



# **Northeastern University**

## **MEP Design Standards**



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## DIVISION 01 - GENERAL

### 01 00 00 – General Design Conditions

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#### **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. 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. All HVAC systems shall be designed to meet the most stringent noise requirements of Table 1, 2015 ASHRAE Applications Handbook, chapter 49 or specific project requirements.
- 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**

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

**6. Energy Efficiency**

- a. Minimize energy consumption while providing the specified function, amenity, and comfort requirements. See [Section 018113 - Sustainable Design Requirements](#).
- b. Systems must be designed to meet the energy efficiency requirements in accordance with 9<sup>th</sup> Edition of the MA State Building Code which is based on the 2015 International Energy Conservation Code (IECC).

**7. Water Consumption**

- a. Minimize water consumption. See [Section 018113 - Sustainable Design Requirements](#).

**8. Waste (Trash/Rubbish) Removal**

- a. See the project program and [Section 018113 - Sustainable Design Requirements](#).

**9. Ease of Operation**

- a. 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 019100 - Commissioning](#) and [Section 017900 - Demonstration and Training](#).

**10. Ease of Maintenance**

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

**11. Ease of Repair**

- a. Elements that do not meet the specified requirements for ease of repair may be used under the following conditions:
  - (1) 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
  - (2) 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
  - (3) The service life expectancy analysis and life-cycle cost substantiation for the specified service life are provided



- (4) Northeastern University accepts them

## 12. Ease of Replacement

- a. 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

- a. Limit sound transmission through the substructure as follows:
- (1) Maintain ambient sound levels in enclosed, occupied, substructure spaces within the noise criteria ranges indicated in Table 2.
  - (2) 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.
  - (3) Achieve the outdoor–indoor airborne sound level reductions for perimeter spaces when tested in accordance with ASTM E 966 and classified in accordance with ASTM E 413 (R94).
  - (4) 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.

**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**

- a. Design and select materials to provide the following exterior appearance requirements and characteristics.
  - (1) The materials must be compatible with adjacent buildings on campus.
  - (2) The materials must match the materials on the existing building.
  - (3) Comply with the requirements of the federal historic district in which the project is located.
  - (4) Comply with requirements of the local architectural control or review commission regulating the area in which the project is located.
  - (5) Glazing appearance.
    - Tint - use as little tint as possible while complying with other requirements.
    - Reflectivity - do not use glass that has been treated to increase its natural reflectivity.
  - (6) Cleanliness of exterior surfaces.
    - Prevent the attraction and adherence of dust and airborne dirt and soot.
    - Exterior surfaces must be washed reasonably clean by normal precipitation.
    - Prevent precipitation from washing settled dust and dirt over surfaces exposed to view.
  - (7) 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.
  - (8) 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 018113 - 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 018113 - Sustainable Design Requirements](#).

## **16. Physical Security**

- a. 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.
  - (1) 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.
  - (2) Security zones are defined as follows:
    - Public access zone - an area to which the public has free access, including public corridors, grounds, and parking lots.
    - Reception zone - an area to which the general public has access but beyond which access is restricted at all times.
    - Operations zone - an area to which only employees (and visitors with a legitimate reason to be there) have access.
    - Secure zone - an area to which access is always controlled and which is monitored continuously.
    - 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**

- a. 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.
  - (1) Provide direct elevator access to mechanical spaces on the lower and upper floors and roof for maintenance purposes where applicable in existing buildings.
  - (2) 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.
  - (3) 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.
  - (4) 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.

- (5) 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.
- (6) 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.
- (7) 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.
- (8) Locate thermometers and gauges, as well as thermometer wells and gauge taps, for easy reading (and changing).
- (9) Where necessary, provide extended grease fittings for concealed or hard-to-reach bearings.
- (10) Provide adequate branch valving to allow for servicing without major shutdowns.
- (11) Equip branch piping serving each floor with shut-off valves.
- (12) Equip branch mains serving fan-coil units, reheat boxes, induction units, convectors, and similar units with flow-measuring devices and balancing valves.
- (13) 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.
- (14) Locate equipment to allow the necessary clearance for removing coils and other sub-assemblies.
- (15) Provide conveniently-located access doors to all enclosed areas housing mechanical equipment.
- (16) Provide lighting and power for servicing equipment.

## **2. Access to Piping Risers**

- a. 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 the greater of either manufacturer' minimum recommended clearance or 3' clear around all units, boilers, heat exchangers, pumps, fans, and similar equipment.
- b. Provide a minimum clearance of 4' in front of electrical panels.
- c. Provide the manufacturer's recommended minimum service areas around all equipment.
- d. Provide a full-length coil pull space. Show all coil pull spaces and access ways on the drawings.
- e. 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.
- f. 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).
- g. Sections or profiles of underground piping must show elevation (with respect to grade), roads, and possible conflicting utilities.

## **D. Disposal Guidelines**

- a. Review the project with the Northeastern University Project Manager during the design- development phase to identify salvageable equipment and hazardous waste.
- b. 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:
  - (1) Meters, meter sockets, and test switches
  - (2) Transformers (10 kva and larger)
  - (3) Fire alarm equipment
  - (4) Other equipment designated by the Northeastern University Project Manager

- c. Ensure that hazardous waste disposal is in accordance with Division 1 standards.
- d. 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**

- a. 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.
- b. 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.
- c. 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.
- d. Verify that adequate clearances have been allowed for expansion, and coordinate space requirements with engineers from all disciplines.
- e. Coordinate control and electrical systems wiring requirements with the electrical engineer.
- f. Coordinate access space and door requirements with engineers from all disciplines.
- g. Verify that electrical outlets have been provided for servicing remote and rooftop equipment.
- h. Coordinate the requirements for motor starters, disconnects, and variable-frequency drives with the electrical engineer.
- i. 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.
- j. Verify with the plumbing engineer that make-up water is available at sufficient flow and pressure.
- k. Verify that expansion joints have been coordinated with building expansion joint location, the structural engineer, and the structural requirements for anchoring.
- l. Verify that there are accessible drains available to serve automatic vents.
- m. Provide sufficient ventilation in mechanical and utility rooms to accommodate heat loads and noxious gases.
- n. Ensure that adequate space is available for piping that must pitch.



- o. Do not route piping through electrical rooms; mount the heating or cooling coils outside the space and duct heated air in.
- p. 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.
- q. Provide hose bibs in mechanical rooms and at rooftop equipment.
- r. Coordinate freeze protection electrical heat tracing requirements with the electrical engineer.
- s. Coordinate metering requirements with the plumbing and electrical engineers.
- t. Coordinate gas train requirements with Northeastern University's insurance carrier.
- u. Coordinate electrical service requirements for fire system tamper and flow switches, fire pumps, and control panel with the electrical engineer.
- v. Provide a ball valve with 3/4" hose thread and a cap at all low points to drain equipment and piping.

**-END-**

## 01 01 01 – Scope of Work

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### **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 010102 - Designer Submittals](#), for detailed engineer submittals to Northeastern University.

### **1. 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.
- 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
  - (1) See [Section 010102 - 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 shop drawing submittals of all mechanical equipment and coordination drawings.
- (2) Review testing or balancing reports.
- (3) Review emissions compliance studies.

### **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**

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

**-END-**

## 01 01 02 – 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 23 and 26.

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

Component Specifications (CSI format)		X	X	
Project Manual		X	X	
Construction Cost Estimate	X	X	X	
Life-Cycle Cost Analysis	X			
Code Review or Analysis	X			
Code Compliance Calculations		X	X	
Block Heating & Cooling Loads	X			
Mechanical Load Calculations		X	X	
Control Points List			X	
Controls Location Plan		X	X	
Electrical Load Calculations	X	X	X	
Submittal List		X	X	
List of Proprietary or Non-University Standard Items	X	X	X	
Archive Documents				X
Record Product Data and Samples				X
Operations and Maintenance Data				X
Warranties and Bonds				X
Spare Parts/Maintenance Materials				X
Progress Photographs				X
As-Built Documents (if required)				X
*	* PD = Preliminary/Enhanced Schematic Design * DD = Design Development * 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
- (2) completeness to easily determine the intended work.
- (3) 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.
- (4) Show demolition on separate drawings.
- (5) 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.



- (6) Where ductwork, piping, conduit, and bus bars interface with the systems or equipment of other divisions, make a clear distinction between division 23 and 26 work and the work of other divisions. Do not make references by subcontractor or trade.
  - (7) Show the key plan, North arrow, and room locations.
  - (8) 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.
  - (9) Provide floor plans for new work.
  - (10) 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.
  - (11) 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.
  - (12) 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.
  - (13) Provide record drawings on 24" by 34" paper and on diskettes upon completion of construction.
  - (14) 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<sub>2</sub>, 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
  - Fuel-oil storage and 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 26 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.
- 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.
  - 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.
- Indicate on the diagram the short-circuit energy available at each bus or tabulate it on the drawing.
  - 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**

- a. 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.
- c. 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.
- d. 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.
- e. Provide hydraulic calculations for fire protection piping.
- f. 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.
- g. 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.
- h. 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.
- i. Submit coordination analyses for all types of overcurrent devices in series. The equipment manufacturer will complete a short-circuit and coordination study.
- j. 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' iso footcandle 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 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 26 and work of other divisions; Do not make references by subcontractor or trade.

- a. Provide separate floor plans or removals and demolition, and for power, lighting, and fire alarm systems.
  - (1) 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.
  - (2) 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.
- b. Provide one-line diagrams for power distribution systems.
  - (1) Indicate on the diagram the short-circuit energy available at each bus or tabulate it on the drawing.
  - (2) 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.
- c. Provide riser diagrams for such systems as fire alarm, intrusion detection, and telecommunications. Include the locations of vertical chases.
  - d. Equipment schedules for feeders, switchboards, panelboards, and lighting fixtures must be in accordance with standard details shown in the relevant standards.
  - e. Provide design and engineering criteria, as well as space and ambient conditions. Specify the system under the designed intent to perform.
  - f. Calculate demands for the following loads:
    - (1) Loads operating at 120 volts
    - (2) Lighting loads
    - (3) All other normal loads
    - (4) Emergency loads, excluding fire pumps (include itemized list)
    - (5) Fire pump, with horsepower rating
    - (6) Standby loads (include itemized list)
    - (7) Maximum coincident demand expected on the normal source and the alternate source
  - g. Where multiple buildings are fed from a load center, list the following information for each building:
    - (1) The expected power factor prior to power factor improvement measures
    - (2) Duty cycles for each category of equipment
    - (3) Sizing calculations for switches over 100 amperes
    - (4) Calculations for selection and sizing of all transformers, including connected load, future loads, harmonics, and temperature considerations
    - (5) Calculations for sizing bus ducts
    - (6) Lighting fixtures catalog cuts
    - (7) Lighting calculations or isofootcandle layouts demonstrating that required illumination levels will be achieved throughout all egress routes
  - h. The building electrical service and distribution should be based on following criteria or conditions:
    - (1) Service entrance configuration
    - (2) Connected load estimate: receptacles, lighting, motors, special loads

- (3) Demand load estimate
- (4) Provision for future load growth
- (5) Level of redundancy or reliability requirement
- (6) Basis for equipment sizing: connected or demand load, load factor, non-linear load, future load growth, overload criteria
- (7) Automatic scheme and interlock
- (8) Over-current protection criteria and degree of selectivity at each voltage level
- (9) Required metering and accuracy
- (10) Provision for testing and maintenance
- (11) Grounding system requirement: safety, instrumentation, lightning protection
- (12) Special protection requirement: transient voltage surge suppression, under-voltage or loss of phase protection, EMI or RFI
- i. The emergency power system should be based on following criteria or conditions:
  - (1) Connected load estimate: receptacles, lighting, motors, special loads
  - (2) Demand load estimate
  - (3) Provision for future load growth
  - (4) Motor starting capability
  - (5) Non-linear loads
  - (6) Transient performance, block load, and unload criteria
  - (7) Generator auxiliary systems: starting, fuel supply and storage, cooling, combustion air supply, exhaust, sound attenuation, fire protection
  - (8) Configuration and mode of operation
  - (9) Required metering and accuracy
  - (10) Provision for testing and maintenance
  - (11) Over-current protection criteria and degree of selectivity
  - (12) Provision for monitoring, supervisory and alarm
  - (13) Interaction with other systems: fire protection, elevator, energy management, security, lighting control
- j. The fire alarm system should be based on following criteria or conditions:
  - (1) System configuration and equipment
  - (2) Type of detection and signaling to be provided in each

- space
- (3) Type of system, initiating device circuit, and signaling circuit per NFPA 72
- (4) Standby power supply
- (5) Interaction with other systems: fire protection, elevator, HVAC, security, fire door and fire curtain, lighting control and egress lighting
- (6) Provision for signaling, monitoring, supervisory and alarm annunciation
- k. The communication and paging system should be based on following criteria or conditions:
  - (1) System configuration and equipment
  - (2) Zone listing
  - (3) Audibility criteria
  - (4) Instrument type and functionality
  - (5) Reliability and redundancy
  - (6) Interaction with other systems: fire alarm, security
  - (7) Power supply: UPS, emergency power, DC battery

**-END-**

## 01 01 03 – General Regulatory and Directive Standards

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*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,<sup>™</sup> which arranges subjects in numbered sections within established divisions. Precede these specifications with the general documents containing bidding documents and general conditions. Use of the CSI MasterFormat<sup>™</sup> 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" = 1'-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, 1st, 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:

<u>Item</u>	<u>Dwg. No.</u>
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-**

## 01 35 13 – Special Project Procedures

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### **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. Crawlspace 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).

**-END-**

## **01 35 14 – Special Procedures for Historic Treatment**

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### **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.

**-END-**

## 01 42 19 – Reference Standards

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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-
- g. Resistive Materials Applied to Structural Members
- h. ASTM E736 - Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members

- i. ASTM E759 - Test Method for Effect of Deflection on Sprayed Fire-Resistive Materials Applied to Structural Members
- j. ASTM E760 - Test Method for Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members
- k. ASTM E859 - Test Method for Air Erosion of Sprayed Fire-Resistive Materials Applied To Structural Members
- l. ASTM E937 - Test Method for Corrosion of Steel by Sprayed Fire Resistive Material Applied to Structural Members
- m. ASTM E119 - Method for Fire Tests of Building Construction and Materials
- n. ASTM E 814 - Fire Tests of Through-Penetration Fire Stops
- o. UL 723 - Test for Surface Burning Characteristics of Building Materials
- p. UL 1479 - Fire Tests of Through-Penetration Firestops
- q. ASTM A361 - Sheet Steel, Zinc-Coated (Galvanized) by the Hot-Dip Process for Roofing and Siding
- r. ASTM D225 - Asphalt Shingles Surfaced with Mineral Granules
- s. ASTM D226 - Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
- t. ASTM D2822 - Asphalt Roof Cement
- u. ASTM D3018 - Class A Asphalt Shingles Surfaced with Mineral Granules
- v. 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
- bb. ASTM D2178 - Asphalt Glass Felt Used in Roofing and Waterproofing
- cc. ASTM D2626 - Asphalt Saturated & Coated Organic Felt Base Sheet used in Roofing
- dd. FS-HH-I-529 - Insulation Board, Thermal (Mineral Aggregate)
- ee. FS-HH-I-1972 - Insulation Board, Thermal-Faced, Polyurethane or Polyisocyanurate
- ff. NRCA - The NRCA Roofing and Waterproofing Manual
- gg. PIMA - Technical Bulletin 281-1, Conditioning Procedures

- hh. ASTM D412 - Rubber Properties in Tension
- ii. ASTM D4637 - Vulcanized Rubber Sheet used in Single Ply Roof Membrane
- jj. ASTM D746 - Brittleness Temperature of Plastics and Elastomers by Impact
- kk. FM Approval Guide - Equipment, Materials, Services for Conservation of Property
- ll. FM Loss Prevention Data 1-28 - Insulated Steel Deck
- mm. FM Loss Prevention Data 1-49 - Perimeter Flashing
- nn. ASTM D746 - Brittleness Temperatures of Plastics and Elastomers by Impact
- oo. FM Approval Guide - Equipment, Materials, Services for Conservation of Property
- pp. ASTM C177 - Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate
- qq. ASTM A526-90 - Spec for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
- rr. ASTM D226-89 - Spec for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
- ss. SMACNA - Architectural Sheet Metal Manual at. ASTM B32 - Solder Metal
- tt. ASTM A653-96 - Spec for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- uu. ASTM B209-93 - Spec for Aluminum and Aluminum: Alloy Sheet and Plate
- vv. ASTM B209-93 - Spec for Aluminum and Aluminum: Alloy Sheet and Plate
- ww. ASTM C790 - Recommended Practices for Use of Latex Sealing Compounds
- xx. ASTM C804 - Recommended Practice for Use of Solvent-Release Type Sealants
- yy. ASTM C834 - Latex Sealing Compounds ba. ASTM C920 - Elastomeric Sealants
- zz. 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

aa. 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
- bb. MCAA(MSS) - Guideline for Quality Piping Installation
- cc. MSS SP 58(MSS) - Pipe Hangers and Supports Materials, Design and Manufacture
- dd. MSS SP 69 - Pipe Hangers and Supports Selection and Application National Association of Plumbing/Heating/Cooling Contractors (PHCC)
- ee. National Environmental Balancing Bureau (NEBB)
- ff. 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
- gg. NCPWB, Welding Procedure Specifications
- ah. Plumbing and Drainage Institute
- hh. Roadmap for Integrating Sustainable Design into Site-Level Operations, US Department of Energy (March 2000)
- ii. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) design guides
- jj. Seismic Restraint Manual Guidelines for Mechanical Systems, 2nd edition SMACNA
- kk. 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
- ll. "Understanding Owner Project Requirements Documentation (Design Intent)," Karl Stum, P.E., National Conference on Building Commissioning (2001)

mm. 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
- aa. 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
  - ASSE 1016
  - ASSE 1017
- h. CAN/CSA-C22.2 No. 110-94
- i. NSF/ANSI 5
- j. NSF/ANSI 61 - Drinking Water System Components Health Effects
- k. UL Motor-Operated Water Pumps Standard

- l. UL 795
- m. 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
- bb. 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
- aa. ARI 850-93 - Commercial and Industrial Air Filter Equipment
- bb. ARI 880 - Air Terminals
- cc. ARI-885 - Procedure for Estimating Occupied Sound Levels in the Application of Air Terminals and Air Outlets
- dd. ASC-A-7001A - Adhesives Standard for Duct Liner Adhesive & Sealant
- ee. ASHRAE - A Practical Guide to Noise and Vibration Control for HVAC Systems, Schaffer, Mark E.
- ff. ASHRAE Standard 129 Schaffer Measuring Air Change Effectiveness
- gg. ASME PTC 11 Schaffer Fans
- hh. ASHRAE 51-1999 Schaffer Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
- ii. ASHRAE 52-1999 Schaffer Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- jj. ASTM F1471 Schaffer Test Method for Air-Cleaning Performance of a High Efficiency Particulate Air Filter System
- kk. CSA C22.2 No. 113-M Schaffer Fans and Ventilators
- ll. Industrial Ventilation: A Manual of Recommended Practice, 24th ed. (2001)
- mm. SMACNA 2002 - Accepted Industry Practices for Sheet Metal Lagging, 1st ed.
- nn. SMACNA - HVAC Air Duct Leakage Test Manual
- oo. SMACNA - HVAC Duct Construction Standards, Metal and Flexible
- pp. SMACNA - Rectangular Industrial Duct Construction Standards
- qq. SMACNA - Duct Design
- rr. SMACNA - Round Industrial Duct Construction Standards
- ss. SMACNA - Duct Liner Applications
- tt. SMACNA - Mechanical Fasteners Standard
- uu. SMACNA - HVAC Air Duct Leakage Test Manual, 1st ed.
- vv. SMACNA - HVAC Duct Systems Inspection Guide, 2nd ed.
- ww. SMACNA - Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th ed.
- xx. UL 181 - Factory-Made Air Ducts and Air Connectors

- yy. UL 181A - Closure Systems for Use with Rigid Air Ducts and Air Connectors
- zz. UL 181B - Closure Systems for Use with Flexible Air Ducts and Air Connectors
- aaa. UL 507 - Electric Fans (1999)
- bbb. UL 555C - Ceiling Dampers bd. UL 555S - Smoke Dampers
- ccc. UL 585 - High-Efficiency, Particulate, Air Filter Units
- ddd. UL 710 - Exhaust Hoods for Commercial Cooking Equipment
- eee. 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
- d. (Red Book)
- e. ANSI/IEEE 142-1991 - Grounding of Industrial and Commercial Power Systems (Green Book)
- f. ANSI/IEEE 241-1990 - Electric Power Systems in Commercial Buildings (Gray Book)
- g. ANSI/IEEE 242-1986 - Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)
- h. ANSI/IEEE 399-1990 - Industrial and Commercial Power Systems Analysis (Brown Book)
- i. ANSI/IEEE 493-1990 - Design of Reliable Industrial and Commercial Power Systems (Gold Book)
- j. ANSI/IEEE 602-1986 - Electric Systems in Health Care Facilities (White Book)
- k. ANSI/IEEE 739-1984 - Energy Conservation and Cost-Effective Planning in Industrial Facilities (Bronze Book)
- l. ANSI 117.1 - Providing Accessibility and Usability for Physically Handicapped People
- m. ANSI Z117.1 - Safety Requirements for Confined Spaces
- n. ANSI/IEEE 100-1988 - Standard Dictionary of Electrical and Electronics Terms
- o. ANSI/IEEE 519-1992 - Harmonic Control in Electrical Systems
- p. ANSI/IEEE 693-1984 - Seismic Design of Substations
- q. ANSI/IEEE 946-1992 - DC Auxiliary Power Systems for Generating Stations
- r. ANSI/IEEE 979-1984 - Substation Fire Protection
- s. ANSI/IEEE 980-1987 - Containment and Control of Oil Spills in Substations
- t. ANSI/IEEE 1001-1988 - Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems
- u. ARI Guideline G - Mechanical Balance of Fans and Blowers
- v. ETL Directory (1987)
- w. IEEE 666-1991 - Electric Power Service Systems for Generating Stations
- x. IEEE 1109-1990 - Interconnection of User-Owned Substations to Electric Utilities
- y. IEEE 1127-1990 - Design, Construction, and Operation of Safe and Reliable Substations for Environmental Acceptance

- z. Lineman's and Cableman's Handbook, 5th ed. (Bradley)
- aa. National Electrical Safety Code Handbook
- bb. Switchgear and Control Handbook (Bradley)
- cc. UL Directories:
  - Electrical Appliance and Utilization Equipment (1990)
  - Electrical Construction Materials (1990)
  - Fire Protection Equipment (1990)
  - Hazardous Location Equipment (1990)
- dd. 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-**

## **01 70 00 – Project Execution and Closeout**

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**Please contact the  
Northeastern University  
Department of Facilities  
Contract Administrator  
about project execution  
and closeout requirements.**

**-END-**

## ■ 01 78 23 – Operation and Maintenance Data

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### **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 230900 – Instrumentation and Control for HVAC](#) 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 230900 – Instrumentation and Control for HVAC](#) and Section 15960 - Laboratory Airflow Control System .

**F. Special Control System O&M Manuals**

See the content requirement in specification [Section 230900 – Instrumentation and Control for HVAC](#) 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®

**-END-**

## 01 78 36 – Warranty Procedures

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### **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 017823 - Operation and Maintenance Data](#).

**-END-**

## 01 79 00 – Demonstration and Training

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### **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**

<b>System Description</b>	<ul style="list-style-type: none"> <li>• Design intent of new or modified systems, subsystems, equipment, and technology</li> <li>• System, subsystem, equipment, and component locations</li> <li>• Special design characteristics, construction features, and operational requirements</li> <li>• Theory and sequence of operations</li> <li>• Operating parameters, operating standards, regulatory requirements, limiting conditions, and performance curves</li> <li>• Materials and processes</li> <li>• Control systems, including control screens or devices; integrated sensors, switches, and other input devices</li> <li>• Safety hazards and precautions, including lockout/tagout procedures</li> <li>• Design features that mitigate safety hazards, such as guarding or other protective devices</li> <li>• Hazardous waste products and contaminants</li> <li>• Regulatory requirements and limitations, including special waste disposal and/or reclamation needs</li> <li>• Odors and other emissions</li> <li>• System, subsystem, and equipment interactions and interfaces, including utilities</li> </ul>
<b>Normal and Emergency Operation</b>	<ul style="list-style-type: none"> <li>• Normal operation, including startup, break-in, control, stopping, and normal shutdown</li> <li>• Automatic and manual control sequences</li> <li>• Routine, normal, seasonal, and weekend operation</li> <li>• Common failure modes and sudden power loss</li> <li>• Emergency operation, including trouble indications (error messages, warnings, alarms), emergency responses, stopping, shutdown, and abnormal or casualty operations</li> <li>• Required sequences for electric or electronic systems</li> </ul>
<b>Preventive and Predictive Maintenance</b>	<ul style="list-style-type: none"> <li>• Testing</li> <li>• Inspection</li> <li>• Adjustments, alignments, calibration, and balancing</li> <li>• Cleaning methods, surface care needs, and agents</li> <li>• Preventive and routine maintenance</li> <li>• Use of special tools and test equipment</li> <li>• Performance optimization, including how to maintain high operational reliability, economy, and efficiency; minimize noise and vibration transmission, and conduct seasonal changeover operations</li> </ul>

**Table 1. O&M Knowledge and Skills - Continued**

<b>Corrective Maintenance and Repair</b>	<ul style="list-style-type: none"> <li>• Troubleshooting</li> <li>• Diagnosis</li> <li>• Repair</li> <li>• Disassembly and disassembly</li> </ul>
<b>Consumables and Spare Parts</b>	<ul style="list-style-type: none"> <li>• Parts identification</li> <li>• Contractor-furnished spare parts and extra materials</li> <li>• Recommended critical spare parts for on-site inventory</li> <li>• Procurement information for replacement parts, repair kits, and materials</li> <li>• Contact information for local suppliers and factory representatives</li> </ul>
<b>Documentation</b>	<ul style="list-style-type: none"> <li>• Installation requirements</li> <li>• Identification systems</li> <li>• Format, content, and use of O&amp;M data, manuals, and project record documents</li> <li>• Warranty and bond terms and conditions, points of contact, material return procedures, effective dates, expiration times, and extension options</li> <li>• Maintenance service agreements and other similar continuing commitments, except sales promotions</li> </ul>

## **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-**

## 01 81 13 – Sustainable Design Requirements

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### 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 1 Appropriate 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

**-END-**

## 01 91 00 – Commissioning

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*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**

2. 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.
3. 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.
4. 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 018113 - Sustainable Design Requirements](#).

### **B. System Design and Performance Requirements**

2. 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.
3. Northeastern University commissioning is a quality-focused process that targets:
  - Documentation
  - Testing
  - Training

4. 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.
5. 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.
6. 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**

2. 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.
3. 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**

<b>General Systems Commissioning</b>	
•	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**

<b>Electrical Systems Commissioning</b>
<ul style="list-style-type: none"> <li>• Building main electrical service switchgear, switchboard, or substation</li> <li>• Major switchboard with breakers rated 200 A or higher</li> <li>• Normal power double-ended substations</li> <li>• Outdoor, liquid type, pad-mounted transformers</li> <li>• Alternate power switchgear</li> <li>• Lighting control systems</li> <li>• Automatic transfer switches</li> <li>• Major switchboards or panelboards following ATS</li> <li>• Emergency power system MCC</li> <li>• Normal power outage simulation tests</li> <li>• Emergency switchgear or switchboard</li> <li>• Emergency panels, including emergency power outlets</li> <li>• Emergency lighting, exit sign and lighting control (testing oversight by the Northeastern University fire marshal)</li> <li>• Fire alarm system (tests are performed by Northeastern University personnel)</li> <li>• Security system (tests are performed by Northeastern University personnel)</li> </ul>

#### **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.

#### **2. 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.

### **3. Commissioning Action Item List**

- a. 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.

### **4. Change Order Reviews and other Construction Phase Documentation**

- a. 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.

### **5. 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.

### **6. Design Intent Document Update**

- a. 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.

## **7. Commissioning Record Book Maintenance**

- a. 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**

### **2. Discovery Phase**

- a. 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?

### **3. Commissioning Plan**

- a. 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.
- b. 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.

- c. See the sample Commissioning Plan.

#### **4. Design Phase Commissioning Kickoff Meeting**

- a. 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.

#### **5. 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.

## **6. 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.

## **7. 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.

## **8. 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 018113 - Sustainable Design Requirements](#) for additional information regarding sustainable design.

## **9. Commissioning Requirements in Technical Specifications**

- a. 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.

## **10. Training Plan Development Design Phase Commissioning Kickoff Meeting**

- 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.

## **11. 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.

## **12. 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.

## **13. 100-Percent Design Review Backcheck**

- a. 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**

- a. 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**

- a. 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**

- a. 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:
  - Does the plan include the need for the balancer to obtain any equipment from the controls contractor in order to balance a system?
  - Does the balancer know how to use the equipment provided by the controls contractor?
  - Must the controls contractor be on-site while the test and balance process is occurring?
  - Does the test and balance contractor understand the direct digital control (DDC) system know how to enter and override control setpoints?
  - 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.
  - Short-circuit and power coordination study review.
  - Electrical system short-circuit analysis review.
    - 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.
    - 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.
  - Electrical harmonic study.
    - 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.
    - 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 in coordinating training events to meet the needs of all participants and to ensure that resources are used effectively.

#### **14. Systems Training Planning**

- a. 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**

- a. 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**

- a. 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:
  - Prove the functionality of the digital control system to collect regular and continuing real time values, and proves the selected sensors work as expected.
  - 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.
  - Establish a history of normal operations.
  - 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**

- a. 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**

- a. 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**

- a. 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 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**

- a. 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-**

## DIVISION 21 – FIRE PROTECTION

### 21 00 00 – Fire Protection 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 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:
  - a. Laboratories: 15%, to allow for additional ductwork for new fume hoods.
  - b. Open storage: 20%, to allow for new walled-off areas.
  - c. Laboratory support spaces: 25%, to allow for new cold room boxes.
  - d. 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-**

## **21 01 03 – Fire Protection Regulatory and Directive Standard**

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### **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 [210000 - 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:
- a. 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 010102 - Designer Submittals](#) and Section 13915 - Fire Suppression for submittals requirements.

**-END-**

## DIVISION 22 - PLUMBING

### 22 00 00 – General Plumbing Design Condition

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#### **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-**

## ■ 22 01 03 – Plumbing Regulatory and Directive Standards

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### **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 22 sections of these standards, as well as [Section 220000 - 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 010102 - Designer Submittals](#) and the Division 22 mechanical sections of these standards for submittals requirements.

**-END-**

## 22 05 53 – Identification of Plumbing Piping and Equipment

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### **A. Summary**

This section contains design criteria for plumbing 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**

<b>Service</b>	<b>Legend</b>	<b>Background Color</b>
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**

<b>Piping System (and Legend)</b>	<b>Color</b>
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 __

## **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.

**-END-**

## ■ 22 11 16 – Domestic Water Piping

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### **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**

- a. Submit domestic water load and non-potable load calculations with sketch.

**2. Construction Documents**

- a. Submit pipe cleaning and pipe pressure test reports.

**D. Materials**

All interior copper water piping above grade must be Type L only.

**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.
- 7. Press type fitting system equal to Viega ProPress acceptable.

**-END-**

## ■ 22 11 19 – Plumbing Specialties

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### **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 backflow preventers where required.
  - a. A check valve must be installed upstream from the reduced-pressure valve to prevent valve dumping every time the main line pressure drops.
  - b. 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

#### **3. Backflow Preventers**

- Watts 909

**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-**

## 22 11 23 – Domestic Water Pumps

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### **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 or stainless steel 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-**

## ■ 22 13 00 – Sanitary or Laboratory Waste and Vent Piping

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### **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 be directed to the sanitary sewer system or storm drain system based on waste type. The use of condensate pumps is approved.
  - a. There must be an indirect connection between air conditioning equipment drain piping and the 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 or copper 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.

- 6.** 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.

### **E. 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.

**F. Materials**

**1. Sanitary, Waste, and Vent Piping**

Gravity flow, 120 F maximum temperature, cast iron or copper 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**

50 psig, 120 F maximum temperature, polypropylene.

**G. 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-**

## ■ 22 13 29 – Sewage and Sump Pumps

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### **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**

- 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-**

## 22 14 13 – Facility Storm Drainage Piping

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### **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" minimum.
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).

### **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.
2. Storm drain: gravity flow, 80 F 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-**

## ■ 22 15 00 – General Service Compressed Air Equipment

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### **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
- Quincy Compressor
- 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-**

## 22 15 13 – Facility Storm Drainage Piping

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### **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° F, 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-**

## ■ 22 15 13 – General Service Compressed Air Piping

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**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: 150 psig, 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-**

## ■ 22 16 00 – Fuel Gas Piping

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### **A. Summary**

This section contains design criteria for fuel gas systems.

### **B. Materials (Natural gas)**

1. Carbon steel.
2. Malleable steel fittings.
3. May be used with Viega MegaPress G fitting system.

### **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-**

## 22 33 00 – 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 systems
- Laundry hot water systems

## **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
- PVI

#### **2. High-Recovery, High-Efficiency Electric Water Heaters**

- AO Smith
- 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-**

## 22 35 00 – Domestic Water Heat Exchangers

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### **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-**

## ■ 22 40 00 – Plumbing Fixtures

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### **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 building 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.

### *a. Counting Fixtures for the Handicapped*

Include all fixtures provided for the physically handicapped in the fixture count. Wherever "gender neutral" 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.

### *b. Gender Neutral Toilet Rooms*

Where practical provide gender neutral toilet rooms.

## **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.

Table-1 below represents the current Northeastern preferred plumbing fixtures.

**Table 1. Northeastern Preferred Plumbing Fixtures**

Type	Manufacturer/Model	Specification Type
Water Closets (Wall Hung)	Toto CT708E Toto TET1LA	CP
Water Closets (Floor Mount)	Toto CST744EL (ADA) Toto CST743S	OP
Urinal	Toto UT447E Toto TEU1LA	CP
Lavatory (Wall Hung)	Toto LT307	OP
Lavatory (China Drop In)	Toto LT402	OP
Lavatory (Undercounter)	Toto LT231	OP
Lavatory (Multi Station)	Bradley LVA-Series	OP
Lavatory Faucet (Manual)	Chicago 2200	CP
Lavatory Faucet (Electronic)	Chicago 116.102.AB.1	OP
Kitchen Sink	-	OS
Kitchen Faucet	Chicago 2300	OP
Drinking Fountain	Elkay VRCGRNTL8WSK	CP
Mop Sink	Chicago 540-LD897SWXFKCP	OP
OS: Open specification - No preference on manufacturer or model. OP: Open Preferred – Manufacturer and/or model listed is preferred but not required. CP: Campus Proprietary - Manufacturer and/or model listed shall be used unless project specific conditions prohibit its use. Manufacturers may present equal fixtures for consideration to be incorporated into this standard.		

**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-**

## ■ 22 45 00 – Emergency Plumbing Fixtures

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### **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**

- Guardian

#### **2. Emergency Eyewash Units**

- Guardian

### **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-**

## 22 47 00 – Drinking Fountains and Water Coolers

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### **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 building 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:

- Hasley 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-**

## 22 60 00 – Laboratory Air and Vacuum Piping

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### **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.

## ■ 22 60 00 – Medical Gas Piping

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### **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 F 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.

## ■ 22 60 00 – Medical Air and Vacuum Equipment

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### **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:

- 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-**

## **22 60 19.53 – Medical Air and Vacuum Equipment**

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### **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-**

## **Division 23 – HVAC**

## **230000 - General HVAC Design Conditions**

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### **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**

- a. 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	RH	Air Supply
Offices and conference rooms	73–75°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)	73–75°F		70–73°F	65°F Night Setback	60°F T-Setback	50%	Summer/ Winter Unoccupied Setback
Equipment rooms	85°F	85°F	65°F	65°F			
Animal rooms (each independent)	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific
Assembly/DH, etc.	73–75°F	HVAC off Temp Uncontrolled	70–73°F	65°F Night Setback	60°F T-Setback	N/A	Summer Unoccupied OFF
Classroom	73–75°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)	73–75°F	78°F Night Setback	70°F	65°F Night Setback	N/A	30–50%	Summer/ Winter Unoccupied Setback
Libraries (dedicated stack areas)	72°F	72°F	68°F	68°F	68°F	50%	ON
Computer rooms	72°F	78°F	72°F	68°F			Project-specific
Museums	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific
Specialty areas	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific	Project-specific

### **3. Equipment Sizing**

- a. Use the following outside design temperatures for sizing mechanical equipment:
  - Use ASHRAE weather data for Boston Logan, station #725090)
  - 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 and International Energy Conservation Code (IECC). 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 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 236400 - Water Chillers](#) for chilled water system design criteria.

## **6. Heating and Humidification Design**

### **a. Applications**

- (a) Steam is used to transport heat into and indirectly humidify the buildings.
- (b) 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.
- (c) 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 the minimum ventilation rates identified in Table 403.3.1.1 of 2015 International Mechanical Code (IMC). 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  $\pm 10^{\circ}\text{F}$ .

- (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

- (a) Design offices, reception areas, and conference rooms to be pressure- neutral to adjacent similar-use areas and pressure-positive with respect to the corridor.

(3) Excess Capacity

- (a) 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 the minimum ventilation rates identified in Table 403.3.1.1 of 2015 International Mechanical Code (IMC).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  $\pm 10^{\circ}\text{F}$ .

- (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

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

(3) Excess Capacity

- (a) 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

- (a) 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) During occupied mode, the amount of fresh outside air must

not drop below the minimum ventilation rates identified in Table 403.3.1.1 of 2015 International Mechanical Code (IMC).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  $\pm 10^{\circ}\text{F}$ .

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

- (2) Pressure Relationships

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

- (3) Excess Capacity

- (a) 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
  - (c) for free cooling. The exhaust system for toilet, locker, and shower rooms must be separate from other building exhaust systems.
  - (d) The amount of fresh outside air must not drop below 25 cfm per person, based on the maximum projected occupancy.
  - (e) Janitor's closets and similar areas must be exhausted at a rate of not less than 10 air changes per hour.
  - (f) The use of fan coil units is discouraged in these areas.

- (2) Pressure Relationships
  - (a) Design toilet, locker, and shower room areas to be pressure-negative relative to adjacent areas and the corridor.
- (3) Excess Capacity
  - (a) 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 residence 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
  - (a) Design animal areas to be pressure-negative relative to adjacent areas and the corridor. Pressurize surgery to meet AAALAC requirements.
- (3) Excess Capacity
  - (a) 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  $\pm 10^{\circ}\text{F}$ .
  - (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
    - (a) Design cafeterias, lounges, and photocopy rooms to be pressure-negative relative to adjacent areas and the corridor.
  - (3) Excess Capacity
    - (a) Size all system components (AHUs, ducts, diffusers, pumps, heat exchangers) to support 10 percent growth anywhere in the system.
  - (4) Redundancy and Diversity
    - (a) 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**

- (1) Equip elevator machine rooms with unit heaters to maintain a minimum temperature of  $60^{\circ}\text{F}$ , if they are located in areas where the temperature is expected to fall below  $60^{\circ}\text{F}$ . 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 than 104°F. Use of ductless split A/C located above the entry door is encouraged.

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

- (1) Equip garages, enclosed driveways, and loading platforms with a mechanical ventilation system per NFPA 88. Provide automatic ventilation controls to minimize exhaust rates while conserving energy. Approximately two-thirds of the exhaust must be taken near the floor or below the loading platform. Consider loading dock heating and protection of any exposed wet piping with electric heat trace.

**j. Other Spaces**

- (1) Design all 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**

- a. Heat recovery shall be provided as required per ~~section C403.2.7 of~~ the 2018<sup>85</sup> International Energy Conservation Code or when deemed appropriate for energy savings. 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 systems for lab uses. 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. During occupied mode, the amount of fresh outside air must not drop below the minimum ventilation rates identified in Table 403.3.1.1 of 2015 International Mechanical Code (IMC).
- 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**

- a. 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 232113 - Hydronic Piping](#) for recommended velocities in piping.

**-END-**

## **230103 - HVAC Regulatory and Directive Standards**

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### **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 230000 - General HVAC Design Conditions](#) and the Division 23 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.

d.e. If any permanent systems were used during construction the contractor shall be responsible for a full cleaning of such unit and replacement of filters if applicable prior to turn over to the university.

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 010102 - Designer Submittals](#) and the Division 23 mechanical sections of these standards for submittals requirements.

**-END-**

## **230513 - 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 [Section 230900 – Instrumentation and Control for HVAC](#), 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-**

## **230519 - Meters and Gauges for HVAC Piping**

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### **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  $\pm 1$  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 be 1/4" 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**

1. 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-**



## **230523 - General-Duty Valves for HVAC Piping**

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### **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 7.

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 7. 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 7.
- 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 7.
- 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.
- Install isolation valves at all horizontal take-offs at each floor so a complete floor can be isolated from another.
- 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**

<b>Steam and Condensate Service Maximum 90 psig Saturated Steam</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating <sup>1, 2</sup></b>
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	Uni on Bon net	1/2"-2"	Bronze/Stainless Bronze/Bronze	Threaded	125 psig SWP
		OS&Y	2-1/2"-10"	Iron/Bronze	Flanged	Class 125
Butterfl y valve	Isolation					
Plug valve	Not used					
Check valve	Steam and condensate horizontal flow	Non Y-type swing check valve (15° 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**

<b>Steam and Condensate Service Maximum 200 psig Saturated Steam</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating 1, 2</b>
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 (15° 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. Glycol, Chilled, and Condenser Water Service**

<b>Glycol, Chilled and Condenser Water Service</b>						
<b>Maximum 150°F and 150 psig (1/2"-12")/125 psig (14"-24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
Ball valve	Isolation	Full port 2-pc.	1/2"-2"	Bronze/Teflon	Sweat <sup>1</sup>	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 valve	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 3. Glycol, Chilled, and Condenser Water Service - Continued**

Glycol, Chilled and Condenser Water Service Maximum 150°F and 150 psig (1/2"–12")/125 psig (14"–24")						
Specialty	Application	Type	Size	Body/Seat Body/Trim	Connection	Minimum Rating <sup>1, 2</sup>
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) <sup>3</sup>	Flanged	Class 125
			5"–24"	Iron/Stainless (3" diameter) <sup>3</sup>	Flanged	Class 125
	Angle suction diffuser end suction pumps		2"–12"	Iron/Stainless (3/16" diameter) <sup>3</sup> Startup strainer = 16 mesh bronze	Flanged	Class 125

- 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].
- SWP = Steam Working Pressure  
CWP = Cold Water Working Pressure  
WOG = Water, Oil, or Gas  
WSP = Working Steam Pressure  
Class = ANSI Standard
- Use 1/8" diameter for plate heat exchanger application.

**Table 4. Glycol, Chilled, and Condenser Water Service**

<b>Glycol, Chilled and Condenser Water Service Maximum 150°F and 275 psig (1/2"–24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
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) <sup>3</sup>	Flanged	Class 250
			5"–24"	Iron/Stainless (3"diameter) <sup>3</sup>	Flanged	Class 250

**Table 4. Glycol, Chilled, and Condenser Water Service - Continued**

<b>Glycol, Chilled and Condenser Water Service Maximum 150°F and 275 psig (1/2"–24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
Strainer	Pump suction	Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter) <sup>3</sup> 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  
WOG = Water, Oil, or Gas  
WSP = Working Steam Pressure  
Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

**Table 5. Hot Water Service**

**Hot Water Service - Maximum 250°F and 175 psig (1/2"–12")/125 psig (14"–24")**

Specialty	Application	Type	Size	Body/Seat Body/Trim	Connection	Minimum Rating <sup>1, 2</sup>
Ball valve	Isolation	Full port 2- pc.	1/2"– 2"	Bronze/Teflon	Sweat <sup>1</sup>	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 valve	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



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	Pump suction	In-line Y- Type	1/2"- 2"	Bronze/Stainless (1/16" diameter)	Threaded	200 psig WOG
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**Table 5. Hot Water Service - Continued**

<b>Hot Water Service</b> <b>Maximum 250°F and 175 psig (1/2"-12")/125 psig (14"-24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
Strainer	Pump suction	In-line Y-Type	2-1/2"-4"	Iron/Stainless (3/16" diameter) <sup>3</sup>	Flanged	Class 125
			5"-24"	Iron/Stainless (3" diameter) <sup>3</sup>	Flanged	Class 125
		Angle suction diffuser end suction pumps	2"-12"	Iron/Stainless (3/16" diameter) <sup>3</sup> 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  
WOG = Water, Oil, or Gas  
WSP = Working Steam Pressure  
Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

**Table 6. Hot Water Service**

<b>Hot Water Service</b> <b>Maximum 250°F and 400 psig (1/2"-12")/250 psig (14"-24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
Ball valve	Isolation	Full port 2-pc.	1/2"-2"	Bronze/Teflon	Sweat <sup>1</sup>	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 valve	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) <sup>3</sup>	Flanged	Class 250
			5"-24"	Iron/Stainless (3" diameter) <sup>3</sup>	Flanged	Class 250



**Table 6. Hot Water Service - Continued**

<b>Hot Water Service</b> <b>Maximum 250°F and 400 psig (1/2"–12")/250 psig (14"–24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
Strainer	Pump suction	Angle suction diffuser end suction pumps	2"–12"	Iron/Stainless (3/16" diameter) <sup>3</sup> 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  
WOG = Water, Oil, or Gas  
WSP = Working Steam Pressure  
Class = ANSI Standard
3. Use 1/8" diameter for plate heat exchanger application.

**Table 7. Fuel Oil Service**

<b>Fuel Oil Service</b> <b>Maximum 150°F and 150 psig (1/2"-12")/125 psig (14"-24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
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 valve	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 7. Fuel Oil Service - Continued**

<b>Fuel Oil Service</b> <b>Maximum 150°F and 150 psig (1/2"-12")/125 psig (14"-24")</b>						
<b>Specialty</b>	<b>Application</b>	<b>Type</b>	<b>Size</b>	<b>Body/Seat Body/Trim</b>	<b>Connection</b>	<b>Minimum Rating<sup>1, 2</sup></b>
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  
WOG = Water, Oil, or Gas  
WSP = Working Steam Pressure  
Class = ANSI Standard

**-END-**

## **230553 - Identification of HVAC Piping and 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 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.

### **C. Tags, Valves, Equipment, and Instruments**

1. 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.
2. Equipment must bear stamped, stainless steel tags.
3. 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.
4. Embossed or engraved aluminum or brass tags may be substituted for stainless steel or laminated tags, if desired.
5. Tags must be at least 1" in diameter, at least 1/8" thick, and attached by S-hooks and chains.

### **D. HVAC Systems Identification**

1. 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.
2. 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.
3. 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.

4. 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
5. The size of legend letters on markers and the length of the color field must be per the latest edition of ANSI.
6. Use the color-coding in Table 1, with names in black letters on a white background and white letters on a green background.

**Table 1. 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

## E. Product Standards

1. Color banding must meet the latest ANSI and OSHA requirements.

**F. Manufacturers**

- Ceel-Co plastic jacket.
- Seton Name Plate Corporation
- Marking Services Incorporated
- Approved equal

**G. Materials**

1. Use Setmark markers by the Seton Name Plate Corporation or approved equal.

**H. 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. Coordinate the numbering system with existing piping tags to avoid duplicate numbers.

**-END-**

## **230593 - Testing, Adjusting, and Balancing for HVAC**

*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**

1. 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.
2. A copy of the balancing report must be included in the O&M Manuals.

**E. 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.

**-END-**



## **230713 - 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**

- a. Insulated kitchen exhaust ducts per NFPA, local code, and Fire Department requirements.

#### **2. Concealed Rectangular, Flat Oval, and Circular Ductwork**

- a. 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**

- a. Insulate supply and return exposed ducts. Insulation requirements to be determined at the design phase.

#### **4. Exposed Round and Flat Oval Ductwork**

- a. 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**

- a. Use of internal duct lining is not allowed without prior approval of Northeastern University Facilities Group. Duct lining of the first 15 feet of ductwork leaving the air handler is not acceptable. Sound attenuators are the preferred system of acoustical attenuation.

### **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.
- 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.

##### **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 lb/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 value 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

## **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-**

## **230719 - HVAC 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. Insulation thickness shall be the greater of Table 1 below or Table C403.2.1 of the 2015 International Energy Conservation Code (IECC).
4. Refer to Table 1 for Northeastern University pipe insulation thicknesses.

**Table 1. Pipe Insulation Thicknesses for Northeastern University Insulations**

<b>Pipe Insulation Thicknesses for Northeastern University Insulations</b>							
<b>Hrs. of Operation &amp; Bldg. Types</b>	<b>10 psi</b>	<b>Steam 30-125 psi</b>	<b>125-250 psi</b>	<b>Condensate</b>	<b>Chilled Water</b>	<b>Domestic Hot Water</b>	<b>Hot Water Heating</b>
8700 hrs./yr. Distr. systems & lab bldgs.	1.5"	3"	4"	1.5"	4"	1"	2"
4000 hrs./yr. Non-lab bldgs.	1"	3"	4"	1"	2"	1"	2"

5. 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**

1. Subject to compliance with the design requirements, provide products by one of the following manufacturers:
  - Owens
  - Corning
  - Certain-Teed
  - Manville
  - Knauf

**D. Materials**

1. Insulate chilled water distribution piping with polyurethane foam wrapped with glass fabric and then coated to insure watertight integrity.

**E. Installation Guidelines**

1. Install pipe insulation as required by the manufacturer.

**-END-**

## **230900 - Instrumentation and Control for HVAC**

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### **A. General**

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 23 & 26
  - 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**

<p><b>Work By Others And Inter-Trade Matrix</b></p> <p>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.</p> <p>2. Refer to Part 1.2 herein for detail definition of terms summarized for convenience only as below:</p> <p>a. Provide means to supply, install on-site, test, verify and document.</p> <p>b. Furnish means to supply to others for installation on-site then terminate, test and verify.</p> <p>c. Install means to install on-site the item supplied by others.</p> <p>C. EMCS = Energy Management and Controls</p> <p>Contractor MC = Mechanical Contractor</p> <p>EC = Electrical Contractor</p>						
<b>Work</b>		<b>Provide</b>	<b>Furnish</b>	<b>Install</b>	<b>LV Wire &amp; Pipe</b>	<b>Line Power &amp; Pipe</b>
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	



**Building Controls and Lighting Controls Inter-Trade Responsibility Matrix**

	<b>Work</b>	<b>Provide</b>	<b>Furnish</b>	<b>Install</b>	<b>LV Wire &amp; Pipe</b>	<b>Line Power &amp; Pipe</b>
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**

<b>Building Controls and Lighting Controls Inter-Trade Responsibility Matrix</b>						
	<b>Work</b>	<b>Provide</b>	<b>Furnish</b>	<b>Install</b>	<b>LV Wire &amp; Pipe</b>	<b>Line Power &amp; Pipe</b>
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 26 Contractor shall provide:

- (1) The Division 26 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 23 & 26, 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 23 & 26, 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, workstation 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**

- (1) 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**

- (1) 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 from 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
  - (1) 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
  - (1) 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**

- a. The controlled equipment shall remain in the last position in case of system failure, or as specified by the Engineer.

## **10. Diagnostics**

- a. 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 23.
- (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 23 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

- (1) 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" NPT 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 0-10V 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.
- o. 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
  - (a) 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) 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
    - (a) 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.**

- (e) 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.
- (f) A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
- (g) Provide appropriate scale range and differential adjustment for intended service.
- (h) 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

- (1) 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

- (1) Variable Frequency Drives (VFDs) are covered in Div.26. All VFDs should come with an appropriate BAS interface – N2 or Bacnet.

## **D. Execution**

### **1. Field Inspection**

- a. 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
  - (1) 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
  - (1) All Control sequences shall be reviewed and approved by Northeastern.
- c. Software Programs
  - (1) 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

- (1) Provide training as requested by Northeastern.

f. EMCS System Quality and Automation Level Maintenance

- (1) 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.

**-END-**

## **231123 - Facility Natural-Gas Piping**

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### **A. Summary**

This section contains design criteria for fuel gas systems.

### **B. Materials**

1. Natural gas.
2. Maximum operating limits: 50 psig, 70°F maximum temperature, carbon steel.
3. Malleable steel fittings.

### **C. Submittals**

Submit the following design and construction documentation.

1. Designer Submittals
  - a. Submit fuel gas calculations, with pipe sizes and sketch, for each gas-user system.
2. Construction Documents
  - a. Submit pipe cleaning and pipe pressure test reports.

**-END-**

## **232113 - Hydronic Piping**

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### **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 230553 - Identification of HVAC Piping and Equipment](#). 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) 10 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
  - a. Submit heating and cooling load calculations, with sketch, for heating hot water, chilled water, and condenser water systems.
- 2. Construction Documents
  - a. Submit pipe cleaning and pipe pressure test reports.

### **D. Manufacturers**

- 1. Manufacturers to be discussed with Northeastern and approved prior to formal print.

### **E. 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.

### **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**

1. Cleaning and flushing requirements are per current Northeastern University Facilities group requirements.

**-END-**

## **232123 - Hydronic Pumps**

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### **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 (greater than 100 gpm up to 4,000 gpm).
2. Use in-line circulator pumps for 100 gpm or less in hot and chilled water 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

- a. Submit pump sizing calculations with system sketch.
2. Construction Documents
  - a. Submit the following test reports:
    - Installed pump performance test and balance report.
    - Pump alignment report.
3. Product Certificates Signed by Manufacturer
  - a. 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

- a. All pumps over 5 hp must have a variable-frequency drive.

## **G. Accessories or Special Features**

### 1. Couplings

- a. 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**

1. 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-**

## **232213 - Steam and Condensate Heating 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**

<b>Equipment</b>	<b>Valve Inlet Pressure</b>
Radiators	5 psig
Convectors	5 psig
Air Handling 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:
  - a. Radiation and convector heating system reduction must be from 15 psig to 5 psig.
  - b. Air handling and related equipment (heating coils, steam humidifiers, unit heaters, heat exchangers, water heaters, and kitchen equipment): 5 – 13 psig.
  - c. 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 230553 - Identification of HVAC Piping and Equipment](#).
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
  - a. Floor plans showing piping

- b. Building sections showing piping
  - c. Isometric diagrams
  - d. Details
  - e. Steam and condensate load calculations with sketch
- 2. Construction Documents
  - a. Coordinated shop drawings
  - b. Catalog cuts on piping, valves, traps, unions, strainers, drains, vacuum breakers, and similar components
  - c. Manufacturer product data and installation instructions
  - d. Pipe cleaning and pipe pressure test reports.

#### **D. Manufacturers**

1. 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 threaded 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**

1. Cleaning and flushing requirements are per current Northeastern University Facilities group requirements.

**-END-**

## **232223 - Steam Condensate Pumps**

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### **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 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 minutes.

### **C. Submittals**

1. Submit pump sizing calculations, with sketch, for condensate return pumps.

### **D. Product Standards**

1. 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)
  - Spirax-Sarco
  - 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**

1. 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**

2. 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-**

## **232500 - HVAC Water Treatment**

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### **A. Summary**

This section contains HVAC system water treatment design criteria.

### **B. Submittals**

1. Submit a water treatment analysis.

### **C. Installation Guidelines**

2. Install coupon racks for heating, cooling and condenser water systems in an accessible location.
3. 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**

7. 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.

8. 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.
9. 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.

10. 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.
11. The cleaner shall not require external heat to ensure its effectiveness.

## **F. Chemicals**

1. 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 and 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-**



## **233113 - Metal Ducts**

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### **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 remoteness from supply air outlets, doors, and windows. Animal areas and toilet rooms shall have separate exhausts. See [Section 230000 - General HVAC Design Conditions](#).
5. 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 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 dampers are allowed on fume hood

ducting.

10. For duct sizing, 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 237300: Air Handling Units](#).

**Table 1. Maximum Duct Air Velocities and Friction Losses**

Location	Low Pressure	Medium Pressure
Main Risers in Shafts	1500 fpm/0.08" per 100'	2000 fpm/0.20" per 100'
Mains in Mechanical Rooms	1500 fpm/0.08" per 100'	2000 fpm/0.20" per 100'
Mains Over Unoccupied Spaces	1500 fpm/0.08" per 100'	2000 fpm/0.20" per 100'
Mains Over Occupied Spaces	1200 fpm/0.07" per 100'	1800 fpm/0.18" per 100'
Branches to Terminal Devices (ex. Diffusers)	750 fpm/0.08" per 100'	N/A
Runout to Terminal Boxes	N/A	1500 fpm/0.15" per 100'

11. Ductwork located in ceiling space near air handling device with filters is to be routed so that filter access/removal space is maintained.
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. Use of internal duct lining is not allowed without prior approval of Northeastern University Facilities Group.
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.
19. 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 than 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 than 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
- e. 0.5 lbs/sq ft (2.5 kg/m<sup>2</sup>) 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 25% 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 than 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
- d. G-90 (G-60 is not acceptable).
- e. 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**

1. 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-**

## **233300 - Air Duct Accessories**

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### **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.
4. Provide fire and smoke dampers at all location required by code.

### **D. 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.

**-END-**

## **233400 - 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 non-overloading 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°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 cfm 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**

- a. See the information above for forward- and backward-curved fans.

### **4. Double-Width Inlet Fans**

- a. 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
  - (1) 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

- (1) 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

- (1) 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**

- a. Submit fan selection calculations.

**2. Product Certificates Signed by the Manufacturer**

- a. 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**

- a. 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
- Twin City
- Loren Cook

## **2. High-Velocity Roof Exhausters for Laboratory Exhaust**

- Loren Cook
- MK Plastics
- 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  $\pm 10$  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 cfm
  - 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  $\pm 5$  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.
- d. Provide an OSHA-approved belt guard for drive components that are located outside of the fan housing.
- e. Provide ports for tachometer speed measurements at the motor shaft.
- f. Provide self-aligning bearings with a minimum L-10 life of 200,000 hours.
- g. Provide extended lubrication lines.
- h. 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-**

## **233600 - 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 are 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**

1. Products must conform to the following standards:
  - NFPA 90A
  - UL 181
  - NEMA 1

### **D. Manufacturers**

1. 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:
2. Office, Conference, Classroom, General:
  - Price



- EnviroTec
  - Titus
3. Lab, Critical Pressurization Spaces
    - Phoenix
    - Siemens

#### **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 230900 – Instrumentation and Control for HVAC](#). 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:
  - Entering water temperature.
  - Leaving water temperature.

- Entering air temperature.
- Leaving air temperature.
- Heating capacity in MBH.
- GPM
- Water side pressure drop.
- 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-**

## **233713 - Diffusers, Registers, Grilles, and Louvers**

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### **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  $\pm 2^{\circ}$  F.
- 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
- b. 500 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.
- c. Intakes near or below ground level not permitted. The minimum height of the bottom of intake must be:
  - 6' above grade
  - 3' above roof
- d. Examine intake locations for proximity to contaminated air exhausts, such as laboratory discharges.
- e. 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:
- g. Perforated diffuser not lower than 0.7 cfm/sq ft
- h. Linear diffuser not lower than 0.3 cfm/sq ft
- i. Architectural diffuser not lower than 0.3 cfm/sq ft
- j. 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**

1. 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**

1. 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**

1. 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.
2. Supply registers must have two sets of directional control blades.
3. Diffusers within same room or area must be of same type and style to provide architectural uniformity.
4. Diffusers should be full-size for 24" x 24" tiles or half-size (24" x 24") for 24" x 48" tiles.
5. Provide surface-mounted diffusers, registers, and grilles with gaskets. Installed them with faces set level, plumb, and tight against the mounting surface.
6. The architect will determine the finish.

## **G. Installation Guidelines**

1. Provide volume dumpers 10' from supply diffusers.

**-END-**

## **234100 - Particulate Air Filtration**

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### **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 cooling towers, and vegetation.
4. Consider:
  - a. Whether a filter with high moisture resistance is needed
  - b. Pressure drop for energy performance
  - c. 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 airfilters.
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, minimal final resistance of 0.6" wc.
  - b. Secondary filters (final filters) must be UL Class 1. Efficiency must be MERV 8 as measured by ASHRAE test standard 52-76. Design filters to operate up to 350 fpm, minimal final resistance of 1.4" wc..

#### **C. Submittals**

1. Submit the following design and testing documentation.
  - Air contaminants
  - Filter selection

#### **D. Product Standards**

1. Products must conform to the following standards:
  - Underwriters Laboratories Class 1 or 2
  - ASHRAE 51
  - ASHRAE 52

#### **E. Manufacturers**

1. 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**

1. 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**

1. 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-**

## **235200 - Heating Boilers**

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### **A. Summary**

This section contains design criteria for heating boilers.

### **B. System Design and Performance Requirements**

1. BR+A to address use of condensing boilers.
2. Use sectional firetube boilers is acceptable. Refer to Northeastern team.
3. 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.
4. Do not use firetube boilers outside of the powerhouse jurisdiction, without coordinating with the Northeastern University Facilities group.
5. All closed-loop, hot water systems must be piped to allow for chemical injection, as needed, for proper water treatment.
6. Equip heating systems with isolation and backflow prevention valves to prevent the cross flow of water systems.
7. Whenever possible, steam systems must be metered at the central monitoring systems. Individual boilers need not be metered. See [Section 013513 - Special Project Procedures](#) on metering.
8. The temperature drop across the boiler must match the boiler manufacturer's criteria and be within the stipulated supply and return temperature ranges.
9. The  $\Delta T$  across the boiler must match the boiler manufacturer's criteria.
10. The tube thickness must be in accordance with Northeastern university specifications.
11. Consider using a tankless heater at the boiler for heating domestic water.
12. 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.

13. For planned shutdown procedures, consult with the Northeastern Project Manager.
14. To ensure sufficient excess or redundant capacity, install two boilers, each capable of handling 70 percent of the total load.
15. Verify the turndown ratio and the minimum steam and hot water usage . Verify that the system design can accommodate minimum and maximum loads.
16. Check boiler room ventilation to ensure that adequate combustion air has been provided.
17. Ensure that the boiler is not located in the same space as refrigerant-using machines.
18. Verify the stack height with local codes and manufacturer requirements.
19. 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.
20. Verify emergency power supply to boiler fans, valves, and controls.
21. For steam boiler maintenance, verify that bypass has been provided around the feedwater heater.
22. 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.
23. 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.
24. 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.
25. Coordinate with the Northeastern University Facilities group regarding plant sizing for future steam loads.
26. 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.
27. 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 010102 - 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
  - a. 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**

1. 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**

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.

**-END-**

## **235700 - Heat Exchangers for HVAC**

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### **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.
7. Coordinate plate and frame heat exchanger bolt extensions with nearby piping and equipment.
8. 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.

**-END-**

## **236200 - Packaged Compressor and Condenser 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-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-**

## **236400 - Water Chillers**

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### **A. Summary**

This section contains design criteria for water chillers.

### **B. System Design and Performance Requirements**

1. BR+A to address modular chillers and magnetic bearing chillers.
2. Select chillers based on performance, service and maintainability, and life-cycle costing.
3. 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.
4. See [Section 230000 - General HVAC Design Conditions](#) for chilled water temperatures and  $\Delta T$ .
5. 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.
6. The Central and Science area chilled water systems are designed to be variable volume, constant pressure, all-primary design systems.
7. All new work must be consistent with variable-volume, all-primary design chilled water systems.
8. 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.
9. 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.
10. Most building systems can use the primary system pressure differential by a direct connection to the chilled water supply and return mains.
11. 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.

12. Secondary loops, bridge circuits, bypasses, or any other system that allows the chilled water supply to shunt to the return are not allowed.
13. 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.
14. 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
15. 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.
16. All chilled water service is metered by the Central Building Utilities Metering System. See [Section 013513 - Special Project Procedures](#).
17. 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.
18. 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.

19. Size two chillers for 70% of the load and pipe them to cross feed with their own and the other chiller's tower.
20. Verify with the structural engineer that a lift beam and winch has been specified to lift chiller motors and compressors.
21. Maintain ambient temperatures in chiller mechanical rooms within 13°F of outdoor ambient design.
22. Verify that the system design can accommodate minimum and maximum loads.
23. On larger chillers, specify the installation of davits with marine boxes and flanged piping to simplify the removal of the heads.
24. Design chiller condensing piping to facilitate the future installation of a brush cleaning system.
25. 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.
26. 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.
27. Typical critical systems include:
  - Laboratories
  - Medical areas
  - Administrative areas
  - Libraries
  - Museums
28. Typical comfort cooling systems include:
  - Offices
  - Residence Facilities
  - Dean's suites
  - Dean's offices
  - Faculty offices
  - Seminar rooms
29. 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.

30. Do not purchase R11 and R12 units. Alternative refrigerants of low toxicity and pressure are the desired refrigerants for the stand-alone systems.
31. Isolate the water systems in such a way that no chiller water could pass into the domestic water system.
32. 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.
33. 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 have been a problem in some Northeastern University facilities.
34. 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.
35. 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.
36. 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
- 37. 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 010102 - 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**

- a. Provide a thermostat to prevent the unit from attempting to start when the ambient temperature is too low.
- b. 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 manhole 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-**



## **236400 - Cooling Towers**

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### **A. Summary**

This section contains design criteria for 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 010000 - 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-**

## **236428 – Modular Heat Recovery Scroll Chillers**

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### **A. Summary**

#### **1. Section Includes:**

- a. Packaged, water to water dual true variable speed scroll compressor modular heat recovery chiller.**

### **B. Modular Dedicated Heat Recovery Chiller**

- 1. System Description: The Dedicated Heat Recovery Chiller shall incorporate True Variable Speed Scroll compressors. Each module shall have a total of 2 Variable Speed compressors. Each refrigerant circuit shall consist of an individual compressor, common dual circuit condenser, dual circuit evaporator, electronic expansion valve (thermal expansion valves not acceptable), and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit Dedicated Heat Recovery Chiller must be able to produce hot water even in the event of a failure of one or more refrigerant circuits.**

#### **2. General**

- a. The Dedicated Heat Recovery Chiller Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.**
- b. Chiller modules shall be AHRI certified. (R-410a Only)**
- c. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.**

#### **3. Compressor**

- a. Each module shall contain two hermetic scroll true variable speed compressors independently circuited and mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure manual reset safety cut-outs. Digital scroll, hot gas bypass and compressors not designed with integral VFD from the same manufacturer will not be acceptable. Compressor must include an internal oil management system to ensure oil return. If single circuit**

modules are proposed, the manufacturer must provide an additional module of the capacity specified for redundancy.

#### **4. Variable Flow Operation – Chilled and Condenser/Hot Water**

- a.** Butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system. Valve shall modulate via a motorized actuator for leaving water temperature control, chiller minimum flow bypass, chiller no load bypass, or head pressure control. Compressor staging based off of return water temperature is not acceptable for temperature control. The motorized actuators shall be modulating NEMA 2, IP-54 with a stroke time of no more than 35 seconds.

#### **5. Evaporator and Condenser**

- a.** Each evaporator and condenser shall be brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig refrigerant side working pressure and 360 psig water side working pressure.
- b.** Normal Dedicated Heat Recovery Chiller Operation
- 1) When Dedicated Heat Recovery Chiller is enabled, the factory supplied Master Controller stages the Dedicated Heat Recovery Chiller capacity from minimum to maximum as required by building load.
  - 2) The Dedicated Heat Recovery Chiller control system shall respond to Entering Water Temperature and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.

**-END-**

## **237300 - Air Handling Units**

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### **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 +/- 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**

- (1) Units must conform to the structural provisions of code, including but not limited to, snow load, seismic forces, and lateral wind loads.

#### **b. Base**

- (1) 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

- (1) 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

- (1) 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. Provide interior lights at each section of unit.
- 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 glycol preheat coil or enthalpy wheel for energy recovery when applicable
  - A chilled water coil
  - A hot water coil
  - A prefilter section
  - A final 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 ASTM E-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, interior lighting at each section, system service switches, and control circuit fuses.

- o. Supply fan motors must have contactors and external overload protection.
- p. The main control panel must be weatherproof with a dead-front cover over the main power circuit controls.
- q. Automatic temperature controls and the sequence of operation must be as shown on the control drawings.
- r. 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 233713 - 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.

### **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**

- a. 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-**

## **237500 – Custom-Packaged, Outdoor Air Handling Units**

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### **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 not 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
- 4. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- 5. 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.
- 6. 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 95°F. 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**

1. 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.

**-END**

## **238123 - Computer Room Air Conditioners**

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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.

**-END-**

## **238126 - 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-**

## **238146 – Packaged Air-to-Water Modular Heat Pump**

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### **A. General**

1. Air to Water Heat Pump Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
2. Unit shall be shipped with all refrigerant piping and control wiring factory installed.
  - a. Each 2-pipe chiller shall have:
    - 1) A single power connection. Provide dual point power if specified.
    - 2) A single hot water/chilled water supply connection.
    - 3) A single hot water/chilled water return connection.
    - 4) A single point for all BAS control connections.
    - 5) Evaporator insulation.
3. Heat Pump shall be designed for parallel Load water flow.
4. The liquid to be chilled/heated will be water containing corrosion inhibitors and antifreeze solution as required.
5. Compressors, heat exchangers, condenser fans, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module. Module shall be provided within a steel enclosure suitable for outdoor use. Exposed steel surfaces shall be provided with a powder coat paint finish.

### **B. Heat Pump Chiller (2-Pipe)**

1. Heat Pump shall incorporate Scroll type compressors and can consist of multiple modules. Each refrigerant circuit shall consist of an individual compressor set, common dual circuit evaporator, dual circuit condenser, electronic expansion valves, reversing valves, liquid line solenoid valves, filter driers, Fin and Tube coil, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit Heat Pump must be able to produce heating or cooling water even in the event of a failure of one or more refrigerant circuits.



2. Source/Sink Fans: Each module shall contain dual ECM fans for each refrigerant circuit. Sound pressure reductions at 30 feet, as compared to standard fan option, ranges from 3-6 dBA.
3. Compressor: Each module shall contain two hermetic scroll compressors in a tandem piping arrangement mounted to the module with rubber-in-shear isolators. Compressors must be designed specifically to produce 130 deg F hot water at 0 deg F ambient in air source heat pump/heat recovery chiller/heater.
4. Load Water Heat Exchanger: Each load water heat exchanger shall be a brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig working pressure.
5. Heat Pump shall have external inputs and outputs to be compatible with the building management system to include Remote Start/Stop capability and Cooling Alarm output.
6. Sound Attenuation Package: Chiller must meet the sound levels shown on the schedule. The following sound attenuation measures must be included at a minimum.
  - a. ECM fans
  - b. Compressor wraps
  - c. 36" discharge attenuators
7. Flow switches: Manufacturer shall factory install flow switches per module. Chillers skids that do not have a flow switch per module are not acceptable.

### **C. Installation**

1. In accordance with manufactures written instructions and recommendations.
2. Coordinate location and all required clearances and code clearances required.
3. Coordinate and provide all interlock wiring.
4. Provide a factory-trained representative, employed by the chiller manufacturer, to perform the start-up procedures as outlined in the start-up, operation and maintenance manual provided by the chiller manufacturer.
5. The HVAC Contractor shall supply the Owner with the following

literature as furnished by the manufacturer prior to start-up:

- a. One (1) complete set of installation drawings.
- b. Field wiring diagrams.
- c. Installation instructions.
- d. Start-up, operation and maintenance instructions.

**- END -**

## **238200 - Convection Heating and Cooling Units**

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### **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-**

## **238216 - Air Coils**

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### **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 glycol-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.

**-END-**

## **238219 - 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. As a basis of design, 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. Any use of fan coil units shall be discussed and approved by Northeastern early in the design process.
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. A galvanized steel cabinet with a baked enamel finish liner, covered with UL 25/50 Mylar or foil.
  - b. 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.

- c. Centrifugal, forward-curved, galvanized steel fans, statically and dynamically balanced, with permanently-lubricated or ball bearing shaft bearings.
  - d. 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.
- 1. Provide manual valves to isolate each fan coil and drains.
    - a. Isolation and valves for cooling coils or heating coils shall be located over condenser drain pan.
  - 2. 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-**

## **238239 - Unit Heaters**

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### **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-**

## **238413 - Humidifiers**

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### **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-**

## **238416 - 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 Systems

#### **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-**

## **Division 26 – Electrical**



## **SECTION 26 00 20** **ALTERATIONS & DEMOLITION**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Demolition and Extension of Existing Electrical Works
  - 2. Electrical Shutdowns
  - 3. Raceways and boxes
  - 4. Conductors
  - 5. Relocations
- 6. Removal and Maintaining Existing Services in Operation
  - 7. Temporary services
  - 8. Maintenance Operation Procedures (MOPs)
  - 9. Cleaning and Repair
  - 10. Installation

#### **1.2 COORDINATION**

- A. Review Contract Documents of other Divisions of Work to determine full extent of Work required.
- B. Coordinate Work with equipment deliveries and plan Work to minimize on-site workdays, electrical shutdowns, and electrical interruptions to equipment and outlets requiring re-connection to new sources. Once on-site Work is started, continue Work until entire Project is completed.
- C. Maintain the existing building and systems in operation during construction unless otherwise permitted.

#### **1.3 PROJECT RECORD DOCUMENTS**

- A. Accurately indicate on Record Drawings equipment or conduits that will remain, have been relocated, or are abandoned in place.

### **PART 2 - PRODUCTS**

#### **2.1 MATERIALS AND EQUIPMENT**

- A. Materials and equipment for patching and extending work: as specified in individual Sections. Where not specifically specified match existing materials and workmanship. Meet all applicable codes and standards.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Field verify measurements and circuiting arrangements.

- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition Drawings are based on casual field observation. Report discrepancies to Owner before disturbing existing installation.
- D. Beginning of demolition means existing conditions are acceptable.

### **3.2 TEMPORARY SERVICES AND MAINTAINING EXISTING SERVICES IN OPERATION**

- A. Disconnect and make safe electrical systems in walls, floors, and ceilings scheduled for removal.
- B. Coordinate utility service work and outages with Utility Company and Owner.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Disconnect electrical circuits in the way of demolition Work and reestablish circuits to remaining outlets and equipment.
- E. Cooperate with using the existing service and distribution equipment for construction power.
- F. Existing Electrical Service: Maintain existing systems in service until permanent cutover. Obtain permission from Owner at least one week before partially or completely disabling any system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- G. Existing Systems: Maintain existing systems in service. Disable system only to make switchovers and connections. Notify the Owner at least one week before partially or completely disabling any system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- H. Obtain Owner approval before interruptions any existing operations. Follow any Maintenance Operation Procedure (MOP) Owner may have. Submit detailed plan of work to be done and existing areas or equipment to be affected.

### **3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK**

- A. Remove, relocate, and extend existing installations to accommodate new construction.
- B. Remove abandoned wiring to source of supply.

- C. Remove underground wiring. Cut conduit below grade and cap.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes that are to be removed or replaced. Cut conduit flush with walls and floors, and patch surfaces. Abandoned conduit left in place shall be identified as such at both ends. Indicate location of the other end if it can be determined.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- F. Disconnect and remove abandoned and indicated panelboards and distribution equipment.
- G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- H. Disconnect and remove abandoned and indicated luminaires. Remove brackets, stems, hangers, and other accessories.
- I. Repair adjacent construction and finishes damaged during demolition and extension work.
- J. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- K. Extend existing installations using materials and methods compatible with existing electrical installations and meeting requirements of this specification.

### **3.4 ELECTRICAL SHUTDOWN**

- A. If an electrical shutdown is necessary, submit a written request at least one week in advance, stating when the shutdown is wanted, the work planned during the shutdown, and the estimated shutdown time. Obtain Owner approval before proceeding.
- B. Plan Work to minimize shutdown. Before starting, have equipment to be used unpacked, checked for damage, and checked dimensionally to insure proper fit. Provide an adequate number of skilled workers prepared to do the required Work during the shutdown period.
- C. Shutdowns are to be at the convenience of the Owner and only after owner review and acceptance of the specific work plan.

### **3.5 RACEWAYS AND BOXES**

- A. Existing conduit meeting present day code and requirements of new Work may be reused if conduit is not damaged, rusted, or detached from supports. Existing conduit meeting these requirements may be intercepted and extended to meet new Work requirements.

- B. Type MC wiring or flexible conduit may be used to reconnect circuits and outlets in inaccessible ceilings and walls where allowed by Code.
- C. Existing boxes meeting present day code and requirements of new Work may be reused if not damaged or rusted and if left in place.
- D. Where new ceilings or wall coverings are installed, provide new box covers and extension rings as required on existing outlets.

### **3.6 CONDUCTORS**

- A. Replace existing conductors when existing raceways are altered to meet new Work, unless otherwise indicated.

### **3.7 RELOCATIONS**

- A. Relocate outlets, lighting fixtures, switches, receptacles, and similar equipment in the way of new Work.
- B. Carefully examine equipment to be relocated. Immediately notify the Owner of equipment defects. After equipment has been certified to be in good condition, clean and reinstall equipment in location indicated. Replace equipment damaged in the removal and reinstallation process. Equipment may be repaired but replace equipment where repairs do not meet with the Owner's satisfaction.

### **3.8 REMOVALS**

- A. In compliance with Federal, State, and Local requirements, legally dispose of equipment and materials removed and not required for reinstallation, unless specifically designated to remain the property of the Owner. Provide certification of proper disposal for all regulated material.

At completion of alteration Work, remove existing conductors not required for proper operation of completed system. Remove abandoned raceways and boxes where exposed or in accessible furred areas, and close openings in remaining boxes. Provide blank, flush plates on abandoned flush outlets.

### **3.9 CLEANING AND REPAIR**

- A. Clean and repair existing materials and equipment that remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and interior of panelboards and check tightness of electrical connections (torque to manufacturer's or NRTL specifications). Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

- C. Luminaires to remain or be relocated: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts, and broken electrical parts.
- D. Clean bottom of panels, switchboards, etc.

**END OF SECTION**

**SECTION 26 05 00**  
**COMMON WORK RESULTS FOR ELECTRICAL**

**PART 1 - GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Common electrical installation requirements.
3. Sleeves for raceways and cables.
4. Sleeve seals.
5. Grout.
6. Fire rated sleeves
7. Watertight seals
8. Smoke and fire stopping seals
9. Expansion/deflection fittings
10. Conduit sealing bushings
11. Acoustical sealant
12. Caulking
13. Cable supports
14. Arc/fire proofing wrap
15. Cable ties
16. Measure/pulling tape

**PART 2 - PRODUCTS**

**2.1 SLEEVES FOR RACEWAYS AND CABLES**

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

**2.2 GROUT**

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

**2.3 FIRE RATED SLEEVE**

- A. Prefilled fire barriers with high smoke resistance and low leakage with intumescent properties.
1. Manufacturers: Subject to compliance with requirements provide products of one of the following:
    - a. 3M prefilled fire barriers Quick pass fire barrier
    - b. Specified Technologies Inc. (STI) Spec Seal Series Fire Plug or EZ Path
    - c. Roxtec

- d. Unique fire stop bulkhead plates
- e. HILTI CP 653 Speed Sleeve
- f. Legrand Flame Stopper
- g. Cobritech

## **2.4 WATERTIGHT SEALS**

- A.** Manufacturers: Subject to compliance with requirements provide products of one of the following:
  - 1. O-Z Gedney Type WSK or FSK (if only one side accessible)
  - 2. Crouse Hinds
  - 3. Appleton

## **2.5 SMOKE AND FIRESTOPPING SEALS**

- A.** Manufacturers: Subject to compliance with requirements provide products of one of the following:
  - 1. Specified Technologies Inc
  - 2. 3M.
  - 3. Protective Coatings, Inc.
  - 4. Carborundum Company.
  - 5. Rotec
  - 6. Unique fire stop
  - 7. HILTI
  - 8. Legrand
  - 9. Cobritech

## **2.6 EXPANSION/DEFLECTION FITTINGS**

- A.** Manufacturers: Subject to compliance with requirements provide products of one of the following:
  - 1. O-Z Gedney – DX for up to 3/4 inch movement in any direction.
  - 2. Crouse-Hinds – XD for up to 3/4 inch movement in any direction.
  - 3. Spring City Electrical Mfg. Co. - Type DF for up to 3/4 inch movement in any direction.
  - 4. Manufacturer of raceways including but not limited to busway, cable tray, wireway, fiber guide, etc.
- B.** Where greater movement than 3/4 inch is required provide fittings or combination of fittings that allow movement in all directions. Fittings shall allow expansion of 3 inches, compression of 3 inches and deflection of 2 inches.
- C.** Provide bonding jumper.

## **2.7 CONDUIT SEALING BUSHINGS**

- A. Description: Seals interior of conduit against fluids and gases.
  - 1. Manufacturers: Subject to compliance with requirements provide products of one of the following:
    - a. O.Z. Gedney type CSB
    - b. Polywater Sealant
- B. Description: Seals around exterior of conduit against fluid and gas.
  - 1. Manufacturers: Subject to compliance with requirements provide products of one of the following:
    - a. O.Z. Gedney type CSM
    - b. Polywater Sealant

## **2.8 CABLE SUPPORTS**

- A. Description: Fitting with wedge type cable support for cables 600V or less installed vertically
  - 1. Manufacturers: Subject to compliance with requirements provide products of one of the following:
    - a. O.Z. Gedney one piece plus type 'S' – indoors
    - b. O.Z. Gedney type CMT – outdoors
- B. Description: Fitting with wedge type cable support for cables over 1000V installed vertically.
  - 1. Manufacturers: Subject to compliance with requirements provide products of one of the following:
    - a. O.Z. Gedney multi-segment plus type "R" – indoors
    - b. O.Z. Gedney type CMT – outdoors

## **2.9 ACOUSTICAL SEALANT**

- A. Manufacturers: Subject to compliance with requirements provide products of one of the following:
  - 1. D.A.P.
  - 2. Pecora - Type BR-96
  - 3. Fremco
  - 4. U.S.G.
  - 5. Substitution: or equal, under provisions of Section 26 00 10.
- B. Sealants for acoustical purposes shall be low voc silicone non-setting sealants.

## **2.10 CAULKING**

- A. Manufacturers: Subject to compliance with requirements provide products of one of the following:
  - 1. D.A.P.
  - 2. Pecora - Type BR-96
  - 3. Fremco



4. U.S.G.
  5. Substitution: or equal, under provisions of Section 26 00 10.
- B. Sealants shall be low VOC 20 year silicone non-setting sealant

## **2.11 ARC/FIRE PROOFING WRAP**

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following:
1. Plymouth 53 ply arc with 77 ply glass with Scotch 69 glass ply cloth.
  2. 3M Scotch 77
- B. Cable arc-proof tape shall be flexible, conformable organic fabric, coated one side with a flame retardant flexible elastomer, self-extinguishing, with the following minimum properties
1. Thickness ASTM D100, 0.76mm.
  2. Intumescent to 0.3 inch (8mm) thick.
  3. Compatible with cable jacket.
- C. Tape for first course on metal objects: 10 mil (250 micrometer) thick, corrosion – protective, moisture resistant, PVC pipe wrapping tape.
- D. Glass cloth tape: Pressure sensitive adhesive type, 112 inch (13mm) wide.

## **2.12 CABLE TIES**

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
1. Minimum Width: 3/16 inch (5 mm).
  2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
  3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
  4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
1. Minimum Width: 3/16 inch (5 mm).
  2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
  3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
  4. Color: Black.
- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
1. Minimum Width: 3/16 inch (5 mm).
  2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).

3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

### **2.13 MEASURE / PULLING TAPE (PULL STRING)**

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following:
  1. Greenlee Tool Division
  2. Muletape
- B. Polyester measure pulling tape durable and stretch resistant.
  1. ½" width – average breaking strength of 1250 lbs.
  2. ¾" width – average breaking strength of 2500 lbs.
- C. Factory lubricated to reduce burn through.
- D. Easy to read footage markings for quick and accurate measurements.

## **PART 3 - EXECUTION**

### **3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION**

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- B. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- C. Right of Way: Give way to piping systems installed at a required slope.
- D. Seal all openings to prevent air transfer between spaces. Provide fire and smoke rated seals in fire rated construction and where required or indicated. Refer to Architectural Drawings for rated construction.
- E. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  1. Outdoors: UV-stabilized nylon.
  2. In Spaces Handling Environmental Air: Plenum rated.
- F. Use putty seals for locations to be accessed in the future. Use sealant for permanent installations only as sealant tends to glue cables together.

### **3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate floors, concrete slabs, concrete or masonry walls, fire-rated floor and wall assemblies, acoustical or full height walls.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 3 inches (75 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise, required by fire or smoke seal product, or unless seismic criteria require different clearance.
- H. Seal space outside of non-fire-rated, non-watertight sleeves with grout for penetrations of concrete and masonry and with approval joint compound for gypsum board assemblies.
  - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable tray, busway, raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable tray, busway, raceway and cable penetrations. Install sleeves and seal penetration sleeves with firestop materials.
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

### **3.3 SLEEVE-SEAL INSTALLATION**

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### **3.4 FIRESTOPPING**

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly.

### **3.5 INSTALLATION OF SEALS**

- A. Watertight Seals
  - 1. Conduits entering from the exterior or below grade shall have watertight fittings on the outside and on the inside of the conduit.
    - a. Fittings on the outside of the conduit shall be O-Z Gedney type FSK or approved equal. Provide type WSK if penetration is within two feet of the high water table. Provide grounding attachment.
    - b. Fittings on the inside of the conduit shall be O-Z Gedney type CSBI or approved equal. Provide type CSBG if penetration is within two feet of the high water table. Provide a blank fitting to seal spare or empty conduits.
    - c. O-Z Gedney type CSM fitting may be used when sealing within a sleeve or cored hole.
    - d. Ploywater foam sealant may be used within conduits for sealing.
  - 2. Conduits penetrating walls above grade shall be installed in sleeves. Seal with foam and caulking around sleeve and conduit to ensure a watertight and air tight seal.
- B. Environmental Seals
  - 1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas or when penetrating the building envelope. Install raceway seal to prevent circulation of air from warmer to colder sections through the raceway.
  - 2. Seal air tight with caulking and insulation around light fixtures and equipment installed in exterior soffits.
- C. Acoustical Seals
  - 1. Provide acoustical sealant around penetrations through sound-sensitive areas such as toilet rooms, conference rooms, electrical or mechanical rooms, elevator rooms, training rooms, etc. Provide at

any wall where Architect or mechanical specifies sound attenuation provisions.

**D. Firestopping Seals**

1. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be fire stopped using approved methods and NRTL-listed products to maintain the fire resistance rating. Follow all listing and manufacturers recommendations and requirements.
2. Installation restrictions of the listing agencies shall be strictly adhered to (e.g. 24 inch (610 mm) minimum horizontal separation between boxes on opposite sides of the wall, maximum square inch opening on wall.
3. Fire stopping in sleeves or in areas that may require the addition or modification of installed cables or raceways shall be soft, pliable, non-hardening fire-stop putty. Putty shall be water resistant and intumescent.
4. Fire stopping in locations not likely to require frequent modifications shall be a NRTL-listed putty, caulk or mortar to meet the required fire resistance rating.
5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.
6. Fire stopping of cable trays or busways through walls shall be with fire rated sleeves with intumescent material, non-hardening putty or with seal bags on top, below and on sides of trays.
7. Fire stopping of plastic pipes shall be accomplished by using a collar specifically listed for the use.
8. Installation methods shall conform to a UL fire stopping system.
9. Provide gas tight sealing fitting and compound at each enclosure around conductors with intumescent fire protection insulation.
10. Provide Specified Technologies SpecSeal fire stop plugs for conduit sleeves.

**E. Explosion Proof seals**

1. Provide seals where required by code.
2. Fill seal with sealant following manufacturer's recommendation being careful to spread conductors so as to allow seal to flow around all conductors.

### **3.6 EXPANSION/DEFLECTION FITTINGS**

- A. Install bonding ground wire across fitting.
- B. Install as recommended by manufacturer. Allow for expansion, contraction or deflection after installation.
- C. Install on raceways rising from underground where exposed to ground movement or extreme temperature variation or freezing.
- D. Install on PVC conduit installations 100 feet or longer.

- E. Install on raceways subject to varying environmental conditions such as exterior/interior, air conditioning/non-air conditioned, refrigerated/non-refrigerated spaces, etc.
- F. Install where raceways, cable trays or busways cross building expansion or seismic joints. Provide two expansion deflection fittings, one on each side of the joint or wall, with a continuous piece of raceway or busway across the joint.
- G. Install where raceways cable trays or busways pass from one building to another.

### **3.7 WATER DAMS**

- A. Provide three inch high water dams across floor penetrations that are not water tight and where there are openings allow the passage of water such as for busway on cable tray penetrations, where seismic or other requirements leave openings around penetrations.

### **3.8 ARC PROOFING**

- A. Unless otherwise indicated, at locations with multiple feeders in manholes, hand holes or pits under equipment arc proof feeder conductors at locations not protected by conduit, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
  - 1. Clean cable sheath.
  - 2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
  - 3. Smooth surface contours with electrical insulation putty.
  - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
  - 5. Band arc proofing tape with one-inch (25mm) wide bands of half-lapped, adhesive, glass cloth tape 2 inches (50mm) on center.
  - 6. Extend arc proofing one-inch (25mm) into duct.

### **3.9 MEASURE / PULLING TAPE**

- A. Provide measure pulling tape in all empty raceways.
  - 1. Provide ½" width, 1250 lbs rated in inner ducts and conduits 2" or less in diameter.
  - 2. Provide ¾" width, 2500 lbs rated in all other raceways.
- B. Provide 18 inches (460 mm) minimum at each end. Secure tape so it will not fall back into raceway.
- C. Install tape after cleaning raceway installation.

### **END OF SECTION**

**SECTION 26 05 19**  
**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600**  
**VOLTS OR LESS)**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This section includes the following:
  - 1. Conductors and Cables
  - 2. Connectors and Splices
- B. Meet the following performance requirements:
  - 1. Where not indicated, size branch circuit wiring per the Energy Code not to exceed 3 percent voltage drop and feeders not to exceed 2% voltage drop. Do not reduce conductor sizes indicated.
  - 2. Conductor insulation shall be rated for 90°C in wet or dry locations to comply with 100% rated overcurrent devices and for derating purposes. Conductor ampacity shall be based on 60°C for circuits of 100A or less. 75°C for circuits over 100A.
  - 3. Aluminum conductor substitution a. Not Allowed

**1.2 QUALIFICATIONS / QUALITY ASSURANCE**

- A. Provide written test results after installation. Indicated procedures and values obtained.

**1.3 PROJECT RECORD DOCUMENTS**

- A. Record actual locations of concealed cable assemblies and branch circuit arrangements and branch circuit numbering.

**PART 2 - PRODUCTS**

**2.1 GENERAL**

- A. Provide single-conductor, annealed copper wire and cable with insulation rated for 600V, installed in RMC or EMT, typically.
- B. The use of aluminum conductors is not allowed.
- C. Wire and cable shall have THHN/THWN-2 or XHHW-2 insulation for indoor/interior, dry, above ground branch circuit and feeder conductors. Type XHHW-2 insulation shall be used for all branch circuit and feeder, wet, above ground and exterior/rooftop applications. Type XHHW-2 insulation shall be used for all conductors installed in below grade applications.

## **2.2 CONDUCTOR COLOR CODING**

- A. Service entrance, branch circuit and feeder conductors shall be color-coded. Conductors #12 and #10 shall be colored with a factory applied solid or striped compound coating (black, red, blue, brown, orange or yellow). Neutrals and equipment grounds shall have solid compound or solid color coating (white, gray and green), except that neutrals with colored stripe shall be used where required by code. Phase conductors #8 and larger with stripes, bands or hash marks shall have background color other than white, green and gray.
- B. Alternative field-applied color coding methods may be used for wire #8 or larger, with color code as specified in other sections of this specification. Coloring shall be applied by the use of flame-retardant vinyl tape, equal to 3M Scotch 35.

## **2.3 CABLE**

- A. Flexible Metal Clad (MC) cable shall be UL Listed with THHN insulated conductors with an insulated grounding conductor within a galvanized steel interlocked armor. Aluminum armor is not acceptable. Connectors shall be provided with lock nut connection to the termination point enclosure.
- B. Flexible Metal Clad (MC) cable utilized for Fire Alarm service shall be identified with a factory applied tracer along the entire length.

## **2.4 SPLICES AND TERMINATIONS**

- A. Ampacity and temperature rating of splices and connectors shall be equal to or greater than those of associated wires and cables.
- B. Make splices in branch circuit or feeder wiring from #12 to #10 with UL-listed, solderless screw on connectors rated 600 V.
- C. Make splices in branch circuit or feeder wiring above #10 with UL-listed 90° C, 600V, compression butt splice barrel equal to Burndy YS-L HYLINK.
- D. Conductor terminations shall be standard bolt-on lugs with hex screws listed for attachment of copper wire and cable to panelboards, switchboards, disconnect switches and other electrical equipment.
- E. Make terminations for stranded conductors on screw terminals with UL Listed 105° C, 600V PVC insulated barrel compression locking fork tongue terminal equal to Burndy TP-LF VINYLUG.
- F. Make bus terminations for conductors #6 and larger with UL-listed 90° C, 600V, compression, long barrel length, two hole lugs equal to Burndy YA-2N. Lugs shall be high conductivity seamless copper electro-tin plated for corrosion protection.



## **2.5 WIRE MANAGEMENT**

- A. Provided by self-extinguishing self-locking nylon ties with -65 to 350° F. range for bundling conductors.

## **2.6 CABLE PULLING COMPOUNDS**

- A. Shall be UL Listed and be suitable for use with the specified cable insulation system. The compound shall reduce the coefficient of friction, while not adding any long term issues to the installation such as premature aging of the insulation system, added flammability or drying in such a manner as to stick the cable in place in the raceway.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Install branch circuits and feeders from the power source to the attachment point as required for a complete system. Provide slack wire for connections to equipment installed by others. Refer to schedules and risers where specific conductor and associated raceway sizes are not indicated on the floor plans.
- B. Connect branch circuit homerun with two or three circuits and common neutral only where specifically shown on the drawings. Circuits with common neutrals shall not be connected to the same phase to ensure cancellation of the return current in the neutral conductor.
- C. 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.
- D. For branch circuit homeruns, MC cable shall transition to conduit/wireways and wire before entering the panelboard
- E. Install wires and cable in raceways as specified. All conductor sizing is based upon no greater than three current carrying conductors in a conduit. Installation of up to six circuits (no greater than twelve current carrying conductors) in a single conduit will be allowed if the conductor sizing is increased to the required ampacity to accommodate de-rating factors required by the NEC and NFPA 70.
- F. The minimum wire size feeder or branch circuit shall be #12 unless #14 specifically allowed for controls and interlock wiring. Branch circuits longer than 75' for 120 V and 175' for 277 V from panel to last outlet shall be increased a minimum of one size above that shown on the drawings to minimize voltage drop to less than 2%.
- G. Conductors shall be identified at all accessible locations in the following manner:

- H. Color code secondary service, feeders and branch circuit conductors as follows:

<b>208/120 Volts</b>	<b>Phase</b>	<b>480/277 Volts</b>
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

- I. Provide nonferrous wire markers, embossed or printed to correspond with the Drawings. Labels shall be permanently marked so that the source of the branch circuit or feeder may be readily identified. Hand written labels are not acceptable. Embossed tag equal to 3M Scotch Code STL-TAG or SCS-TM shall be applied with two miniature cable ties or slipped through both end holes. Heat bonded tag equal to 3M Scotch Code SCS-HB shall be permanently affixed with a heat gun.

### 3.2 CABLE

- A. Flexible Metal Clad (MC) cable may be used in concealed locations for branch circuit wiring.
- B. Conductor color code shall comply with identification requirements as indicated in this Section.

### 3.3 SPLICES AND TERMINATIONS

- A. No more than twelve splices of current carrying conductors or six circuits, whichever is greater, shall be allowed in a single enclosure or junction box.
- B. Splices and terminations shall be sized to the specified conductor. The insulation shall be cut back with the appropriate tools such that the conductors are not nicked or damaged.
- C. The compression tool shall be appropriate for the installation of the provided lug or butt splice to ensure pressure necessary for a proper connection is applied.
- D. Terminations shall not be stacked or bent unless specifically listed for the application.
- E. Arc-proofing shall be applied to all feeders greater than 100 Amperes where multiple circuits are installed in common enclosures such as handholes, manholes and junction boxes. Apply tape in single, half-lapped layer as required by manufacturer's recommendations. Secure with strips of red plastic film tape on 208Y/120V conductors and yellow plastic film tape on 408Y/277V conductors.

### **3.4 CABLE PULLING**

- A. Pull cables that share conduit at same time into completely installed raceway. Conductors shall not be pulled in raceways with existing wiring.
- B. Submit cable pulling calculations for engineers approval prior to all mechanically assisted pulls. Attach pull ropes to conductors with basket-weave grips on pulling eyes. Provide means to measure tension during entire pull. Utilize pulling compounds to lessen friction in accordance with the manufacturer's recommendations.
- C. Mechanically assisted pulls shall utilize equipment specifically designed for the purpose such as ropes, electric wench, pulleys, etc. The use of a motorized vehicle to assist in a cable pull is prohibited.

### **END OF SECTION**

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**SECTION 26 05 26**  
**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes:
  - 1. Conductors
  - 2. Grounding Bus
  - 3. Mechanical Connectors
  - 4. Exothermic Connections
  - 5. Rod Electrode

**1.2 QUALIFICATIONS / QUALITY ASSURANCE**

- A. Provide written test results after installation.

**1.3 PROJECT RECORD DOCUMENTS**

- A. Submit test reports of service ground resistance and resistance readings from ground bar to ground bar.

**PART 2 - PRODUCTS**

**2.1 CONDUCTORS**

- A. Insulated Conductors: Copper wire or cable insulated for 600 V with a green continuous outer covering.

**2.2 GROUNDING BUS**

- A. Manufacturers:
  - 1. B-Line
  - 2. Erico
  - 3. Harger
- B. Rectangular bars of annealed copper, 1/4 by 4 inches (6 by 100 mm) in cross section, unless otherwise indicated; with insulators. Provide pre-drilled NEMA 2-hole lug holes as required.

**2.3 MECHANICAL CONNECTORS**

- A. Manufacturers:
  - 1. O.Z. Gedney
  - 2. Burndy
  - 3. Harger
  - 4. Erico
- B. Material: Bronze.

- C. NRTL listed for grounding; UL 497
- D. Listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) acceptable to Authorities Having Jurisdiction for the application, and for specific types, sizes, and combinations of conductors and other items connected.
- E. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
  - 1. Pipe Connectors: Clamp type, sized for pipe.
  - 2. Conductors: Long barrel two bolt, compression type with observation window.

## **2.4 EXOTHERMIC CONNECTIONS**

- A. Manufacturers:
  - 1. Caldweld.
  - 2. Thermoweld.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## **2.5 ROD ELECTRODE**

- A. Manufacturers:
  - 1. Harger
  - 2. Erico
- B. Ground Rods: Copper-clad steel, 3/4 inch in diameter by 10 feet (19 mm by 3 m).

# **PART 3 - EXECUTION**

## **3.1 APPLICATIONS**

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Grounding Bus: Install in electrical and communication rooms, in rooms housing service equipment, and elsewhere as indicated.
  - 1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
  - 2. In rooms with medium voltage distribution equipment wrap room with ground bus on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

### **3.2 EQUIPMENT GROUNDING**

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.

### **3.3 INSTALLATION**

- A. Grounding and Bonding for Piping:
  1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
- B. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- C. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- D. Provide grounding as required by the lightning protection system, including bonding all metallic objects within six feet of down conductors.
- E. Provide Bonding bushings on all raceways that terminate in eccentric and concentric knockouts and conduit entry openings not enclosed by metal structure.
- F. Bond metal fences and gates around the transformers and generators to the transformer/generator grounding system.

### **3.4 TRANSFORMER GROUNDING**

- A. Provide grounding of transformers as separately derived systems, as required by the Electrical Code. Ground to the nearest building steel frame or code-approved grounding electrodes.
- B. Bond neutral, equipment grounding conductor, transformer case and the grounding electrode at the transformer.
- C. For exterior transformers grounding electrode to consist of a grounding around the concrete pad and at least two rod electrodes. Bond to transformer in at least two separate locations.
- D. Provide grounding at utility transformers in accordance with utility company requirements.

### **3.5 GENERATOR GROUNDING**

- A. Provide grounding of the generators as separately derived systems, as required by the Electrical Code.
- B. Bond the generator neutral and generator frame together and to the grounding electrode conductor.
- C. For exterior generators grounding electrode to consist of a grounding around the concrete pad and at least two rod electrodes. Bond to a generator in at least two separate locations.

### **3.6 TELECOMMUNICATIONS SYSTEM GROUNDING**

- A. Provide a copper ground bus in each communications room.
- B. Connect the ground bus to building steel.
- C. Ground bars in consecutive Telecommunication Rooms and conduits and cable tray entering the room shall be bonded together using a hollow braided, bare copper conductor.

### **3.7 FIELD QUALITY CONTROL**

- A. Field inspection and testing will be performed per NETA standards.
- B. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

### **END OF SECTION**

**SECTION 26 05 29**  
**HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Support, Anchorage, and Attachment Components
  - 2. Fabricated Metal Equipment Support Assemblies
- B. Meet the following performance requirements:
  - 1. Size for 200% minimum safety factor.
  - 2. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a quantified professional engineer, using performance requirements and design criteria indicated herein.
  - 3. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
  - 4. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
  - 5. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.
- C. System Description:
  - 1. Support systems and procedures for installing electrical systems.

**PART 2 - PRODUCTS**

**2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Provide all supplementary steel, factory fabricated channels and supports required for the proper installation, mounting and support of all Electrical equipment, piping, etc., required by the Specifications.
- B. Channel support systems shall comply with MFMA-4, be a minimum of #12 gauge, hot-dipped galvanized, stainless steel or fiberglass for exterior and pre-galvanized or hot-dipped for interior applications.
- C. Supplementary steel and factory fabricated channels shall be firmly connected to building construction in a manner approved by the Owner's Representative as herein specified.
- D. The type and size of the supporting channels and supplementary steel shall be determined by the Contractor and shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.



- E. All supplementary steel and factory fabricated channels shall be installed in a neat and workmanlike manner parallel to the walls, floors and ceiling construction. All turns shall be made with 90 degree and 45 degree fittings, as required to suit the construction and installation conditions.
- F. All supplementary steel including factory fabricated channels, supports and fittings shall be galvanized steel, aluminum or stainless steel where exposed or subject to rust producing atmosphere. Factory fabricated channels shall be manufactured by Unistrut, H-strut, Powerstrut or approved equal.

### **PART 3 - EXECUTION**

#### **3.1 APPLICATION**

- A. All equipment shall be anchored to a support structure. Comply with Manufacturer's recommendations.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by and scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter for light fixtures and 1/2" (12mm) for other loads. Size for a minimum of 200% safety factor. Provide double nuts and lock down washers for adjustability, maximum of 4 threads allowed beyond nut, cut or grind ends as required.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps or single-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.
- D. For light commercial facilities only with no seismic design requirements spring-steel clamps designed for supporting single conduits without bolts may be used for 3/4-inch (19-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E. Provide support system materials and accessories as follows:
  - 1. Interior non-corrosive areas:
    - a. Pre-galvanized
    - b. Hot dip galvanized.
  - 2. Interior corrosive areas:
    - a. Stainless steel
    - b. Fiberglass
  - 3. Exterior use:

- a. Hot dip galvanized.
  - b. Stainless steel
  - c. Fiberglass
- 4. Underground use:
  - a. Fiberglass
  - b. Stainless steel
- F. Install support systems sized and fastened to accommodate weight of equipment. Fasten hanger rods, support chains or wire, conduit clamps, and outlet and junction boxes to building structure using expansion anchors, cast-in-place inserts or beam clamps. Do not use spring steel clips and clamps. Provide channel spanning structural members where required.
- G. Provide multiple trapeze supports where appropriate.
- H. Do not fasten supports to piping, support wires, ductwork, mechanical equipment, or conduit.
- I. Do not drill structural steel members.
- J. Do not attach to roof deck.
- K. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.
- L. Install free-standing electrical equipment on concrete pads, and bolt to pad using Seismic rated Rawl studs.
- M. Install surface-mounted cabinets backboards, panelboards etc. with a minimum of four anchors. Provide steel channel supports to stand backboards one inch (25 mm) off wall.
- N. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.
- O. When obstructions such as ductwork, etc., do not allow direct connection to building structure, provide channel supports, rated for three times the working weight to be supported, across the obstruction to allow direct support of the equipment or material. Support the channel with threaded rods supported directly from the building structure.
- P. Rigidly support all equipment, material and devices unless specifically indicated otherwise.

### **3.2 PAINTING**

- A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.



- B. Non-metallic coatings: clean damaged areas and coat with equivalent material of the same thickness with procedures and materials recommended by the manufacturer.

**END OF SECTION**

**SECTION 26 05 33**  
**RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
1. Metal Conduit and Tubing
  2. Nonmetallic Conduit and Tubing
  3. Metal Wireways
  4. Nonmetallic Wireways
  5. Surface Raceways
  6. Boxes, Enclosures, and Cabinets

**PART 2 - PRODUCTS**

**2.1 RACEWAYS AND BOXES**

- A. Galvanized Rigid Steel Conduit (GRSC, RMC)
1. GRSC shall be zinc-coated steel that conforms to ANSI C80.1, UL Specification No. 6 and Federal Specification WW-C-581e by Allied Tube and Conduit, Republic Steel, Wheatland Tube or approved equal.
  2. GRSC fittings shall be threaded. Split couplings or non-threaded fittings shall not be used.
  3. Nipples and Close Nipples shall be GRSC, length as noted or as required to conform to field conditions.
- B. Electrical Metallic Tubing (EMT)
1. EMT shall be zinc-coated steel that conforms to ANSI C80.3, UL Standard No. 797 and Federal Specification WW-C-563 a by Republic Steel, Allied Tube and Conduit or approved equal.
  2. EMT fittings shall be zinc plated pressed steel gland and ring compression or zinc plated pressed steel set screw type that shall form a positive ground path. Utilize double set screws for 1 ¼" and up.
- C. Polyvinyl Chloride (PVC) Non-metallic Conduit
1. PVC conduit and fittings shall be Schedule 40 or Schedule 80, 90o C. UL Listed equal to Carlon Plus 40 or Plus 80. PVC shall meet NEMA Specification TC-2, TC-3 and UL-651.
  2. PVC, fittings and solvent cement shall be by single approved manufacturer.
  3. PVC shall be sunlight resistant and listed for exposed or outdoor usage.
- D. Miscellaneous Conduit Fittings

1. Elbows shall be standard radius unless noted otherwise. Where Large Radius elbows are specified, provide 48" radius unless noted otherwise.
2. Bushings shall be threaded pressed steel hot dipped galvanized with conduit end stop and integrally molded noncombustible phenolic insulated surface rated for 150o C.
3. Bonding bushings shall be threaded pressed steel hot dipped galvanized with conduit end stop and integrally molded noncombustible phenolic insulated surface rated for 150o C with a lay-in tin plated copper grounding lug.
4. Exposed conduit expansion fittings shall be hot-dipped galvanized malleable iron with external bonding jumper equal to O.Z./Gedney Type EX for RGS or Type TX for EMT (4" maximum expansion).
5. Provide water-tight gland sealing assemblies with pressure bushings equal to OZ/Gedney Type WSK for new cast-in-place installations or GPT LINK-SEAL® modular seals for retrofit (core drilling of existing walls) as required for below grade wall and floor penetrations.

**E. Flexible Metallic Conduit**

1. Liquidtight Metal Conduit shall be UL Listed fabricated from a spiral wound strip of heavy gauge, corrosion resistant, hot dipped galvanized steel equal to Electri-flex Company Type LA or Anamet Electrical, Inc. Type UA. The jacket shall be flame retarded, sunlight resistant PVC extruded over the spiral wrap. Sizes through 1 ¼" shall have an integral copper bonding strip.
2. Liquidtight fittings shall be UL listed zinc plated insulated throat.
3. Flexible metal conduit shall be UL Listed non-jacketed steel fabricated from a spiral wound strip of heavy gauge, corrosion resistant, hot dipped galvanized steel equal to Electri-flex Company Type BR.

**F. Wireways**

1. Wireways shall be minimum 16-gauge steel with all straight runs having hinged spring-latched covers. Finish shall be painted over a corrosion resistant phosphate pretreatment to protect against corrosion. Interior parts shall be smooth and free of sharp edges and burrs. Provide wireway as identified on the drawings for NEMA 1, 3R or 12 service. Wireways shall be equal to Square D and UL Listed.

**G. Outlet Boxes**

1. Outlet and switch boxes on concealed work shall be at least 4" square, galvanized pressed steel conforming to UL 514A. Where installed in plaster, boxes shall be fitted with galvanized steel plaster covers (number of gangs as indicated/required) of required depth to finish flush with finished wall or ceiling. Outlet boxes shall be by RACO, Steel City -Thomas & Betts, Crouse Hinds, Appleton Electric Company, or approved equal.
2. Outlet boxes installed in masonry walls or in concrete decking shall be UL Listed for the application.

3. Outlet boxes used as junction boxes shall be minimum 4-11/16" square and 2" deep. Outlet boxes for telecommunications/data outlets shall be minimum of 3" deep.
4. All switch and receptacle boxes shall be minimum 4" square for up to (2) devices, or solid ganged boxes for over (2) devices. Boxes shall be provided with 1/2" raised galvanized device covers for exposed conduit work.
5. Outlet boxes on exposed interior conduit systems, shall be threaded-hub, cast-malleable iron with an aluminum polymer enamel coating, conduit type fitting FS or FD suitable for wiring devices installed. Device covers shall be coated malleable iron with moisture sealing gasket and stainless steel fasteners.
6. Outlet boxes for exterior surface mounting shall be cast aluminum alloy with an aluminum polymer enamel coating equal to Appleton Type FS or FD. Conduit entries shall be threaded cast hubs. Device covers shall be cast aluminum alloy with moisture sealing gasket and stainless steel fasteners.
7. All boxes shall have at least one tapped and threaded grounding hole for connection of a 10-32 grounding screw.
8. Box depth shall accommodate code required volume for the specified installation. Through wall boxes shall not be used.
9. Outlet boxes for various systems including but not limited to fire alarm, paging and master clocks shall be specifically made for the purpose and sized as required by the manufacturer. Boxes shall be cast where exposed to physical damage or installed in an exposed exterior location. All surface mounted fire alarm back boxes shall be red in color.
10. Provide 3m fire barrier moldable putty pads (or equal) for every backbox located in a fire rated wall.

#### H. Junction and Pull Boxes

1. Provide galvanized steel junction and pull boxes where indicated and as necessary to facilitate installation. Steel shall be minimum 16 gauge. Junction and pull boxes shall be of code required dimensions. Cover shall be of the same type and thickness material as the box construction and shall be reinforced or formed to prevent deflection under its own weight.
2. Junction and pull boxes intended for dry interior locations shall be NEMA 1 enclosures with accessible, removable screw-on covers. Covers shall be secured with corrosion-resistant screws with keyhole slots to accommodate easy removal.
3. Junction and pull boxes intended for wet or exterior locations shall be NEMA 3R enclosures with hinged gasketed covers. Hinge shall be galvanized steel with stainless steel pin. Covers shall be secured with corrosion-resistant zinc plated lockable pull catches.
4. Custom fabricated medium to large junction and pull boxes (4'-0" or larger in any direction) shall have internal structural steel bracing welded to form a rigid assembly adequate to maintain

- alignment and shape in shipment and installation and contain fiberglass cable supports.
5. All interior and exterior pull and junction boxes shall be gray enamel powder coat painted over the galvanized metal.

## **PART 3 - EXECUTION**

### **3.1 RACEWAYS AND BOXES**

#### **A. General**

1. Unless specified or shown on Drawings otherwise, install raceways and conduits concealed. Raceways and conduits may be run exposed on unfinished walls and basement ceilings with exposed structure, in mechanical rooms, electric rooms, attics and roof spaces.
2. Run concealed raceways and conduits in as direct lines as possible with minimum number of bends of longest possible radius. Install exposed raceways and conduits parallel to or at right angles to building lines.
3. 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
4. Raceway and conduit runs shall be mechanically and electrically continuous from supply to outlet. Conduit shall enter and be secured to metallic enclosures with lock nut and bushing inside. Provide additional exterior lock nut for RGS connections. Bushings shall be the bonding type for conduit connections to metallic enclosures with concentric or eccentric knockouts. Lock nuts and bushings will not be required where conduits are screwed into threaded hubs.
5. Size raceways and conduits as required by MEC unless oversized raceways and conduits are shown on the Drawings. Raceways and conduits shall be  $\frac{3}{4}$ " minimum.
6. Install conduit systems complete before installation of conductors. Blow through and swab after plaster is finished and dry, and before conductors are installed.
7. Raceways and conduits supports shall be rigidly attached to the building structure utilizing corrosion resistant components suitable for use with the selected raceway or conduit. Refer to the seismic restraint sections of this specification for any additional requirements.
8. Field bending, cutting and threading shall be executed with the proper tools, resulting in bends and shortened conduits and raceways that are equivalent to factory fabricated and purchased components.
9. Provide standoff clips for conduits on exterior and wet location walls. Protect all vertical conduit runs from the entrance of foreign material before installation of conductors and the final closure of the raceway system. All spare conduits (vertical and horizontal runs) shall be sealed with a bushing and appropriate insert to prohibit entrance of debris or vermin. Affix a label that indicates "Spare Conduit to "

at each seal.

Label shall be in accordance with the labeling section of this specification.

**B. Galvanized Rigid Steel Conduit (GRSC, RMC)**

1. GRSC may be used for all raceway applications outlined for EMT and PVC. GRSC shall be used in locations where subject to accidental damage or abuse and for all above grade exterior applications unless other wiring methods are specified on the drawings. All circuit conductors in excess of 600 V shall be installed in RGS.
2. GRSC shall not be used in corrosive environments.
3. All GRSC fittings shall be threaded. Utilize Erickson couplings where joining two threaded conduits that can not be rotated.

**C. Electrical Metallic Tubing (EMT)**

1. EMT may be used for lighting and receptacle branch circuits, telephone, fire alarm, communications, signal and instrumentation circuits and for control circuits. EMT may be used in masonry walls, above hung ceilings, in equipment rooms, in mechanical and electrical chases and closets, in exposed locations along ceilings or walls above normal traffic level and where not subject to accidental damage or abuse.
2. EMT shall not be used in exposed applications below 8 feet above finished floor or in exterior or damp/wet/corrosive locations. Electrical, telephone and communications closets are considered exempt from this restriction and EMT may be installed below 8' AFF in this application only. EMT shall not be installed underground, in slabs on grade, in exterior locations, in hazardous areas, or for circuits operating at more than 600 V.

**D. Polyvinyl Chloride (PVC) Non-metallic Conduit**

1. PVC may be used for installation in concrete or direct burial applications where not subject to damage. PVC may be used in corrosive environments where specifically allowed on the drawings.
2. PVC shall not be used for penetrations from concrete slabs. Transition to RGS shall be made a minimum of 2" below the slab finished surface, prior to penetration.
3. All connections shall utilize solvent and glue in accordance with the recommendations of the conduit manufacturer.

**E. Miscellaneous Conduit Fittings**

1. Expansion/Deflection Fittings: Raceways and conduit buried or secured rigidly on opposite sides of building expansion joints and long runs of exposed conduit subject to expansion and contraction due to variations in temperature shall have expansion fittings. Raceways and conduit shall cross building expansion joints at right angles. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting. Fittings shall safely deflect and/or expand/contract to twice the distance of potential movement.



2. Penetrations of all below grade exterior walls and flooring shall require approval by the engineer and architect. Submit proposed penetration points, size openings and penetration methods to engineer and architect. Penetrations shall utilize sealing fittings appropriately sized for the application. Duct bank penetrations are excluded from this requirement.
  3. Sealing Fittings shall be installed wherever conduits pass from warm to cold locations to minimize condensation within the conduit. Sealing fittings shall be installed with RGS penetration of the wall and terminate in a suitably sized junction box.
  4. Refer to other specification sections for requirements pertaining to sealing for hazardous atmospheres.
- F. Liquidtight Flexible Metallic Conduit
1. Provide flexible metallic conduits for connections to electrical equipment and to equipment furnished under other Divisions that are subject to movement, vibration or misalignment and/or where noise transmission must be eliminated or reduced.
  2. Make connections to motors and equipment with pvc jacketed flexible metallic conduit and liquid-tight connectors. Liquidtight flexible metal conduit shall be used in short runs to connect motors where movement and vibration requires a flexible connection. Minimum length shall not be less than 1'-0", maximum length shall not exceed 5'-0".
- G. Wireways
1. Wireways shall be provided where specifically shown on the drawings or where the group mounting of controllers, disconnects, enclosures, etc warrant the use for elimination of multiple short conduit runs. Wireways shall be provided complete with all required appurtenances necessary to have a totally enclosed system rated for the environment. Wireways shall not be installed in any location where subject to accidental damage or abuse.
- H. Raceway and Conduit Installation in Concrete Slabs
1. Raceways and conduit may be installed in slabs where specifically allowed on the drawings. Maximum outside diameters of raceways in slabs shall not exceed 1/3 slab thickness. No more than two 3/4" raceways shall cross in floor slab at a single point. Lateral spacing of parallel raceways shall be at least 6" on centers. Submit raceway layout plan for approval to architect and engineer and obtain signoff from the structural engineer of the actual installation before pouring slabs. All in slab installations shall be photographed, with prints and negatives appropriately marked and turned over to the owner at job completion.
  2. Raceways and conduit shall not be placed in slabs less than 3" thick.
- I. Outlet Boxes

1. Outlet and switch boxes shall be securely fastened to metal studs with a minimum of two self-tapping screws. Boxes three gang and greater shall be securely fastened to studs on both sides of the box.
  2. Fasteners for mounting boxes in damp or wet locations shall be stainless steel.
  3. Pressed steel boxes shall not be used for exposed surface mounted locations below 8'0" AFF.
  4. Outlet and switch boxes shall not be installed back to back. Stagger box installation to adjacent stud spaces to maintain sound separation between rooms.
  5. Floor boxes shall not be used above grade level in concrete decking without the approval of the structural engineer and architect. Floor slab installations shall not degrade the required structural or fire rating integrity of the floor deck.
- J. Junction and Pull Boxes
1. Junction box covers shall be accessible. Do not install junction boxes above suspended ceilings except where ceiling is removable or where an access panel is provided.
  2. Pull boxes connected to concealed conduits shall be mounted with covers flush with finished wall or ceiling.
  3. Pull boxes exposed to rain or in damp/wet locations shall be weatherproof NEMA 3R unless noted otherwise on the drawings.
  4. No pull box shall be within 2 feet of another.
  5. Provide clamps, grids, cable ties and other non-conductive or combustible appurtenances to secure cables. No cable shall be unsupported for more than 30". Cables shall not touch or be unsupported within 1" of the box cover.
  6. Each junction and pull box shall have a suitable laminated plastic nameplate with white cut letters identifying power source, voltage and driven load of the associated branch circuits or feeders.
- B. Submit box sizing calculations to confirm all box dimensions are in accordance with code requirements with product data prior to installation.

**END OF SECTION**

## **SECTION 26 05 53** **IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Power Raceway Identification Materials
  - 2. Metal-Clad Identification Materials
  - 3. Control Cable Identification Materials
  - 4. Power Conductor Identification Materials
  - 5. Equipment Identification Labels
  - 6. Arc Flash Labeling
- B. Meet the following performance requirements:
  - 1. Identification shall be of a material and attachment method suitable to the environment where it is located. Exterior identification shall be weather, chemical and UV resistant.
- C. Provide consistent, informative labeling for all furnished wired or installed equipment and devices. Coordinate with the Drawings, Specifications and Short Circuit, coordination and Arc Flash report.

#### **1.2 REGULATORY REQUIREMENTS AND STANDARDS**

- A. ANSI Z535 Safety Standards.
- B. ANSI A13.1.
- C. OSHA

#### **1.3 SUBMITTALS**

- A. Submit materials, colors and nameplate schedule for review prior to order.
- B. Submit materials, colors and schedule for signage for review.
- C. Submit on mounting methods and material.

### **PART 2 - PRODUCTS**

#### **2.1 POWER RACEWAY IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-

resistant coating and matching wraparound adhesive tape for securing ends of legend label.

- D. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

## **2.2 METAL-CLAD CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

## **2.3 CONTROL CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
  - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
  - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

## **2.4 POWER CONDUCTOR IDENTIFICATION MATERIALS**

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

## **2.5 EQUIPMENT IDENTIFICATION LABELS**

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height

shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

1. Extra strength laminated TZ Tape by P.Touch or approved equivalent.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed. Minimum letter height shall be 3/8 inch (10 mm).

## **2.6 DEVICE PLATE IDENTIFICATION LABELS**

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
1. Extra strength laminated TZ Tape by P.Touch or approved equivalent.

## **2.7 ARC FLASH LABELS**

- A. Arc flash labels shall be machine printed vinyl signs complying with OSHA and NFPA 70E requirements including information and OSHA compliant color coding and symbology.

# **PART 3 - EXECUTION**

## **3.1 INSTALLATION**

- A. All equipment and designated devices shall be properly identified by means of permanent, clear and concise nameplates, tags, signs, directories or color coding.
- B. Verify identity of each item before installing identification products.
- C. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install nameplates and signs, etc. parallel to equipment lines.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Self-Adhesive Identification Products: Degrease and clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Provide nameplates indicating "Breakers to be operated by Authorized Persons only" for the following:
1. Fire Alarm System
  2. Security System
  3. Sound System

4. ATC Control Panel
  5. Elevator Circuit
  6. Emergency Lighting
- H. Conductor Color Coding: 1/8 inch (3 mm) lettering and provide nameplate at each panelboard and switchboard indicating color coding system. Mount on the interior of the door if so equipped; otherwise on the back of the trim.
- I. Cabinets and pull boxes: 3/8 inch (9 mm); identify system (e.g. telephone, data, fire alarm, sound, etc.).

### **3.2 IDENTIFICATION SCHEDULE**

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 20 A, and 120 V to ground: Identify with self-adhesive vinyl label self-adhesive vinyl tape applied in bands. Install labels at source and terminations.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Emergency power
  2. Power
  3. Security
  4. Fire alarm
  5. Telecom
- C. Power-Circuit Conductor Identification, 600 V or Less: Where conductors can be exposed (for example junction boxes, panels, loads, etc.), use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for conductors.
    - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
    - b. Colors for 208/120-V Circuits:
      - 1) Phase A: Black.
      - 2) Phase B: Red.
      - 3) Phase C: Blue.
      - 4) Neutral: White
    - c. Colors for 480/277-V Circuits:
      - 1) Phase A: Brown.
      - 2) Phase B: Orange.
      - 3) Phase C: Yellow.
      - 4) Neutral: Gray.
    - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are

made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

2. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with control wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control fire alarm and low voltage system wiring.
- D. Power-Circuit Conductor Identification, More than 600 V: Where conductors are exposed, use write-on tags or nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.
- E. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- F. Conductors to Be Extended in the Future: Attach write-on tags or marker tape to conductors and list source.
- G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
  1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

### 3.3 COLOR CODE SYSTEM FOR LABELLING AND ENGRAVED NAMEPLATES

<b>System Use</b>	<b>Background Color</b>	<b>Text Color</b>	<b>Remarks</b>
Over 600Volts	Orange	Black	
Base Bldg Power	Black	White	
Generator/Life Safety	Red	White	

### 3.4 ARC FLASH LABELS

- A. Label distribution equipment with arc flash labels per the Arc Flash study.



- B. Provide labels at each bus and piece of equipment in the report
- C. Provide labels at each access point to distribution equipment including rear and side access door.

**END OF SECTION**



## **SECTION 26 22 00** **LOW-VOLTAGE TRANSFORMERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Manufacturers
  - 2. General Transformer Requirements
  - 3. Distribution Transformers
  - 4. Buck-Boost Transformers
  - 5. Identification Devices
  - 6. Source Quality Control

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
  - 1. General Electric Company.
  - 2. Siemens Energy & Automation, Inc.
  - 3. PowerSmiths
  - 4. Square D; Schneider Electric.
  - 5. Controlled Power Company.
  - 6. Eaton Electrical Inc.; Cutler-Hammer Products.

#### **2.2 GENERAL TRANSFORMER REQUIREMENTS**

- A. Design, manufacture and testing of transformers shall meet requirements of NEMA No. ST 20 and UL Standards.
- B. Power transformers shall be two winding dry type for general power and lighting applications. Transformers rated 1000 kVA or below shall be UL listed and bear required Listing Mark.
- C. Transformer minimum efficiencies shall comply with DOE 2016 unless specifically noted otherwise.
- D. Transformers shall use properly classified UL approved temperature ratings. Temperature rise ratings shall be in accordance with UL 506. Insulation ratings shall be 220 degrees C based upon a 150 degrees C rise. Transformers supplied to this specification shall be able to operate continuously at 100 percent nameplate rating at ambient temperatures not exceeding 40 degrees C. Maximum temperature at top of enclosure shall

not exceed 50 degree C rise above 40 degree C ambient. Transformers 5 KVA and above shall be able to meet ANSI/IEEE C57.96 daily overload requirements listed in drawings. Transformers loaded in accordance with this paragraph shall be capable of long service life under thermal conditions specified with no need for derating.

- E. Lug kits and ground bus shall be provided by the manufacturer of the transformer.
- F. Transformer cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below core saturation point. Transformers shall have aluminum windings, continuous wound construction with vacuum impregnated insulation using non-moisture-absorbing varnish. There shall be no metal-to-metal contact between core and coil and enclosure.
- G. Primary winding of transformers rated less than 30 kVA shall have at least two taps, each providing 5% increment below full rated voltage. Each primary winding of each transformer 30 kVA and larger shall have six taps, two of which shall provide 2-1/2% increments above full rated voltage and four of which shall provide 2-1/2% increments below full rated voltage.
- H. Dry-type K-13 rated transformers shall be provided where indicated on drawings. Neutral bars shall be sized for at least 200 percent ampacity of secondary phase conductors. A full length copper electrostatic shield shall be included, producing an average effective coupling capacitance of 30 picofarads between primary and secondary. Electrical noise attenuation shall average 120 db common mode and 30 db normal mode.
- I. Enclosures shall be of heavy gauge steel and meet UL 506 requirements for the following characteristics:
  - 1. Ventilation Openings
  - 2. Cable Bending Space
  - 3. Surface Temperature Rise
  - 4. Wiring Compartment Temperature Rise
  - 5. Terminations
- J. Transformers shall have sound levels equal to or lower than those established in latest revision of ANSI/IEEE C89.2.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Verify that ground connections are in place. Maximum ground resistance shall be 5 ohms at location of transformer.

### **3.2 INSTALLATION**

- A. Install Products in accordance with manufacturer's instructions. Provide clearance for ventilation as indicated by the Manufacturer, 6 inches (150 mm) minimum, 12 inches (300 mm) preferred.
- B. Set transformer plumb and level.
- C. Use flexible conduit, 3 ft minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- D. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.
- E. Provide seismic restraints as required by code.
- F. Provide grounding and bonding in accordance with Section 26 05 26.
- G. At a minimum, provide required ventilation space indicated on nameplate.

### **3.3 ADJUSTING**

- A. Measure primary and secondary voltages and make appropriate tap adjustments. Set for nominal single phase voltage of 120V – 125V at no load. Record tap settings on record drawings.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

**END OF SECTION**

## **SECTION 26 24 16** **PANELBOARDS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. General Requirements for Panelboards
  - 2. Accessory Components and Features

#### **1.2 COORDINATION**

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - 1. Notify Construction Manager, Contractor, and Owner no fewer than [two] <Insert number> days in advance of proposed interruption of electric service.
  - 2. Do not proceed with interruption of electric service without Construction Manager's, Contractor's, and Owner's written permission.
  - 3. Comply with NFPA 70E.
- B. Coordinate recessed panelboards dimensions and surface mounted panelboard support requirements and locations.

#### **1.3 EXTRA MATERIALS**

- A. Provide the following additional materials:
  - 1. Six of each panelboard key.
  - 2. Two spare circuit breaker lock-on devices for each panelboard.
  - 3. Spare circuit breakers for each size and type in addition to units indicated on the Drawings where space is available in the panelboards.

### **PART 2 - PRODUCTS**

#### **2.1 GENERAL**

- A. Provide dead-front lighting and power panelboards where shown on drawings and as scheduled.
- B. Panelboards shall meet or exceed requirements of NEMA Standard Publication PB-1, and UL-50 and 67. Panelboards shall be UL-listed.
- C. Where panelboards are used as service entrance equipment, they shall comply with all NEC and UL requirements for service. The panelboard shall include a UL service entrance label, incoming line isolation barriers and a removable neutral bond to ground for solidly grounded wye systems.

- D. Where panelboards are installed in Kitchens, the enclosure shall comply with NEMA 250, Type 4X.
- E. Enclosures shall be at least 20 inches wide made of galvanized steel. Gutter space shall be in accordance with MEC requirements for the specified combination of devices and accessories. Provide a gutter extension and barrier of same gage and finish as panelboard enclosure where feeder cables supplying the mains of a panel are carried through it's box to supply other electrical equipment.
- F. Provide a directory card located inside panelboard door, mounted in transparent card holder.
- G. Fronts shall be reinforced steel with concealed hinges and concealed trim adjusting screws. Trim clamps are unacceptable. Where two section panels are required, bolt boxes together to form one unit. Trim shall be two-piece construction with doors of equal size over each section. Trims shall be cleaned, primed and painted gray ANSI 61.
- H. For panelboards up to 400 amps, provide cabinets with flush hinges and combination catch and lock to cover circuit breaker handles. Provide a directory card with a clear plastic cover mounted inside the door. Power and lighting panels shall have heavy-duty, continuous, section vertical-hinged to box section for access to wiring gutters in addition to trim door (Door-in-Door). All locks shall be keyed alike. Panelboards greater than 400 amps shall be provided with a four-piece front to cover wiring gutter and wiring access areas.
- I. Nameplates shall be in accordance with other sections of this specification.
- J. The manufacturer shall warrant equipment to be free from defects in materials and workmanship for 1 year from date of installation or 18 months from date of purchase, whichever occurs first.
- K. Basis-of-Design Product: Panels shall be GE A- Series II for 400 A and below unless more than (1) 125 amp or larger branch breaker and/or space is specified. GE Spectra Power panelboards shall be provided for all applications greater than 400 amps and to accommodate multiple branch breakers greater than 125 amps Approved equal panelboards by Eaton Cutler-Hammer, Siemens or Square D will be considered.

## **2.2 BUSSING**

- A. Phase, Neutral and Ground bus bars of panels shall be copper (98% conductivity). Phase and Neutral busses shall be rated to carry at least full rating of the panel as identified on the schedules.
- B. Split solid neutral bus, with rated capacity equal to the phase bus, shall be plated and located in main compartment for all incoming neutral cables to be same length. Neutral bus shall be 200% rated where double sized neutrals are indicated and/or where the panel is supplied via a K-rated transformer.
- C. Provide separate equipment ground bus for each panelboard. Where an isolated ground is specified, provide an additional isolated ground bus, which shall be insulated from the panel enclosure and equipment ground.

- D. Panelboards shall be fully rated to interrupt symmetrical short-circuit current available at the terminals.
- E. All lugs shall be UL listed tin-plated aluminum suitable for copper or aluminum cable for sizes indicated on the drawings. Provide oversized lugs to accommodate designed cable sizes or increase gutter space to allow use of solid stud compression lugs where necessary. All terminations shall be suitable for 75 degree C cable.
- F. Provide bus connections for future overcurrent devices with suitable insulation and bracing to maintain proper short circuit rating and voltage clearances. All required hardware shall be installed and be in place for ready insertion of future breaker without the need to relocate or adjacent units. Future spaces shall accommodate frame sizes up to 50% of the main bus ampacity.
- G. Minimum integrated short circuit rating: 10,000 amperes RMS symmetrical for 240 volt rated panelboards; 22,000 amperes RMS symmetrical for 480 volt panelboards, provide higher where indicated on the Drawings or the Overcurrent Protective Device Coordination study.

## **2.3 OVERCURRENT DEVICES**

- A. Molded case circuit breaker shall be equal to GE Spectra RMS™ Molded Case Circuit Breakers.
- B. Circuit breakers less than 250A shall be provided with thermal magnetic trip units. Breakers with frame sizes 250A or larger shall be provided with digital electronic trip units and the following field-adjustable settings  
Instantaneous trip.
  - 1. Long- and short-time pickup levels.
  - 2. Long- and short-time time adjustments.
  - 3. Ground-fault pickup level, time delay, and  $I^2t$  response.
- C. Group mounted breakers shall be connected to the vertical bus by bolted connections.
- D. Circuit breaker frames shall be constructed of a high-strength, molded, glass-reinforced polyester case and cover. Breakers shall have an overcenter, toggle handle-operated, trip free mechanism with quick make, quick break action independent of the speed of the toggle handle operation. The design shall provide common tripping of all poles. Breakers shall be suitable for reverse feeding.
- E. Breakers shall have ON and OFF position clearly marked on escutcheon. Breakers shall include a trip-to-test means on the escutcheon for manually tripping the breaker and exercising the mechanism and trip latch.

- F. Breakers shall include factory installed mechanical lugs. Lugs shall be UL listed and rated 75 or 60/75 degrees C as appropriate. Breakers shall be standard, 80 percent rated.
- G. Internal accessories shall be UL Listed for field installation without removing the circuit breaker cover. Internal accessories shall be common to all frame sizes. Shunt trips, undervoltage releases, auxiliary switches, and bell alarms shall be available for all breakers and shall install from the front of the circuit breaker or molded-case switch.

## **2.4 ACCESSORY COMPONENTS AND FEATURES**

- A. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
  - 1. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
  - 2. Provide permanent lockout capability per OSHA requirements on overcurrent devices.
  - 3. Provide lock-on devices on the circuits serving the following systems.
    - A. Fire Alarm System
    - B. Security System
    - C. Sound System
    - D. ATC, BMS, BAS Control Panel
    - E. Emergency Lighting

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Provide 1/2" spacers for panelboards mounted at exterior walls below grade to establish 1/2" air space behind panel.
- B. Inspect installed panelboard(s) for anchoring, alignment, grounding and physical damage. Clean interiors to remove construction debris, dirt and shipping materials.
- C. Check tightness of all electrical connections with calibrated torque wrench. Minimum acceptable values are specified in manufacturer's instructions.
- D. Adjust all circuit breakers and doors for free mechanical operation as described in manufacturer's instructions.
- E. Adjust circuit breaker trip and time delay settings to values determined by the short circuit and coordination study.
- F. Directories shall be typed to indicate loads served by each circuit and mounted in a holder behind a clear protective covering.

- G. Circuit breakers used as a motor disconnecting means, and not in sight of the motor and the driven machinery location, shall be capable of being locked in the open position.
- H. Circuit breakers supplying fire alarm equipment and any others loads noted on the schedules shall be capable of being locked in the ON position. The locking means shall not inhibit the ability of the circuit breaker from performing its protective function.

**END OF SECTION**



## **SECTION 26 25 00** **ENCLOSED BUS ASSEMBLIES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Manufacturers
  - 2. Enclosed Bus Assemblies
  - 3. Plug-In Devices
- B. System Description:
  - 1. Complete busway system

#### **1.2 COORDINATION**

- A. Coordinate installation and pathway with all other trade work. Show installation on coordination drawings.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
  - 1. General Electric Company; Electrical Distribution & Control Division.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D; Schneider Electric.
  - 4. Eaton Electrical Inc.; Cutler-Hammer Products.

#### **2.2 ENCLOSED BUS ASSEMBLIES**

- A. To be Discussed
- B. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
  - 1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure
  - 2. Voltage: [120/208] [240] [480] [277/480] V; 3 phase; [100] [200] [percent neutral capacity].

3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
  4. Bus Materials: Current-carrying [copper] [aluminum] conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
  5. Ground:
    - a. 50 percent capacity integral with housing.
    - b. 50 percent capacity internal bus bars of material matching bus material.
    - c. 50 percent capacity isolated, internal bus bar of material matching bus material.
  6. Enclosure: [Steel with manufacturer's standard finish] [Aluminum with manufacturer's standard finish] [Weatherproof, steel or aluminum with manufacturer's standard finish, sealed seams, drains, and removable closures].
  7. Fittings and Accessories: Manufacturer's standard.
  8. Mounting: Arranged flat, edgewise, or vertically without derating.
  9. The busway shall have a minimum of 6-cycle short-circuit rating of 85 kA RMS symmetrical for ratings through 800 Amp, 100 kA RMS symmetrical for ratings through 1350 Amp, 125 kA RMS symmetrical for ratings through 1600 Amp, 150 kA RMS symmetrical ratings through 2500 Amp, and 200 kA RMS symmetrical for ratings through 5000 Amp.
  10. Each busway section shall be furnished complete with joint hardware and covers. The busway joints shall be a single-bolt, non-rotating, removable bridge design. All bridge joints shall be furnished with torque-indicating double head joint bolts and Belleville washers. The bridge joint shall utilize a captive nut retainer on the opposite side of the torque-indicating bolt. The bridge joint design shall ensure proper installation without the use of a torque wrench, and provide visual indication that the joint has been tightened to the proper torque value. Each busway joint shall allow for a minimum length adjustment of +/- 0.5 inches. De-energization of busway shall not be required for safe testing of joint
- C. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure.
  2. Voltage: [120/208] [240] [480] [277/480] V; 3 phase; [100] [200] [percent neutral capacity].
  3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
  4. Bus Materials: Current-carrying [copper] [aluminum] conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.

5. Ground:
  - a. 50 percent capacity integral with housing.
  - b. 50 percent capacity internal bus bar of material matching bus material.
  - c. 50 percent capacity isolated, internal bus bar of material matching bus material.
6. Enclosure: [Steel, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings] [Aluminum, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings].
7. Fittings and Accessories: Manufacturer's standard.
8. Mounting: Arranged flat, edgewise, or vertically without derating.
9. The busway shall have a minimum of 6-cycle short-circuit rating of 85 kA RMS symmetrical for ratings through 800 Amp, 100 kA RMS symmetrical for ratings through 1350 Amp, 125 kA RMS symmetrical for ratings through 1600 Amp, 150 kA RMS symmetrical ratings through 2500 Amp, and 200 kA RMS symmetrical for ratings through 5000 Amp.
10. Each busway section shall be furnished complete with joint hardware and covers. The busway joints shall be a single-bolt, non-rotating, removable bridge design. All bridge joints shall be furnished with torque-indicating double head joint bolts and Belleville washers. The bridge joint shall utilize a captive nut retainer on the opposite side of the torque-indicating bolt. The bridge joint design shall ensure proper installation without the use of a torque wrench, and provide visual indication that the joint has been tightened to the proper torque value. Each busway joint shall allow for a minimum length adjustment of +/- 0.5 inches. De-energization of busway shall not be required for safe testing of joint.

## **2.3 PLUG-IN DEVICES**

- A. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Circuit breakers shall be thermal magnetic unless connected to normal power busways in which the MCCB shall utilize digital electronic trip units and the following field-adjustable settings Instantaneous trip.
  1. Long- and short-time pickup levels.
  2. Long- and short-time time adjustments.
  3. Ground-fault pickup level, time delay, and  $I^2t$  response.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
  2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
  3. Support bus assembly to prevent twisting from eccentric loading.
  4. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
  5. Fasten supports securely to building structure according to Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- C. Install busway to allow expansion and deflection across building joints.
- D. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight.
- E. Install a water tight concrete curb at least 3 inches (75 mm) high around bus-assembly floor penetrations.
- F. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- G. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
- H. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

**END OF SECTION**

## **SECTION 26 27 26** **WIRING DEVICES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Manufacturers
  - 2. Straight Blade Receptacles
  - 3. GFCI Receptacles
  - 4. Tamper-Proof Receptacles
  - 5. USB Receptacles
  - 6. Snap Switches
  - 7. Wall-Box Dimmers
  - 8. Occupancy/Vacancy Sensors
  - 9. Wall Plates
  - 10. Floor Service Fittings
  - 11. Poke-Through Assemblies
  - 12. Multi-Outlet Assemblies
  - 13. Finishes

#### **1.2 COORDINATION**

- A. Verify color of Devices with Architect and Drawings prior to purchasing except for receptacles on emergency systems shall be red and standby systems shall be orange.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the first manufacturer listed below, substitutions that match the first manufacturers characteristics by the subsequent listed manufacturers may be acceptable but require prior approval by Owner:
  - 1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
  - 2. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
  - 3. Leviton Mfg. Company Inc. (Leviton).
  - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

#### **2.2 STRAIGHT BLADE RECEPTACLES**

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide the following: a. Hubbell; HBL5351 (single), CR5352 (duplex).

## **2.3 GFCI RECEPTACLES**

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Hubbell; GF5362.
- C. Hospital-Grade, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with UL 498 Supplement SD.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Hubbell; HGF8300.

## **2.4 TAMPER PROOF RECEPTACLES**

- A. To be Discussed

## **2.5 USB RECEPTACLES**

- A. To be Discussed

## **2.6 SNAP SWITCHES**

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
- C. Pilot Light Switches, 20 A:
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Hubbell; HPL1221PL for 120 V and 277 V.
  2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Hubbell; HBL1221L.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

## **2.7 WALL-BOX DIMMERS**

- A. To be Discussed

## **2.8 OCCUPANCY/VACANCY SENSORS**

- A. To be Discussed

## **2.9 WALL PLATES**

- A. Provide 0.032" nominal brushed Type 430 stainless steel device plates by the manufacturer of the wiring device for all flush mounted switches and receptacles installed in dry locations and where not subjected to physical abuse. Ganged plates shall be of one-piece construction to accommodate the required number of installed devices. Oversized plates to cover wall finish blemishes adjacent to the device box shall not be used.
- B. Residential Applications Only: Provide high-impact smooth nylon device plates by the manufacturer of the wiring device for all flush mounted switches and receptacles installed in dry locations and where not subjected to physical abuse. Fastening screws shall be color matched to the plate, plate color and to the device. Ganged plates shall be of one piece construction to accommodate the required number of installed devices. Oversized plates to cover wall finish blemishes adjacent to the device box shall not be used.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

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## **2.10 POKE-THROUGH ASSEMBLIES**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
  1. Hubbell Incorporated; Wiring Device-Kellems.
  2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
  3. Square D/ Schneider Electric.
  4. Thomas & Betts Corporation.
  5. Wiremold Company (The).
- B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
  1. Service Outlet Assembly: [Flush type with two simplex receptacles and space for two RJ-45 jacks] [Flush type with four simplex receptacles and space for four RJ-45 jacks].

2. Size: Selected to fit nominal [3-inch (75-mm)] [4-inch (100-mm)] cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused [3-inch (75-mm)] [4-inch (100-mm)] cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of [two] [four], 4-pair, Category 6e voice and data communication cables.

## **2.11 MULTIOUTLET ASSEMBLIES**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
  1. Wiremold Company (The). Series 4000
  2. Hubbell Incorporated; Wiring Device.
  3. Mono-Systems Inc.
- B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Steel with manufacturer's standard epoxy coated finish.
- D. Provide compartment divider for use with power and telecommunications wiring.

## **2.12 FINISHES**

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
  1. Wiring Devices Connected to Normal Power System: As indicated on Drawings and as selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
  2. Wiring Devices Connected to Emergency Power System: Red.
  3. Standby Power: Orange.



## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

#### **A. Coordination with Other Trades:**

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

#### **B. Conductors:**

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Existing Conductors:
  - a. Cut back and pigtail, or replace all damaged conductors.
  - b. Straighten conductors that remain and remove corrosion and foreign matter.
  - c. Pigtail existing conductors is permitted provided the outlet box is large enough.
4. Do not share neutral conductors between circuits for GFCI and AFCI outlets.
5. Provide a neutral conductor to all switch locations controlling line-to-neutral lighting loads.

#### **C. Device Installation:**

1. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
2. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
3. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
4. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
5. Tighten unused terminal screws on the device.
6. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

- D. Receptacle Orientation:
  - 1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
- E. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- F. Dimmers:
  - 1. Install dimmers within terms of their listing.
  - 2. Verify that dimmers used for fan speed control are listed for that application.
  - 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### **3.2 IDENTIFICATION**

- A. Comply with Division 26 Section "Identification for Electrical Systems."
  - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

### **3.3 SEALING**

- A. Provide weatherproof seals under the device plate and around the device for outlets in exterior walls or walls between environmentally or pressure controlled rooms.

## **END OF SECTION**

**SECTION 26 28 16**  
**ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
1. Fusible and Non-Fusible Switches
  2. Molded-Case Circuit Breakers
  3. Molded-Case Switches
  4. Enclosures

**1.2 COORDINATION**

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Construction Manager, Contractor and Owner no fewer than five days in advance of proposed interruption of electric service.
  2. Indicate method of providing temporary electric service.
  3. Do not proceed with interruption of electric service without Construction Manager's Contractor's and Owner's written permission.
  4. Comply with NFPA 70E.

**PART 2 - PRODUCTS**

**2.1 FUSIBLE AND NON-FUSIBLE SWITCHES**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  2. Siemens Energy & Automation, Inc.
  3. Square D; a brand of Schneider Electric.
  4. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- B. Type HD, Heavy Duty, Single Throw, rated for circuit voltage 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- C. Type HD, Heavy Duty, Double Throw, rated for circuit voltage, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  - 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Required for all disconnects installed on the load of Variable Speed Drives for purposes of sending a "stop" signal to the drive when the disconnect switch is opened.
  - 4. Lugs: Mechanical type, suitable for number, size, and conductor material.
  - 5. Service-Rated Switches: Labeled for use as service equipment.

## **2.2 MOLDED-CASE CIRCUIT BREAKERS**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
  - 1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D; a brand of Schneider Electric.
  - 4. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic trip less than 250A Electronic Trip Circuit Breakers from sizes 250A and larger or as indicated on Drawings: Field-replaceable rating plug, RMS sensing, with the following field-adjustable settings:
  - 1. Instantaneous trip.
  - 2. Long- and short-time pickup levels.
  - 3. Long- and short-time time adjustments.
  - 4. Ground-fault pickup level, time delay, and I<sup>2</sup>t response.
- D. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

E. Features and Accessories:

1. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
3. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

## **2.3 MOLDED-CASE SWITCHES**

- A. Basis-of-Design Product: Subject to compliance with requirements provide the product indicated on the Drawings or the first listed manufacturer or product below. Subject to compliance with requirements a comparable product by one of the others listed may be acceptable:
1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  2. Siemens Energy & Automation, Inc.
  3. Square D; a brand of Schneider Electric.
  4. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Features and Accessories:
1. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
  2. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.

## **2.4 ENCLOSURES**

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  2. Outdoor Locations: NEMA 250, Type 3R.
  3. Kitchen or Wash-Down Areas: NEMA 250, Type 4X, stainless steel.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Install fuses in fusible devices.

#### **3.2 IDENTIFICATION**

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved laminated-plastic nameplate.

#### **3.3 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in the "Overcurrent Protective Device Coordination Study".

**END OF SECTION**

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**SECTION 26 51 00**  
**INTERIOR LIGHTING**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Lighting Fixtures and Components, General Requirements

**1.2 COORDINATION**

- A. Coordinate fixture mountings with ceiling types and provide the required components for correct mounting of the fixture, including plaster frames, slope adjusters, etc.

**PART 2 - PRODUCTS**

**2.1 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS**

- A. Provide lighting fixtures, equipment and components where shown on Drawings, as listed in fixture schedules and as specified, wired and assembled. Provide approved aligned canopies, hangers and other appurtenances as required, for a complete and functional system.
- B. All new lighting fixtures shall be UL listed and shall have an individual IES test report indicating fixture performance.
- C. Coordinate fixture mountings with ceiling types and provide the required components for correct mounting of the fixture, including plaster frames, slope adjusters, etc. Review architectural reflected ceiling drawings and notify Architect of discrepancies prior to ordering fixtures or submitting shop drawings. No additional compensation will be allowed if wrong fixtures are ordered because coordination was not performed.
- D. Provide all LED fixtures with appropriate drivers and accessories for a complete installation. Standard led driver shall be class 2, 24v dc constant current with standard 0-10v dimming built-in with 5-year warranty.
- E. LED arrays/modules shall be UL and ROHS compliant. Additionally, led arrays shall comply with IESNA LM-79 and LM-80 standards. Standard module shall be rated for 50,000 hours to l70 (70% lumen maintenance over life); 5 year warranty.
- F. LED modules shall be replaceable and shall not require specialized tools to service.
- G. Refer to the lighting fixture schedule for specific ballast requirement. In general:

1. Fluorescent fixtures shall have electronic ballasts with high power factor, 277V or 120V, with sound rating "A" and shall be CBM-certified. Total harmonic distortion rating shall be less than 10%. Ballasts shall be instant start or programmed rapid start for maximum performance and energy savings and have a minimum ballast factor of 0.88. Acceptable ballasts manufacturer are Osram Sylvania Inc., Advance Electric, or approved equal.
- H. Electronic ballasts that operate T-5 and compact fluorescent lamps shall have end-of-lamp-life shut down to protect against lamp over heating.
- I. Refer to the lighting future schedule for specific lamp type, CRI and color.
  1. Tungsten-halogen lamps shall be rated for 130V.
  2. Fluorescent lamps shall have minimum CRI rating of 82.
  3. Acceptable lamp manufacturers are: Osram Sylvania Inc., G.E., Philips, or approved equal.
- J. Refer to fixture schedule for specific lamp and ballast/driver requirements which may deviate from this specification.
- K. Install insulated bushings at points of entrance and exit of flexible wiring.
- L. Provide polyester covers to protect fixtures during construction.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Lamps
  1. Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed in the fixtures just prior to the completion of the project.
  2. Lamps shall be handled with cotton gloves to avoid finger print markings.
  3. Florescent lamps on dimmed circuits shall be "conditioned" in accordance with manufacturers recommendation by operating for at least 120 hours at full voltage.
- B. Fixtures
  1. Accessories
    - a. Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation. Open type fluorescent fixtures with exposed lamps shall have a wire-basket type guard.
  2. Suspended Fixtures
    - a. Suspended fixtures shall be provided with swivel hangers in order to ensure a plumb installation. Pendants, rods, or chains 4 feet or longer excluding fixture, shall be braced to limit swinging. Bracing



shall be 3 directional, 120 degrees apart. Single unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple unit or continuous-row fluorescent units shall have a tubing or stem for wiring at one point, and a tubing or rod suspension provided for each length of chassis including one at each end. Maximum distance between adjacent tubing or stems shall be 10 feet. Rods shall be of not less than 3/16 inch diameter. Flexible raceway shall be installed to each fixture from an overhead junction box unless flexible cord specified on the schedule. Fixture to fixture wiring installation is allowed only when fixtures are installed end to end in a continuous run.

3. Ceiling Fixtures
  - a. Ceiling fixtures shall be coordinated with and suitable for installation in, on, or from the suspended ceiling provided under other sections of these specifications. Installation and support of fixtures shall be in accordance with the NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive type of suspended ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling panels, in conformance with UL-03.
4. Do not install fixtures until work of other trades that may damage fixtures is completed.
5. Provide plaster frames for fixtures recessed in gypsum board or a plaster ceiling.
6. Do not suspend or support lighting fixtures or safety chains from hung ceiling, conduit or duct. Support fixtures with safety chain from structural members only.
7. Provide unistrut below ducts where fixture locations coincide with HVAC duct or mechanical piping runs. Provide threaded rods to support unistrut.
8. Support luminaries at least two points to prevent rotation.
9. Incandescent and tungsten halogen lamps shall not be operated, other than for initial testing, before final inspection.
10. Handling of reflectors shall be done only with cotton gloves to avoid imprinting fingerprints on reflective surfaces.

## **END OF SECTION**