdoor Round Duct External Insulation and Waterproofing**

   a. Extend insulation at standoff brackets.

b. Provide an aluminum jacket with 2" lapped joints on round ductwork.

2. Outdoor Round or Rectangular Duct External Rubber Steel Insulation and Waterproofing

Install flexible, unicellular, elastomeric foam rubber sheet insulation as follows.

a. Insulate the standing seams with the same thickness as the duct.

b. Glue the insulation to the duct, and seal butt joints with full coverage of Armstrong 520 or an approved, comparable adhesive. Provide two layers of insulation to equal the required thickness. Lap the two layers so that they are not in the same location.

c. Apply two coats of an approved vinyl lacquer coating over woven glass yarn mesh glued to the insulation surface with Insulcolor or an approved, comparable lagging adhesive.

d. Aluminum jacketing shall be determined by Northeastern University. If aluminum jacketing is required, it will be based on individual projects.

-END-

15083

Pipe Insulation

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A. Summary

This section contains design criteria for piping insulation and jacketing.

B. System Design and Performance Requirements

1. Verify with the Northeastern University Facilities group that information related to insulation and jacketing is the most recent.
2. Insulation must be fibrous glass insulation with a factory-applied, fire retardant, vapor barrier jacket and a K factor of at least 0.23 at a mean temperature of 75°F. ASTM
E-84 fire hazard ratings must be 25 flame spread, 50 smoke developed and 50 fuel contributed.
3. Refer to Table 1 for Northeastern University pipe insulation thicknesses.

Table 1. Pipe Insulation Thicknesses for Northeastern University Insulations

Pipe Insulation Thicknesses for Northeastern University Insulations							
Hrs. of Operation & Bldg. Types	**10 psi**	**Steam 30-125 psi**	**125-250 psi**	**Condensate**	**Chilled Water**	**Domestic Hot Water**	**Hot Water Heating**
8700 hrs./yr. Distr. systems & lab bldgs.	1.5”	3”	4”	1.5”	4”	1”	1.5”
4000 hrs./yr. Non-lab bldgs.	1”	3”	4”	1”	2”	1”	1.5”

4. Subject to change for individual projects, chilled water insulation directives must be as follows:
   a. Insulate 12-inch diameter and smaller chilled water return piping and all chilled

water supply piping.

b. Do not insulate 14-inch diameter and larger chilled water return piping

C. Manufacturers

Subject to compliance with the design requirements, provide products by one of the following manufacturers:

1. **Insulation**
   - Owens
   - Corning
   - Certain-Teed
   - Manville
   - Knauf

D. Materials

Insulate chilled water distribution piping with polyurethane foam wrapped with glass fabric and then coated to insure watertight integrity.

E. Installation Guidelines

Install pipe insulation as required by the manufacturer.

-END-

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Valves

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section summarizes the design criteria for valves used in plumbing and HVAC systems. Valve requirements for steam, steam condensate, condenser water, chilled water, hot water glycol, and fuel oil services are shown in Tables 1 through 8.

Refer to Steam and Chilled Water Utilities Design Guidelines (SCUDG) for all utility piping going into building through and including the pressure reducing valve for steam or the chilled water.

B. System Design and Performance Requirements

1. General

- Cast or stamp the name of the manufacturer and guaranteed working pressure on the valve bodies.
- Valves of a similar type must be by a single manufacturer.
- Provide chain operators for valves 3" and larger that are installed 7' or more above floor.
- Gaskets and packings must not contain asbestos.
- Frexatalic gaskets preferred on high temperature and high pressure applications.
- Ratings must include ANSI class rating and hole pattern for flanges.
- All steam system valves in steam and condensate piping must be gate or globe valves. Ball valves are not permitted. Butterfly valves are only acceptable with written authorization from the design professional.

2. Butterfly Valves

- Provide lug-style butterfly valves as shown in Tables 1 through 8. When required by the manufacturer, install valves in the proper direction for shutoff and dead-end service.
- General service valves must be ductile iron body and threaded-lug, with resilient EPDM seats, stainless steel disks, and 416 stainless stems.
- Valves 6" and larger must have gear operators.
- Valves small than 6" must have seven-position levers.
- If valves are used for fuel oil, provide reinforced Teflon seats and 316 stainless disks.
- For chilled water systems, select high-performance butterfly valves for isolation and shutoff applications on mains and branches over 4" in diameter.

3. Ball Valves

- Hot water systems should incorporate ball valves for isolation purposes.
- Ball valves may be used on chilled water lines that are 4" in diameter and smaller. The pressure rating must be per ANSI standard.
- Provide full-port, two-piece ball valves with reinforced Teflon seats, seals, bearings, stainless steel balls, and packing.
- Select 1-1/4" ball valves for drains.
- Valves on insulated piping must have 2" extended stems.
- All ball valves must have locking handles to allow servicing and removal of equipment.

4. Globe Valves – To Be Approved by Northeastern University Prior to Construction Document Phase

- Provide globe valves as shown in Tables 1 through 8.
- Refrigerant valves must be back-seating, globe stop valves, winged and sealed.

1" and under cap valves must have diaphragm packing.

5. Plug Valves

- Provide plug valves with 70 percent port openings for balancing.
- Provide gear operators with memory indicators.

6. Check Valves

- Use silent and lift checks for heating hot water and chilled water systems.
- Use swing checks for steam systems.

7. Spring-Loaded Relief Valves

- Reliefs must be ASME-approved.
- For water reliefs, pipe the discharge into an indirect drain. Where permitted by the building code, pipe chiller refrigerant and steam relief devices through the building envelope.

8. Gate Valves

- Steam systems should incorporate gate valves for isolation purposes.
- Provide gate valves as shown in Tables 1 through 8.
- Gate valves may be used on 4" and smaller chilled water lines. The pressure rating must be per ANSI standard.
- Select 1", full-port gate valves for vents.
- In general, gate valves must have OS&Y rising stems to indicate position. For restricted clearances, gate valves must have non-rising stems. The contractor must submit the location where each type of gate valve is used.

9. Serrated-Tip Laboratory Faucets

For use on laboratory faucets, serrated-tip laboratory faucets must have vacuum breakers.

C. Manufacturers

Subject to compliance with the design requirements, provide products by one of the following manufacturers:

1. Butterfly Valves

a. 2" to 12" lug valves:

- Jamesbury

b. 2" to 12" wafer valves:

- Jamesbury
- Milwaukee
- Zwick

2. Threaded and Soldered Ball Valves

- Stockham, B-22T series
- Apollo
- Hammond
- Gates

3. Globe Valves

a. 2" threaded and soldered valves:

- Stockham, B-22T Series
- Milwaukee
- Apollo
- Hammond

b. 2" to 12" flanged valves:

- Stockham, B-22T Series
- Milwaukee
- Apollo
- Hammond
- Zwick

4. Plug Valves

- DeZurik
- Carol Test
- Kyro Test

5. Check Valves

a. Check swing 2" threaded and soldered valves:

- Stockham, B-22T Series
- Milwaukee
- Hammond
- Zwick

b. Check swing 2" to 12" flanged valves:

- Stockham, B-22T Series
- Milwaukee

- Nibco
- Apollo
- Hammond
- Zwick

c. Check lift 2" threaded and soldered valves:

- Stockham, B-22T Series
- Milwaukee
- Nibco
- Hammond

6. Gate Valves

a. 2" threaded, soldered, and flanged valves:

- Stockham, B-22T Series
- Milwaukee
- Apollo
- Hammond

b. 21/2" to 12" flanged valves:

- Stockham, B-22T Series
- Milwaukee
- Apollo
- Hammond
- Zwick

7. Laboratory Faucet Vacuum Breakers

- Nidel 3/8" (double-tight inline)
- T&S BL-5550-8.2 (double-tight inline)

8. Steam Heat Exchanger Vacuum Breakers

- Hoffman

9. Steam Valves

- Jenkins
- Stockham
- Zwick

10. Circuit Setters

- Armstrong

Bell & Gossett

Griswold

Tour Anderson

11. Balancing Valves

- Armstrong
- Bell & Gossett
- Griswold
- Tour Anderson

12. Triple Duty Valves

- Bell & Gossett

D. Materials

Combination balancing shut-off valves must be of bronze body or brass ball construction with glass and carbon-filled TFE seat rings. The valves must have differential pressure readout ports across the valve seat area. Readout ports must be fitted with internal EPT inserts and check valves. The valves must have memory stops to allow them to be closed for service, then reopened to setpoint without disturbing the balancing position. Balancing valves cannot be used for isolation valves.

E. Installation Guidelines

1. Distilled Water Systems

Avoid the use of snap-action valves and/or faucets.

2. Circuit Setters and Valves

- Circuit setters are required in the supply and return of heating hot water and chilled water coils.
- Valves are inexpensive compared to the function they perform. Provide a sufficient number of valves to isolate equipment for maintenance purposes by showing a valve between each piece of equipment on a loop or header.
- Install isolation valves on both sides of control valves and coils, and on the entering and leaving sides of equipment.
- Provide adequate balancing valves to facilitate and verify reliable

test and balance.

3. Back-Water Valves

Northeastern University has experienced flooding from city sewers. When the potential for flooding exists, special attention to details (including the use of back-water valves) is required at basement and area drain installations. Back-water valves are not totally satisfactory, and their use should be limited to storm lines. A more satisfactory installation is the use of sump pumps and sewage ejectors.

4. Vacuum breakers

Equip water faucets having provisions for hose attachments with vacuum breaker back-flow preventers. Note that serrated-tip laboratory faucets are included in this category.

- Type (when available): Integral; (otherwise) vandal-proof spout-end.
- Angle should not be used on faucets because of spillage onto sink tops.

F. Reference Tables

Table 1. Steam and Condensate Service

Steam and Condensate Service Maximum 90 psig Saturated Steam						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating [1, 2]**
Ball valve	Isolation					
Gate valve	Isolation	OS&Y	2-1/2"–36"	Iron/Bronze Iron/Iron	Flanged	Class 125
Globe valve	Manual steam modulation only	Union Bonnet	1/2"–2"	Bronze/Stainless Bronze/Bronze	Threaded	125 psig SWP
		OS&Y	2-1/2"–10"	Iron/Bronze	Flanged	Class 125
Butterfly valve	Isolation					
Plug valve	Not used					

Check valve	Steam and condensate horizontal flow	Non Y-type swing check valve (15º angle)	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	125 psig WSP
			2-1/2"–30"	Iron/Iron	Flanged	Class 125
Strainer	Control valves and flow meters and steam traps	Y-Type	1/2"–2"	Iron/Stainless (1/16" diameter)	Threaded	Class 125
			2-1/2"–10"	Iron/Stainless (3/64" diameter)	Flanged	Class 125
			12"–24"	Iron/Stainless (1/16" diameter)	Flanged	Class 125
Vacuum breaker	Steam coils and HX and condensate trap legs	Steam vacuum breaker	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	Class 125

1. These are minimum ratings. For actual maximum allowable valve and strainer ratings, refer to the documents listed under References.
2. SWP = Steam Working Pressure WOG = Water, Oil, or Gas WSP = Working Steam Pressure Class = ANSI Standard

Table 2. Steam and Condensate Service

Steam and Condensate Service Maximum 200 psig Saturated Steam						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating 1, 2**
Ball valve	Isolation					
Gate valve	Isolation	OS&Y	2-1/2"–36"	Iron/Bronze Iron/Iron	Flanged	Class 250
Globe valve	Manual steam modulation only	Union Bonnet	1/2"–2"	Bronze/Stainless Bronze/Bronze	Threaded	250 psig SWP
		OS&Y	2-1/2"–10"	Iron/Bronze	Flanged	Class 250
Butterfly valve	Isolation					
Plug valve	Not used					
Check valve	Steam and condensate horizontal flow	Non Y-Type swing check valve (15º angle)	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	250 psig WSP
			2-1/2"–30"	Iron/Iron	Flanged	Class 250
Strainer	Control valves and flow meters and steam traps	Y-Type	1/2"–2"	Iron/Stainless (1/16" diameter)	Threaded	Class 250
			2-1/2"–10"	Iron/Stainless (3/64" diameter)	Flanged	Class 250
			12"–24"	Iron/Stainless (1/16" diameter)	Flanged	Class 250
Vacuum breaker	Steam coils and HX and condensate trap legs	Steam vacuum breaker	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	Class 250

1. These are minimum ratings. For actual maximum allowable valve and strainer ratings, refer to the documents listed under References.
2. SWP = Steam Working Pressure
   WOG = Water, Oil, or Gas WSP
   = Working Steam Pressure
   Class = ANSI Standard

Table 3. Steam and Condensate Service

Steam and Condensate Service Maximum 200 psig Saturated Steam						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1,2]**
Ball valve	Isolation					
Gate valve	Isolation	OS&Y	2-1/2"–36"	Iron/Bronze Iron/Iron	Flanged	Class 250
Globe valve	Manual steam modulation only	Union Bonnet	1/2"–2"	Bronze/Stainless Bronze/Bronze	Threaded	250 psig SWP
		OS&Y	2-1/2"–10"	Iron/Bronze	Flanged	Class 250
Butterfly valve	Isolation					
Plug valve	Not used					
Check valve	Steam and condensate horizontal flow	Non Y-Type swing check valve (15º angle)	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	250 psig WSP
			2-1/2"–30"	Iron/Iron	Flanged	Class 250
Strainer	Control valves and flow meters and steam traps	Y-Type	1/2"–2"	Iron/Stainless (1/16" diameter)	Threaded	Class 250
			2-1/2"–10"	Iron/Stainless (3/64" diameter)	Flanged	Class 250
			12"–24"	Iron/Stainless (1/16" diameter)	Flanged	Class 250
Vacuum breaker	Steam coils and HX and condensate trap legs	Steam vacuum breaker	1/2"–2"	Bronze/Teflon	Threaded (Use dielectrics for condensate)	Class 250

1. These are minimum ratings. For actual maximum allowable valve and strainer ratings, refer to the documents listed under References.
2. SWP = Steam Working Pressure
   WOG = Water, Oil, or Gas WSP
   = Working Steam Pressure
   Class = ANSI Standard

Table 4. Glycol, Chilled, and Condenser Water Service

Glycol, Chilled and Condenser Water Service Maximum 150ºF and 150 psig (1/2"–12")/125 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Ball valve	Isolation	Full port 2-pc.	1/2"–2"	Bronze/Teflon	Sweat[1]	400 psig WOG
		Full Port 2-pc.	1/2"–2"	Bronze/Teflon	Threaded	400 psig WOG
Gate valve	Not Used					
Globe valve	ATC modulation	Control valve	1/2"–2"	Bronze/Metal	Threaded	400 psig WOG
Butterfly valve	Isolation	General service	2 1/2"–12"	Ductile iron/EPDM	Threaded Lug	175 psig CWP 150 psig bi-directional shutoff 150 psig dead-end service
		General service	14"–24"	Ductile iron/EPDM	Threaded Lug	150 psig CWP 150 psig bi-directional shutoff 150 psig dead-end service
Plug value	Throttling	Non-lubricated	3"–12"	Steel/Iron	Flanged	Class 125
Check valve	Pumps	Silent	1/2"–2"	Bronze/Bronze	Threaded	200 psig WOG
		Silent globe	2-1/2"–24"	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern swing	1/2"–2"	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2"–24"	Iron/Bronze	Flanged	Class 125
Strainer	Control valves and flow meters	Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
			2-1/2"–4"	Iron/Stainless (1/16" diameter)	Flanged	Class 125
			5"–24"	Iron/Stainless (1/8" diameter)	Flanged	Class 125

Table 4. Glycol, Chilled, and Condenser Water Service—Continued

Glycol, Chilled and Condenser Water Service Maximum 150ºF and 150 psig (1/2"–12")/125 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Strainer	Pump suction	In-line Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
			2-1/2"–4"	Iron/Stainless (3/16" diameter)[3]	Flanged	Class 125
			5"–24"	Iron/Stainless (3" diameter)[3]	Flanged	Class 125
		Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter)[3] Startup strainer = 16 mesh bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP = Steam Working Pressure
   CWP = Cold Water Working Pressure
   WSP = Working Steam Pressure
   WOG = Water, Oil or Gas
   Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

Table 5. Glycol, Chilled, and Condenser Water Service

Glycol, Chilled and Condenser Water Service Maximum 150ºF and 275 psig (1/2"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Ball valve	Isolation	Full port 2-pc.	1/2"–2"	Bronze/Teflon	Threaded	600 psig WOG
Gate valve	Not used					
Globe valve	ATC modulation	Control valve	1/2"–2"	Bronze/Metal	Threaded	600 psig WOG
Butterfly valve	Isolation	High performanc e	2-1/2"–24"	Carbon steel/ PTFE	Threaded lug	285 psig CWP
Plug value	Throttling	Non-lubricated	3"–12"	Steel/Iron	Flanged	Class 300
Check valve	Pumps	Silent	1"–2"	Bronze/Bronze	Threaded	Class 300
		Silent globe	2-1/2"–24"	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern swing	1/2"–2"	Bronze/Bronze	Threaded	Class 300
			2-1/2"–24"	Iron/Bronze	Flanged	Class 250
Strainer	Control valves and flow meters	Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	Class 250
			2-1/2"–4"	Iron/Stainless (1/16" diameter)	Flanged	Class 250
			5"–24"	Iron/Stainless (1/8" diameter)	Flanged	Class 250
	Pump suction	In-line Y-Type	1/2"–2"	Iron/Stainless (1/16" diameter)	Threaded	Class 250
			2-1/2"–4"	Iron/Stainless (3/16" diameter)[3]	Flanged	Class 250
			5"–24"	Iron/Stainless (3" diameter)[3]	Flanged	Class 250

Table 5. Glycol, Chilled, and Condenser Water Service—Continued

Glycol, Chilled and Condenser Water Service Maximum 150ºF and 275 psig (1/2"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Strainer	Pump suction	Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter)[3] Startup strainer = 16 mesh bronze	Flanged	Class 250

1. These are minimum ratings. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP = Steam Working Pressure
   CWP = Cold Water Working Pressure
   WSP = Working Steam Pressure
   WOG = Water, Oil or Gas
   Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

Table 6. Hot Water Service

Hot Water Service Maximum 250ºF and 175 psig (1/2"–12")/125 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Ball valve	Isolation	Full port 2-pc.	1/2"–2"	Bronze/Teflon	Sweat[1]	400 psig WOG
		Full port 2-pc.	1/2"–2"	Bronze/Teflon	Threaded	400 psig WOG
Gate valve	Not used					
Globe valve	ATC modulation	Control valve	1/2"–2"	Bronze/Metal	Threaded	400 psig WOG
Butterfly valve	Isolation	General service	2-1/2"–12"	Ductile Iron/EPDM	Threaded lug	200 psig CWP 200 psig bi-directional shutoff 200 psig dead end service
			14"–24"	Ductile Iron/EPDM	Threaded lug	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Plug value	Throttling	Non-lubricated	3"–12"	Steel/Iron	Flanged	Class 125
Check valve	Pumps	Silent	1/2"–2"	Bronze/Bronze	Threaded	200 psig WOG
		Silent globe	2-1/2"–24"	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern swing	1/2"–2"	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2"–24"	Iron/Bronze	Flanged	Class 125
Strainer	Control valves and flow meters	Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
			2-1/2"–4"	Iron/Stainless (1/16" diameter)	Flanged	Class 125
			5"–24"	Iron/Stainless (1/8" diameter)	Flanged	Class 125
	Pump suction	In-line Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG

Table 6. Hot Water Service—Continued

Hot Water Service Maximum 250ºF and 175 psig (1/2"–12")/125 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Strainer	Pump suction	In-line Y-Type	2-1/2”–4"	Iron/Stainless (3/16" diameter)[3]	Flanged	Class 125
			5"–24"	Iron/Stainless (3" diameter)[3]	Flanged	Class 125
		Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter)[3] Startup strainer = 16 mesh bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP = Steam Working Pressure
CWP = Cold Water Working Pressure
WSP = Working Steam Pressure
WOG = Water, Oil or Gas
Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

Table 7. Hot Water Service

Hot Water Service Maximum 250ºF and 400 psig (1/2"–12")/250 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Ball valve	Isolation	Full port 2-pc.	1/2"–2"	Bronze/Teflon	Sweat[1]	Do not use
		Full port 2-pc.	1/2"–2"	Bronze/Teflon	Threaded	600 psig WOG
Gate valve	Not used					
Globe valve	ATC modulation	Control valve	1/2"–2"	Bronze/Metal	Threaded	600 psig WOG
Butterfly valve	Isolation	High performance	2-1/2"–24"	Carbon steel/PTFE	Threaded lug	740 psig CWP
Plug value	Throttling	Non-lubricated	3"–12"	Steel/Iron	Flanged	Class 250
Check valve	Pumps	Silent	1"–2"	Bronze/Bronze	Threaded	Class 250
		Silent globe	2-1/2"–24"	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern swing	1"–2"	Bronze/Bronze	Threaded	Class 250
			2-1/2“–24"	Iron/Bronze	Flanged	Class 250
Strainer	Control valves and flow meters	Y-Type	1/2"–2"	Bronze/Stainless (20 mesh)	Threaded	600 psig WOG
			2 1/2"–4"	Iron/Stainless (1/16" diameter)	Flanged	Class 250
			5"–24"	Iron/Stainless (1/8" diameter)	Flanged	Class 250
	Pump suction	In-line Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	600 psig WOG
			2-1/2"–4"	Iron/Stainless (3/16" diameter)[3]	Flanged	Class 250
			5"–24"	Iron/Stainless (3" diameter)[3]	Flanged	Class 250

Table 7. Hot Water Service—Continued

Hot Water Service Maximum 250ºF and 400 psig (1/2"–12")/250 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Strainer	Pump suction	Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter)[3] Startup strainer = 16 mesh bronze	Flanged	Class 250

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP = Steam Working Pressure
   CWP = Cold Water Working Pressure
   WSP = Working Steam Pressure
   WOG = Water, Oil or Gas
   Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

Table 8. Hot Water Service

Fuel Oil Service **Maximum 150ºF and 150 psig (1/2"–12")/125 psig (14"–24")**						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Ball valve	Isolation	Full port 3-pc.	1/2"–2"	Carbon steel/PTFE	Threaded	250 psig WSP
Gate valve	Isolation		1/2"–2"	Bronze/Metal	Threaded	Class 125
Globe valve	ATC modulation	Control valve	1/2"–2"	Bronze/Metal	Threaded	400 psig WOG
Butterfly valve	Not used					
Plug value	Throttling	Non-lubricated	3"–12"	Steel/Iron	Flanged	Class 125
Check valve	Piping	Y-Pattern swing	1/2"–2"	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2"–24"	Iron/Bronze	Flanged	Class 125
Strainer	Control valves and flow meters	Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
			2-1/2"–4"	Iron/Stainless (1/16" diameter)	Flanged	Class 125
			5"–24"	Iron/Stainless (1/8" diameter)	Flanged	Class 125
	Pump suction	In-line Y-Type	1/2"–2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
			2-1/2"–4"	Iron/Stainless (3/16" diameter)	Flanged	Class 125
			5"–24"	Iron/Stainless (3" diameter)	Flanged	Class 125

Table 8. Hot Water Service—Continued

Fuel Oil Service Maximum 150ºF and 150 psig (1/2"–12")/125 psig (14"–24")						
Specialty	**Application**	**Type**	**Size**	**Body/Seat Body/Trim**	**Connection**	**Minimum Rating[1, 2]**
Strainer	Pump suction	Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter) Startup strainer = 16 mesh bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP = Steam Working Pressure
   CWP = Cold Water Working Pressure
   WSP = Working Steam Pressure
   WOG = Water, Oil or Gas
   Class = ANSI Standard

-END-

15122

Gauges

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for meters and gauges.

B. System Design and Performance Requirements

1. Pressure gauges must be bronze Bourdon tube-type, accurate to ±1 percent.
2. Pressure gauges must be easily accessible and easily read. Gauges readable from the floor at less than 5' must have 4-1/2" dials. Other gauges must have 6" dials. Gauge graduations must meet the limit requirements of normal operation. Gauges must indicate at mid-scale.
3. Thermometers must have a 9" scale and white face with black-filled engraved letters. Thermometers must be angular or straight-stemmed, as conditions necessitate.
4. Combination pressure and temperature (P/T) test plugs must be1/4" or 1/2" NPT. Plugs must be rated at zero leakage from vacuum to 1000 psig.

C. Manufacturers

Subject to compliance with the design requirements, provide products by one of the following manufacturers: Faceplate readings shall reflect designed working temperatures and pressures. The gauges shall read either 20 psi or 20°F above or below design values.

1. Pressure gauges:
   - U.S. Gauge
   - Trerice
   - Ashcroft
2. Thermometers:
   - U.S. Gauge
   - Trerice
   - Ashcroft
3. Combination pressure and temperature (P/T) test plugs:
   - Peter Equipment Company “Petes Plug”
   - Sisco, Inc. “P/T Plugs”

D. Materials

1. Thermometer wells must be bronze, non-mercury filled.
2. Combination pressure and temperature (P/T) test plugs must be constructed of solid brass with a Nordel valve core suitable for temperatures up to 350°F.
3. Gauges must have white faces with black-filled, engraved lettering. Gauge bodies must be set in phenolic cases. Provide siphons and shut-off cocks and pigtails for each pressure gauge.

E. Accessories or Special Features

Provide combination pressure and temperature (P/T) test plugs with extension fittings for each plug suitable for use with 2" maximum pipe insulation.

F. Installation Guidelines

1. Install thermometer wells to ensure the minimum restriction of water flow in the pipe.
2. Provide access for reading gauges.
3. To facilitate performance verification and for on-going operation and maintenance, provide sufficient temperature and pressure gauges and flow meters beyond that necessary to control the systems.
4. Provide pressure and temperature (P/T) test plugs close to the controlling sensors for verifying their calibration.

-END-

15140

Domestic Water Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for domestic water systems piping within a facility.

B. System Design and Performance Requirements

1. The maximum water velocity in piping must not exceed 5 feet per second.
2. Provide water shock absorbers at all flush valves and other locations where sudden valve closures would cause water hammer. Do not use capped air columns, which become water logged after a period of time.
3. The maximum static water pressure at fixtures must be 75 psig. Provide pressure reducing valves where static pressure exceeds 75 psig.
4. For large plan spaces, such as laboratories, consider a looped piping system to facilitate changes to the system and provide redundancy of feed and constant pressure to all areas.
5. Provide adequate expansion loops and anchors.
6. Be sure building service connections coordinate with the HVAC equipment.
7. Provide freeze protection for exterior water lines, such as cooling tower feeds.
8. Install hose bibs in all machinery rooms, kitchens, and in all rooms containing floor drains but no water-supplied fixtures.

9. Design professional(s) shall review city water pressure at a nearby city water hydrant. Northeastern Fire Marshal's office maintains hydrant test data for 2 years. If not available, design professional(s) shall request a hydrant test. Copy of test shall be included in design development package along with pressure calculations. This will determine if a domestic water pressure booster pump(s) are required.

C. Submittals

Submit the following design and construction documentation.

1. **Designer Submittals**

   Submit domestic water load and non-potable load calculations with sketch.

2. **Construction Documents**

   Submit pipe cleaning and pipe pressure test reports.

D. Materials

All interior copper water piping above grade must be Type L only.

1. **Domestic Cold Water**

   Maximum operating limits: 100 psig, 250 ₣ maximum temperature: copper

2. **Domestic Hot Water**

   Maximum operating limits: 100 psig, 250 ₣ maximum temperature: copper

3. **Domestic Hot Return**

   Maximum operating limits: 100 psig, 250 ₣ maximum temperature: copper

4. **Non-Potable Water**

   Maximum operating limits: 100 psig, 250 ₣ maximum temperature: copper

E. Installation Guidelines

1. Install an isolation valve on each piping riser.
2. Install drain valves with 3/4" hose connections and caps at all low points in the system.
3. To prevent transmitting vibrations through the piping system, install flexible connections on piping connected to vibrating equipment.
4. Do not install plumbing piping in transformer vaults, switchboard rooms, data centers or telephone rooms.
5. Install frost-proof hose bibs every 100 ft around the building, on the roof for washing down air handling unit coils, and in mechanical rooms.
6. Do not use mechanical joining components.

-END-

15150

Sanitary or Laboratory Waste and Vent Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for sanitary, laboratory waste, and vent systems piping within a facility.

B. System Design and Performance Requirements

1. Use cast iron or copper Type M drain lines for sanitary drainage. Plastic or copper will radiate noise more readily to the surrounding spaces. Acid waste piping to be utilized in lab drainage.
2. The lab waste drainage and vent piping system must be separate from the domestic sanitary waste and vent system until after lab waste neutralization system tanks. Laboratory wastes and animal cage washroom floor drains must pass through the neutralization system.
3. All condensate from air conditioning equipment and other HVAC drains, including cooling tower overflow and drain, must go to the sanitary sewer system. The use of condensate pumps is approved.
   a. There must be an indirect connection between air conditioning equipment drain piping and the sanitary plumbing system.
   b. All traps must be deep seal type and provide trap primers where deemed necessary.
   c. Open-sight drains, if used, must not be in concealed spaces. Provide trap primers for drains.

4. The following requirements apply to the condensate drains from cooling coils and to the drains from sections of air conditioning units and plenums.
   a. All fan coils must have condensate drain lines, even if designed for sensible cooling only. Provide a sufficient number of unit drain risers to permit a slope in the horizontal drain lines of at least one inch per 40 feet. The minimum horizontal drain must be 3/4 inches in diameter. As a general rule, the maximum horizontal run must be 40 feet. The use of condensate pumps is authorized.
   b. As a general rule, avoid condensate drainage directly through the wall to the ground.

C. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

Submit sanitary and laboratory fixture count calculations with sketch.

2. Construction Documents

Submit pipe cleaning and pipe pressure test reports.

D. Materials

1. Sanitary Waste and Vent Piping

Gravity flow, 120°F maximum temperature, cast iron pipe.

2. Force Main

Maximum operating limits: 50 psig, galvanized steel.

3. Lab Vent Piping

Gravity flow, 100°F maximum temperature, polypropylene.

4. Lab Waste Piping

Gravity flow, 120°F maximum temperature, polypropylene.

5. Lab Waste Forced Main

150 psig, 120°F maximum temperature, polypropylene.

E. Installation Guidelines

1. Maintain air gaps, as required by code, where indirect waste discharges into traps or funnel drains.
2. Provide floor drains with trap primers at the following locations:
   a. At fire protection riser alarm valves and at test-and-drain valves when not discharged through a wall.
   b. At pumps, refrigeration compressors, air compressors, vacuum pumps, boilers, water heaters, air conditioning equipment, water softeners, and other locations as required.
   c. In kitchens near dishwashers, steam kettles, large refrigerators, and at other locations as required.

-END-

15160

Storm Drainage Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for storm drainage system piping within a facility.

B. System Design and Performance Requirements

1. 1/4"/ft slope (minimum).
2. Where slope is not feasible, locate drains below the adjacent roof surface near the center of structural framing bays, but not near columns, girders, and intersections with vertical surfaces. Drain size must be 3" IPS (minimum), with strainer.
3. When the roof area is surrounded by parapet walls, provide emergency overflow scupper drains, as required by code, in addition to interior drains. The bottom of the scupper, if used, must be above the top of the cant strip (or 4" above the top of the roof surface at the drain).
4. Use the latest code or BOCA Basic Plumbing Code-2003, whichever is more stringent, for 2" rainfall per hour for a 1-hour duration and a 100-year return period.

C. Submittals

Submit the following design and construction documentation.

1. **Designer Submittals**

   Submit storm roof drain sizing calculations with sketch.

2. **Construction Documents**

   Submit pipe cleaning and pipe pressure test reports.

D. Materials

1. Use cast iron drain lines where noise is a consideration. Plastic or copper radiates noise more readily to surrounding spaces. Acid waste piping approved for lab applications.
2. Storm drain: gravity flow, 80 ℉ maximum temperature, cast iron pipe.

E. Installation Guidelines

1. Take below-grade clear water drains to a sump pit. Use duplex sump pumps to pump the water into the gravity house drain.
2. Take footing drains through a sediment interceptor before connecting them to a sump pit.
3. Provide insulation on storm drain piping based on acoustical considerations (i.e. theaters, museums, libraries, etc.)
4. Provide insulation on storm drain piping that passes through an environment that may cause condensation.

-END-

15181

Hydronic Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for hydronic heating and cooling system piping and specialties within a facility.

B. System Design and Performance Requirements

1. Design piping, hangers, and braces for seismic zone 2. The hanger supplier is not responsible for seismic design. The engineer is responsible for the design of anchors, thrust restraints, guides, and similar components.
2. Include pipe marking requirements in the project specifications. See Section 15075, Mechanical Identification. Underground systems design must include buried identification and warning tape for damage prevention.
3. Underground systems design requires an evaluation of cathodic protection. If needed, the engineer will design these systems, not the vendor.
4. Leak detection is generally not required on underground chilled water systems.
5. For large plan spaces, such as laboratories, consider a looped piping system to facilitate changes to the system and provide redundancy of feed and constant pressure to all areas.
6. Provide adequate expansion loops and anchors.

7. Water velocity and pressure drop limits.
   a. Water velocity over occupied spaces.
      (1) 4 fps is the maximum water velocity for 2" and smaller piping.
      (2) 8 fps is the maximum water velocity for 2-1/2" and larger piping to minimize water noise.
   b. Water velocity over equipment or unoccupied spaces.
      (1) 4 fps is the maximum water velocity for 2" and smaller piping.
      (2) 8 fps is the maximum velocity for 2-1/2" and larger piping.
   c. Minimum velocity and pressure drop for air removal.
      (1) 1-1/2 to 2 fps is the minimum velocity for 2" and smaller piping.
      (2) 0.75 ft/100 ft is the minimum pressure drop for 2-1/2" and up piping.
   d. The maximum pressure drop is 4 ft/100 ft.

C. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

Submit heating and cooling load calculations, with sketch, for heating hot water, chilled water, and condenser water systems.

2. Construction Documents

Submit pipe cleaning and pipe pressure test reports.

D. Manufacturers

Manufacturers to be discussed with Northeastern and approved prior to formal print.

E. Materials—Chilled Water Piping

Pipe and fittings must be manufactured in the USA. System selection is project-specific. The following underground piping systems are acceptable:

- Welded steel pipe in tunnel or half tunnel
- Direct-buried, cement-lined ductile iron
- Welded steel pipe in insulated FRP conduit

F. Installation Guidelines

1. Piping design must include drains at low points and vents at high points.
2. Install a control valve on each piping riser.
3. Install a drain valve with a 3/4" hose connection and cap at all low points in the system.
4. Ensure that water piping pitches up in the direction of flow.
5. Piping connected to vibrating equipment must have flexible connections to prevent transmitting vibrations through the piping system.
6. Do not install piping in transformer vaults, switchboard rooms, data centers, or telephone rooms, unless absolutely necessary. If necessary, consult with the electrical engineer regarding equipment protection.
7. Do not use mechanical joining components.

G. Quality Control—Testing Methodology and Extent

1. Specify weld inspection and testing that is appropriate for the project.
2. Specify hydrostatic testing at 150 percent of the design pressure. Testing at 150 percent of the working pressure is not acceptable.

H. Cleaning and Adjusting

Cleaning and flushing requirements are per current Northeastern University Facilities group requirements.

-END-

15182

Steam and Condensate Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for steam and steam condensate piping.

B. System Design and Performance Requirements

1. Determine the point of connection to the existing steam distribution system only after conferring with the Northeastern University Facilities group.
2. Any steam used for building heating must be low pressure (5–11 psig).
3. Steam must be supplied to equipment steam control valve inlets at the pressures indicated in Table 1.

Table 1. Valve Inlet Pressures

Equipment	Valve Inlet Pressure
Radiators	5 psig
Convectors	5 psig

Air heating coils	13 psig max. (Lower pressures may be used if indicated by engineering or economic considerations.)
Heat exchangers	5-13 psig
Steam humidifiers	5-13 psig
Kitchen equipment	13 psig
Sterilizers	13 psig usually
Laboratory equipment	13 psig usually

4. Provide pressure reducing stations as required for each of the following services:
   - Radiation and convector heating system reduction must be from 15 psig to 5 psig.
   - Air handling and related equipment (heating coils, steam humidifiers, unit heaters, heat exchangers, water heaters, and kitchen equipment): 5 – 13 psi.
   - Sterilizing and laboratory equipment: Low pressure steam at 15 psi.
5. Size PRV stations for the calculated peak demand for heating and humidification plus equipment (process) load. For equipment load, use 100 percent of the largest single user, plus 25 percent of all other users.
6. Where a single pressure reducing valve size exceeds 4 inches or the turn-down ratio (maximum load/minimum load) is greater than 10, provide two PRVs in parallel, approximately 1/3 plus 2/3 with a single bypass.
7. Where the steam service includes capacity for future expansion, size all components except the PRVs for the future. Size the PRVs for the present load.
8. Provide single a pressure gauge across the PRV with a shutoff cock in both upstream and downstream sensor tubes.
9. Service rooms in which PRV stations are located must be of suitable size to permit easy access for equipment maintenance. If possible, provide two means of egress.

10. Provide identification for each PRV as described in Section 15075: Mechanical Identification.

11. Where feasible, low-side protection must be a pressure-relief valve with the discharge piped to the outdoors. Where such an arrangement is impracticable, use a fail-safe valve that shuts off on high pressure. Where a fail-safe valve is used, it should have a modulating action and should be arranged to throttle in an attempt to maintain a pressure in excess of normal low pressure. Provide a safety limiting valve (SLV) in series with, and upstream of, the PRV. The safety limiting valve must be a line size PRV with an external steam pilot sensing the steam pressure after the PRV. Should the PRV leak, allowing the uncontrolled flow of high-pressure steam into the low-pressure piping, the SLV must close to maintain a preset pressure above the setpoint of the PRV but below the safe working pressure of the downstream steam-consuming equipment. Arrange alarms to indicate that the PRV is not functioning. For example: PRV set to discharge at 8#; HP alarm set for 12#, and fail-safe valve attempts to maintain 15#.

12. Design all pressure reducing stations with a three-valve bypass, using a globe valve in the bypass line.

13. The pilot assembly must contain two sensing diaphragms capable of sensing the reduced, regulated pressure.

14. Because they require little maintenance, solid expansion loops are preferred over mechanical-type devices, which are subject to approval.

15. The minimum steam line size must be 1" for horizontal runs and 3/4" for vertical runs of steam and condensate. Make any necessary size reduction at the equipment.

16. Do not run long, horizontal pipe lines at the floor.

17. Allow 20 percent spare capacity in steam and condensate line sizing.

18. Piping design must include drains at low points and vents at high points.

19. Design piping, hangers, and braces for the seismic zone indicated in Section 00200: Information Available to Designers. The hanger supplier is not responsible for seismic design. The engineer is responsible for the design of anchors, thrust restraints, guides, and similar components.

20. Include pipe marking requirements in the project specifications. Underground systems design must include buried identification and warning tape for damage prevention.

21. For any large steam service, such as the low pressure system for a large building, provide a small, globe-type, warm-up valve, located for convenient operation, to by-pass the main shut-off valve.
22. Design the returns from all pieces of steam-operated equipment to flow by gravity to the return main, flash tank, or pump set. This condition might require trenches in basement floors when pipe space is not provided below basements. Mount hot water generators, converters, and air heating coils high enough to allow gravity condensate flow.
23. Steam condensing equipment using modulating control valves must be float-thermostatic type with an operating pressure range suitable for the maximum steam supply pressure. Trap capacities are must be scheduled on the drawings in pounds of condensate per hour at a one-quarter psi pressure differential across the trap, based on the inlet of the trap being 18 inches below the condensate outlet on the coil. The allowable pressure drop across the trap may be increased correspondingly with increased head provided in the drip leg.
24. Traps on steam line drip points must be inverted-bucket type or fixed orifice, with a bimetallic thermal element for air removal, and with a working pressure range suitable for the maximum line pressure.
25. Do not lift condensate if the system has modulating valves.

C. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

- Floor plans showing piping
- Building sections showing piping
- Isometric diagrams
- Details
- Steam and condensate load calculations with sketch

2. Construction Documents

- Coordinated shop drawings
- Catalog cuts on piping, valves, traps, unions, strainers, drains, vacuum breakers, and similar components
- Manufacturer product data and installation instructions
- Pipe cleaning and pipe pressure test reports.

D. Manufacturers

Manufacturers to be discussed with Northeastern and approved prior to formal print.

E. Materials

1. Pipe and fittings must be manufactured in the USA.
2. Steam pressure reducing valves:
   a. Use self-contained, stainless steel regulators with fluorocarbon compound inserts suitable for steam service.
   b. In all cases, use cast iron valves with ANSI Class 250 body pressure ratings at 450°F.
   c. All valves must be capable of shutting off tight against full primary pressure up to the full body rating.
   d. 2" and smaller valves must have treaded ends. 2-1/2" and larger valves must be 250 flanged.
   e. Actuators must be constructed of cast iron or pressed steel and bolted to the main part of the valves. The use of threaded locknuts is not permitted.

F. Quality Control—Testing Methodology and Extent

1. Specify weld inspection and testing that is appropriate for the project.
2. Specify hydrostatic testing at 150 percent of the design pressure. Testing at 150 percent of the working pressure is not acceptable.

G. Cleaning and Adjusting

Cleaning and flushing requirements are per current Northeastern University Facilities group requirements.

-END-

15185

Hydronic Pumps

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for plumbing and HVAC system hydronic pumps.

B. System Design and Performance Requirements

1. Use end-suction pumps for most systems.
2. Use in-line pumps for 100 gpm or less in hot water heating systems.
3. Use double-suction pumps for large-capacity hot water and chilled water systems.
4. Provide pressure gauges for every pump, except small “boosters,” which must have gauge cocks only.
5. Specify that piping and pumps be installed and connections aligned, but not made up, until inspection by Northeastern University. All piping must be supported independently of the pumps.
6. In-line, end-suction and split-case pumps bearing frame and pump internals must be serviceable without disturbing motors or connected piping.
7. Select pumps for an impeller diameter not greater than 90 percent of the maximum pump impeller diameter.
8. Select pump motors to be non-overloading at any point along the pump impeller curve.
9. Select pumps between 65 and 115 percent of best efficiency point along the pump impeller curve.
10. Specify shaft grounding systems when variable-frequency drives are applied.

C. Submittals

Submit the following design, construction, and certification documentation.

1. Designer Submittals

Submit pump sizing calculations with system sketch.

2. Construction Documents

Submit the following test reports:

- Installed pump performance test and balance report.
- Pump alignment report.

3. Product Certificates Signed by Manufacturer

Specify that pumps be inspected by the manufacturer's authorized representative who must submit a written report to the engineer with a copy to Northeastern University stating that the pump has been properly installed, is operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Product Standards

Products must conform to the following standards:

- Hydraulic Institute standards
- ASME PTC 8.2 and 9
- CSA standards
- UL Motor-Operated Water Pumps Standard

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **In-Line Pumps**
    - Bell & Gossett
    - Taco
    - Grundfos

2. **Booster Pumps-Circulator**
    - Bell & Gossett
    - Taco
    - Grundfos

3. **End-Suction Pumps**
    - Bell & Gossett
    - Taco
    - Armstrong

4. **Double-Suction Pumps**
    - Bell & Gossett
    - Taco
    - Armstrong

5. **Vertical-Split and Split-Case Pumps**
    - Bell & Gossett (structural steel base with groutable coupling replacement, without removing motor or pump).
    - Provide pump alignment on a strong base.
    - Provide an integral, variable-frequency drive for all large pumps over 5hp.

6. **Suction Diffuser**
    - Taco
    - Armstrong

F. Materials

1. Double-Suction Split-Case Pumps

a. Double suction pumps must have horizontally- or vertically-split casings.

b. Materials of construction must be a bronze-fitted pump and must include a cast-iron casing, bronze shaft sleeves, alloy steel shafts, and a bronze-enclosed double-suction impeller. Provide re-greasable ball bearings, replaceable casing wear rings (at all critical clearances between the impeller and volute), drains and vents, flexible coupling, coupling guards, and a steel baseplate. At the manufacturer's option, a stainless steel shaft with no sleeve may be substituted for the shaft components.

c. When mounted vertically, split case must be designed for complete servicing without disturbing piping or alignment.

d. Pump volute must be supplied with plugged vent drain and gauge tappings at suction and discharge ports.

e. Provide internally-flushed ceramic seal seats and carbon seal rings.

f. Where a variable-frequency drive (VFD) is used with the pump, provide an elastomer coupling that is compatible with the VFD technology applied to the pump.

2. End-Suction Pumps

a. End-suction pumps must be based mounted, horizontally coupled, with vertically-split cases.

b. Materials of construction must be for a bronze, fitted pump and must include cast iron casings; bronze shaft sleeves; alloy steel shafts; and bronze, enclosed impellers. Provide regreaseable or permanently-lubricated ball bearings, replaceable casing wear rings (at all critical clearances between the impeller and volute), drains and vents, coupling guards, and a steel base plate.

c. Pump casings must have vent and drain ports, and must have gauge ports at the suction and discharge nozzles.

d. The base plate must be structural steel.

e. Provide a flexible-type coupler and coupling guard.

f. Where a variable-frequency drive (VFD) is used with the pump, provide an elastomer coupling that is compatible with the VFD technology applied to the pump.

3. **In-Line Pumps**

   a. In-line pumps must have bronze-fitted construction and must include cast iron casings, bronze or copper shaft sleeves, alloy steel shafts, and bronze impellers. Bearings shall be either sleeve-type or re-greaseable ball bearings.

   b. In-line pumps must have a working pressure of 175 psi, a ceramic seal seat, and a carbon seal ring.

   c. Pump casings must have vent and drain ports, and must have gauge ports at the suction and discharge nozzles.

   d. Provide replaceable casing wear rings at all critical clearances between the impeller and volute and between the drain and vent connections. Provide a flexible coupling or direct drive connection between the pump and motor. If the schedule pump includes ball bearings and a direct drive motor-to-impeller connection, the submitted pump must not have sleeve bearings or a flexible coupling between the pump and motor.

   e. Pumps for domestic water applications must be of bronze construction.

   f. Where a variable-frequency drive (VFD) is used with the pump, provide an elastomer coupling that is compatible with the VFD technology applied to the pump.

4. **Pump Motor Drives**

   All pumps over 5 hp must have a variable-frequency drive.

G. Accessories or Special Features

1. **Couplings**

   Couplings must be approved by the Northeastern University Facilities group.

2. **Strainers**

   a. For water service, strainers must be the same size as entering pipe size and have a maximum clean pressure drop of one psid.

   b. Use pump startup strainer screens for cleaning, and remove the afterwards.

   c. Provide a blow-off valve on each strainer. Where feasible and permitted by code, blow-off must be piped to the closest drain.

3. **Suction Diffusers**

a. Suction diffusers must have an angle-type body with inlet vanes and a combination diffuser – strainer orifice cylinder. Suction diffusers must also have 200 psi cast-iron body and stainless steel sleeve with 5/32" perforations. Units must include flanged connections, a removable gasketed cover, a permanent magnet, and straightening vanes.

b. Provide a 16-mesh startup strainer.

c. Provide blow-off tapping and a valve on the bottom of the unit.

d. Provide a full-size inlet and outlet.

4. **Triple-Duty Valve**

a. Triple-duty valves must have a combination non-slam check valve with a loaded-weight, contoured disc. The valves must feature calibrated regulation of pump discharge flow and a positive shut-off.

b. Valves must be repacked under full line pressure.

c. The valve must be capable of operating in conditions up to 170 psi and 300°F.

H. Special Requirements—Source Control

The manufacturer must maintain an inventory of all wearing parts within 50 miles of Boston, MA.

I. Installation Guidelines

1. Provide pump suction fittings on the suction sides of base-mounted, centrifugal pumps.
2. Provide combination pump discharge valves on the discharge sides of base-mounted centrifugal pumps.
3. Support pump fittings with floor-mounted pipe and flange supports.
4. Each pump must be level and re-aligned. Base-mounted pumps must be grouted.
5. Provide a spring-loaded check valve in the pump discharge, in lieu of a swing check valve.
6. All steam and condensate pumps must be vented to the outdoors.
7. All steam and condensate pumps must be fitted with wafer check valves, thermometers, and Y-type strainers.
8. The receivers on condensate pumps must be sized for a minimum of 15 minutes of

net storage.

9. All duplex pump sets require electric alternators for the two pumps.

J. Quality Control

1. If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards and listed in the project specifications do not conflict with commissioning procedures for testing and training.
2. Specify that at least one final alignment be performed in the field.

-END-

15186

Steam and Condensate Pumps

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for steam and condensate pumps.

B. System Design and Performance Requirements

1. All condensate must be returned to the boiler plant by a duplex condensate return pump set discharging into a pumped return line.
2. To reduce condensate temperature to a specified pumping temperature of 200 °F, flash tanks must be installed on condensate return lines ahead of the condensate receiver.
3. Size condensate pumps for 2-1/2 to 3 times the amount of condensate returned in one minute.
4. To prevent short-cycling of the pump, size the storage capacity of the receiver to allow a full discharge flow rate for 1-1/2 to 3 minutes.

C. Submittals

Submit pump sizing calculations, with sketch, for condensate return pumps.

D. Product Standards

Products must conform to ANSI/Hydraulic Institute 8.1–8.5.

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **Condensate Transfer Pumps**
    - Hoffman
    - ITT-Domestic

- Grundfos

2. **Pressure-powered pumps (liquid movers)**
    - Gestra
    - Johnson
    - Armstrong
    - Spence

F. Materials

1. Ensure that a gauge glass is provided with the unit.
2. Use a thermometer and pressure gauge in the discharge line from the unit.

G. Installation Guidelines

Design the installation so that the units are accessible for service. If a duplex condensate pump is installed in the pit, locate the starter, disconnect switch, and alternator outside and adjacent to the pump pit.

H. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15189

HVAC Water Treatment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains HVAC system water treatment design criteria.

B. Submittals

Submit a water treatment analysis.

C. Installation Guidelines

1. Install coupon racks for heating, cooling and condenser water systems in an accessible location.
2. Install chemical shot feeders in areas that are easily accessible and where shot feeders can be washed down.
4. Clean and flush all water lines before connecting them to the central plant.
5. Provide backflow preventers on all systems using chemical treatments.
6. Provide a means of secondary containment for all chemical treatment drums.

D. General

The contractor shall provide chemicals and labor for the pre-operational cleaning of all condenser, chilled, glycol or hot water and related equipment piping systems. This cleaning method is not intended for potable water systems.

E. Preparation for Clean-Out

All systems must be prepared prior to the introduction of the chemical cleaner.

1. Contractor shall flush all systems, including mud from drop legs. The piping system must be free of mud, silt and construction debris. Remove, clean and replace all strainers. All Systems shall contain city water.
2. Complete circulation must be achieved during the cleaning procedure. A minimum flow rate of 2 ft/sec. needs to be maintained to insure that the cleaning chemicals will work properly. All manual, electrical, air and thermostatic operated valves must be open. All dead end runs must be looped together with piping not less than 1/3 the size of the run. This piping is to remain in place until cleaning is complete.
3. A minimum of 1-1/2" ball or gate valve is to be permanently installed in the low point of each system for the purpose of draining each system.
4. The cleaner shall not require external heat to ensure its effectiveness.

F. Chemicals

The cleaning solution shall be formulated to remove light grease, cutting oils, loose mill scale, organics and extraneous construction debris. The cleaner shall contain inorganic phosphate, an organic corrosion inhibitor, a dispersant, and oil emulsifiers. Enough cleaner should be used to treat all of the piping to remove oil and grease and to permit a uniform passivating film to form.

G. Pre-Operational Cleaning

1. Add chemical directly into the closed loop system before the recirculation pumps to ensure rapid mixing an distribution throughout the system. Refer to MSDS sheets for safety information.
2. For ideal metal passivation, adjust the pH to 6.5. to 7.5 with a small amount of sulfuric acid.
3. Recirculate the system for 16-24 hours.
4. Open and drain mud legs and low points periodically during the cleaning process.
5. Drain systems completely paying particular attention to mud from drop legs and all low points.

6. Refill the system with clean, potable water, check all strainers, recirculate and drain completely.
7. Refill the system again. The length of time between the completion of the cleaning procedure and addition of the corrosion inhibitor shall not exceed twenty-four (24) hours.
8. Add the recommended level of closed loop inhibitor. The system is now ready for operation.
9. Procedure to connect chilled water to the Central Plant chilled water system consists of the following requirements: a) Central Plant personnel must be notified at least two working days before planned start-up. b) Central Plant personnel must observe the system in the clean-up as listed in step one. c) Central Plant personnel must test the water in step 8 for pH and level of corrosion inhibitor. d) Central Plant personnel must test the system for trapped air by opening the manual air vents and checking some drains. e) Central Plant personnel will valve the system to be part of the Central Plant chilled water system.
10. Procedure for all other water and glycol-water mixes is to test the water in step 8 for pH and level of corrosion inhibitor and test the system for trapped air by opening the manual air vents and checking some drains.
11. A service report will be generated on-site by the water treatment representative, certifying that the systems have been cleaned in accordance with the above procedures and shall be copied to the mechanical contractor. A copy of the service report can also be forwarded to the consulting engineer (as requested).

-END-

15194

Fuel Gas Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for fuel gas systems.

B. Materials

1. Natural gas.
2. Maximum operating limits: 50 psig, 70 ℉ maximum temperature, carbon steel.
3. Malleable steel fittings.

C. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

Submit fuel gas calculations, with pipe sizes and sketch, for each gas-user system.

2. Construction Documents

Submit pipe cleaning and pipe pressure test reports.

-END-

15211

General Service Compressed Air Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for non-medical compressed air piping systems and accessories.

B. System Design and Performance Requirements

Design compressed air systems for longevity, durability, and flexibility.

C. Materials

Compressed air—maximum operating limits: 125 psig, 120 ℉, copper. Type L wrought fittings only.

D. Submittals

Submit compressed air calculations, with sketch, for compressed air system equipment selection and piping.

E. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15212

Laboratory Air and Vacuum Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for pipe, fittings, and specialties for laboratory air and vacuum systems.

B. System Design and Performance Requirements

1. Design laboratory air and vacuum systems for longevity, durability, and flexibility.
2. Design compressed air and vacuum systems for medical, surgical, dental, and laboratory facilities to be completely independent of each other.
3. Provide a dew point monitor for the compressed air system, and the list the required system dewpoint in the contract documents.
4. All compressed dry air, medical gas piping, and vacuum piping shall be Type L copper. Fittings shall be brazed and purged with inert gas during installation.

C. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

Submit laboratory air and vacuum calculations, with sketch, for piping and equipment selection.

2. Construction Documents

Submit pipe cleaning and pipe pressure test reports.

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15213

Medical Gas Piping

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for pipe, fittings, and specialties for medical gas piping systems.

B. System Design and Performance Requirements

1. Design laboratory air and vacuum systems for longevity, durability, and flexibility.
2. Design compressed air and vacuum systems for medical, surgical, dental, and laboratory facilities to be completely independent of each other.
3. Provide a dew point monitor for the compressed air system, and list the required system dewpoint in the contract documents.

C. Materials

Medical Air—maximum operating limits: 125 psig, 120 ℉ copper.

D. Submittals

Submit the following design and construction documentation.

1. Designer Submittals

a. Submit medical air and vacuum calculations, with sketch, for piping and equipment selection.

b. Provide dewpoint.

2. Construction Documents

Submit pipe cleaning and pipe pressure test reports.

E. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15251

General Service Compressed Air Equipment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for non-medical, general service compressed air equipment, including air dryers.

B. System Design and Performance Requirements

Design compressed air systems for longevity, durability and flexibility.

C. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Ingersoll rand
- Scales
- Zerk (Air Dryers)
- Atlas Copco

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15252

Laboratory Air and Vacuum Equipment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for laboratory air and vacuum systems equipment, including air dryers.

B. System Design and Performance Requirements

1. Design laboratory air and vacuum systems for longevity, durability. and flexibility.
2. Vacuum pumps serving laboratories must be duplex package, with receivers, alarms, and control panels. Each pump must be capable of carrying the entire load.
3. Air compressors serving laboratories must be duplex or triplex package, with alarms, desiccant dryers, receivers, and control panels.
4. Design compressed air and vacuum systems for medical, surgical, dental, and laboratory facilities to be completely independent of each other.

C. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15255

Medical Air and Vacuum Equipment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for medical air and vacuum systems, including compressors, dryers, purification, filters and vacuum pumps, and oral evacuation systems.

B. System Design and Performance Requirements

1. Design laboratory air and vacuum systems for longevity, durability. and flexibility.
2. Vacuum pumps serving medical facilities must be duplex package, with receivers, alarms, and control panels meeting NFPA 99 requirements. Each pump must be capable of carrying the entire load.
3. Air compressors serving laboratories must be duplex or triplex package, with dryers, receivers, alarms, and control panels. Air compressors must meet NFPA 99 requirements.
4. Design compressed air and vacuum systems for medical, surgical, dental, and laboratory facilities to be completely independent of each other.
5. Provide a dew point monitor for the compressed air system, and list the required system dewpoint in the contract documents.

C. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- ITT Domestic Clincal
- Nash
- Beacon Medical
- Ingersoll-Rand

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15410

Plumbing Fixtures

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for plumbing fixtures, including faucets and flush valves.

We encourage use of innovative new products: When designers want to use new products, they are required to present to Northeastern Utilities and Engineering for discussion, review and approval.

B. System Design and Performance Requirements

Design the plumbing system for safety, longevity, durability, and flexibility. Provide thermostatic mixing and pressure balancing valves for all baths and showers.

1. Fixture Quantities (General)

Northeastern University will tolerate under-fixturing on individual floors or in specific building areas only if horizontal or vertical occupant access to fixtures in other areas is sensible.

a. Base quantities on the anticipated maximum, normal-use bui1ding capacity.

b. Quantities must be satisfactory to code-enforcing officials and/or funding agencies. Use the quantities listed in Table 1 as a guide for preliminary planning.

c. For all new or remodeled building construction, the aim is to satisfy anticipated demand. However, avoid over-fixturing because of the comparatively high cost of these facilities and spaces.

d. When comparing proposed quantities to codes or other required standards, be aware that codes and standards usually apply to fixture totals for an entire single-type occupancy building. Therefore, fixture quantities on each floor of such a building need not necessarily meet codes or standards.

2. Fixture Quantities

Verify fixture quantities as specified by state and local building codes.

a. *Office Buildings*

The OSHA quantities for water closets and urinals listed in Table 1 are satisfactory.

Table 1. Fixture Quantities

Water Closets, Lavatories, and Urinals					
	Men		Women		Men & Women
Persons	WCs	Urinals	WCs	Persons	Lavatories
1-5	1	0	1	1-15	1
6-15	1	0	1	16-36	2
16-35	2	0	2	31-60	3
36-55	2	1	3	61-90	4
56-80	3	1	4	91-125	5
81-110	4	1	5	126-170	6
111-150	4	2	6	171-205	7
151-190	5	2	7		

b. *Research Buildings*

Per code, fixture quantities should be the same as for office buildings, but only if it is anticipated that all occupants will be in the building as constantly as occupants of an office building. If the building program does not define this constancy, it must be determined for its effect on fixture quantities. If proposed quantities are less than the code requirements, a code exception will be investigated.

c. *Places Of Assembly*

Designers may recommend fixture quantities in places of assembly. See the applicable code for minimum requirements. However, provide no less than two of each type of fixture in any one toilet room.

d. *Libraries*

Per code, a library, depending on its type, could fall into either the same category as an office building or in the public or semi-public building category. Evaluate each library according to its type and category. Some small libraries can be categorized as classrooms. A large library, such as Sterling Memorial, could fall into a category not covered by code. As a guide for such a separate category, about one sanitary fixture (water closet or urinal) per 50 reader seats (and about the same number of lavatories) should be adequate, if facilities for staff are considered separately. A proposal involving such a separate category should be approved by code or funding authorities prior to incorporation into a building.

e. *Other Building Types*

If fixture quantities are not stated in the building program for other types of buildings, base the quantities on modifications of those developed by the architect and approved by Northeastern University and code or funding authorities for the types of buildings listed above.

f. *Counting Fixtures for the Handicapped*

Include all fixtures provided for the physically handicapped in the fixture count. Wherever "unisex" toilet rooms are used, apply each WC as a deduction from the combined requirement for both sexes before apportioning the remaining needs among such gang toilet rooms as might be designated for each sex. Unisex toilet rooms are preferred, where feasible, for this use.

3. Mounting of Fixtures

Hang fixtures on walls wherever possible. Use chair hangers or (as for a battery of lavatories) a less expensive substitute.

4. Fixture Types

a. *Lavatories*

Northeastern University prefers vitreous china lavatories with integral back and front faucets. The minimum size is 20" W x 18" outside. Space is 26" o.c.

b. *Water Closets*

Water closets must be elongated, siphon-jet action, with open front white seats. Include flush valves where feasible and specify ‘dual-flush’ flush valves where appropriate.

c. *Urinals*

Urinals (men only) must be vitreous china, siphon-jet action, with flush valves. For standards of quality, see the manufacturers and model numbers listed below under Manufacturers.

5. Plumbing Fittings

For lavatory faucets, use fittings that are not self-closing.

C. Manufacturers

Verify all acceptable manufacturers with Northeastern prior to final printing.

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15412

Emergency Plumbing Fixtures

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for emergency eyewash and shower units.

B. System Design and Performance Requirements

1. Design the plumbing system for safety, longevity, durability, and flexibility.
2. Provide a tempered water supply for all emergency showers and eyewashes.
3. Eyewashes must be full-face.

C. Product Standards

Products shall conform to ANSI-358.1 standards.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **Emergency Showers**
    - Speakman
    - Symmons
2. **Emergency Eyewash Units**
    - Haws

E. Installation Guidelines

1. Verify that tempered water has been specified for emergency fixtures.
2. In conjunction with code and standard requirements, emergency showers must be located in adjacent corridors or at the hazard room door exits. The showers are to be accessible, require not more than 10 seconds to reach, and be within a travel

distance of no greater than 50 ft from the hazard rooms.

3. Provide emergency showers and eyewash fountains for:
   - Laboratories
   - Boiler rooms
   - Cooling towers
   - Chemical treatment areas
   - Deionizing acid regenerant tank
   - Battery charging rooms
   - Provide additional emergency showers and eyewash fountains in other areas that:
     – have hazardous materials that will be used in the area, and
     – have no other emergency showers and eyewash fountains located within 50 feet of the area.
4. Provide full-size ball valves to isolate emergency showers or eyewash fountains. Lock the valves in the open position.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15415

Drinking Fountains and Water Coolers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for drinking fountains and water coolers.

B. System Design and Performance Requirements

Design the plumbing system for safety, longevity, durability, and flexibility.

1. Fixture Quantities (General)

Northeastern University will tolerate under-fixturing on individual floors or in specific building areas only if horizontal or vertical occupant access to fixtures in other areas is sensible.

a. Base quantities on the anticipated maximum, normal-use bui1ding capacity.

b. Quantities must be satisfactory to code-enforcing officials and/or funding agencies.

c. For all new or remodeled building construction, the aim is to satisfy anticipated demand. However, avoid over-fixturing because of the comparatively high cost of these facilities and spaces.

d. When comparing proposed quantities to codes or other required standards, be aware that codes and standards usually apply to fixture totals for an entire single-type occupancy building. Therefore, fixture quantities on each floor of such a building need not necessarily meet codes or standards.

2. Fixture Quantities

Verify fixture quantities as specified by state and local building codes.

C. Product Standards

Products must conform to ANSI/NSF 61 standards.

D. Manufacturers—Stainless Steel Water Coolers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Halsey Taylor
- Elkay
- Oasis

E. Bottle Filling Stations

Where ever possible, water coolers are to be specified with a bottle filling station, like Halsey Taylor's HYDROBOOST, Elkay's EZH2O and Oasis's Aqua Point.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15430

Plumbing Specialties

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for water and drainage piping specialties, including backflow preventers, vacuum breakers, mixing valves, water hammer arrestors, and domestic water meters.

B. System Design and Performance Requirements

1. Before design commences, professionals shall contact local water authority for complete requirements.
2. Design the plumbing system for safety, longevity, durability, and flexibility.
3. Install an approved, reduced-pressure, double-check type valve in both the potable and non-potable water supplies.
    a. Only potable water must supply drinking fountains, lavatories, sinks, janitor closets, safety showers, eyewash stations, and water heaters.
    b. Non-potable water or potable water is to must supply fire protection systems, toilets, urinals, fume hoods, laboratory sinks, outside hose bibs, and other supplies not for human consumption.
    c. A check valve must be installed upstream from the reduced-pressure valve to prevent valve dumping every time the main line pressure drops.
    d. Provide isolation valves between potable water and non-potable water.
    e. Identify and label gray-water systems.

C. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **Mixing Valves**
    - Speakman
    - Symmons
2. **Water Hammer Arrestors**
    - Wade
    - JMJ Cord
3. **Backflow Preventers**
    - Watts

D. Installation Guidelines

1. Where reduced-pressure backflow preventers are installed, install a floor drain nearby that will accommodate the full flow from the backflow preventer emergency dump port, if the valve malfunctions.
2. Install a hose bib at least every 100 ft around a building and in the mechanical room. Install a non-freeze type hose bib on the roof, near the air handling units.
3. Use trap primers only when necessary. Install them in accessible locations for maintenance.

E. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15441

Domestic Water Pumps

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section includes design criteria for inline, end suction, and water pressure boosters for domestic water pumping systems.

B. System Design and Performance Requirements

1. Provide a three-pump system for water booster pumping. Size one pump for approximately 1/3rd of the total water demand. Size each of the other two pumps for approximately two-thirds of the total water demand. Design the system so the smaller pump will run constantly until the water demand exceeds the capacity of the pump, at which point the smaller pump will stop and one of the large pumps will start. When the water demand exceeds the capacity of the larger pump, the smaller pump will automatically restart and operate together with the larger pump to provide the total water demand. The third pump will act as a standby pump. The pumps must be free of cavitation over their operating range.
2. The system must be controlled by a combination of flow or pressure switches and pressure-regulating valves, and must be designed to prevent water hammer.
3. Provide pressure gauges for every pump.
4. Specify that piping and pumps be installed and connections aligned, but not made-up, until inspection by Northeastern University. All piping must be supported independently of the pumps.
5. In-line, end-suction, and split-case pumps bearing frame and pump internals must be serviceable without disturbing motors or connected piping.
6. Select pumps for an impeller diameter not greater than 90 percent of the maximum pump impeller diameter.
7. Select pump motors to be non-overloading at any point along the pump impeller curve or in combination with other pumps.

8. Provide pressure gauges for every pump, except small so-called “boosters" which must have gauge cocks only.
9. Select pumps between 65% and 115% of best efficiency point along the impeller curve.
10. Consider a storage tank to reduce the number of pump starts.

C. Submittals

Submit the following construction and certification documentation.

1. Construction Documents

Submit the following test reports:

- Installed pump performance test and balance report.
- Pump alignment report.

2. Product Certificates Signed by Manufacturer

Specify that pumps be inspected by the manufacturer's authorized representative who must submit a written report to the engineer with a copy to Northeastern University stating that the pump has been properly installed, is operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Product Standards

Products must conform to the following standards:

- Hydraulic Institute standards
- ASME PTC 8.2 and 9
- CSA standards
- UL Motor-Operated Water Pumps Standard

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. In-Line Pumps

- Bell & Gossett
- Taco

2. **Booster Pumps—Circulator**
   - Bell & Gossett (lubricated bearing with oil seals)
   - Taco (sealed bearing)
   - Grundfos

3. **City and Hot Water Pressure Booster Pumping Systems**
   - Bell & Gossett (multiple control panel, 2-3 pumps with small tank)
   - Canaris Corporation
   - Grundfos

4. **Suction Diffuser**
   - Bell & Gossett
   - Taco

F. Materials

All wetted parts in recirculation hot water pumps and in-line boosters must be of bronze construction (bronze impellers only).

G. Accessories or Special Features

1. **Couplings**

   Couplings must be approved by the Northeastern University Facilities group.

2. **Strainers**
   1. For water service, strainers must be the same size as entering pipe size and have a maximum clean pressure drop of one psig.
   2. Use pump startup strainer screens for cleaning, and remove them afterwards.
   3. Provide a blow-off valve, full size full port ball valve on each strainer. Where feasible and permitted by code, blow-off piping must have plug.
   4. Strainer material for use in domestic water systems must be of stainless steel construction.

H. Special Requirements—Source Control

The manufacturer must maintain an inventory of all wearing parts within 50 miles of

Boston, MA.

I. Quality Control Testing

After factory assembly, the packaged pumping system must be hydrostatically tested and undergo a complete electric and hydraulic test from 0 to 100% design flow at the factory. All controls, pump sequencing devices, alarms and instrumentation must be tested and calibrated for proper operation during factory testing.

J. Installation Guidelines

1. Specify that pumps be aligned, doweled, and grouted.
2. Provide pump suction fittings on the suction sides of base-mounted, centrifugal pumps.
3. Provide a pump discharge valve on the discharge sides of each base-mounted centrifugal pump.
4. Support pump fittings with floor-mounted pipe and flange supports.
5. Each pump must be level and re-aligned. Base-mounted pumps must be grouted.
6. Provide a spring-loaded check valve in the pump discharge, in lieu of a swing check valve.
7. If the pump motor is above 15 hp, provide a beam or rail system for removal from a crowded mechanical room.

K. Quality Control

1. If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.
2. Specify that at least one final alignment be performed in the field.

-END-

15445

Sewage and Sump Pumps

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section includes design criteria for sewage ejector and sump pumping systems.

B. Submittals

Submit the following design, construction, and certification documentation.

1. Designer Submittals

Submit pump sizing calculations for sewage ejectors and sump pumps.

2. Construction Documents

Submit an installed pump performance test and balance report.

3. Product Certificates Signed by Manufacturer

Specify that pumps be inspected by the manufacturer's authorized representative who must submit a written report to the engineer with a copy to Northeastern University stating that the pump has been properly installed, is operating correctly, and the installation is acceptable to the manufacturer in every respect.

C. Product Standards

Products must conform to the following standards:

- Hydraulic Institute standards
- ASME PTC 8.2 and 9
- CSA standards
- UL Motor-Operated Water Pumps Standard

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. Sewage Ejector Pumping System

- SKB
- Weil
- Peabody Barnes
- KSB

2. Sump Pump

- Bell & Gossett (vertical flow series 800)
- Weil

E. Special Requirements—Source Control

The manufacturer must maintain an inventory of all wearing parts within 50 miles of Boston, MA.

F. Installation Guidelines

If the pump motor is above 15 hp, provide a beam or rail system for removal from a crowded mechanical room or air handler.

When more than one pump is connected to a common discharge, each pump must have independent intake and discharge isolation valves and discharge check valves. All valves and check valves must be serviceable without entering the sump tank or sump pit. Each sump tank or pit shall have an independent high level alarm that goes to the energy management system.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15480

Domestic Water Heaters

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for tankless, instantaneous- and storage-type electric, gas, hot water heaters, both household and commercial.

B. System Design and Performance Requirements

1. Design the plumbing system for safety, longevity, durability and flexibility.
2. The setpoint temperature for water heaters must be 120°F for general service and 140°F for kitchen dishwasher preheat. Provide mixing valves to distribute water to fixtures at 110°F.
3. Provide a minimum of two central water heaters for dormitories.
4. Provide temperature and pressure gauges at the inlet and outlet of each water heater.
5. Provide a minimum of two central domestic water heaters for each laboratory facility, each supplying 75% of demand. Coordinate with the Northeastern University Facilities group for other types of facilities for number of water heaters.
6. Use circulated hot water piping system, limiting dead ends to 20 feet.
7. Install lockable-type shutoff valve, with lock, locked in the open position between the expansion tank and cold water supply.
8. Provide a properly sized pressure and temperature relief valve for each domestic water heater.
9. Recirculating pumps in domestic water heating systems must be of bronze construction.

C. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

Submit domestic hot water load calculations for:

- 180° dish washers
- Building domestic hot water heaters
- Kitchen booster hot water system
- Laundry hot water system

2. Product Certificates Signed by Manufacturer

Specify that water heaters be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the water heaters have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Product Standards

Products must conform to the following standards:

- ASHRAE 90.1b
- ASME

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. High-Recovery, High-Efficiency Gas Water Heaters

- AO Smith
- Maxi-Therm
- PVI

2. High-Recovery, High-Efficiency Electric Water Heaters

- AO Smith
- Maxi-Therm

- PVI

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15487

Heat Exchanger Water Heaters

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for steam, hot water, instantaneous, and storage-type water heaters.

B. System Design and Performance Requirements

1. Design the plumbing system for safety, longevity, durability and flexibility.
2. Domestic hot water generators must be double wall.
3. Indirect water—thermo-max.

C. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

Submit domestic hot water load calculations for:

- Building domestic hot water heaters
- Kitchen booster hot water system
- Laundry hot water system

2. Product Certificates Signed by Manufacturer

Specify that water heaters be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the water heaters have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Product Standards

Products must conform to the following standards:

- ASHRAE 90.1b
- ASME

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **Instantaneous Steam Water Heaters (below 15 psi steam pressure)**
   - Leslie
   - Armstrong
2. **Semi-Instantaneous Steam Water heaters (greater than 20 psi and less than 60 psi steam pressure)**
   - Patterson-Kelley
3. **Indirect Water Heaters**
   - Thermo-Max
   - Triangle Tube

F. Installation Guidelines

1. Provide pull space for coils.
2. Provide a 2' minimum clearance around the units for maintenance.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards and listed in the project specifications do not conflict with commissioning procedures for testing and training.

-END-

15518

Firetube Boilers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for firetube boilers.

B. System Design and Performance Requirements

1. Use sectional firetube boilers is acceptable. Refer to Northeastern team.
2. General requirements include showing the location of utility service connection points, verifying the capacity of these connection points, and installing equipment in a safe, well lit, and accessible location.
3. Do not use firetube boilers outside of the powerhouse jurisdiction, without coordinating with the Northeastern University Facilities group.
4. All closed-loop, hot water systems must be piped to allow for chemical injection, as needed, for proper water treatment.
5. Equip heating systems with isolation and backflow prevention valves to prevent the cross flow of water systems.
6. Whenever possible, steam systems must be metered at the central monitoring systems. Individual boilers need not be metered. See Section 01350: Special Project Procedures on metering.
7. The temperature drop across the boiler must match the boiler manufacturer's criteria and be within the stipulated supply and return temperature ranges.
8. The ΔT across the boiler must match the boiler manufacturer's criteria.

9. The tube thickness must be in accordance with Northeastern university specifications.
10. Consider using a tankless heater at the boiler for heating domestic water.
11. Alternate fuel source:
    a. Consider uninterruptible gas, or use dual fuel-fired units as an alternative.
    b. When equipping boilers for #2 diesel fuel, ensure all lines are a minimum of 1/2" OD and are equipped with the appropriate fire and check valves.
12. For planned shutdown procedures, consult with the Northeastern Project Manager.
13. To ensure sufficient excess or redundant capacity, install two boilers, each capable of handling 70 percent of the total load.
14. Verify the turndown ratio and the minimum steam and hot water usage . Verify that the system design can accommodate minimum and maximum loads.
15. Check boiler room ventilation to ensure that adequate combustion air has been provided.
16. Ensure that the boiler is not located in the same space as refrigerant-using machines.
17. Verify the stack height with local codes and manufacturer requirements.
18. To comply with applicable codes and preclude drawing stack discharge into intakes due to wind circulation patterns around the building, verify that stack discharge is located away from outdoor air intakes.
19. Verify emergency power supply to boiler fans, valves, and controls.
20. For steam boiler maintenance, verify that bypass has been provided around the feedwater heater.
21. Determine maximum loads by adding existing steam demands and new connected loads, applying diversity factors, and allowing credit for heat recovery devices. Include boiler plant auxiliary equipment and distribution line losses in the load calculations. Determine existing loads from boiler plant records.
22. The plant must be capable of supplying the maximum steam demand with the largest boiler not operating, and with the largest pump of each service not operating.

23. The plant must be capable of supplying the minimum steam demand with the smallest boiler in a normal mode of operation, and with all auxiliary equipment operating within recommended turn-down ranges. The capacity of the smallest boiler must be sufficient for peak demand in the non-heating season.
24. Coordinate with the Northeastern University Facilities group regarding plant sizing for future steam loads.
25. Do not consider these heat recovery boilers part of the boiler plant capacity unless they can operate with their own burners, independently of the heat-generating device.
26. Provide 10 January days storage for plants which have natural gas and oil capability and 15 January days storage for plants which have capability for oil only. Where unusual local conditions exist, the design engineer may recommend deviation from these requirements.

C. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

a. See Section 01330: Designer Submittals.

b. Submit calculations for:

- Connected steam loads with future load considerations
- Condensate loads with future load considerations
- Heating hot water loads with future load considerations

c. Submit a boiler combustion test report.

2. Product Certificates Signed by Manufacturer

Specify that boilers be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the boilers have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Accessories or Special Features

If the manufacturer is to provide economizers, non-return valves, stacks, drum-level controls, microprocessors, and similar components, ensure that they are included in the specifications, along with required performance.

E. Installation Guidelines

1. Allow building access for replacement of boilers and boiler components. List maximum permissible boilers dimensions in the specifications.
2. Allow space around boilers for tube pull and replacement.
3. Provide adequate access to boiler components, especially on top where a catwalk might be required.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

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15625

Water Chillers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for water chillers.

B. System Design and Performance Requirements

1. Select chillers based on performance, service and maintainability, and life-cycle costing.
2. Specify factory testing for each new chiller, witnessed by the Engineer and Owner with cost of testing and engineer and Owner travel expenses included in Contractor pricing.
3. See Section 00705: General HVAC Design Conditions for chilled water temperatures and ΔT.
4. Provide differential pressure control systems for all chilled water systems over 20 psi that use “commercial” quality valves, or specify control valves based on actual chilled water system pressure.
5. The Central and Science area chilled water systems are designed to be variable volume, constant pressure, all-primary design systems.
6. All new work must be consistent with variable-volume, all-primary design chilled water systems.
7. The primary pumps in the plant provide a constant-pressure differential to a control point in the system. At any point in the system, the pressure differential remains relatively constant.
8. In general, the Northeastern University Facilities group extends service to the "project boundary line" of the project to be served. Building projects are generally designed to connect to the distribution at that point. The exact boundary will vary, and is determined on a case-by-case basis. Contact the Northeastern University Facilities group.

9. Most building systems can use the primary system pressure differential by a direct connection to the chilled water supply and return mains.
10. Remote points in the system might have a low pressure differential requiring a booster pump. The use of building circulation or booster pumps must be reviewed and approved in advance by Northeastern university before including them in the design.
11. Secondary loops, bridge circuits, bypasses, or any other system that allows the chilled water supply to shunt to the return are not allowed.
12. Use of the chilled water supply for condenser water in direct expansion refrigeration equipment is not allowed. The chilled water return may be used for condensing and returned to the chilled water return piping. A circulation pump is required.
13. The project manager, in consultation with the Northeastern University Facilities group will supply the following information to the designer.
    a. The location of interconnections to the chilled water distribution system.
    b. The supply pressure at the point of interconnection.
    c. The pressure differential available across the mains at the point of interconnection (determined by the hydraulic model or empirical data).
    d. Supply temperature range
14. The building control system must include controls to perform the following functions.
    a. Maintain design temperature drop at full-load conditions.
    b. When necessary, operate booster pumps to maintain design flow and prevent over-pressurization of the return main when pumps are running.
    c. Maintain the flow rate within design conditions.
    d. The use of balancing valves on the chilled water distribution system is not usually necessary. Distribution mains are sized to supply chilled water to all areas of campus at a pressure differential usable by the building system. Within building systems, particularly retrofit installations, balancing valves might be necessary.
15. All chilled water service is metered by the Central Building Utilities Metering System. See Section 01350: Special Project Procedures.

16. Equip all chillers with flow proving switches wired to prevent the compressor from starting until chilled water and condenser water flow have been established. Differential pressure switches are preferred. If flow switches are used, piping must be large enough to permit paddle installation without trimming.
17. Energy-efficient centrifugal chillers should be selected at 0.50-.60 kw/ton at full load and approximately 0.4 kw/ton at partial load. Screw chillers should be selected at 0.62-0.72 kw/ton and air cooled chillers at 0.7-0.78 kw/ton.
18. Size two chillers for 70% of the load and pipe them to cross feed with their own and the other chiller's tower.
19. Verify with the structural engineer that a lift beam and winch has been specified to lift chiller motors and compressors.
20. Maintain ambient temperatures in chiller mechanical rooms within 13°F of outdoor ambient design.
21. Verify that the system design can accommodate minimum and maximum loads.
22. On larger chillers, specify the installation of davits with marine boxes and flanged piping to simplify the removal of the heads.
23. Design chiller condensing piping to facilitate the future installation of a brush cleaning system.
24. Pipe chilled water circuits for complete functional flexibility. Provide cross-connection for chilled water pumps, suctions, and discharges. Provide automatic on/off valves where necessary to avoid pumping through an inoperative chiller.
25. Provide a chilled water filter, connected from the pump discharge back to the suction, for 1% to 2% of total flow with a constant flow device in the branch piping, for new or existing systems. Include the filter gpm in the chilled water pump capacity.
26. Typical critical systems include:
    - Laboratories
    - Medical areas
    - Administrative areas
    - Libraries
    - Museums
27. Typical comfort cooling systems include:
    - Offices

- Residence Facilities
- Dean’s suites
- Dean's offices
- Faculty offices
- Seminar rooms

28. Some units on campus (in computer rooms) are completely stand-alone with their own condensing units. Those units that cannot stand alone should be connected to the chilled water return from the central plant as a condensing medium.
29. Do not purchase R11 and R12 units. Alternative refrigerants of low toxicity and pressure are the desired refrigerants for the stand-alone systems.
30. Isolate the water systems in such a way that no chiller water could pass into the domestic water system.
31. As a minimum, safety devices are required for protection against high head pressure, oil failure, and electrical malfunctions. They will be reset manually. Any rupture disc should vent outside to a safe location.
32. Pumps and compressors, as they are located in individual buildings, must take into account the seismic restrictions for people in the adjacent areas. Noise and vibration has been a problem in some Northeastern University facilities.
33. Central air conditioning systems for a building or group of buildings must be served by two or more chillers. The size of the various chillers should be such that the load profile of the facility is matched as close as practicable through the sequential use of the selected chillers. A load profile analysis may indicate the beneficial use of two or more chillers of different size.
34. Base the selection of refrigeration equipment for system capacity over 100 tons on an economic life-cycle cost analysis. The analysis must consider the hours of operation at various loads and the life expectancy of each piece of equipment. Apply relevant Northeastern University guidelines for an engineering economic analysis.
35. The selection of the most appropriate equipment must be made by comparing three alternatives from the following types:
    - Chiller size less than 200 tons
        - Electric driven reciprocating chiller
        - Electric driven centrifugal chiller
        - Electric driven screw chiller

  - Electric driven scroll compressor
  - Steam absorption (single stage) chiller
- Chiller size from 200 tons to 1,000 tons
  - Electric driven constant speed centrifugal chiller
  - Electric driven variable speed centrifugal chiller
  - Electric driven screw chiller
  - Steam absorption (single or double stage) chiller
- Chiller size over 1,000 tons—give special consideration to combined solutions such as:
  - Electric driven centrifugal powered by engine driven generator with waste heat boiler and absorption

36. Refrigeration equipment for small air conditioning systems with capacity less than 100 tons does not need a life-cycle analysis and the comparison of three alternatives. For smaller sizes, air-cooled, direct expansion units may be used. For larger sizes, air-cooled chillers may be used.

C. Installation

1. The contractor is responsible for the notification of all sections or individuals identified by the project manager at least three days prior to disruption of utilities.
2. The contractor will provide a 24-hour emergency telephone number that will be maintained at the Physical Plant Control Center or the Northeastern University Utilities Department.
3. During installation, the contractor must have personnel available for immediate response in case of emergency (for example, broken pipes or interrupted electricity).
4. Testing of the chilled water system must be accomplished with the Physical Plant mechanics, and when specified, requires certification from an independent testing company.

D. Submittals

Submit the following design, testing, and certification documentation.

1. **Designer Submittals**
   a. See Section 01330: Designer Submittals.
   b. Submit calculations for:

- Chilled water tonnage
- Chilled water gpm
- Chilled water temperature requirements
- Chilled water temperature differential

2. **Contractor Submittals**

   Submit a factory test report.

3. **Product Certificates Signed by Manufacturer**

   Specify that chillers be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the chillers have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- York
- McQuay
- Trane
- Multistack

F. Accessories or Special Features

1. **Flow Proving Switches**

   Equip all chillers with flow proving switches wired to prevent the compressor from starting until chilled water flow has been established. Differential pressure switches are preferred. If flow switches are used, piping must be large enough to permit paddle installation without trimming.

2. **Safety Cut-Outs**

   All safety cut-outs must be manual reset types. Provide time delay for all machines.

3. **Required Devices**

   1. Provide a thermostat to prevent the unit from attempting to start when the ambient temperature is too low.

2. Provide a head pressure controller for cooling tower applications.

G. Quality Control Testing

Specify a factory test with the engineer and a Northeastern University witness to verify performance kw/ton at design operating conditions and at integrated part load value (IPLV).

H. Installation Guidelines

1. Allow sufficient clearance and access in building construction for replacement chillers and parts, and for normal chiller maintenance.
2. In new construction, the equipment room layout must provide designated space for a future machine and accessories equal in size to the largest machine being furnished. In existing buildings or plants, it is sufficient to dot-in future building expansion, if necessary, to provide the space for the future machine. In either case, space must be designated for the future starter, pumps, and cooling tower.
3. Locate chiller plants at grade level for ease of servicing. Size, arrange, and valve the plant piping for installation of the future chiller, pumps, cooling tower, and other equipment.
4. Allow sufficient clearance for tube bundle pulling and cleaning.
5. Provide marine boxes and piping to facilitate head removal.
6. Do not install chillers in the same space as fuel-firing equipment, such as boilers and water heaters.
7. Arrange chilled and condenser water piping with offsets for flexibility. Adequately support and brace the piping independently of the chiller to avoid strain on the unit.
8. Install each water pipe connected to a chiller with a flexible connection, as necessary for seismic conditions. See Section 00200: Information Available to Designers for seismic requirements.
9. Use a flexible connection at least 24" long to make all water chiller electrical connections.
10. Use vibration elimination hangers to hang all piping connected to chillers.

I. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15635

Refrigerant Monitoring and Safety Equipment

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for refrigerant monitoring and safety equipment.

B. System Design and Performance Requirements

1. General requirements include showing the locations of utility service connection points, verifying the capacity of these connection points, and installing equipment in a safe, well-lit, and accessible location.
2. Verify emergency power for refrigerant monitoring and ventilation equipment.

C. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15641

Open-Circuit, Mechanical Draft Cooling Towers

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A. Summary

This section contains design criteria for open-circuit, mechanical draft cooling towers.

B. System Design and Performance Requirements

1. General requirements include showing the locations of utility service connection points, verifying the capacity of these connection points, and installing equipment in a safe, well-lit, and accessible location.
2. Size towers for 70 percent of the load, and pipe them to cross-feed with the other towers.
3. Locate the cooling tower so that spray or plume, which can be a source of Legionella, cannot enter outdoor air intakes.
4. Consult the tower manufacturer for the octave band sound power ratings of the tower and for assistance in sound evaluations. An analysis of the proposed cooling tower relative to adjacent occupancies must be made considering noise, fan horsepower, and the cost of alternative cooling tower selections. The 60 dBA requirement at 120 feet in Section 00700: General Design Conditions, may be changed for particular projects (lower for critical locations, which may also require attenuation, and higher for non-critical locations).
5. Verify that the tower is located such that condenser pumps have sufficient net positive suction head (NPSH).
6. Provide water treatment for cooling towers, and show the location of the equipment on the drawings.
7. Treatment chemicals may be put into the return piping if the feed pump is interlocked with cooling water flow.
8. Cooling towers for systems that are not to be drained in winter must be winterized for automatic winter operation.

9. If a cooling tower by-pass is provided, the by-pass must discharge to the cooling tower basin(s) rather than to the outlet piping.
10. Provide for hoist beams overhead so that the condenser and chiller heads can be removed.
11. Piping to refrigeration equipment must be supported independently. Piping to chillers must include offsets and mechanical couplings or flanges to permit removal of heads and tubes.

C. Product Certificates Signed by Manufacturer

Specify that cooling towers be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the cooling towers have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Manufacturers

- Marley
- Baltimore Air Coil
- Evapco

E. Materials

Use stainless steel drain pans and distribution (hot) decks for long service life and to help in restricting microbial growth.

F. Installation Guidelines

1. Install davits, beams, or other means for assisting in the removal and replacement of tower motors larger than 15 hp. Vibration switches are required.
2. For multiple tower installations, provide for equalizing pipe, and provide balancing valves in the supply and return piping.
3. Valve each tower separately for servicing.
4. Provide for sufficient free and unobstructed space around the tower per manufacturer recommendations to ensure adequate air supply.
5. Do not locate towers downstream of boiler stacks or upstream and near to outdoor air intakes.
6. Install tower piping to allow for expansion and contraction flexibility between the

tower and piping.

7. Low point sump drains shall be installed.
8. The cooling tower must be located to avoid problems with noise, vibration, air recirculation or drift.
9. Provide security and maintenance lights and receptacles for maintenance at the cooling tower. When access to the tower is greater than 7 feet above grade, provide structural ladder and platform to enable access to the access doors in the cooling tower sidewalls.
10. At stations where cottonwood or similar types of trees are likely to interfere with cooling tower operation, provide easily-cleaned screens or roughing filters at the air inlets.
11. Consider how several drums of chemicals with spares might be moved to and from the point of use

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15672

Air-Cooled Condensers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for air-cooled condensers and condensing units.

B. System Design and Performance Requirements

1. Units must consist of coils with integral sub-cooling, and casings with stands.
2. Coil must be aluminum plate fins on mechanically-expanded copper tubes. Coils must be cleaned, dehydrated, sealed, leak tested at 150 psig, and pressure tested at 420 psig.
3. Fans must be direct-drive, propeller fans protected with guards.
4. Condensers must have two, 3-phase motors and one permanent split capacitor motor for use with accessory speed controls suitable for reduced-voltage starting. Motors must be pre-lubricated, with built-in overload protection.
5. Fan shafts must be corrosion-protected. Fan blades must have an irradiate or aluminum finish. Magnetic contactors must be field-supplied. Provide magnetic contractors in accessory fan cycling control packages to cycle fans in response to the outdoor ambient temperature.
6. Casings must have baked enamel finishes. Provide access panels for electrical connections.
7. Provide openings for power and refrigerant connections.

C. Installation Guidelines

1. Locate the condenser or condensing unit away from side and overhead restrictions. Maintain at least a one-half length or full-width distance from side restrictions, or as directed by the manufacturer. Overhead clearance should not restrict the full discharge of hot air.
2. Do not locate the discharge near outdoor air intakes.

3. Mount air-cooled condensers on grade on a concrete pad that is 6" larger all around than the condenser. The bottom of the pad should be carried below the frost line.
4. When mounted on the roof, a steel framework should be erected. Install vibration pads between the structural framework and the condenser supports.
5. Do not install the condenser or condensing unit in locations where the coils can become plugged, such as near cottonwood trees or in locations where construction is to take place in the near future. When not possible, provide easily-cleaned screens or roughing filters at the air inlets.

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15710

Hydronic and Steam Heat Exchangers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for shell and tube heat exchangers and for plate and frame heat exchangers.

B. System Design and Performance Requirements

1. Shell and tube heat exchangers are typically used for heating. Plate and frame heat exchangers are used for cooling applications.
2. The engineer must ensure that no cross-contamination occurs and that the materials are suitable for service.
3. Design heat exchanger piping so that the heat exchanger can be backwashed. Include a floor drain of sufficient size to accommodate the backwash.
4. Provide redundancy for both heating and cooling heat exchanger installations.
5. Provide separate heat exchangers for reheat and for perimeter heating systems.
6. Provide safety pressure relief valves on both sides of the unit between the heat exchanger and shut off valves to guard against thermal expansion when the unit is not in service and to protect against over-pressurization. Provide relief valves on heated fluid connections. Install relief valves full size of valve connection to floor drain.
7. Maintain manufacturer-recommended clearances for service and maintenance.
8. Provide piping connections to facilitate heat exchanger service and maintenance.
9. Provide shutoff valves at heat-exchanger inlet and outlet connections.
10. Provide a vacuum breaker at the heat exchanger steam inlet connection.
11. Provide a hose-end valve to drain the shell.

C. Product Standards

1. ASME Compliance

Fabricate and label heat exchangers in compliance with the ASME Boiler and Pressure Vessel Code, Section VIII: Pressure Vessels, Division 1.

2. Registration

Fabricate and label shell and tube heat exchangers in compliance with Tubular Exchanger Manufacturers Association standards.

D. Manufacturers

Subject to compliance with the design requirements, provide products by one of the following manufacturers:

1. Shell and Tube Heat Exchangers—Heating and Steam-to-Hot Water Applications

- ITT Industries
- Bell and Gossett
- Armstrong Pumps, Inc.
- Bryan Steam Corp.

2. Gasketed Plate and Frame Heat Exchangers—Chilled Water Applications)

- Alfa Laval
- Tranter PHE, Inc
- ITT Industries
- API Heat Transfer Inc.

E. Special Requirements

1. All heat exchangers must have a pressure rating of at least 125 psig for both the shell and tube bundle, even if the operating pressures are less. For high-pressure applications (above 15 psig), the shell and head must be rated for the maximum steam temperature available at the building location.
2. Equip the shell with an ASME-approved pressure/temperature relief device, piped appropriately.

3. Pipe and test heat exchangers using high pressure steam in accordance with the ASME Power Piping Code. Hydrostatic tests are required of all high-pressure components, inclusive of tests across closed valves (leakage tests). Both high- and low-pressure exchangers must be ASME-rated.

F. Installation Guidelines

1. Install glycol heat exchangers only in mechanical rooms.
2. All glycol shall be propylene.
3. Pipe heat exchangers to enable easy venting.
4. Provide service access with sufficient clearance for draining.
5. Provide sufficient pull space for shell and tube heat exchangers.
6. For plate and frame heat exchangers, provide sufficient space for adding and removing plates.
5. Coordinate plate and frame heat exchanger bolt extensions with nearby piping and equipment.
6. Heat exchanger backwashing must be accomplished without dismantling the unit and by just adding a hose.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

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15725

Air Handling Units

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for air handling units.

B. System Design and Performance Requirements

1. Provide each plenum with a trapped condensate drain piped to an open waste. The trap seal must be deep enough to withstand system pressures, but at least 6” from bottom of drain to bottom of the lowest part of the trap for constant volume systems; 8” for VAV systems—positive or negative at the trap inlet—and maintain trap seal. Allow at least 1" to drain.
2. All built-up systems and all air handling units installed without cooling coils must be constructed with all necessary perforated plates to provide systems resistance equal to the cooling coil.
3. When final filtration is provided in an air handling unit downstream from the cooling coils, make provisions to avoid wetting the filters. Carefully evaluate blow-through units in this application.
4. Air handling unit supply and exhaust air fans serving laboratories are redundant.
5. Air handling units shall have easy access rail type fan assemblies. Service +/or replacement of fan must be easy to accomplish; proper clearances must be observed.

C. Designer Submittals

1. Submit calculations for air handler airflow, pressure sizing and trap depth.
2. The manufacturer's representative must check air handling units of 5 hp and over for proper installation, alignment, belt tension, and operation. File a written report with the engineer, and provide a copy to Northeastern University. The report must state that at the time of the report the fan is running properly and is acceptable to the

manufacturer in every respect.

3. Provide sound-level data by octave band from 25 Hz to 8000 Hz for both supply and return connections at 5 feet distance from the AHU.

D. Manufacturers

Manufacturers offering products that may be incorporated in the work are subject to compliance with the design requirements, in its entirety.

E. Materials

1. Housing Construction for Factory-Built Modular Units

a. Structural Criteria

Units must conform to the structural provisions of code, including but not limited to, snow load, seismic forces, and lateral wind loads.

b. Base

The base must consist of steel beams or channels for direct bearing support of the steel floor and major components in the casing. The base must be painted with rust-inhibiting primer and rust-inhibiting exterior enamel. The base must have steel lifting lugs (1/2" minimum) welded to the corners of each rigging module.

c. Floor

(1) The floor must be of 3/16" thick steel plate welded to the base. Pans must be braced and welded at sufficient intervals to support internal equipment components and live loads without sagging or pulsating. The floor must be painted with rust-inhibiting primer and rust-inhibiting exterior enamel. Floor drains must be 2" Type L copper piping, extended to the bottom closure of the base unit. Insulate all piping within the base frame.

(2) The underside of the floor must be continuously insulated with two layers of 1-1/2" thick (minimum) rigid fiberglass insulation board, with a density of three pounds per cubic foot.

d. Coil Drain Pan

(1) The main drain pan must extend beneath the entire cooling coil, including the coil pipe header and return bends in the airway. The main drain must

extend a minimum of 18" downstream of the coils.

(2) The main drain pan must be 16-gauge stainless steel, continuously welded to form a watertight basin. The sides must be at least 4" high, with threaded 2" half-couplings welded to one side for drainage.

(3) Provide intermediate drain pans beneath each stacked cooling coil, extending a minimum of 12" downstream of the coil. These intermediate drain pans must have 2" sides and 1-1/4" stainless steel or copper vertical leader pipes to the bottom pan. Provide dielectric fittings between different materials.

(4) Avoid the use of condensate pumps; the preferred method is gravity drainage. For gravity drainage and efficient removal of condensate, air handling units must be installed with sufficient elevation to allow for required condensate trap and piping run out clearances to drain at least 6" for constant volume systems and 8" for variable volume systems.

e. *Humidifier Drain Pan*

Provide a 16-gauge stainless steel drain pan beneath the humidifier section, with 2" sides and fully welded seams. Provide 2" drain piping from the sloped pan to the unit floor drain.

f. *Walls, Partitions, and Roof Structure*

(1) Designate panel skin thickness, stiffener, frame spacing and thickness, and core density to eliminate panel pulsation and to limit the maximum deflection at design pressures to 1/200 of any span.

(2) Panels must be double-walled, with an inner 20-gauge (minimum) liner and a 16-gauge (minimum) exterior sheet. The inner wall at the fan section must be perforated galvanized steel or aluminum. Panels downstream of the cooling coil and/or the final filter must have fibrous glass completely encapsulated in a high-strength plastic film meeting NFPA 90A requirements to preclude any fiber entraining in the airstream. Exterior surfaces must be suitable for weather exposure (including rust-inhibiting primer and exterior enamel).

(3) The minimum panel thickness must be 4" filled with a full thickness of three pounds per cubic foot fiberglass insulation board. Panel sandwich construction must incorporate a thermal break at all structural members. Panels, including insulation, must meet NFPA-90A fire hazard rating

requirements. Noise transmission must be limited so that the noise level does not exceed 65 dB at any location within 10 feet of the unit.

(4) Access doors must be double-walled, with construction and performance as specified for panels. Doors must close tight against the gasket and must be air-tight.

(a) Provide one 12"x12" window (double-glazed acrylic, tempered- or wire-glass) in each door. Provide air-tight runner seals and desiccant in the air space.

(b) Doors must be a nominal 70" high and 24" wide. Doors must have three tapered latches to force the door against the gasket, and must have a full-height stainless steel piano hinge on the upstream side.

(c) Doors on the suction side of the fan must swing outward, and doors on the discharge side of the fan must swing inward. Latches must operate from both sides of the door.

(d) Access doors are required for both faces of heating and cooling coils and at fan sections, automatic dampers, louvers, humidifiers, and filters. Show access sections on the drawings.

(5) Provide removable, gasketed access panels for removal of the fan and motor. Panels must be bolted in place. Provide supports for field mounting of piping, control panels, and miscellaneous lightweight components.

(6) Panels must be factory-sealed and air-tight at the corners and seams, without visible caulking on the casing exterior. Modules assembled in the field with caulking and gasketing must be air-tight, without visible exterior caulking.

(7) Provide sufficient room for removal of the fan and fan shaft from the air handler.

g. Roof

The roof must have a one percent minimum pitch after deflection under snow load, without external standing seams. Cover the assembled roof with a continuous rubber membrane roofing system, with a 20-year warranty. Provide underlayment as required by the roof membrane manufacturer. The roof membrane must be installed by an installer approved by the membrane manufacturer. Roof construction must provide a bearing capacity for suspension of field-installed mechanical piping. Roof construction must be 4" thick, with insulation as specified for wall panels.

2. **Field-Erected Units**
   a. Units shall be installed on galvanized steel dunnage. Units shall have horizontal discharge and return air section.

   b. Provide galvanized, rigid-steel conduit from the fan motor through the casing wall. Use liquid-tight, flexible-steel conduit for the connection to the fan motor. Rigid conduit must be fixed to the casing and must not interfere with operation or access.

   c. Provide two empty, rigid-steel conduit sleeves at each compartment for ATC wiring and air tubing. Conduit sleeve locations of the must be coordinated by the testing, adjusting, and balancing contractor.

   d. Provide two weather-tight duplex receptacles on the exterior of the unit in appropriate locations. Circuit separately from the lights.

   e. Provide a local disconnect switch for the fan motor, directly outside the fan enclosure.

3. **Packaged Air Handling or Blower Coil Units**
   a. Air handling units must be factory-assembled, tested, and shipped in one piece. Provide the manufacturer's certified drawings before the building steel fabrication drawings are prepared.

   b. Air handlings units must consist of:
   - A single wall cabinet, except the wet section
   - A chilled water coil
   - A hot water coil
   - A filter section
   - Supply fan sections

   c. The frame and unit base must be 12-gauge, galvanized steel. The exterior panels must be 18-gauge, galvanized steel. Provide gasketed, hinged access doors to each section.

   (1) Provide 1" thick, 1-1/2 lb density insulation that has the following characteristics when tested in accordance with ASTME-84:
   - Maximum K-factor of 0.27
   -

- Maximum flame spread of 25
- Maximum smoke developed of 50

(2) Provide lifting brackets on each unit base to accept cable or chain hooks.

d. Provide removable hydronic coils fabricated from 1/2" or 5/8" OD seamless copper tubing with copper heads, mechanically bonded to rippled and corrugated aluminum fins.

(1) Provide vent and drain connections.

(2) Leak test at 250 psig: air pressure under water, guarantee for 150 psig working pressure.

e. Provide a double-walled stainless steel drain pan for the cooling coil that is connected to a threaded drain connection extended through unit base.

f. Provide galvanized steel filter racks, with specified filters accessible from both sides of the unit.

g. Panel filters must be 1" standard efficiency throwaway filters, mounted in galvanized steel filter frames. Provide one complete spare set of filters for each unit.

h. Supply fans must be backward curve centrifugal-type fans.

i. Supply fans must be statically and dynamically balanced for quiet operation.

j. Fan wheels must be fabricated from aluminum, with the fan blades continuously welded to the back plate and end rim.

k. Units must have solid steel fan shafts mounted in heavy-duty 200,000-hour ball bearings that can be lubricated.

l. The entire fan assembly must be completely isolated from the unit bulkhead with neoprene gasketing and mounted on double deflection, spring isolators (minimum 1". deflection).

m. Supply fan motors must be heavy-duty, high-efficiency type motors, with variable-pitch sheaves and adjustable bases for proper alignment and belt tension adjustment. Motors must also be 1800 rpm, open drip-proof type motors with ball bearings that can be lubricated.

n. Wire and test air handling units at the factory before shipment. Wiring must meet NEC and UL standards. Provide 115V control circuit transformers, 115V receptacles, system service switches, and control circuit fuses.

(1) Supply fan motors must have contactors and external overload protection.

(2) The main control panel must be weatherproof with a dead-front cover over the main power circuit controls.

o. Automatic temperature controls and the sequence of operation must be as shown on the control drawings.

p. Provide sufficient room so that the fan and fan shaft can be removed from the air handler.

F. Quality Control Testing—Custom Air Handling Unit Factory Tests

1. Pressure test each coil to be installed in the unit per the latest edition of ARI Standard 410. Bulk sampling test results are not acceptable. Test pressures must be 150 psig for steam preheat coils, 150 psig for water heating coils, and 200 psig for water cooling coils. Tests must be conducted by an independent testing agency. The test results must be reviewed and approved by the engineer before installing the coils.

2. Conduct a vibration test on the fans. Operate the fans at the design RPM. In the case of an air handling unit with multiple fans, conduct the test with each fan operating individually, and with all other possible operating combinations. The fan, motor, drive, and base assembly vibration must be brought to within two mils double amplitude. The test must be witnessed by an independent testing agency and video-taped. The test results and video tape must be reviewed and approved by the engineer before the unit is shipped.

3. Air pressure test the air handling unit at 150 percent of normal operating pressure, per the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. Conducted both positive and negatively tests. All duct connections must be capped, and the individual modules (if so constructed) must be sealed temporarily.

4. Leakage must not exceed one percent of the total design CFM when operating at 150 percent of the design pressure. A Northeastern University representative must witness the test. (The contract documents must include a provision for the contractor to include airfare and accommodations for one Northeastern University representative in the bid price.)

5. Conduct a fan performance test of the assembled air handling unit. The test must include the operation of the fans at three representative output levels. Simulate external duct resistance to demonstrate fan performance. The airflow measurements

must be conducted by an independent testing agency and witnessed by a Northeastern University representative (at the same time as the pressure test for the air handling unit).

6. Conduct a noise level test at 100 percent of the normal operating pressure and 100 percent of the normal system air flow. The noise level cannot exceed 65dB at any location within 10 feet of the unit.
7. Energize all electrical devices before shipment to ensure operational integrity. Tests must be witnessed by an independent testing agency. The results must be reviewed and approved by the engineer before the air handling unit is shipped.
8. The Northeastern University representative must have at least one week's time to review the shop drawing of the unit, including sound data, before witnessing any of the above tests.

G. Installation Guidelines

1. General

a. Install air handling units so that the coil or fan shaft can be replaced.

b. Provide access to all components for servicing and maintenance.

c. When mixing return and outdoor air, mixing should supply the cooler (outdoor) air at the top of the mixing box plenum and provide as much distance as possible before the heating or cooling coil.

2. Outdoor Air Intakes

a. Do not place fresh air louvers near a loading dock or near diesel generator exhaust.

b. Do not locate intakes near collected organic debris, such as wet leaves, animal nests, trash, wet soil, and grass clippings, or in low areas where dust and moisture collect.

c. Design outdoor air intakes to exclude rain and snow intake (see Section 15855: Diffusers, Registers, Grilles, and Louvers). Intake louvers must have screens.

d. Verify that intakes do not provide ledges that will collect bird droppings.

e. Locate intakes per code to ensure adequate separation and dilution given the contaminant source concentration and nature, the direction of prevailing winds, and building geometry.

f. Install intakes at least six feet above grade and three feet above the roof.

3. **Accessories or Special Features**
   a. Units shall be provided with ultraviolet light (UV) systems for mold control. A vapor proof housing shall be provided for the UV lights.

H. Quality Control

1. **Field Tests**
   a. Air pressure test the air handling unit at 150 percent of normal operating pressure, per the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. Conduct both positive and negative tests. All duct connections must be capped, and the individual modules (if so constructed) must be sealed temporarily.
   b. Leakage must not exceed one percent of the total design CFM when operating at 150 percent of the design pressure. An independent testing agency must witness the test.
   c. Conduct a fan performance test of the assembled air handling unit. The test must include the operation of the fans at three representative output levels. Simulate external duct resistance to demonstrate fan performance. The airflow measurements must be conducted by an independent testing agency.
2. **Commissioning**

   If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

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Rooftop Air Conditioners

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for rooftop package and custom air conditioners.

B. System Design and Performance Requirements

1. Sound levels at building entrances and exits must meet City of Boston acoustical requirements.
2. Rooftop air handling units shall be horizontal discharge / return. Do no discharge directly down through a curb.
3. Unit shall be installed on dunnage or rails. Do not installed unit on sleepers.
4. Glycol/hot water and steam are the preferred methods for preheat coils. Provide recirculation pumps for each preheat system. Confirm with Northeastern prior to design.
5. Coordinate seismic installations with the structural designer, and verify that code requirements are met.
6. For units equipped with cooling coils, size air handling cabinets for a maximum coil face velocity of 475 fpm.
7. When blow-through units are specified, ensure that there is an appropriate means of distributing air across the entire coil face. The use of plenum fans in blow-through applications is preferred because they promote even air distribution and velocity across the coil face.
8. Plenum fans are preferred in draw-through applications where discharge duct configurations (associated with centrifugal fans) cause system effect losses and noise.
9. To minimize noise from a rooftop units:

a. Follow ASHRAE and SMACNA recommendations for duct transition geometry near the fan.

b. Use round ductwork over sensitive spaces.

c. Locate units as close to the main supporting columns as possible.

d. Cut out only enough decking for ducts. Units shall be supported by steel dunnage / roof rails for small units. Units shall have horizontal discharge / return. Do not select units with bottom discharge.

e. Do not oversize units.

f. When an elbow must be placed within 1.5 duct diameters of a high-velocity fan discharge, it should be placed along a radius elbow that does not have turning vanes.

g. After test and balance has determined the proper fan speed using an adjustable sheave, replace the adjustable sheave with a fixed one of the proper pitch.

h. Ensure that there is adequate structural support for the equipment and that wall and floor assemblies have sufficient mass to attenuate low-frequency noise around the equipment.

C. Submittals

1. Designer Submittals

Custom unit designs must be reviewed and approved by Northeastern University Engineering.

2. Construction Documents

The contractor must certify that rooftop air conditioners, accessories, and components will withstand seismic forces.

D. Product Standards

Products must conform to the following standards:

1. Units must be ARI-certified and listed.
2. Electrical components, devices, and accessories must be listed, labeled, and marked for intended use—as defined in NFPA 70, Article 100—by a testing agency acceptable to authorities having jurisdiction.
3. The refrigeration system must be fabricated and labeled in compliance with

ASHRAE 15: Safety Code for Mechanical Refrigeration.

4. The energy-efficiency ratio must be equal to or greater than prescribed by ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.
5. The coefficient of performance must be equal to or greater than prescribed by ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.

E. Manufacturers

Manufacturers offering products that may be incorporated in the work are subject to compliance with the design requirements, in its entirety. Substitutions shall be approved by Northeastern prior to design selection. Acceptable manufacturers are as follows:

- McQuay
- York (JCI)
- Trane

F. Materials

1. Exterior doors on all custom units must be stainless steel.
2. Do not use exposed fiberglass ductwork in air handlers.

G. Accessories or Special Features

1. Whenever possible, provide motor lift rails on units with motors larger than 10 hp.
2. Spaces for controls must be kept dry and the temperature maintained between 60 and 95ºF. Provide a walk-in heated space for controls.
3. Equip small package units with self-diagnostics.
4. Factory-installed controls must be compatible with the Northeastern University building automation system.
5. Direct-drive actuators and damper blades must be driven by gears instead of linkages. These designs improve the mechanical reliability of the economizer/outdoor air section by reducing the number of moving parts.
6. Units shall be provided with ultraviolet light (UV) systems for mold control. A vapor proof housing shall be provided for these UV lights.

H. Extra Materials

Provide two sets of filters and fan belts.

I. Special Requirements

1. Install gutters above exterior doors that drain away from the doors.
2. Provide all units with a laptop plug-in port for unit analysis.
3. Design variable-frequency drive (VFD) enclosures with an appropriate ventilation fan.
4. Maintain the minimum clearance between VFD cabinets recommended by the manufacturer.
5. Outside air dampers must be airfoil-type with edge seals to provide a tight-closing, low-leakage damper.
6. All water coils must have copper tubes and return bends with a minimum thickness of .035." Headers must be non-ferrous. Fin spacing should not exceed 12 fpi.
7. Use manual reset freezestats; automatic freezestats controlled by the EMS are acceptable.
8. All closed-loop heating/cooling systems to rooftop air handlers must have adequate air venting. Vents must be automatic, with a ball valve between the vent and the piping, and equipped to handle system pressure.
9. Unit roofs must be sloped.
10. Drain pans must be at least 18-gauge stainless steel, insulated, and pitched to drain. Drain pans must extend in the direction of airflow far enough to catch condensate at the maximum recommended coil air velocity.
11. Units must have single-point power connections.
12. Each section of the unit that provides service access must be equipped with watertight, wire-guarded marine lights. At least one ground-fault-interruption receptacle must be located at each access side of the unit.
13. Unit steel dunnage must be 12” minimum clearance to finished roof to ensure the correct fit.
14. At a minimum, provide access doors at fan and cooling coils.
15. Fans, motors, and drives must be internally spring-isolated on a structural steel base, complete with flex connections and lateral restraints.

16. The roof and floor must be of double-wall construction. Panels must be unitized to prevent disturbing the insulation if the panels are removed.
17. Perforated inner walls are acceptable for use in all sections, except in the outside air intake, cooling coil, and humidifier sections.
18. The doors on positively-pressurized sections must swing inward. The doors on negatively-pressurized sections must swing outward.
19. Coils sections must be separated by a minimum space of 18". Each coil section must be equipped with a full-size access door.
20. Controls must be located in a heated space. Provide sufficient space to work with the door to the air handling unit closed.

J. Installation Guidelines

1. Do not block maintenance or coil-pull access doors with equipment or piping installations.
2. Exposed heating or cooling piping and valves on the roof is prohibited. Locate all valves and piping within the building or within the air handling unit.
3. Verify that unit installations are level.
4. All roof penetrations must be sealed and waterproofed.

K. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

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Computer Room Air Conditioning Systems

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A. Summary

This section contains design criteria for computer room vertical and horizontal air conditioning systems.

B. System Design and Performance Requirements

1 Provide for additional equipment and running online so that if any part of the process cooling system fails, the remaining equipment will continue to properly cool the room.

2. Provide local alarm and an alarm to the building automation system:
   - Temporary loss of power
   - On failure or need for servicing of the equipment
   - Loss of airflow
   - Dirty filters
   - Any overload condition
   - Excessive room temperature

3. Determine whether the use of outdoor air is cost-effective. The cost of humidification might outweigh savings in compressor energy.

4. Specify cooling systems that discharge air at a relative humidity that meets computer manufacturer relative humidity requirements, without relying on underfloor mixing.

5. Coordinate with room designer and to provide methodology to make room vapor-tight.

6. No A/C units shall be installed above a finished ceiling.

C. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

- Estimated cooling load
- Life cycle cost of humidification
- Report on the methods used to make the room vapor-tight
- Life-cycle cost of the cooling system, including cost to make room vapor-tight

2. Product Certificates Signed by the Manufacturer

Specify that computer room air conditioning units be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Northeastern University stating that the computer room units have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Manufacturers—Vertical Units

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Liebert
- Stultz
- Trane
- McQuay
- Sanyo
- Mitsubishi

E. Installation Guidelines

1. When ventilation air is brought into the computer room, provide a positive ventilation system to take in outside air and discharge into the intake of the process cooling system.
2. Ensure that all cracks are sealed, including cracks in any sub-floor, to preclude dust from entering the data processing equipment. Ensure that the room is a vapor-tight envelope.
3. Verify that there is sufficient space in underfloor distribution to allow for the

velocity pressure of the air handler discharged air to develop into static pressure. Not doing so can lead to hot spots where the pressure is insufficient to enter the data processing equipment.

4. Avoid running condenser water feed lines in underfloor cavity.
5. Provide accessible shutoff valves.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

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Split-System Air Conditioners

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A. Summary

This section contains design criteria for split-system air conditioners.

B. System Design and Performance Requirements

Provide complete a DX system for central station air conditioning. The system must consist of matching air-cooled condensing units, compressors, piping, controls, wiring, and other accessories, as well as the appurtenances necessary to provide a fully-automatic system. In addition, this section shall include variable refrigerant flow zoning systems.

C. Materials

1. Condenser coils must be aluminum plate fins, mechanically bonded to seamless copper tubes, circuited for subcooling.
2. Provide openings for power and refrigerant connections.
3. Provide a service access panel.
4. Provide copper tubes, circuited for sub-cooling. Provide propeller fans arranged for vertical discharge. Condenser fan motors must have inherent protection, and must be permanently-lubricated and resiliently-mounted. Fans must have safety guards. Provide controls for cycling fans.
5. Compressors must be serviceable, hermetic compressors, with external spring isolators and an automatically reversible oil pump.
   a. Compressors must unload in steps, in response to suction pressure, for partial load operation. Separate compressors from condenser fans and coils.
   b. Multiple compressor units must have stop-start fans and coils. Compressor motors must have a part-winding start.
6. Provide refrigerant piping between air-cooled condensing units and air conditioning

units. Refrigerant piping must be equipped with the necessary auxiliary equipment, such as strainers, sight glasses, oil traps, scale traps, changing valves and other devices, to make the system complete and operable under fully-automatic control.

7. Refrigeration piping must be ACR copper tubing made up with wrought copper fittings, using silver solder and installed with a nitrogen charge while soldering. Use the piping size recommended by the manufacturer of the air conditioning unit and matching air-cooled unit. Casings must be galvanized steel finished with baked enamel

8. Provide complete working refrigeration piping diagram(s) for each refrigeration system approved by the manufacturer, including line size. Pre-approve all refrigeration equipment. Components of the refrigeration system shall be identified on the diagram by piece of equipment, equipment manufacturer and model number.

D. Manufacturers

- Trane
- York
- Rheem
- Daikin
- Mitsubishi
- Sanyo

E. Variable Refrigerant Flow Zoning Systems

The system varies power consumption by adjusting the compressor speed to optimize energy usage. This system will allow some indoor units to operate in the cooling mode and other units to operate in a heating mode. The indoor evaporator units must have electronic expansion valves.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15752

Humidification Systems

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for humidification systems.

B. System Design and Performance Requirements

1. Install humidifiers only in areas justified by research requirements. Humidity control must be approved by the Northeastern University Facilities group.
2. Central plant steam used for heating must not be used for humidification. Steam used for humidification must be generated by a dedicated steam boiler.
3. Provide automatic shut-off valves in steam supply piping for situations when the humidifiers are not in operation.
4. Central humidifiers must be multiple-manifold, steam-jacketed humidifiers, with duct-mounted sensors or controllers and high-limit control.
5. If humidification is undertaken, coordinate with design architect to ensure that the building has an excellent vapor barrier throughout to prevent moisture flow into the building materials. .

C. Submittals

Submit humidifier load calculations for worst-case winter and economizer operations.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. **Steam Humidifiers**
   - Dristeem Ultrasob
   - Walton

- Nortec

2. **Ultrasonic Humidifiers**
   - Stultz
   - Walton

3. **Steam-to-Steam Reboilers**
   - Dristeem SST Stainless Steel

4. **Automizer Type**
   - Cool-Fog

5. **Electronic**
   - Nortec

E. Installation Guidelines

1. Allow sufficient downstream dispersion from humidifiers in the air handling units and ductwork to ensure complete evaporation before impingement on downstream equipment, filters, or fittings.
2. Where necessary, provide a downstream moisture eliminator to provide additional protection against the wetting of air handler components.
3. Review humidifier load for economize operation; it will be maximum. Do not use economize mode of operation without doing a life cycle cost analysis
4. In areas where DI water is not used, there must be filtering (TBD).
5. If R.O. or DI water used, please use 316 S.S.

F. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15755

Dehumidification Systems

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for heat wheels, heat pipes, and desiccant-type dehumidification systems.

B. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

Provide a description of how the system will respond during latent-peak and part-load conditions. Provide shop drawings and control sequences.

2. Product Certificates Signed by the Manufacturer

Specify that dehumidifiers be inspected by the manufacturer's authorized representative, who shall submit a written report to the engineer with a copy to Northeastern University stating that the dehumidifiers have been properly installed, that they are operating correctly, and that the installation is acceptable to the manufacturer in every respect.

C. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. Desiccant Dehumidifiers

- Cargocaire
- Engelhardlicc
- Low Humidity Sytems

2. Refrigerant-Type Dehumidifiers

- Desertaire Domestic

- Dunham-Bush

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15761

Air Coils

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for HVAC system hydronic, electric, and steam coils.

B. System Design and Performance Requirements

1. Initiate a discussion with the Northeastern University Facilities group about the need for split coils, center supply, and similar types of equipment, to provide good air distribution.
2. Use non-freeze, steam preheat coils wherever steam is available in sufficient quantities. Use hot water-glycol preheat coils where steam is not available.
3. Provide electric coils equipped with perforated plates to equalize airflow across the face.
4. Provide completely drainable chilled water coils. Coils must be ARI certified, and the scheduled performance must be guaranteed by the manufacturer. At design conditions, the coils must provide a minimum water temperature rise of 15 °F.
5. The cooling coil face velocity must not exceed 450 fpm for constant-volume systems and 550 fpm for variable-volume systems. Base the cooling coil face area on a maximum face velocity. Provide an intermediate drain trough for each section of coil banks more than one coil high. Extend the trough a minimum of 6" downstream of the coil face, and pipe it individually piped to the unit pan. Each coil section drain must have a deep seal trap and extend to an open sight drain.
6. The cooling section of a built-up unit must have a trapped drain at the bottom. Deep seal traps might necessitate raising the entire unit above the floor or disposing of drainage on the floor below.
7. Preheat coils must be face or bypass steam coils (integral or conventional) or water coils for hot gycol–water systems. Preheat coils downstream of heat recovery

wheels or coils may be standard steam distributing coils.

8. Provide hot glycol–water systems for preheat coils, unless face and bypass steam coils (integral or conventional) are used. Hot glycol–water is preferred over steam for heating coils and reheat systems. To maintain flow rates at a relatively high level, reset the hot water temperature inversely with outdoor temperature. Coordinate with Northeastern prior to selection and design.
9. Where heat recovery equipment is used in conjunction with a preheat coil, size the preheat coil for the total load in case the heat recovery equipment becomes inoperable.
10. The preheat and heating coil maximum face velocity must be 600 fpm for standard coils and 600 fpm for integral-face and bypass coils to hold the pressure drop to about 0.25" WC.
11. Offset the piping to coils, and arrange shut-off valves and flanges or unions to permit the removal of the coil from the side of the unit.
12. Heating coils immediately upstream of the cooling coils must be designed for face velocities close to that of the cooling coils.

C. Submittals

Provide a list of heating and cooling coil selections.

D. Manufacturers—Steam Coils

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Aerovent
- Armstrong – Type C or T coils for below freezing temperatures
- Centifeed
- Wing-bypass steam coils
- Heatcraft

E. Materials

1. General

Limit the coil depth to six rows and no greater than 14 fins/in. Use multiple coils if a single coil will not suffice. Allow access space for cleaning on the entrance and exit sides of the coils.

2. **Glycol–Water Coils**
   a. Coils must have copper tubes with helically-wound aluminum fins.
   b. Casing must be hot-dipped galvanized steel.
   c. Headers must have stainless steel barrels with vents; drains; and serpentine, continuous tube design suitable for 200 psig working pressure.
   d. Coils must be housed in a factory-fabricated frame, independent of the unit casing.
   e. Coil frames must be 11-gauge, hot-dipped, galvanized steel.
   f. Coil frames must support coil sections independently to enable the coil to be removed through the unit casing normal to direction of airflow, without disturbing other coil sections.
   g. Coil casings must have a removable panel on each side.
   h. Cooling coils shall have stainless steel frames.
   i. All connections to coils shall have isolation valves.

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15763

Fan Coil Units

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for hot water, chilled water, and steam fan coil units.

B. System Design and Performance Requirements

1. New buildings should not allow for fan coil units. Fan coil units should only be used if ductwork cannot be installed in an existing building, or if local loads are beyond the capacity of the building air conditioning system.
2. If fan coil units are used, systems must be four-pipe, with floor-mounted units at the exterior wall when serving as perimeter heat. Two-pipe fan coil units may be ceiling-mounted or concealed above the ceiling for cooling only.

C. Submittals

Submit heating or cooling load calculations for fan-coils and the reason why they are needed.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- York
- Trane
- McQuay
- Airtherm
- Williams
- Or manufacturer approved by Northeastern facilities

E. Materials

1. Fan coil units must include the following components:
   - A galvanized steel cabinet with a baked enamel finish liner, covered with UL 25/50 Mylar or foil.
   - Service panels on the bottom of ceiling-mounted equipment that must be hinged or provided with safety chains to prevent them from falling when opened.
   - Centrifugal, forward-curved, galvanized steel fans, statically and dynamically balanced, with permanently-lubricated or ball bearing shaft bearings.
   - A water coil with aluminum fins mechanically bonded to staggered 1/2" O.D. copper tubes. Leak test the coil at an air pressure of 350 psig.
2. Provide manual valves to isolate each fan coil and drains.
   - Isolation and valves for cooling coils or heating coils shall be located over condenser drain pan.
3. Drain pans shall be cross-braced.

F. Installation Guidelines

Provide for filter, motor, and valve maintenance access.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

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Radiation

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for hot water, steam radiation systems and chilled water systems. Included are ceiling mounted radiation and valance systems.

B. System Design and Performance Requirements

Install radiation where wall loss is greater than 200 btuh/lineal ft. Any VAV system shall have perimeter radiation; minimum pressure requirement is 85 psi.

C. Submittals

Furnish shop drawings that state the pressure range of the radiators.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Runtal
- Sterling
- Vulcan
- Panel Radiator
- Edwards

E. Materials

1. Enclosures must be galvanized steel with 18-gauge front panels.
2. Enclosure brackets and element hangers must be no farther apart than 4 ft.
3. Support the heating element with sliding saddles, and provide positive positioning of the element in the enclosure. Fins must not impinge on brackets or enclosure joints during expansion or contraction.
4. Provide a tamper-proof, modulating output control damper.
5. Provide hinged access doors with tamper-proof operators.
6. Provide expansion compensators every 20 ft on straight runs.

F. Installation Guidelines

Where feasible, simplify housekeeping procedures for steam and hot water radiation by avoiding the use of floor-set or recessed-in-floor radiation, and mount wall-hung radiation at least 4" off the floor.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15766

Cabinet and Unit Heaters

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for electric, heating hot water cabinet and unit heaters.

B. System Design and Performance Requirements

1. Cabinet unit heaters should be used in and near outdoor entrances, at the base of stairwells, and in other locations that require heat but do not have the wall space for fin tube radiation.
2. Unit heaters should be used in non-public spaces that require additional heat and have water available. Non-public spaces include mechanical and storage rooms. Electric unit heaters should be used in electric rooms.
3. Electric cabinet heaters should be used only if the cost to run steam or hot water is prohibitive.
4. The mechanical system engineer will determine hot water cabinet heater piping installation guidelines.
5. Ducted hot water units in electric equipment and elevator equipment rooms.

C. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- York
- Trane
- Airtherm
- Manufacturer approved by Northeastern Facilities

D. Materials

1. Electric Cabinet Heaters

a. Cabinet heaters must be factory-assembled for field installation. Cabinets must be sheet metal with corrosion-resistant finishes.

b. Heating coils must be single terminal end, long-life electric fin tube coils, with brazed helical-coiled fins.

c. Provide cabinet heaters with automatic reset thermal overload protectors.

2. Hot Water and Steam Cabinet Heaters

a. Cabinet heaters must be factory-assembled for field installation.

b. Coils must have seamless copper serpentine tubes and aluminum or copper fins bonded to the tubes. Coils must be tested at 200 psig air pressure without leaks.

c. If filters are required, they must be disposable.

d. Provide a factory-mounted disconnect switch.

e. Each unit must be valved separately and have union connections to facilitate easy removal. This includes isolation valves.

3. Hot Water and Steam Unit Heaters

a. Unit heaters must be factory-assembled for field installation.

b. Coils must have seamless copper serpentine tubes and aluminum or soldered copper fins bonded to the tubes. Coils must be tested at 200 psig air pressure without leaks.

c. Hangers and supports must incorporate vibration and isolators. The motor and fan must be separated from the heater by resilient vibration isolators. Provide OSHA-approved fan guards on the heaters

d. Each unit must be isolated and valved separately and have union connections to facilitate easy removal

e. Each unit must be provided with an electrical disconnect switch (no toggle switches permitted).

E. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15815

Metal Ducts

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for rectangular and round metal ductwork, duct liners, and hangers for supply, return, and exhaust systems.

B. System Design and Performance Requirements

1. Keep the ductwork layout simple. Use short, direct runs where ever possible, and conserve ceiling space.
2. All return/exhaust air should be ducted. The use of ceiling plenums for return/exhaust air requires prior consent by Northeastern.
3. Perchloric acid fume exhaust ductwork must be individually ducted without connection to other exhausts.
4. Fume hoods and contaminated or hazardous areas must be exhausted by a system of ducts entirely separate from all other exhaust systems. The location of area exhausts should be carefully coordinated with reference to remoteness from supply air outlets, doors, and windows. Animal areas and toilet rooms shall have separate exhausts. See Section 00705: General HVAC Design Conditions.
5. Wherever possible, exhaust ducts carrying noxious or corrosive fumes must be under negative pressure; connect them on the suction side of the fan.
6. Review appropriate SMANCA sections (laboratory) when designing duct distribution systems.
7. Design of displacement ventilation systems and other specialized systems and other specialized distribution systems shall be reviewed and approved in writing on a job by job basis by Northeastern Facilities.
8. Keep fan discharge ducts as short as possible, and make them completely air-tight. One method of ensuring tightness is to line the duct with a coating that meets code and NFPA 90A requirements. Install flexible duct connectors on the fan discharge, taking special care to guard against leaks.

9. Provide a volume damper in each (supply and exhaust) branch duct depending on application. No volume dampers are allowed on fume hood ducting.

10. For low pressure systems, limit the maximum air velocities and/or friction losses to the figures shown in Table 1. Ductwork sizes must also be consistent with the system sizing requirements described in Section 15725: Air Handling Units.

11. Ductwork located in ceiling space near air handling device with filters is to be routed so that filter access/removal space is maintained.

Table 1. Maximum Duct Air Velocities and Friction Losses

Location	Velocity/Friction
Main supply	1800 fpm/0.08" per 100'
Main return	1800 fpm/0.08" per 100'
Main exhaust	2500 fpm/0.10" per 100'
Branch supply	1600 fpm/0.08" per 100'
Branch return	1400 fpm/0.08" per 100'
Branch exhaust	1800 fpm/0.10" per 100'
At supply outlet	750 fpm
At return/exhaust intake	400 fpm
Within the space	50 fpm

12. Install triple-vaned, full-radius turning vanes within 35' of the air handling unit discharge, within 10' of a FCU discharge, or whenever the velocity exceeds 2000 fpm. Where the velocity exceeds 2500 fpm, use five, full-radius turning vanes. Do not use turning vanes in exhaust or return ductwork.

13. Limit the reduction in area due to obstructions to not more than 10 percent. Streamline obstructions inside ducts. Limit transitions to a 15 degree slope on the upstream side and a 30 degree slope on the downstream side.

14. Install access panels for duct cleaning every 50 l.f. on horizontal ducts, and the inspection or servicing of dampers, controls, or duct-mounted equipment. Install the panels in accessible locations. Panel sizes must be appropriate to the need and may be larger than the minimum sizes listed in Table 2.

Table 2. Minimum Sizes for Access Panels

Location	Minimum Size
Fire dampers	12" x 12"
Combination fire and smoke dampers	12" x 12"
Smoke dampers	6" x 6"
Automatic control dampers	6" x 6"
Manual volume dampers (2 sq ft and larger)	6" x 6"
Inlet side to all coils	12" x 12"
Suction and discharge sides of inline fans	24" x 24"
At additional locations indicated on drawings, or specified elsewhere	12" x 12"
Flow measuring stations	12" x 12"

15. Install access doors ductwork on both sides of fire dampers and duct-mounted coils, where possible.

16. Ductwork should not be lined.

17. Install ducts with the fewest possible joints.

18. Locate ducts vertically ,horizontally, parallel, and perpendicular to building lines. Avoid diagonal runs. Install duct systems along the shortest route that does not obstruct useable space or block access for servicing the building and its equipment.

29. Install insulated ducts with a minimum clearance of 1" outside of the insulation.

20. Provide 4" (100 mm) wide galvanized sheet metal collars at sleeves and prepared openings, sized to cover the entire duct penetration, including sleeve and seal, and to accommodate duct insulation, as necessary. Edges must have milled lips ground smooth and painted to match the duct finish.

21. Ductwork must be free from vibration under all conditions of operation.

22. No pipe, conduit, hanger, architectural element, or structural member may pass through any duct.

23. Do not route ductwork through transformer vaults or electrical equipment spaces and enclosures.

24. The maximum length of flexible duct is 6' (1800 mm).

25. Specify that duct system interiors be vacuumed to remove dust and debris before final acceptance.

26. Provide protection on duct openings during construction.

C. Materials

1. Galvanized Steel Supply, Return, and Non-Hazardous Exhaust Ducts per latest SMANCA - Standards

a. High-pressure ductwork must not be less than 24-gauge.

b. Low-pressure ductwork must not be less that 26-gauge.

c. Use the Ductmate, Nexus, or Transverse Duct Connection systems to join galvanized steel exhaust ducts.

d. Use duct sealant to seal galvanized steel exhaust ducts.

e. Exhaust ducts must be pitched to drain whenever there is a possibility that water will collect in or on them.

2. Choosing Material for Fume Hood Ducts

a. Materials for fume hood ducts must be carefully selected. In most cases, Type 304/316 stainless steel is satisfactory. Use number 2B finish in concealed areas and number 4 finish in exposed areas.

b. Use Type 304/316 stainless steel for laboratory or fume hood exhaust. However, in severe applications, a more resistant material should be used.

c. Final selection should not be made without consulting Northeastern University's Office of Environmental Health and Safety.

3. Stainless Steel Ducts Used for Fume Hood and Hazardous Exhaust

a. High-pressure ductwork must not be less than 24-gauge.

b. Low-pressure ductwork must not be less that 26-gauge.

c. Stainless steel ducts must be sealed by providing welded joints and pitched so that moisture cannot collect in them. Mechanical joints shall be considered based on application.

d. Fabricate fume hood ductwork in accordance with SMACNA requirements. However, do not cross-break. Increase the gauge to provide a gauge that is 0.5 lbs/sq ft (2.5 kg/m^2) heavier than standard.

4. Stainless Steel Ducts Used for Non-Hazardous, Moist Air

a. Use stainless steel ducts for collecting non-hazardous moist air, such as dishwasher or shower room exhausts. Use Type 304 stainless steel for the following:

- For all ductwork outside the building
- For all ductwork outside dishwasher and shower rooms
- 15 feet downstream of humidifiers and dryer exhausts
- For any duct containing more than 25percent air from a shower

b. Use number 2B finish in concealed areas and number 4 finish in exposed areas.

c. High-pressure ductwork must not be less than 24-gauge.

d. Low-pressure ductwork must not be less that 26-gauge.

e. Stainless steel ducts must be sealed using duct sealant and pitched so that moisture cannot collect in them.

5. **Additional Materials Requirements (Per Latest SMANCA Sections)**

a. Use stainless steel for exhaust ducts, from inlet to discharge, for glass washers, dish washers, cart washers, and cage washers. Joints must be welded, and the ducts must be pitched to drain.

b. Kitchen grease exhaust ductwork must be of 16-gauge, welded steel construction, and pitched to meet code and NFPA 96 requirements.

c. Use galvanized steel for all supply and return and non-hazardous, non-moisture-carrying exhaust ductwork. The ductwork must have a galvanized coating of G-90 (G-60 is not acceptable).

d. Provide the proper pressure and leakage-rated, gasketed, and duct-mounted access doors or panels. In insulated ducts, access doors must be insulated, double-wall doors. Door material gauges, the number of hinges, and the number and type of door locks must meet SMACNA duct construction standards. Unhinged doors must be chained to the frame with at least 6" of chain to prevent loss of the door. For seal Class A, hinged doors and screwed or bolted access panels are not acceptable. Access doors must be leakage-rated, neoprene-gasketed, UL 94 BF1 listed, DUCTMATE Sandwich doors. Door metal must be the same as the attached duct material. For grease and high temperature ducts, the door assembly must be rated for 2300°F.

D. Installation Guidelines

1. Do not route fume or kitchen exhaust through fire walls.

2. Keep ductwork routed outdoors and across roofs to a minimum; route ductwork within the building as much as possible.

E. Quality Control—Ductwork Field Tests

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training. Provide duct leakage tests.

1. Systems with a Design Static Pressure of Less than 2" Positive or Negative

Before installing exterior duct insulation, test all supply, return, and exhaust ductwork for air leakage. Conduct the tests per the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. The test pressure must be 25 percent greater than the design duct operating pressure. The total allowable leakage must not exceed 5.0 percent of the total system flow. When partial sections of the duct system are tested, the summation of all sections must not exceed the 5.0 percent total allowable leakage for the system. The test must be witnessed by an independent testing agency.

2. Systems with a Design Static Pressure of More than 2" Positive or Negative

Before installing exterior duct insulation, test all supply, return, and exhaust ductwork for air leakage. Conduct the tests per the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. The test pressure must be 25 percent greater than the design duct operating pressure. The total allowable leakage must not exceed 1.0 percent of the total system flow. When partial sections of the duct system are tested, the summation of all sections must not exceed the 1.0 percent total allowable leakage for the system. The test must be witnessed by an independent testing agency.

F. Cleaning and Adjusting

Specify that all ductwork and plenums be cleaned before the job is turned over to Northeastern University. Northeastern University Facilities must approve before formally accepted. In special areas where extreme cleanliness is required, specify that ducts and plenums be vacuum-cleaned. Before consideration of acceptance of the duct systems or plena inspection, acceptance by Northeastern University's job coordinator is required.

-END-

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Duct Accessories

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for volume dampers, fire and smoke dampers, vanes, duct silencers, and duct hardware.

B. System Design and Performance Requirements

1. Base control and smoke damper leakage characteristics on tests performed per AMCA Standard 500 test procedures. Limit air leakage to 6 cfm per square foot at 4" wg differential pressure.
2. Dampers larger than 12" in height must be opposed, multi-blade dampers.
3. Make dampers 1/4" undersize.

C. Installation Guidelines

1. Install volume dampers on each supply, return, and general exhaust duct take-off and at each take-off to the register, grille, or diffuser, as close to the main duct as possible.
2. For systems above 15,000 cfm, provide smoke dampers in the return and supply air ducts to isolate the air handling unit. Provide filters in accordance with NFPA 90A. These smoke dampers may also be used for smoke control functions. The unit smoke dampers must be interlocked with the unit supply air fan to close and isolate the unit when the fan stops. To prevent excessive pressures due to supply or return fans still operating, it is necessary to open these dampers before starting the fans.
3. Provide sufficiently sized access doors at all fire dampers to allow for damper/linkage resetting.

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section.

-END-

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Fans

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A. Summary

This section contains design criteria for supply, return, and exhaust system fans.

B. System Design and Performance Requirements

1. General

a. Base fan size selections on the manufacturer's published sound level, effluent exhaust, and/or cfm and static pressure requirements.

b. Specify that protective coatings be applied to components in or out of the airstream (or both) to resist chemical attack and corrosion.

c. Specify whether the fan rotation arrow must be shown as part of the manufacturer’s unit or installed by the contractor.

d. Select all scheduled fan motor sizes, 1/2 hp and larger, as follows for supply fans, return fans, and exhaust fans to provide for increasing the rpm above design, if necessary.

(1) Using design air quantity and static pressure (adjusted as necessary for altitude, temperature, fan inlet restrictions, discharge conditions, and system effect factors), select a fan from fan curves that will operate well within the stable range at a reasonable static efficiency. Note fan speed.

(2) Add 10 percent, but not to exceed 3/4 inches of water, to design static pressure. Using the same design cfm, check for satisfactory operation of the fan. Note the fan brake horsepower required to prevent overloading at any point on the fan curve.

(3) Critical fan systems shall have nonoverloading motors.

e. Select outlet velocities and fan tip speed for quiet operation. Higher outlet velocity and static pressure result in increased sound output. Balance cost and space against sound and efficiency. The fan manufacturer’s catalog should be consulted for outlet velocities and fan tip speed.

f. The largest single factor causing poor fan performance is a poorly-designed inlet connection. See the SMACNA duct design guide for fan inlet and outlet system effect factors that contribute to fan performance loss and increased noise.

g. Verify that fans have been isolated from the building structure.

h. Use flexible connectors to isolate all fans connected to ductwork. Use flexible conduit to connect the electric motor to the power source.

i. Fan performance curves are based on dry, “standard” air at 70^{o}F at sea level. Include temperature and pressure corrections when operating at other conditions. (Note: kitchen fans operate at high temperatures.)

j. Explosion-proof construction must include an explosion-proof motor; explosion-proof disconnect switch; static resistant belts; and an aluminum, non-sparking wheel.

k. All fans must be statically and dynamically balanced individually by the manufacturer to within 1 mil double amplitude at 125 percent of the rated speed.

l. Use direct-drive fans with variable frequency drives whenever possible (depending on the airstream) to avoid losses and maintenance associated with belt-drive units.

m. Centrifugal fans must meet the class requirements of project design, with a minimum Class II. All motors shall be high efficiency type. All fans greater than 10 hp must have variable frequency drives. All fans must have bearing rated for 200,000 hours.

n. Fans 50 hp and over must have fixed-pitch sheaves on the fan and motor.

o. Select fans to operate well within the critical limits of the shaft and bearings.

p. Air handling unit supply and exhaust air fans serving laboratories must be redundant. Verify with Northeastern prior to design. Redundant fans not normally required.

q. Fans used for fume hood and other contaminated exhaust must have bearings, drives, motors, and all controls located outside the airstream. Fans serving such systems must not be interlocked with the supply units.

r. All fans that will exhaust fume hoods must be non-sparking and must be either coated steel (Heresite, PVC) or of corrosion resistant construction.

s. Laboratory exhaust systems must use redundant, high-plume blowers. Verify with Northeastern as most systems are manifolded.

t. Perchloric fume exhaust fans must be of non-sparking construction.

u. Forward-curved fan wheels can deliver large volumes of air at slow speeds and a steep brake horsepower curve and can be overloaded if the static pressure drops. Where noise might be a factor, use forward-curved fan wheels up to 20" in diameter. Because of its curved shape, a forward-curved fan wheel cannot be used where there is foreign material present in the air that would lodge in the blade cup. Forward-curved fan wheels are used primarily in small ventilating fans, with lower pressures, where the use of a backward-inclined wheel would create too high an operating speed for the bearings. A backward-inclined fan wheel gives the fan a flat horsepower curve, and proper fan motor selection will never cause it to be overloaded.

v. As a general guideline, use backward curved fans for systems less than 12,000 cfm and less than 4" total design static. Specify air foil fans for conditions in excess of 16,000 cfm or 4" design TSP . Consider air fans on systems below 8,000 cfn based on system static.

w. Provide sufficient room so that the fan and fan shaft can be removed.

2. Roof Ventilators

a. Avoid large roof ventilators servicing extensive duct runs.

b. Avoid the use of direct-driven roof ventilators with wheels in excess of 20" nominal diameter. Specify V-belt drive arrangements to provide for flexibility.

c. Specify shaft seals to prevent the entry of contaminated exhaust air into the motor compartment.

d. Specify a non-fused, disconnect switch in an appropriate enclosure (to suit environmental conditions), mounted adjacent to the motor.

e. Specify mesh size, material, and function to exclude the entry of birds or insects.

f. Specify dampers for use with roof ventilator fans.

g. Specify an aluminum, felt-edged damper that opens when the fan is started and is closed by gravity when the fan is shut off. Do not use gravity dampers when local wind conditions or stack effect will cause the damper to chatter open and closed.

h. Specify electric motor-operated dampers when positive and tight closure is necessary and shall be provided with electric disconnect switch.

i. Specify a hinged sub-base for wheel diameter sizes through 36". For larger sizes, specify a mounting pedestal with a removable access panel.

j. Provide with bird screens.

3. Utility Vent Sets

See the information above for forward- and backward-curved fans.

4. Double-Width Inlet Fans

Allow one fan diameter between the fan and side wall casing and two fan diameters between adjacent double-width fan inlet collars.

5. Propeller Fans

a. Limit the use of propeller fans to locations with low static pressures and where noise is not a factor. Propeller fans handle large volumes of air at low static pressures and low power consumption. The use of ductwork adversely affects their efficiency, greatly reduces the volume of air they will handle, and increases power consumption.

b. When propeller fans must operate against an appreciable resistance, and when running at high speeds, they are generally not suited for quiet operation due to high tip speeds.

6. Inline Fans

a. *Centrifugal In-Line Fans*

The wheel may have forward- or backward-curved blades. Forward-curved blades generally produce less head and are economical at low static pressure and low capacity. Backward-curved blades are the most efficient. Centrifugal in-line fans are well-suited for use at high static pressure and high capacity. A variation of the backward-curved blade has an airfoil cross-section that produces quiet and efficient operation in its range, and is well suited for high pressure and high capacity use.

b. *Axial In-Line Fans*

Because of the air turbulence in this type of fan, axial in-line fans are not recommended for quiet operation at high capacity, without providing fan silencers.

c. *Vaneaxial In-Line Fans*

Vaneaxial fans are similar to axial in-line fans and are provided with flow vanes. Vaneaxial fans are well-suited for high pressure and capacity use and are most suitable for variable-volume and/or variable-pressure systems. Sound attenuation is usually required for this type of fan. Vaneaxial fan airflow may be controlled by an adjustable blade pitch or variable frequency drives.

C. Submittals

Submit the following design and certification documentation.

1. Designer Submittals

Submit fan selection calculations.

2. Product Certificates Signed by the Manufacturer

The manufacturer's representative must check each fan of 25 hp and over for proper installation, alignment, belt tension, and operation. The manufacturer's representative must submit a written report to the engineer, with a copy to Northeastern University, stating that at the time of the report, the fan is running properly and is acceptable to the manufacturer in every respect.

D. Product Standards

Products must conform to AMCA standards—certified and sealed.

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

1. General Supply and Exhaust Fans

- Greenheck
- Buffalo Forge
- Loren Cook

2. High-Velocity Roof Exhausters for Laboratory Exhaust

- Strobic
- MK Plastic
- Greenheck

3. Belts

- Browning
- Gates

4. Blowers

- Buffalo Forge
- New York Blower
- Aerovent
- Barry Blower
- Hartzell

F. Equipment

1. Centrifugal Fans

a. Centrifugal fans must have welded steel housings and wheels balanced dynamically and statically.

b. Provide V-belt, variable-pitch drives, with spring-loaded belt tensioners, for ±10 percent speed variation.

c. Fans must be equipped with backward-curved blades connected to an electric motor so that in no instance can the fan motor be overloaded at the capacities shown on the drawing schedule. Provide an open, drip-proof motor on an adjustable base.

d. Provide V-belt drives sized as recommended by the manufacturer. Belt construction must be rubber and cord. Belt sets must be matched for length. Belt capacity must be 150 percent of the motor horsepower rating. Belts must be stamped A- or B-type. Sheaves must be cast and machined iron steel larger than the minimum diameters recommended for a particular belt. Sheaves must be dynamically and statically balanced.

e. Provide belt guards of 18-gauge steel mesh, perforated steel sheets, or expanded steel sheets, with angle frames and galvanized steel or rigidly-braced iron trim.

f. Provide ports for tachometer speed measurements at the fan shaft.

g. Provide spring vibration isolation bases.

h. Provide seismic isolation as required by code.

i. Provide an inlet screen, bolted access door, bearings with an L-10 life of 200,000 hours, and anti-corrosion coatings.

j. Fan shall be selected not to exceed 1200 rpm.

2. Centrifugal Roof Exhausters

a. Provide V-belt (dome, low-silhouette, or penthouse), variable-pitch, belt-drive fans certified to bear the AMCA seal.

b. Provide a 12" high, pre-fabricated aluminum roof curb with a lining that provides at least 30% sound reduction.

c. Provide the following components:
   - Gravity backdraft dampers
   - Motorized dampers on any fan greater than 1,000 cfms
   - Bird screen
   - Spun aluminum housing
   - Disconnect switch
   - Inlet venturi orifice
   - Vibration isolation
   - Permanently-lubricated ball bearings
   - Enclosed, fan-cooled motor
   - Junction box

d. Belt drives must have ±5 percent speed variation and a spring-loaded belt tensioner. Direct drives must have speed controllers in the junction boxes.

e. Fan must be selected not to exceed 1200 rpm.

3. Centrifugal In-Line Fans

a. The tubular housing must be heavy-gauge steel, all-welded construction. Provide a bolted and gasketed full-access door with a “swingout” clamshell design to permit inspection or removal of the fan impeller.

b. The fan wheel and drive assembly must be statically and dynamically balanced at the factory.

c. V-belt capacity must be 150 percent of the motor horsepower rating. Fan motor pulleys must be adjustable-pitch pulleys. Provide an adjustable motor base.

Provide an OSHA-approved belt guard for drive components that are located outside of the fan housing.

d. Provide ports for tachometer speed measurements at the motor shaft.

e. Provide self-aligning bearings with a minimum L-10 life of 200,000 hours.

f. Provide extended lubrication lines.

g. Fan must be selected not to exceed 1200 rpm.

G. Accessories or Special Features

Provide fan guards for the motor side and the discharge side of propeller fan installations less than 7' above the floor. Provide expandable wire mesh on the intake and motor-operated shutters on the discharge to protect the fan and building interior against rain, snow, and sleet intake when the fan is off. Motorized shutters prevent wind pressure from chattering when the fan is off.

H. Extra Materials

Specify one spare belt set for each type of fan.

I. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

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Air Terminal Units

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for constant- and variable-volume air terminal units.

B. System Design and Performance Requirements

1. Verify that VAV boxes can provide turndown to the minimum setpoint cfm when the system static pressure decreases.
2. Do not oversize VAV boxes in an attempt to decrease sound power output. Decreased airflow across the velocity sensor can produce erratic readings at low flow.
3. Consider series-type, fan-powered boxes in lieu of parallel-type boxes. Series boxes provide constant air circulation. Fan and motor noise is also less noticeable than with on-off or parallel-type boxes.
4. Schedule the following:
   - Minimum and maximum air flows
   - NC level, discharge and radiated
   - Duct inlet and outlet sizes
   - Motor horsepower and power requirements
5. Show power connection to VAV boxes.

C. Product Standards

Products must conform to the following standards:

- NFPA 90A
- UL 181
- NEMA 1

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- AccuSpec
- Phoenix
- Titus

E. Equipment

1. Air terminal units must be 24-gauge galvanized steel, lined with 1-1/2 pound insulation as required by UL-181 and NFPA-90A. Insulation must be covered with hospital-grade Mylar® or foil meeting NFPA fire and smoke requirements.
2. Provide a damper motor suitable for electronic (DDC) control.
3. Responsibilities for providing a damper actuator and DDC VAV box controller, including a velocity pressure transducer and control transformer, are described in Section 15950: Energy Management and Control Systems. The terminal box manufacturer must include with their bid the costs of mounting the controller on their box and piping the controller's transducer to their flow sensor (in accordance with the control manufacturer's instructions).
4. Provide 3' long sound attenuators and a hot water reheat coil. If used, Northeastern prefers to use fin tube radiation near the outside walls for heat. Provide an access door at the reheat coil section, before and after the coil.
5. Boxes must have multipoint averaging-type airflow sensors.
6. The contractor must include the following items with the shop drawing submittal:
    a. The name of the terminal box manufacturer.
    b. The name of the temperature controls manufacturer.
    c. A statement that the mechanical division contractor has contacted both vendors and verified that the terminal box and VAV DDC controller are compatible with each other and that they can perform all sequences of operation shown on the control drawings
7. Provide power to VAV boxes using 24 volt transformer or line voltage as required.
8. Provide the following addition AC information for VAV boxes with reheat coils:
    a. Entering water temperature.
    b. Leaving water temperature.

c. Entering air temperature.

d. Leaving air temperature.

e. Heating capacity in MBH.

f. GPM

g. Water side pressure drop.

h. Water side rows.

F. Installation Guidelines

1. On drawings, show access space for the VAV box control panel, damper actuator, filter, fan motor, and reheat valve.
2. On drawings, show the access door downstream of the reheat coils.
3. On drawings and in specifications, indicate that a minimum of 2-1/2 duct diameters of straight duct must be maintained for flex duct entering the VAV box.

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

-END-

15855

Diffusers, Registers, Grilles, and Louvers

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for covers, diffuser, grilles, registers, and intake and discharge louvers.

B. System Design and Performance Requirements

1. Supply, Return and Exhaust Outlets

a. Equipment must handle air quantities at operating velocities. Select and apply the air distribution apparatus so that the temperature in the occupied zone varies no more than ±2℉.

b. Air motion in the occupied space must be between 25 and 45 fpm over the full control range of the variable-volume controller.

c. The noise criteria level in the space must be no greater than that scheduled on the drawings and 30 noise criteria where not scheduled.

d. The supply diffuser must be located in the center of the room and uniformly placed in the center of tiles and in logical patterns that include lighting, sprinklers, and other similar types of equipment.

e. Damper shall be placed at duct branch line off main feeding diffuser or 10 ft minimum from diffuser.

f. The return or exhaust grille may be located anywhere (with the exception of laboratory fume hoods) in the room, but as far as possible from the supply outlet. Give special attention to laboratory supply diffusers with fume hoods. The location of all supply diffusers must minimize the creation of eddy currents in the fume hood that could spill the fume hood's contents into the laboratory. The velocity of the air in front of the fume hoods must be less than 50 fpm or 1/2 of the hood face velocity.

g. If fintube radiation is not used (with permission from the Northeastern University Project Manager and Facilities group), then the supply diffuser should be located on the outside walls and be of the linear type.

2. Air Intakes

a. Size all intakes (without snow draw potential) to provide an air velocity of 600 fpm or less. Louvers reduce the free area by at least 50 percent and usually much more. Size and locate intakes to prevent the entrance of light fluffy snow (intake velocity < 250 fpm) and polluted air peculiar to the building site.

b. Intakes near or below ground level not permitted. The minimum height of the bottom of intake must be:
   - 6' above grade
   - 3' above the roof

c. Examine intake locations for proximity to contaminated air exhausts, such as laboratory discharges.

d. All intakes must have a 1/2" mesh wire screen on the outside or as required by code.

3. Additional Requirements

a. Avoid the use of perforated ceilings for the air supply. If such a system seems unavoidable, consult with the Northeastern University Facilities group before designing the installation to discuss specific requirements.

b. Supply registers and grilles must be double-deflection type.

c. Where possible, ceiling diffusers must be adjustable for air pattern.

d. All registers and grilles must be equipped with appropriate setting frames. Ceiling-mounted devices must match ceiling type.

e. As a rule of thumb, decrease the selected noise criteria level of selected diffusers by 3 db for every doubling of the number of diffusers in the space.

f. Minimum throttling cfm to avoid dumping:
   - Perforated diffuser not lower than 0.7 cfm/sq ft
   - Linear diffuser not lower than 0.3 cfm/sq ft
   - Architectural diffuser not lower than 0.3 cfm/sq ft

g. State in the specification state that the contractor must adjust linear diffuser air directional vanes.

C. Designer Submittals

1. Submit schedules on the drawings of all air distribution apparatus. List the following data in the schedules:
   - Item number, location, and/or area served
   - Style or model
   - Listed size
   - Cubic feet per minute, SP
   - Noise criteria
   - Throw
   - Drop (where applicable)
   - Plan symbol
   - Material
   - Finish
   - Any remarks
   - Frame Type
   - Neck Size
2. Rooms that have pressure requirements different from adjacent rooms must show the relative room pressurization on an airflow drawing. The airflow drawing must show the supply diffusers, exhaust or return grilles, and fume hoods (if any), including the cfm capacity for each unit.

D. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Titus
- Price
- Metalaire
- Krueger
- Anemostat
- Tuttle and Bailey

E. Materials

Do not use expanded metal or stamped or formed grilles, unless the air intake size is sufficient to provide a velocity of 600 fpm or less and to prevent snow draw through the louver or grille under maximum air flow conditions.

F. Equipment

a. Each grille, register, and diffuser provided must have the accessories necessary to perform satisfactorily and to be fully adjustable, including opposed-blade volume dampers operable from the front, air deflectors, vanes, blanking quadrants, and similar components. At each inlet and outlet device, provide accessories to accomplish the positive regulation of air volumes and the uniform distribution of airflow over the outlet.

b. Supply registers must have two sets of directional control blades.

c. Diffusers within same room or area must be of same type and style to provide architectural uniformity.

d. Diffusers should be full-size for 24" x 24" tiles or half-size (24" x 24") for 24" x 48" tiles.

e. Provide surface-mounted diffusers, registers, and grilles with gaskets. Installed them with faces set level, plumb, and tight against the mounting surface.

f. The architect will determine the finish.

G. Installation Guidelines

Provide volume dumpers 10’ from supply diffusers.

-END-

15861

Air Filtration

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains design criteria for disposable, extended surface, activated carbon, and HEPA air filtration systems.

B. System Design and Performance Requirements

1. Understand the function of the facility and the needs of Northeastern University and the facility users, as well as the source of outdoor air drawn into the facility for ventilation.
2. Meet with Northeastern University and the facility users to obtain specific data and information about the nature, concentration, particle size, and distribution rate of airborne contaminants generated within the facility.
3. Meet with Northeastern University and the facility users to obtain specific data and information about the nature, concentration, particle size, and distribution rate of outdoor contaminants, such as auto or factory pollution, construction dust, contaminants from to cooling towers, and vegetation.
4. Consider:
   - Whether a filter with high moisture resistance is needed
   - Pressure drop for energy performance
   - Cost and ease of filter disposal for Northeastern University
5. Select the minimum efficiency-reporting value (MERV 8) filters necessary to effectively filter particles sizes and gases encountered. Include MERV designations in specifications along with the expected final resistance value.
6. Select absorbents for gas-phase chemical control. Specify with test coupons.
7. In some cases, design conditions might require more efficient filtering than that afforded by non-HEPA filters. In such cases, discuss filtering needs with the Northeastern University Facilities group and facility users before selecting the air

filters.

8. Specify bags, pocket attachment, cubes, framing, and surface area for best dirt holding capacity, pressure drop, and life-cycle use.
9. Select the filter retaining devices and sealing materials—gaskets and seals—to withstand air stream contaminants and ensure that there is no bypass around the filter.
10. Oversize filter banks as much as possible to increase filter life-cycle and decrease fan energy.
11. The design face velocity should not exceed 500 fpm for all filters.
12. The contractor will supply a construction set of filters and a set of filters for c.o. per AHU.
13. Provide the following for all systems handling 200 cfm or more and for all high-efficiency applications, regardless of size:
    a. Primary air filters (pre-filters) must be UL Class 2, 1" thick, polyethelene filters. Efficiency must be MERV 8 as measured by ASHRAE test standard 52–76. Design filters to operate up to 350 fpm.
    b. MERV 6: 35 < E3 < 50, minimum final resistance of 0.6" wc.
    c. Secondary filters (final filters) must be UL Class 1 with an efficiency of 90 to 95 percent as measured by ASHRAE test standard 52–76. Design filters to operate up to 500 fpm.
    d. MERV 14: 75 </= E185, 90 < E2, 90 </= E3; minimum final resistance of 1.4" wc.

C. Submittals

Submit the following design and testing documentation.

1. **Designer Submittals**
    - Air contaminants
    - Filter selections

D. Product Standards

Products must conform to the following standards:

- Underwriters Laboratories Class 1 or 2
- ASHRAE 51
- ASHRAE 52

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work :

F. Accessories or Special Features

1. Provide filters with a Dwyer magnehelic filter gauge across each filter bank, equipped with an adjustable flag to indicate the need to change filters.
2. The preferred filter face dimension is 24" x 24".

G. Extra Materials

Specify the number of filters to be used during construction, plus one additional filter set to be installed at the end of construction before air balancing.

H. Installation Guidelines

1. Provide access to filters. Ensure that piping, ductwork, and electrical system components do not block access. If installing an air handler in a ceiling space, locate it where the filter access or removal space is away from ductwork.
2. Do not allow the air handling system to be operated during construction without all particle filtration in place. Construction dirt, dust, and debris can accumulate in ductwork and lead to indoor air quality problems and the loss of LEED certification.

I. Quality Control

1. If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.
2. Provide minimum of 2" 6" clearance space to change filters.

J. Startup and Training

Include the following statement in the specifications: *"The contractor is responsible for installing new filters throughout the system immediately before the completion of all contract work."*

-END-

15950

Energy Management and Control Systems

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. General

Paragraph 1 – Summary is provided here for informational purposes for the Design Engineer. It is provided to help create the job specific Specification that needs to replace this section before being issued to the contractors.

1. Summary

a. This section shall specify work required to provide a complete and fully operational Energy Management and Control System (EMCS),integrated into the Northeastern network, and installed in accordance with Northeastern standards.

b. The Design Engineer shall accompany this EMCS Specification with job specific:

- Sequences of operation
- Control Schematics
- Point list with Northeastern acronyms
- Job related specific instructions
- Relevant mechanical, electrical, structural drawings
- Related work under other divisions
- Job specific requirements by Division 15000 & 16000
- Definition of Existing and New HVAC equipment to be controlled

2. Related Work by Others

a. Provide the services of EMCS's field engineer to supervise work specified in other Paragraphs of this Section:

(1) Installation of automatic valves and separable wells furnished under this Section.

(2) Provision of necessary valved pressure taps, water drain and overflow connections and piping.

(3) Provision of auxiliary contacts, control transformers and Hand-Off-Auto Switches on magnetic starters with buttons and switches in required configurations.

(4) Installation of automatic dampers.

(5) Provision of blank off plates (safing) required to install dampers smaller than duct size.

(6) Assembly of multiple section dampers with interconnecting linkages and extension of shafts through duct for external mounting of damper motors.

(7) Provision of sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate by experimentation; affix permanently when stratification is eliminated.

(8) Provision of access doors or other approved means of access through ducts for service to control equipment.

(9) Installation of in-duct or fan inlet airflow measuring stations.

(10) Installation of variable frequency drives.

(11) Furnishing and installing of self-contained radiation valves.

(12) Laboratory temperature shall be controlled by the BMS. The BMS shall signal the heating coils and input signal to the supply / exhaust valves to maintain proper pressurization.

(13) All BacNET controlled equipment i.e. AHUs, chillers, proprietary lab controls, shall transmit all trend data to the BMS. This shall be in place prior to commissioning.

(14) Provide UPS for all building level master EMS controllers. UPS shall be sized to supply the controller for 24 hours in the event of a power disruption.

Table 1. Core Inter-Trade Responsibility Matrix

Work By Others And Inter-Trade Matrix

1. The demarcation of work and responsibilities between the EMCS Contractor and other related trades shall be as generally outlined in the INTER-TRADE RESPONSIBILITY MATRICES herein. Refer also to other parts of the Specifications for details and clarifications.
2. Refer to Part 1.2 herein for detail definition of terms summarized for convenience only as below:
   a. Provide means to supply, install on-site, test, verify and document.
   b. Furnish means to supply to others for installation on-site then terminate, test and verify.
   c. Install means to install on-site the item supplied by others.

C. EMCS = Energy Management and Controls Contractor
MC = Mechanical Contractor
EC = Electrical Contractor

	Work	Provide	Furnish	Install	LV Wire & Pipe	Line Power & Pipe
1.	EMCS Nodes, equipment, housings, enclosures and panels and power from EC panels.	EMCS			EMCS	EMCS
2.	EMCS software, firmware and project specific software configurations and database entries.	EMCS				
3.	EMCS low voltage and communication wiring	EMCS			EMCS	
4.	EMCS conduits and raceway	EMCS			EMCS	
5.	Control Relays	EMCS			EMCS	
6.	Concrete and/or inertia equipment pads and seismic bracing	MC				
7.	EMCS network routers, bridges, hubs and associated cabling.	EMCS			EMCS	EC
8.	Campus-wide Ethernet communications network	Northeastern IT			EMCS	
9.	Central Building Utility Metering System communication trunk (via telephone lines)	Northeastern IT			EMCS	

Table 1. Core Inter-Trade Responsibility Matrix—Continued

Building Controls and Lighting Controls Inter-Trade Responsibility Matrix						
	Work	**Provide**	**Furnish**	**Install**	**LV Wire & Pipe**	**Line Power & Pipe**
10.	Temperature Control Panels	EMCS			EMCS	EC
11.	VAV Box controller and Terminal Unit Nodes		EMCS	MC	EMCS	EC
12.	Automatic dampers		EMCS	MC	EMCS	EC
13.	Manual valves	MC				
14.	Automatic valves		EMCS	MC	EMCS	EC
15.	VAV boxes	MC				
16.	Pipe insertion devices and taps including thermowells, flow and pressure stations, etc.		EMCS	MC	EMCS	EC
17.	Current Switches.	EMCS			EMCS	
18.	Power Distribution System monitoring interfaces		EC	EC	EC	EC
19.	Central Building Utility Metering System	EMCS				EC
20.	EMCS interface with Chiller control package	EMCS			EMCS	EC
21.	Chiller controls interface to EMCS (N2, BACNet)	MC			EMCS	EC
22.	Chiller and Boiler Flow Switches	MC			EMCS	
23.	Boiler control package	MC			EMCS	EC
24.	Water treatment system	MC			MC	EC
25.	Variable Frequency Drives		EMCS	EC	EMCS	EC
26.	Refrigerant monitors		MC	EMCS	EMCS	EC
27.	Isolation room monitors	EMCS			EMCS	EC
28.	Fume hood controls	EMCS			EMCS	EC
29.	Medical gas panels	MC			EMCS	EC
30.	Laboratory Air Valves		EMCS	MC	EMCS	EC
31.	Computer Room A/C Unit site-mounted controls		MC	EMCS	EMCS	EC
32.	Fan Coil Unit controls	EMCS			EMCS	EC
33.	Unit Heater controls	EMCS			EMCS	EC
34.	Packaged Rooftop Unit (RTU) space mounted controls		MC	EMCS	EMCS	EC

Table 1. Core Inter-Trade Responsibility Matrix—Continued

Building Controls and Lighting Controls Inter-Trade Responsibility Matrix						
	Work	**Provide**	**Furnish**	**Install**	**LV Wire & Pipe**	**Line Power & Pipe**
35.	Packaged RTU factory-mounted controls	MC			EMCS	EC
36.	Packaged RTU field-mounted controls	EMCS			EMCS	EC
37.	Cooling Tower Vibration Switches	MC			EMCS	EC
38.	Cooling Tower Level Control Devices	MC			EC	EC
39.	Cooling Tower makeup water control devices	MC			EC	EC
40.	Starters, HOA switches	EC			EMCS	EC
41.	Control damper actuators	EMCS			EMCS	EC
42.	Tenant Meters	EMCS			EMCS	EC

NOTE: The Design Engineer shall specify any other job specific requirements for the EMCS contractor.

b. Division 16000 Contractor shall provide:

(1) The Division 16000 contractor shall provide for adequate task lighting above each Direct Digital Controller (DDC) cabinets and other associated panels to provide for unit service, by adding light fixtures if necessary, regardless of whether specifically shown on the drawings or not.

(2) Dedicated circuit breakers for DDC or other associated field cabinets that shall have protective guards preventing accidental (manual) switching off the designated circuit breakers.

(3) Dedicated and tagged circuits from the standby power service wired to all DDC panels. Location of these panels on the contract drawings are the responsibility of the design engineer.

(4) All labor and material to mount, power, and connect VFDs to appropriate motors.

3. System Description

a. *Scope*

(1) Provide labor, materials, services, equipment and engineering necessary for a complete and operational Energy Management and Control System (EMCS) as indicated on Contract Drawings and specified herein, including but NOT limited to the following:

(a) Controls for air handling systems including air flow control for laboratories, supply fans, heating coils, humidifiers, return fans, exhaust fans, exhaust hoods, dampers, and VAV boxes, etc., as per the specifications Sections 15000 & 16000, mechanical and electrical drawings.

(b) Controls for pressurization and airflow including variable frequency drives, dampers, static pressure and flow stations and pressure control valves, etc.

(c) Controls for hydronic systems including heat exchangers, chilled water system, chilled water differential pressure control, coils, pumps, condensate, and heat recovery, etc., as per the specifications by Division 15000 & 16000, and mechanical and electrical drawings.

(d) Furnishing and installing laboratory airflow and hood control systems approved by Northeastern University Facilities Engineering Department as per the contract documentation.

(e) Complete system engineering, software generation, work- station graphics and project management of controls installation including consultations of control sequences with Northeastern University Systems Engineering before control software generation.

(f) Ensure all work stations, web access have been updated, synchronized with the completed project graphics and sequence of operations by the ATC at the time of commissioning.

(2) Provide complete electrical installation of controls including:

(a) Connection of field sensors, DDC panels, and field controllers.

(b) Connection of all DDC field communication wiring. Connection of building level controllers to the Northeastern Network as per instructions by Northeastern Facilities Systems Engineering department.

(c) Extension of dedicated 120VAC control circuit power feeds from control cabinets to field devices (e.g. valves, dampers, VAV box digital controllers, and fan-coil digital controllers).

(d) All junction boxes for DDC wiring, raceways, and other components of the installations (circuit breakers) shall be marked blue for easy identification by the controls mechanics.

(e) Ethernet wiring shall be installed by Northeastern Telecommunications; initiated by the Northeastern Project Manager with a START request. Telephone lines as means of communication for control devices is not acceptable.

(3) Provide the services of control manufacturer's representative to be on-site during the entire time that the start up, testing and balancing procedures, and commissioning, detailed in this specification, takes place. Representative shall be part of manufacturer's service organization and shall be skilled in the adjustment and calibration of all control devices as well as being capable of modifying and checking system software. Perform calibration, system validation and startup, and acceptance testing in presence of Owner's representative and/or Systems Engineer. Provide 15 days notice before acceptance test. Notice shall certify that system is complete and operates as required by Contract Documents. When system performance is deemed satisfactory, system parts shall be accepted for beneficial use and the one year vendor's warranty shall begin.

(4) Note any additional requirements noted elsewhere in this specification.

(5) Provide DDC system supplier's warranty of performance of entire system, including electric components, as required by Contract documents. Performance and components requirements are established by control sequences and diagrams on Drawings and by this Section.

(6) DDC system shall perform all sequences of operation, which may be listed on control drawings or attached to this specification. Controls supplier shall provide all devices necessary to completely perform sequences whether such devices are explicitly shown on the drawings, specified, or not shown or specified. A complete functioning system should be supplied requiring no manual intervention. This should include sequences plus any necessary shutdown sequences to inhibit alarms and nuisance system messages and still leave the system in a safe reporting position.

b. *DDC Interfaces*

(1) Communication on the campus level is via the campus network. Any device connected to this network must be approved by Northeastern Facilities Systems Engineering and by Northeastern Facilities Information Services departments.

(2) Communication to third party controllers such as VFDs, fume hood controllers, package unit controllers, etc., if specified by the Engineer, should be Bacnet. JCI N2 acceptable for Andover Alerton controlled systems.

(3) The Engineer shall consult with Northeastern Facilities Systems Engineering on available and supported interfaces and pre-selected communications and controls and automation systems for Northeastern installations.

4. Submittals

a. The EMCS contractor shall submit within 30 days after award installation drawings and control strategies for review.

b. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; FMS Contractor name, address and phone number; FMS Contractor project manager, quality control manager, and project engineer names and phone numbers.

c. Each submittal shall include the following information.

(1) EMCS riser diagram, showing all DDC controllers, operator workstations, network components, and network wiring.

(2) One-line schematics and system flow diagrams showing the location of all control devices.

(3) Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name (Northeastern standard acronym), Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number.

(4) Contractor's own written description for each sequence of operations, to include the following:

(a) Sequences shall reference input/output and software parameters by name and description.

(b) The sequences of operations provided in the submittal by the EMCS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.

(c) Points shall be referenced by Northeastern acronym, including all software points such as programmable setpoints, range limits, time delays, and so forth. In general the point naming convention must follow a building-system outline – all points must have their building associated in their full point name.

(d) The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.

(e) User interface functional outline. The outline shall include each display (graphics) screen to be provided, data to be displayed, and links to other screens. The outline must follow existing Northeastern Person Machine Interface (PMI) color-graphic screens. The outline level hierarchy shall start with the building name. Separate trees for floor controls and separate trees for major systems (heat exchangers, AHU's, etc.). It must be easily identifiable which AHUs server which floors or parts of floors. Graphic links short cutting to major systems are encouraged – i.e. a link to an AHU graphic from a VAV graphic.

(5) Detailed Bill of Material list for each panel, identifying: quantity, part number, description, and associated options.

(6) Control Damper Schedules. This spreadsheet type schedule shall include a separate line for each damper and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, and Actuator Type.

(7) Control Valve Schedules. This spreadsheet type schedule shall include a separate line for each valve and a column for each of the valve attributes, including: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Calc CV, Design Pressure, Actual Pressure, and Actuator Type.

(8) Cataloged cut sheets of all equipment used. This includes, but is not limited to the following: DDC panels, peripherals, sensors, actuators, dampers, system components, and so forth.

(9) Range and scale information for all transmitters and sensors. This sheet shall clearly indicate one device and any applicable options. Where more than one device to be used is on a single sheet, submit two sheets, individually marked.

(10) Training course outlines (if required).

(11) Hardware data sheets for all operator workstations, local access panels, and portable operator terminals.

(12) EMCS Contractor shall not order material or begin fabrication or field installation until receiving authorization to proceed in the form of an approved submittal. EMCS Contractor shall be solely responsible for the removal and replacement of any item not approved by submittal at no cost to the Owner.

d. For jobs contracted directly by Northeastern with their submittal, the contractor shall submit a detailed and guaranteed job schedule to Northeastern Project Manager for approval. The "schedule" shall include, but not be limited to, start and completion dates for all activities during design, engineering, installation, software generation, commissioning, and turnover phases of the project. The contractor shall take full responsibility for non-compliance with the approved schedule. The final schedule shall be submitted to Northeastern no later than twenty (20) days after the contract award date.

e. Prior to software generation, the EMCS contractor shall submit the following information for review to Northeastern Facilities Systems Engineering:

(1) Complete set of approved submittals.

(2) "Tree" outline of color graphics for the front-end Operator's Work Station (OWS).

(3) Samples of Trends and History standard reports on the front end OWS.

(4) List of alarm points, their limits, classification of alarms, associated alarm messages interlocks with devices to inhibit alarms, and other relevant alarm reporting features.

(5) Initial setpoint values for controlled variables and schedules.

(6) List of advisories for operators for manual control.

f. All devices on submittal shop drawings shall be identified by Northeastern acronyms.
These identifiers shall also be used in description of operation, in control layouts, and on data sheets for ease in cross-referencing. Final control drawings shall be CAD generated in a format compatible with the AutoCAD system.

5. O&M Manuals

Prior to final system acceptance an Operation and Maintenance Manual shall be generated to describe function and operation of all control system components and shall include operating and trouble-shooting procedures. Submit three (3) sets of each Manual. Three (3) hard copies and three (3) electronic copies. The Manual shall be easily understood, for use by the Northeastern Control Center (CC) personnel; shall show the total integrated control system; and shall include:

a. Include the following documentation in the Hardware Manual:

(1) General description and cut sheets for all components.

(2) Detailed wiring and installation illustrations and complete calibration procedures for each field and panel device.

(3) Complete trouble-shooting procedures and guidelines.

(4) Complete operating instructions for all systems.

(5) Maintenance Instructions: Document all maintenance and repair/replacement procedures.

(6) Calibration requirements and instructions.

b. Include the following documentation in the DDC Software Manual:

   (1) Sequence of Operations.

   (2) Program Listing of Software Source Code or Flow Chart Diagrams of Programming Objects.

   (3) Printed listing of controller and operator workstation database files.

   (4) Software Point Name Abbreviation List including point name with Northeastern acronym, Description, Controller Where Located, Point Type and Point ID.

   (5) I/O Point List; Include Point Name (Northeastern acronym), Controller Location, Point Number, Control Device, Range and Span.

   (6) Printouts of all; Reports, Group Listings and Alarm Messages.

c. It is the responsibility of the EMCS Contractor to assure that the Northeastern Customer Service Department has all current documentation regarding the installed EMCS. As part of this Scope of Work, the EMCS contractor, upon updating Northeastern Customer Service with current information, will issue a Letter of Compliance to the CM/GC, acknowledging that the Northeastern Physical Plant Department has all current information, in electronic format, regarding the following:

   (1) System Engineering Manual.

   (2) System Installation Manual.

   (3) Programming Manual.

   (4) Engineering and Troubleshooting Bulletins.

   (5) Operator Workstation Software Manual.

   (6) All other pertinent manuals published by the control system manufacturer.

d. All manuals shall be provided in hard copy format and on a single Compact Disk (CD) as part of an on-line documentation system through the operator workstation.

e. Record Drawings including sequences of operation.

f. Complete database and software program of system in suitable electronic format will be sent by the EMCS Contractor to the Northeastern Customer Service Department with a copy of the Letter of Transmittal sent to the GC/CM.

6. Warranty

a. *Material*

The Control System shall be free from defects in material and material workmanship under normal use and service. If within thirty six (36) months from the date of completion any of the equipment herein described is defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the EMCS Contractor free of charge.

b. *Installation*

(1) The Control System shall be free from defects in installation workmanship for a period of twelve (12) months from acceptance. The EMCS Contractor shall, free of charge, correct any defects in workmanship within four (4) hours of notification by the Owner.

(2) During this guarantee period, the EMCS Contractor shall warrant the proper operation of the control system and implemented control strategies. During this twelve (12) month period, the performance of the controlled HVAC system associated algorithms shall be examined and verified by the EMCS Contractor and Northeastern. Any tuning, software corrections or enhancements to the application software algorithms installed for the project shall be made at the request of Northeastern and provided by the EMCS Contractor at no additional cost to the University.

c. *Warranty Service*

Service technicians shall be dispatched to effect remedial action or to make enhancements within twenty-four (24) hours of being notified. Service shall be available 24 hours a day, 365 days a year.

d. *Certification of Product Availability*

Furnish certificate from manufacturer of control system that expansion hardware and software shall be available for a minimum of seven (7) years from date of completion. Supply Northeastern with complete database of system on acceptable disks.

B. Products and Systems

1. Acceptable Manufacturers

2. System Performance—Direct Digital Control (DDC)

a. Control shall be performed by a field programmable, microprocessor based, digital system controller that incorporates Direct Digital Control. The Direct Digital Controller shall provide all control and necessary energy management functions and provide for display and local adjustments via connection to a portable PC terminal.

b. Each major HVAC system shall have an individual dedicated controller controlling all functions of the HVAC system in a standalone mode in case of communications failure with the building controller, including time programs, etc.

c. The Direct Digital Controller shall perform its assigned control and energy management functions, including time schedules, as a stand-alone unit. Additionally, it shall be incorporated into the University EMCS Network. The EMCS Network communications is via campus Ethernet.

d. Communications at the Campus level, from the building controller to vendor specific front end Operator Work Station (OWS) is via industry standard protocols.

e. The Direct Digital Controller shall perform its full control and energy management functions, regardless of the condition of the Northeastern communications link. System shall be designed with maximum fault tolerance, such that the failure of one controller shall not disrupt communications to Work Stations or other controllers in the EMCS network. The stand alone capabilities shall include, but not be limited to:

   (1) Closed loop control functions (P, PI, PID, Incremental, Floating, etc.), and cascading of control loops, scheduling, time profiles.

   (2) Energy management functions including, but not limited to: scheduling, time programs, economizer control, supply air reset, supply water reset, adaptive optimal start, optimization functions, etc.

   (3) Execution of programs written by the contractor to meet job specific requirements.

   (4) Control processes shall be designed with the necessary data points to make setpoints, prop bands, etc adjustable without requiring download or system interruption.

(f) Control algorithms shall be available and resident in the building or local controller to permit proportional, integral, and derivative control modes in any combination to meet the needs of the application.

(g) The standard tolerances for Northeastern applications are +/-0.5 °F; +/-5% RH; +/- 0.2 in. w.c. static pressure; +/-1 psig, unless otherwise requested by the mechanical engineer and approved by Facilities Systems Engineering Department. Other control modes such as incremental, floating or two position, shall be available to adapt to job needs.

(h) All point names associated with control algorithms, including software point names, shall follow Northeastern University standard acronyms. All control loops shall be fully electronic.

(i) The EMCS shall be capable of performing all the energy management functions necessary to reduce energy consumption. These programs shall include, but not be limited to:

(1) Supply air reset using space load demand.

(2) Enthalpy is the preferred method of economizer control. Dry bulb may be acceptable with Northeastern Facilities System Engineering approval.

(3) Optimal start using an adaptive algorithm to prevent the need for manual adjustment of parameters. Discussion to occur with Northeastern to determine if optimal start is needed per project.

(4) Facility and system specific algorithms as directed by Northeastern University Facilities Systems Engineering.

(5) A library of routines available in firmware must be capable of generating additional programs for specific requirements. These shall include, but not be limited to the following: chiller efficiency, boiler efficiency, seasonal and "dead band" control, VAV fan matching control, psychometric chart DX control, totalizing, holiday programming, etc.

(j) The DDC controller shall contain all necessary mathematics, logic, utility functions, standard energy calculations, and control functions in ROM to be available in any combination for programming the unit. All programming shall be from the designated Engineering Work Station. Programming routines available shall include, but not be limited to the following:

(1) Math Routines - Basic arithmetic, Boolean logic, relational logic, fixed formulas for psychometric calculations.

(2) Utility Routines - Process entry and exit, variable adjustments and output, alarm indication, power fail restart, local I/O interface.

(3) Control Routines - Signal compensation, loop control, energy conservation, timed programming.

(4) Final control programs shall be stored in non-volatile EEPROM or battery backed up RAM for up to 72 hours on power failure.

(5) In addition, all software programs shall be stored at the Engineering Work Station computer on the hard disk drive for review, modification and downloading to the controller in the field.

(k) The DDC controller shall contain in its program a non-destructive self-test procedure for testing memory and processor functions. Alarms shall be sent to the designated Work Stations for any abnormality within the processor, memory, as well as all analog point failure, and all program deviation alarms. All process and hardware variables shall be identified as being reliable or unreliable. When a calculation is required to use a value, sensed or calculated, which is identified as being unreliable, the calculation shall use a preprogrammed default value and the "unreliable status" shall be reported at the designated Work Stations.

3. Software

a. Software generation shall follow standard Northeastern University sequences for heat exchanger control, condensate alarming, psychometric chart control of DX systems, and reset schedules as approved by Northeastern Facilities System Engineering.

b. All device names (acronyms) shall follow Northeastern University standard naming conventions.

c. Software alarms shall be provided for analog deviation, run-time, utility services failure, space comfort range deviation, and additional alarms as directed by Northeastern University Facilities Systems Engineering.

d. Alarms shall report device location, software name, description, and criticality of alarm. Alarms shall report to the designated Work Stations and be logged on the alarm printer showing date and time of alarm.

e. All control software programs shall be loaded onto the hard disk drive of the Engineering Work Station. Also, the Northeastern Controls Systems Engineer will be given his or her own copy.

f. All networked controllers must be loadable form a remote connected workstation. It must not be necessary to go to a controller directly and load it, provided that it is on-line.

g. The PMI (Person Machine Interface) programs, such as color graphics, summaries, reports, etc., shall be developed by the contractor, approved by Northeastern Facilities Systems Engineering Department and loaded to the Engineering Work Station and controllers prior to the initial job walk-through. The controls vendor should be prepared to construct and re-construct the "front end" for reasonable improvements at no cost to Northeastern University.

4. Alarm Management

Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, to minimize network traffic, and to prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

a. *Point Change Report Description*

All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

b. *Prioritization*

(1) The installer shall set up all system analog points with high and low alarm limits. All digital system points shall be associated with a status feedback point and all exceptions shall be reported as alarms. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized and filtered to minimize nuisance reporting and to speed operator response to critical alarms.

(2) The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

(3) The controls system will maintain an audit trail of operator activity. This will include but not be limited to - log in, log out, overrides, set point changes, schedule changes, system changes, downloads, uploads, and alarm activity.

c. *Critical and Non-Critical Alarm Routing*

(1) Critical alarms shall be displayed at the designated workstations, printed at the alarm printer, and paged to the on-duty maintenance person over the owner's or vendor's paging system, as requested by the owner. Alpha pages shall provide sufficient information to identify the equipment and the point in alarm and the time and date of occurrence.

(2) All other alarms shall be considered non-critical and shall be displayed and acknowledged before being sent to the alarm log.

d. *Report Routing*

Alarm reports, messages, and files shall be directed to a Northeastern-defined list of operator devices, or devices used for archiving alarm information or reports. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

e. *Alarm Messages*

(1) In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an alarm message to more fully describe the alarm condition or direct operator response.

(2) Each standalone DDC panel shall be capable of storing an alarm message for each point.

f. *Auto-Dial Alarm Management*

(1) Dial-up systems are unacceptable.

5. Color Graphics—Follow Northeastern Convention

a. The graphics shall be able to display and provide animation based on real-time data that is acquired, calculated, or entered.

b. Multiple graphic applications shall be able to execute at any one time on a single workstation.

c. All graphics shall be constructed from basic graphical objects.

d. Any basic object, any group of basic objects, or any symbol or group of symbols, shall be capable of being animated.

e. It shall be possible to change values (setpoints) and states in system controlled equipment from the color graphics screen, based on user privilege level.

f. A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing all drawing functions, defining all calculations to be executed as part of the graphic, defining all animations, and defining all runtime binding. It is not acceptable for separate programs to be required to do these various functions.

g. The EMCS system shall be provided with a very complete symbol library containing all of the basic symbols used to represent HVAC, FIRE, LIGHTING, CCTV, and SECURITY components of a typical EMCS system. Exact components and conventions to be discussed with Northeastern.

h. The EMCS Contractor shall fully configure the color graphics and plot all associated control/monitoring points on the screen. Copies of all color graphics screens shall be provided to Northeastern Facilities System Engineering for approval.

   (1) The operator interface shall allow users to access the various system schematics, sections of the building or floors via a graphical penetration scheme, menu selection, or text-based commands. Floor plans shall display room numbers and each zone shall be color-coded. The operator shall be able to point and click on a room or zone of rooms (in the case of an air handler that serves more than one zone). The room or zone shall display an animated flow diagram of the mechanical equipment that serves that zone, with all control and monitoring points associated with that piece of equipment, including setpoints. Setpoints shall be overridden or modified from this screen.

   (2) At the discretion of Northeastern Facilities Systems Engineering, a tabular format may be used for presentation of space data.

i. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention. Damper and valve positions, air and water flow shall be animated and shall represent actual, current conditions.

j. The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

k. Any point in a state of alarm shall change the color of its symbol to red until it is no longer in alarm.

l. At the discretion of Northeastern Facilities Systems Engineering, a tabular format may be used for presentation of space data.

m. With every analog re-settable value their setpoint shall be also displayed on the screen.

6. Historical Trending and Data Collection

a. Each Building Controller shall store trend and point history data for all analog and digital inputs and outputs, as follows:

(1) Any point, physical or calculated, may be designated for trending. Three methods of collection shall be allowed:

- Defined time interval
- Upon a change of value
- Whenever a value is out of range

(2) Each network controller shall have a dedicated RAM-based buffer for trend data. In the case of a system controller, it must have at least 1 MB of dedicated storage (ALC). For a building level controller it must have at least 128 MB of storage data for operations and trends. A building controller almost must have at least 50% spare capacity for expansion.

b. Trend and change of value data shall be stored within the controller and then uploaded to the trend database(s). Uploads shall occur based upon one of the following: user-defined interval, manual command, when the trend buffers are full, or scheduled.

c. The system shall provide a configurable data storage subsystem for the collection of historical data. Data is stored in SQL database format.

d. To enable users to easily access stored data, the system shall provide the capability to store historical data in more than one file system (i.e., removable media, separate hard drives, or a remote network file system.

e. Provide a trend viewing utility that shall have access to all database points.

f. Provide database access through an Open Database Connectivity (ODBC) interface – a standard Application Programming Interface (API) for accessing data from relational databases.

g. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name.

h. The trend viewing utility shall have the capability to view up to 32 data sources at one time in a tabular or graphical format.

i. Graphic displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.

j. It shall be possible to display trend data in histogram (X-Y plots) format as well as area and bar graphs.

k. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.

l. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed. This function shall also be operator selectable.

m. The display range shall consist of magnitude and units fields. The units are seconds, minutes, hours, days, and months.

n. Provide a wild card capability when specifying a display range for data retrieval within the historical database. Wild carding shall allow the user to easily specify relative time based date ranges for the retrieval of data.

o. A time offset capability shall be available to assist in a user's analysis. The offset visually shifts the data being displayed to allow a user to concurrently view information without having to scroll the display.

p. The system shall be capable of printing a hard copy record of the trends as they are displayed on the workstation.

q. Prior to system acceptance, the EMCS contractor shall initiate a minimum of 24-hour trends for every connected point to the EMCS. These trends shall be used by the operators to diagnose start-up and operational problems. Additionally, the EMCS shall be capable of generating longer-term trend logs to diagnose adverse long-term trends.

7. Sequence of Operation

a. The EMCS contractor shall develop their own written description for each sequence of operations, to include the following:

(1) Sequences shall reference input/output and software parameters by name and description. Use actual system point names in sequences.

(2) The sequences of operations developed by the EMCS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.

(3) Points shall be referenced by Northeastern acronym, including all software points such as programmable setpoints, range limits, time delays, and so forth.

(4) The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.

b. Prior to loading the software the control algorithms must be approved by the Engineer, Northeastern Project Manager and Northeastern Facilities Systems Engineering.

NOTE: The design engineer is to provide detailed sequences of operation for all equipment that shall enable the EMCS contractor to develop their own functional sequences for generation of software. These design sequences can be detailed here, or more preferably on the contract control drawings.

8. Redundancy

a. Sufficient redundancy shall be provided such that operation shall continue unimpaired given the failure of any single DDC unit. Failure of any point module shall not impair functions of other modules, loops, DDC, OWS, etc.

b. Field equipment (i.e. pump) operation shall continue unimpaired given the complete failure of communications between distributed DDC and Designated Work Stations. Procedures for system shutdown and recovery of failed DDCs shall be provided by the EMCS contractor.

9. Position of Failed Equipment

The controlled equipment shall remain in the last position in case of system failure, or as specified by the Engineer.

10. Diagnostics

The EMCS shall provide the operator with information, which shall allow efficient operation by identification of unfavorable trends, e.g. system performance below normal, equipment not operating as expected, etc. Tuning screens shall aid the operators in tuning individual PID loops from the designated Work Stations.

11. Digital Communication Interface—Drivers

a. Necessary hardware, software and application programming shall be provided to interface to third party systems if specified for the job.

b. All points from these systems shall be mapped over to the DDC system.

C. Component Specification

1. Remote DDC Units

a. Remote DDC units shall accommodate all points specified by the Engineer.

b. The DDCs shall be located near the highest concentration of field points. The location shall be approved by Northeastern Facilities Systems Engineering Department.

c. The DDC controller shall be enclosed in a cabinet. The cabinet shall be constructed such that it can be mounted and electrical terminations made during the installation phase of the project, without the control electronics being installed. The cabinet shall be NEMA rated for its location and expected environment. The DDC electronics shall be modular and shall be added during the commissioning phase of the project. The DDC cabinet and any associated units, for example Field Equipment Units (FEUs) shall be provided with a master keyed lock, keys turned over to Northeastern Physical Plant.

d. The EMCS shall also be expandable by adding additional field interface units that operate through the processor in the DDC Controller. The processor in the DDC shall be able to manage remote field interface units, expanding its control loop and energy management point capacity.

e. The DDCs shall be stand alone, with CPU's, clock, and communication interfaces.

f. The DDCs shall contain point modules, interface modules, etc. for the connected field equipment and third party controllers.

g. Control, communication and power circuits shall be individually electronically isolated to protect against transients, spikes, and power surges.

h. The DDC shall be an approved UL system, with a UL listing as a Signaling System.

2. Field Instruments

a. *Dampers and Damper Actuators*

(1) Automatic dampers shall be of modular sections. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 48". Damper blades shall be 16-gauge minimum and shall not exceed six (6) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. Additional stiffening or bracing shall be provided for any section exceeding 48" in height. All damper bearings shall be made of stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Damper blade and seal material must be compatible with use. Dampers of 48"x48" size shall not leak in excess of 8.5 CFM per square foot when closed against 4" w.c. static pressure when tested in accordance with AMCA Std. 500.

(2) Two-position dampers shall be parallel blade, and modulating dampers shall be opposed blade.

(3) Dampers shall be Class II with leakage not to exceed 10 CFM per square foot at 1" W.G.

(4) Acceptable manufacturers are: Johnson Controls D-1300, Ruskin CD36, and Vent Products 5800. Other models must be approved by Northeastern University Systems Engineering.

b. *Smoke Dampers and Actuators*

(1) Smoke dampers shall be of modular sections. Bearings shall be self lubricating porous bronze. Side seals shall be spring loaded stainless steel. Blade seals shall be rated to withstand 250 DEGF. The smoke damper sections shall be specified under Division 15000.

(2) Each smoke damper shall be UL555S listed and bear UL label attesting to same.

(3) Leakage rating under UL555S shall be leakage Class II (10 CFM per square foot at 1" W.G.).

(4) Appropriate electric actuator shall meet all applicable UL555S qualifications for both dampers and actuators.

(5) Smoke dampers shall be supplied with the motor factory mounted, with end switches to signal open/close position.

(6) Acceptable manufacturers are: Johnson Controls SD-1300 or Ruskin SD-36. Other models must be approved by Northeastern University Systems Engineering.

c. *Damper Actuators*

(1) Damper and valve actuators shall be electronic and will be direct shaft mount.

(2) Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

(3) Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. Each damper bank (outdoor air, return air and exhaust air) will have a separate output from the controller. The control signal shall be 0-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 0-10 VDC or 4-20 mA. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

(4) Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as “quick acting,” shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

(5) All actuators shall include a feedback mechanism sensing actual position to provide a positive feedback to the DDC. Feedback sensed from controller command output is not acceptable. Exceptions must be approved by Northeastern University Systems Engineering. All actuators shall be labeled with software name.

d. *Automatic Control Valves*

(1) All control valves required by the control system are to be provided by the EMCS Contractor for installation by the Division 15000 Contractor. Valves shall fail to normally open or closed position as specified. Modulating single seated straight through valves for chilled water, hot water, or steam service shall be provided with equal percentage contoured throttling plugs. Use v-port ball valves as preference.

(2) All control valves shall be provided with electric actuators. All actuators shall include a feedback mechanism sensing actual position to provide a positive feedback to the DDC. Feedback sensed from controller command output is not acceptable. Exceptions must be approved by Northeastern Systems Engineering. All actuators shall be labeled with software name.

(3) Valves 2" and smaller shall be ANSI class 250, brass body, or cast iron screwed connections. Valves larger than 2" shall be ANSI class 125, cast iron body, flanged connections. Stems shall be stainless steel with packing guaranteed against leakage for one year past contractual warranty with only packing nut adjustment required. The valve ANSI class must be correct for the application. This section does not supersede the requirement for the engineer to choose the correct valves for the design application.

(4) Valve schedule shall indicate capacity, pressure drop, size, and CV rating. All control valves shall operate smoothly without hunting or cycling and be capable of operating within the temperature and pressure range of the controlled fluid without leakage through the packing.

(5) Where control valves are shown or described in the sequence of operations to operate in sequence with other valves, dampers, or controlled devices, valves shall be either hardware or software sequenced to achieve the required sequence. Each sequenced valve shall have a separate output from the controller.

(6) Maximum pressure drop across the control valves shall be 5 psi.

(7) Acceptable manufacturers: Johnson Controls, Belimo, Warren, Honeywell, Aries, Bray. Other models must be approved by Northeastern Systems Engineering.

(8) Thermostatic fin tube radiation control valves shall be an assembly of a valve body and self-contained actuator top with remote mounted sensor. Actuator shall be replaceable without removal of valve body from piping. Actuator shall have a built-in set-point dial.

(a) Valve and actuator shall be Honeywell-Braukmann Model V110D valve with T104F series actuator, or models approved by Northeastern Systems Engineering.

(b) All required accessory pieces for remote mounting of sensor bulb shall be included.

e. *Device Feedback Exceptions*

(1) Waiver of hardware feedback requirements for HVAC devices serving individual isolated zones - where the controlled variable sensors are in a close proximity to the device (coil) - may be made by approval of Systems Engineering. Such devices include valves, dampers for fan-coil units VAV boxes, and unit heaters.

(2) In those instances where exceptions are made, the controlled variable (i.e. discharge air temp) shall provide the feedback indication.

f. *Thermostats*

Not used in this specification. The use of pneumatic thermostats must be pre-approved by Northeastern Systems Engineering.

g. *Low Temperature Detection*

(1) Low temperature detection thermostats shall be DPST, snap acting contacts rated for 16 amps at 120VAC, or SPST with a dedicated 2-pole relay with manual reset. One set of N.C. contacts shall be hard wired to stop the protected coil's fan and the second set of contacts for alarm input to the DDC.

(2) Thermostat capillary shall have a minimum sensitive length of 20 feet, and shall be installed in a serpentine fashion a maximum of 18 inches downstream of the coil it is protecting. For coils less than 10 sq. ft., shorter capillaries shall be acceptable. Thermostats shall activate if any 2 inch section of capillary is below setpoint.

(3) Install one thermostat per 20 square feet of coil to be protected. Multiple thermostats shall be electrically wired in series.

(4) All low temperature detectors shall be labeled with software name.

(5) Acceptable manufacturers: Johnson Controls A70, Honeywell. Other models must be approved by Northeastern University Systems Engineering.

h. *Low Steam Pressure Switch*

(1) Low steam pressure switches shall be 0 to 15 PSIG range, SPST with contacts opening on pressure decrease, snap acting with automatic reset.

(2) Switches shall be supplied with siphon "pig tail".

(3) All low steam pressure switches shall be labeled with software name.

(4) Acceptable manufacturers: Johnson Controls. Other models must be approved by Northeastern University Systems Engineering.

i. *Temperature Sensors*

(1) All temperature sensors shall be resistance temperature devices (RTDs) having an accuracy of not less than 1% across full scale range. Sensors shall be nickel wound with a reference resistance of 1000 ohms.

(2) All sensors shall be labeled with software name.

j. *Space Temperature Sensors*

(1) Room sensors shall be constructed for either surface or wallbox mounting.

(2) Room sensors shall have the following options when specified:

(a) Setpoint reset slide switch providing a +/- 2 degree (adjustable) range with a 6 degree deadband between heating and cooling set-points. The nominal heating set-point should be 68 and the cooling 72 (adjustable).

(b) Common heating/cooling setpoint slide switches.

(c) A momentary override request push button for activation of after-hours operation.

(d) Digital display of temperature and or set point(s).

(3) Acceptable Manufacturers: Alerton or Andover. Other models must be approved by Northeastern University Systems Engineering.

k. *Duct Temperature Sensors*

(1) Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.

(2) Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

(3) For outdoor air duct applications, a weatherproof NEMA 3R mounting box with weatherproof cover and gasket shall be used.

(4) For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used. Capillary supports at the sides of the duct shall be provided to support the sensing string.

(5) Acceptable Manufacturers: Johnson Controls TE Metastat, ACI, BAPI. Other models must be approved by Northeastern University Systems Engineering.

l. *Well Insertion Temperature Sensors*

(1) When thermowells are required, the sensor and well shall be supplied as a complete assembly, including well head and Greenfield fitting.

(2) Thermowells shall be stainless steel pressure rated and constructed in accordance with the system working pressure. Brass thermal wells are unacceptable.

(3) Condensate temperature sensors shall be provided with stainless steel wells

and rated for operating temperatures up to 250-300°F.

(4) Thermowells and sensors shall be mounted in a threadolet or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.

(5) Thermowells shall be constructed of 316 stainless steel.

(6) Acceptable Manufacturers: Kele. Other models must be approved by Northeastern University Systems Engineering.

m. *Humidity Sensors*

(1) The sensor shall be a solid state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.

(2) The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, or 0-10V 0-100% linear proportional output.

(3) The typical humidity transmitter shall have +/-5% accuracy on a range scale. Where applicable, a +/- 2% accuracy shall be used – vivarium, cultural properties, etc.

(4) Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with Sealtite fittings and stainless steel bushings.

(5) A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

(6) Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

(7) Acceptable Manufacturers: Johnson Controls, Veris Industries, and Vaisala. Other models must be approved by Northeastern University Systems Engineering.

n. *Differential Pressure Transmitters (Air/Air)*

(1) General Air and Water Pressure Transmitter Requirements

(a) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

(b) Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

(c) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

(d) A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

(2) Low Differential Water Pressure Applications (0” - 20” w.c.)

(a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA or 0-10V output in response to variation of flow meter differential pressure or water pressure sensing points.

(b) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

- .01-20” w.c. input differential pressure range.
- 4-20 mA or o-10V output.
- Maintain accuracy up to 20 to 1 ratio turndown.
- Reference Accuracy: +0.2% of full span.

(c) Acceptable Manufacturers: Setra, Veris and Mamac.

(3) Medium to High Differential Hot Water Pressure Applications (Over 21” W.C.)

(a) The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

- Differential pressure range 10” w.c. To 300 PSI.
- Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).

(b) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

(c) Acceptable Manufacturers: Setra, Kele, and Veris.

(4) Building Differential Air Pressure Applications (-1” to +1” w.c.)

(a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA or 0-10V output in response to variation of differential pressure or air pressure sensing points.

(b) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

- -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
- 4-20 mA or 0-10V output.
- Maintain accuracy up to 20 to 1 ratio turndown.
- Reference Accuracy: +0.2% of full span.

(c) Acceptable Manufacturers: Johnson Controls. Other models must be approved by Northeastern University Systems Engineering.

(5) Low Differential Air Pressure Applications (0” to 5” w.c.)

(a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA or 0-10V output in response to variation of differential pressure or air pressure sensing points.

(b) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

- –1.00” to 5.00”) w.c. input differential pressure ranges. (Select range appropriate for system application.)
- 4-20 mA or 0-10V output.

- Maintain accuracy up to 20 to 1 ratio turndown.
- Reference Accuracy: +0.2% of full span.

(c) Acceptable Manufacturers: Johnson Controls. Other models must be approved by Northeastern University Systems Engineering.

(6) Medium Differential Air Pressure Applications (5” to 21” w.c.)

(a) The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:

- Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
- Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG).
- Thermal Effects: <+.033 F.S./Deg. F. Over 40°F. To 100°F. (calibrated at 70°F).

(b) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

(c) Acceptable manufacturers: Johnson Controls. Other models must be approved by Northeastern University Systems Engineering.

1. Air Flow Monitoring

(1) Fan Inlet Air Flow Measuring Stations

(a) At the inlet of each fan where shown on contract documents and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.

(b) Each traverse probe shall be of a dual manifold, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching air flow. The manifold should not have forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching air stream.

(c) The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.

(d) Air flow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc.,or Ebtron. Other models must be approved by Systems Engineering.

(2) Single Probe Air Flow Measuring Sensor

The single probe air flow measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to air flow velocity.

(3) Duct Air Flow Measuring Stations

(a) Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of Fundamentals, as well as in the Industrial Ventilation Handbook.

(b) Traverse stations shall be connected to ductwork with bolts at flanges; stations shall be removable for cleaning. Each probe mounted within the station shall contain multiple total and static pressure sensors placed at equal distances (for rectangular ducts) or at concentric area centers (for circular ducts). The number of sensors provided with each flow station shall comply with the ASHRAE standards for duct traversing. The airflow traverse station shall produce a steady non-pulsating flow signal without need for correction factor or special calibration. The station shall be capable of measuring airflow through the station to within 2% of actual flow.

(c) The probes shall be installed perpendicular to the velocity profile gradient.

(d) Traverse probes or stations that incorporate honeycomb grid or tube type airflow straighteners are not acceptable.

(e) Traverse stations shall be constructed out of the same type material as the duct material.

(f) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

(g) Installation Considerations

1 The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" w.c. at 1000 feet per minute, or .23" w.c. at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 2% as determined by U.S. – GSA certification tests, and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.

2 The units shall have a self-generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.

3 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

4 Where control dampers are shown as part of the airflow measuring station, opposed blade precision controlled volume dampers integral to the station and complete with electric actuator and linkage shall be provided.

5 Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

(h) Acceptable manufacturers: Air Monitor Corp., Tek-Air, and Ebtron.

Other models must be approved by Northeastern University Systems Engineering.

(4) Static Pressure Traverse Probe

(a) Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.

(b) Acceptable manufacturers: Cleveland Controls. Other models must be approved by Northeastern University Systems Engineering.

(5) Shielded Static Air Probe

A shielded static pressure probe, where shown on contract documents, shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

p. Status And Safety Switches

(1) General Requirements

Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the EMCS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

(2) Current Sensing Switches

(a) The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

(b) Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

(c) Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

(d) Acceptable manufacturers: Veris Industries. Other models must be approved by Northeastern University Systems Engineering.

(3) Air Filter Status Switches

NOTE: If specified by the Engineer for special applications Otherwise, Northeastern does not require monitoring of filter alarms.

(a) Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.

(b) A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

(c) Provide appropriate scale range and differential adjustment for intended service.

(d) Acceptable manufacturers: Johnson Controls.
Other models must be approved by Northeastern University Systems Engineering.

(4) Air Flow Switches

(a) Differential pressure flow switches shall be bellows or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

(b) Acceptable manufacturers: Johnson Controls.
Other models must be approved by Northeastern University Systems Engineering.

(5) Air Pressure Safety Switches

(a) Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

(b) Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

(c) Acceptable manufacturers: Johnson Controls and Cleveland Controls.
Other models must be approved by Systems Engineering.

q. Control Relays

Output relays for start/stop control shall be plug in type, DPDT or 3PDT 10A rated. Relays shall be mounted at or within the motor starters, or in the Field Panels.

r. *Chilled Water Pressure and Flow Control*

(1) Chilled Water Pressure Transmitters

(a) Chilled water pressure transmitters shall be used to monitor chilled water supply and return pressures as well as control of building differential pressure as specified.

(b) Pressure range shall be 0-200 PSIG with zero adjustment.

(c) Acceptable manufacturer: Viatran #247/347 –substitutions approved by Northeastern University.

(2) Chilled Water Differential Pressure Control Valve

(a) For chilled water control valves, the Engineer shall provide calculated pressure data for the EMCS contractors; the EMCS contractors shall submit calculations showing that the proposed valves are suitable for the application.

(b) Control valves shall be sized by EMCS contractor and shall be guaranteed to meet the flows and pressure controls specified. Control valves shall be suitable for same pressure conditions as specified for valves in Section 15000 and shall close against differential involved. Valves shall be sized to operate accurately and with stability from 10% to 100% of maximum design flow

(c) Control valves 2” and smaller and with a primary system differential of less than 50 PSID shall be Johnson Controls VG1000 Series or Belimo B2XX modulating ball valves. Valves shall be provided with spring return electric actuation, positive position feedback and manual override.

(d) Control valves larger than 2” or with a primary system differential of greater than 50 PSID shall be KTM Model WO401-62.3L Wonder Single V ball valve. Valves shall be provided with electric actuation, positive position feedback and manual override.

s. *Variable Frequency Drives*

Variable Frequency Drives (VFDs) are covered in Div.16000. All VFDs should come with an appropriate BAS interface – N2 or Bacnet.

D. Execution

1. Field Inspection

The EMCS contractors should visit the site and familiarize themselves with the existing installations, maintenance and operating practices at Northeastern.

2. Installation

a. The EMCS contractor is responsible for locating all the instrumentation throughout the HVAC system and building. The EMCS contractor is also responsible for proper function of instruments dependent on the location (for example, flow meters, instruments susceptible to noise vibration, RF, transmission losses, temperature, etc.).

b. The EMCS contractor is responsible for wire terminations at the DDC, field points, third party controllers, phone terminals 10BaseT jacks. Any interposing relays and other equipment required for field points shall be supplied by the EMCS contractor.

c. Upon completion of the installation, the EMCS contractor shall completely test, verify and tune the system, to render ready for use the complete control system. Upon completion of testing, the entire sequence of operation shall be tested and verified by the EMCS contractor, and a representative of Northeastern University.

3. Quality Assurance

a. *System Reliability*

No single failure of I/O, CPU, or operator interface shall affect the operation of more than one equipment (pump, controller, etc.).

b. *Control Sequences*

All Control sequences shall be reviewed and approved by Northeastern.

c. *Software Programs*

All software programs shall be reviewed and approved by Northeastern before being loaded into controllers in the field. This review of software sequences does not relieve the contractor from its responsibility to provide a complete and fully operational system and DOES NOT relieve the EMCS contractor of responsibility of modifying control sequences at the direction of Northeastern during the guarantee period of 18 months, at no cost to the University.

d. *Contractor's Field Tests*

(1) General

(a) Complete field tests shall be performed on all sub-systems. Each individual function tested and proven correct in function and response.

(b) EMCS contractor shall provide the services of a fully qualified service engineer whom, together with authorized representative, shall perform tests. Tests shall be performed after EMCS contractor is satisfied that automation systems are adjusted and operating in accordance with specification requirements.

(2) Instrument Accuracy (NIST Traceable)

- Temperature: 1/4°F or 1/2 percent of full scale, whichever is less
- Pressure: 1 psi or 1 percent of full scale, whichever is less
- Humidity: 2 percent RH
- Flow: 1/2 percent of maximum flow
- Electrical: 1/2 percent of full scale

(3) Field Equipment Test Procedures

Control panels shall be demonstrated via a functional end-to-end test, such that:

(a) All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.

(b) All analog input channels shall be verified for proper operation and accuracy.

(c) All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.

(d) If a point should fail testing, perform necessary repair action and re-test failed point and all interlocked points.

(e) Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.

(f) Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

(g) Tune and verify the operation of each PID loop.

(h) Test all communication protocols to connected third party controllers by verifying the function of each point or displayed values of points mapped through the communication protocol. The verification must be on both ends, on the EMCS contractor's system as well as on the third party controlled field instrument and/or controller.

(i) Testing of connected ultrasonic and electrical meters shall constitute testing at the instrument level, verification of flow, temperatures and pressures by hand held devices, communications testing at the communications hub level, and final verification of data at NuNet with Northeastern University Systems Engineering.

(4) The Control Center Work Station Test Procedures

The OWS test procedures shall be as follows:

(a) Communication with each DDC control panel shall be demonstrated.

(b) Operator commands shall be explained and demonstrated.

(c) The PMI software compliance with the as-built documentation, operating manuals and existing field installation shall be demonstrated to Northeastern. Graphics shall include all device statuses and sensed values for each installed system. Graphics shall be dynamically updated.

(5) NuNet Interface Test Procedures

Test procedures are requested for metering interfaces as part of the project. The interface to NuNet server shall be demonstrated by:

(a) Communication verification to each field point shall be demonstrated.

(b) Operator commands shall be explained and demonstrated.

(c) Access of field data, and DDC files.

(d) Time outs/retries/error checks.

(e) Transmit value/change value.

(f) Alarm reporting, alarm acknowledgment, avoidance of nuisance alarms, inhibition of alarms for devices out of service, shutdown, etc. shall be demonstrated.

(g) Messages and advisories related to operation and safety shall be demonstrated.

(h) Report formatting, ad hoc report generation, system data printout shall be demonstrated.

(i) Trending features shall be demonstrated for each trend set up in the system.

(j) PID loop functions and PID loop tuning shall be demonstrated.

(k) Optimization functions shall be demonstrated by changing input parameters to simulate real life situation.

(l) Testing of communications at the campus level as well as all communications to third party systems must be witnessed and approved by Northeastern University Systems Engineering.

(6) Completion of Installation

When the installation has been completed, the system shall be placed in operation by a trained and qualified service engineer in the employ of the EMCS manufacturer.

e. *Training*

Provide training as requested by Northeastern.

f. *EMCS System Quality and Automation Level Maintenance*

It is not the intent of this specification to show all conditions, or to give a detailed specification for control, automation and optimization of building HVAC systems. The EMCS contractor is advised to visit the site, examine all existing documentation, interview the operating personnel and Systems Engineering staff, and to come up with the most optimum solution for the project. This includes areas not specifically defined in the HVAC documentation, such as alarm management, problem analysis, energy and operations optimization, systems diagnostics, reporting, and other areas pertaining to automation and systems operation. The proposed system and systems engineering solutions should not be in any way inferior to the existing systems in operation at the University.

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Testing, Adjusting, and Balancing

This document provides design standards only, and is not intended for use, in whole or in part, as a specification. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Northeastern University Project Manager.

A. Summary

This section contains standards and guidelines for testing, adjusting, and balancing mechanical systems.

B. System Design and Performance Requirements

1. Specifications must provide for the balancing and adjusting of all air, hot water heating, and chilled water cooling systems.
2. Balancing specifications must require written reports on the design and actual capacities of pumps and fans, motor voltage, amperage, rpm, and the design and performance of terminal units.
3. Air balancing must be done by a balancing contractor, not by the mechanical or sheet metal contractor. Preliminary balancing is the responsibility of the mechanical contractor. Final balancing of the system must be performed by a Northeastern University approved balancing contractor. Include a statement in the base specifications that the mechanical contractor must provide additional mechanical equipment and/or features, such as turning vanes, volume dampers, splitter dampers and duct sealing, as determined by the approved balancing contractor for proper system balancing.
4. On large jobs, Northeastern University contracts directly for all air balancing work. Determine whether this will be the case on a given job by conferring with the Northeastern University Facilities group before writing the specifications.
5. As soon as possible after the TAB contractor is selected, specify that the TAB contractor must review the contract documents to ensure that the design intent is completely understood, identify potential balancing problems, and develop a written report that outlines the balancing procedure and lists areas of concern. The contractor must also examine the drawings for potential balancing or other problems that might affect future HVAC system operation.

6. Specify that a meeting must take place at job site before commencing test and balancing work. Meeting attendees must include the TAB contractor, design engineer, and mechanical contractor. The purpose of the meeting is to ensure that all attendees completely understand system operation and participate in designing and building a balanced and properly-controlled HVAC system. If commissioning is included in project scope, coordinate with the commissioning authority.

C. Product Certificates Signed by the Contractor

1. Include a copy of the certificate and a list of calibrated instruments, with date of calibration, in the balancing report.
2. At least one supervisor of the balancing firm must be certified by the National Environmental Balancing Bureau (NEBB).

D. Suppliers

The air and hydronic systems balancer must be a NEBB member. Do not use air-balancing contractors with only Associated Air Balance Council (AABC) membership. Only NEBB contractors provide the quality of work required by Northeastern University. NEBB requires that all testing instruments must be calibrated.

A copy of the balancing report must be included in the O&M Manuals.

E. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards and listed in the project specifications do not conflict with commissioning procedures for testing and training.

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