SECTION 15000—MECHANICAL GENERAL PROVISIONS

A. Introduction
   1. This section includes a number of general mechanical issues that need to be considered for all designs but have not yet included in a specific DRM Section.
   2. Reference the following DRM sections for additional mechanical requirements:
      a. 2.02 Classroom Design Standards
      b. 2.04 Animal Care Design Standards
      c. 2.05 Custodial Requirements
      d. 2.09 Mechanical Details
      e. 2.11 College of Medicine Design Standards
      f. 3.00 Standard Specification Sections, (Division 15)

   3. Chilled Water Coil Applications
      a. Chilled water from the central chilled water plants distributions systems is to be used for air conditioning whenever available. Building chilled water interface and campus distribution requirements to be design as indicated by the utility sections of the DRM. Coils are to be sized for the greatest practical Delta-T for the application and in no case less the 14ºF with an entering water temperature of 42ºF during the cooling season. Systems requiring off-season cooling (winter) should be avoided, when required designer shall closely coordinate the requirements and availability and temperature of the chilled water system.

   4. HVAC Systems
      a. HVAC systems shall consist of a central air system with heating and cooling provided by the central chilled water and steam distribution systems whenever available. Equipment to be located in equipment rooms meeting the space requirements associated ASHRAE guidelines identified in the Systems and Equipment Handbook. The system design parameters are to be determined by the project Life Cycle Cost analysis but will generally include the following features:
         1) Variable Air Volume (VAV) with minimum air hot water reheat coils
         2) VFD control of fans and pumps
         3) Individual room temperature control
         4) DDC control system
         5) Outside air economizer cycles
         6) Ventilation control
         7) Return air fan.
         8) Laboratories should include a means of airflow tracking control with fume hoods provided with variable air volume control.
         9) Motors for HVAC fan/pump applications should be premium efficiency and VFD rated, when applicable.

B. Acoustic Considerations in HVAC Design
   1. General
      a. Noise and vibration control is important in any mechanical design. Communication in a quiet and distraction free environment is essential to the classroom. Vibration sensitive equipment, such as balances and electron microscopes, are common research tools. The high volumes of air required to ventilate and air condition research and teaching labs

increase the difficulty of maintaining an acoustically acceptable environment.

b. Outdoor noise generated by exhaust fans, cooling towers and condensing units etc must also be considered regarding its impact on neighbors and university personnel.

c. Acceptable noise and vibration criteria must be established early in the design so that equipment, piping, and ductwork that require vibration isolation can be identified.

d. An experienced acoustical consultant should be included in the design team of critical spaces and performing spaces.

2. References

a. ASHRAE – 1999 ASHRAE Applications Handbook.

b. *A Practical Guide to Noise and Vibration Control for HVAC Systems* by Mark E. Schaffer.

3. Background Noise Criteria

Type of Space	**RC(N) or NCB with neutral (N) sound quality**
Private residence or Apartment	25-35
Offices	
Executive Offices	25-30
Private Offices	30-35
Open – Plan Areas	35-40
Conference rooms	25-35
Public Circulation	40-45
Lobbies and Corridors	35-40
Academic areas	
School Classrooms < 750 sq ft	30-40
School lecture rooms > 750 sq ft	25-35
Libraries	30-40
Laboratories	
Labs without fume hoods	35-40
Labs w/ fume hoods teaching	35-45
Labs w/ fume hoods research	40-50
Other Spaces	
Retail Shops	35-45
Church Sanctuaries	25-30
Gymnasiums	40-50

These guidelines are the result of a consensus and may be in some instances considered conservative. Depending on subjective response and economic considerations they may be increased somewhat where the noise spectrum is balanced, similar in slope to an RC rating curve.

When sound quality is important specify criteria in terms of RC (N). If freedom from annoyance is not a major consideration but speech communication is then specify in terms of the more liberal NC may be used.

Outdoor noise: Is expressed in dBA, measured at property line, Zone or property use dependent, may vary dependent on time of day, duration, presence or fluctuations, impulsive sounds and preexisting ambient noise.

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- New classroom standard planned for introduction in 2001 or 2002 will call for a weighted dBA 35, 60dBC approx. NC 30.
- Growing pressure may dictate background noise levels in schools as much as 10 dB lower.
- A 3 dB change in sound level is just noticeable. A 5dB increase in sound level is a significant difference. A 10 dB change is perceived as twice(or half) as loud.

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1. General Requirements: System Design
   a. Fans:
      1) Consider several types when designing HVAC systems and include noise among selection criteria.
      2) Specify the octave band fan-only sound power levels for critical fan equipment.
      3) Confirm that data provided by manufacturers is reasonable and verifiable.
      4) Verify that you have good aerodynamic conditions at the fan inlet and discharge. Fan blade rotation, airflow distortions and obstructions and changes in airflow direction cause turbulence. Excessive turbulence creates high-pressure drops, high-energy costs and high noise levels. Fan outlets create an uneven discharge pattern and turbulence. The velocity profile takes about 3 dias (or 3h) to smooth out. Any fitting or obstruction within that space will create a higher than expected pressure drop. A fitting may be within 1.5 dias if it conforms to the fan's rotation. Fan discharge fittings should conform to the fan's rotation. Fan inlets should be at least the width of the wheel dia away from walls or other obstructions. The fan discharge transition should be 15º max for a min of 3 dias.
      5) Fan Modulation devices: Use only VFDs. VFDs should have critical frequency jump-band to avoid certain fan or motor rpm settings which may cause sympathetic vibrations. Do not use inlet vanes for air volume reduction.
      6) Select fans to the right of the SP curve near peak mechanical efficiency.
      7) Design for low noise and low turbulence.
      8) Select vibration isolators on the basis of the fan's lowest practical rpm.

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- Over sizing can result in more low frequency noise. It's best to select so the design operating point is to the right of peak static pressure near peak mechanical efficiency. Do not select to the left of or at the peak of the static pressure curve because if the system SP is less than anticipated

you could approach the surge region where the operation is unstable and the fan begins to develop high levels of low frequency noise.

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b. AHUs

1) Plug fans with discharge plenums may be used to reduce noise generated at duct take off from AHU. They may be used to solve anticipated problems from a difficult design of the unit's discharge.

c. Ductwork

1) Turning vanes: If square elbows must be used they should include extended (trailing edge) turning vanes. The extended edge length should be equal to 3x the distance between the vanes as they are spaced across the duct.
2) Tee splits: Avoid bull nosed tees. Two square back-to-back elbows with extended turning vanes are better and two radiused back-to-back elbows are the quietest.
3) Limit Lateral transitions: Lateral transitions should not be more than 30º offsets, not 90º. For critical spaces use 15 º offset. The quietest offset would be two 15 degree max. Square offsets (two closely spaced elbows) should not be used unless extended turning vanes are included. Don't specify that ducts must run parallel or perpendicular to building beams and columns.
4) No transitions, obstructions, turns, dampers etc, within 3 Dia, (3x duct height), of another accessory or outlet.
5) Round vs. rectangular: Use rectangular duct in areas where noise may be allowed to break out such as storage rooms, janitors closets etc. Use round duct to reduce noise break out to the adjacent areas.
6) Duct takeoffs: Use low resistance and low turbulence fittings. Typical takeoffs should avoid the butt tap but include the conical tap and the 45º tap. For low noise takeoffs use the radius tap (less low frequency noise) or the 45º entry tap for less high frequency noise.
7) Fire dampers to be out of the airstream.
8) Airfoil blades on control dampers will reduce turbulence.

d. Terminal Units

1) For rooms with moderate air requirements, up to 1.5 cfm/sq ft, the unit's radiated NC should be 5 points lower than the room's NC rating. Make the selection at design cfm and + 1½ " SP.
2) Select for an inlet velocity of around 1500 FPM.
3) Mount as high above the ceiling as possible.
4) Inlet length to be a minimum of 3D straight run of sheet metal duct, not flexible duct or fiberboard.
5) Lined plenum outlet 5' min. If used flex duct to diffusers to be lined with spun nylon liner, not polyethylene.
6) If pressure drop across the unit is more than 1 ½" add an auxiliary manual damper (minimum 3D) upstream to absorb some of the system pressure.
7) Always locate terminals close to the main air handler and above

non-sensitive areas. Do not locate a single or dual terminal unit over an area with an NC of 30 or less. Do not locate a fan-powered unit over a room with an NC of 40 or less.

8) Fan powered boxes to be selected for constant, not intermittent fan operation.

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- Noise is discharge noise from inlet and outlet and radiated noise through the casing.
- Terminal inlet velocity has little effect on sound power levels. This is because at any given SP no matter what the inlet dia. is the damper will adjust to maintain volume.
- Compare terminal unit noise in the 125 Hz band.
- Static pressure across a terminal unit has a great effect on Sound Power Levels at all frequencies.
- Lined flexible duct to diffusers should have spun nylon liner not polyethylene. The nylon is porous and lets noise penetrate the fiberglass more easily.
- On sensitive applications consider annular ring velocity sensors. Crossed velocity sensors can be 19dB louder than annular rings on a well-selected box however the ring isn't as accurate.

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e. Grilles, Registers and Diffusers

1) Locate at least 6' from critical listening positions.
2) Locate throughout space to decrease throw requirements and reduce the air volume per device.
3) Provide 3D straight duct to inlet connections.
4) Do not locate dampers within 3D of the device.
5) Select at 5dB below room NC.

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- A damper less than 3D away from the outlet device increases noise up to 5dB if the damper is wide open and 15-40dB if the damper is ½ closed.
- These devices are rated in terms of NC levels in a standard room with a specified room attenuation factor. This factor is the difference between the devices Sound Power Level and the expected sound pressure level in the room. Most manufacturers use a factor of 10dB, some may use 8dB.
- These ratings may be misleading since NC ratings are based on uniform flow conditions, this may not exist in practice. Space may not match specified attenuation factors. Ratings consider only one device in the room.
- ASHRAE recommends using RC ratings rather than NC in selecting these devices.
- In the 2000hz band the RC allows levels about 5 dB higher than NC. Select at 5dB below NC to compensate for this.

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f. Vibration Isolation

1) Avoid taut flex conduit, specify it's to be slack to the touch.
2) Specify vibration isolation verification to take place in both static

and dynamic conditions.

3) Select vibration isolators on the basis of the fan's lowest practical rpm.

g. Specifications

1) Do **not** require all ducts to run parallel to structural beams and columns.
2) Should include: "Where field interference requires different routing from that shown on the drawings the contractor shall submit shop drawings with the proposed alternate layout for approval."
3) To minimize turbulence and noise, minimize duct velocities and minimize pressure drop. Maintain smoothest possible airflow into and out of AHUs and fans.
4) Lined plenums are good for low frequency sound attenuation. Use duct liner and elbows to control mid-frequency sound.
5) On supply duct use duct liner downstream of coils and terminal units only.
6) Do not use lined duct in labs
7) Size sound attenuators for PD= 0.25". Increase face area to decrease self-noise.

h. Mechanical Spaces and General Construction

1) Plan mechanical space to be surrounded by non-critical areas, janitor's closets, rest rooms, stairways, elevators etc.
2) Design and detail walls, doors and frames and penetrations to provide sound isolation to avoid transference of sound.
3) Acoustic ceilings provide good noise reduction provided there is a significant air space between the ceiling and the duct or terminal box.
4) Size duct shaft clearance for the greater of either 10% of the duct's larger dimension or 6".

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- Space planning, surround the mechanical room with non-critical rooms, allow sound to break out in these areas.
- Envelope selection: the best walls for mid and high frequencies include batt insulation, airspace, independent studs and the mass of extra layers of sheet rock. Sheet rock and insulation best for.. Concrete block walls provide good low frequency sound isolation and can be improved by filling with grout and painting it.
- A suspended ceiling will help control equipment room noise as will a ventilated (with sound trap) lined sheet metal box around the equipment.
- A floating floor is another, expensive, option.
- Seal penetrations with rock wool and caulk with silicone.
- Seal the wall/slab or the wall/wall interface.
- Door frame detail should include insulation and sheet rock to the full thickness of the frame.

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SECTION 15190—MECHANICAL IDENTIFICATION

A. Description:
   1. This Section covers the requirements associated with the design and application of mechanical systems identification.

B. References:
   1. ASHRAE - Piping Systems Identification standards
   2. ASME A13.1 - Scheme for the identification of piping systems.

C. General Requirements:
   1. Design identification systems following the appropriate codes, best recommended practices and University standards.

D. Design Document Requirements:
   1. Clearly identify the requirements and applications for system identification tags, nameplates, pipe markers and stenciling.
   2. All systems and components shall be provided with an identifying label during the design process. This labeling shall be coordinated with the existing standard labeling practices for the University. Remodeling projects shall utilize the next available label for that system.

E. Delivery, Handling and Storage: Not applicable.

F. Certification and Testing: Not applicable.

G. Submittals:
   1. Direct contractors to provide product data, lists of wording, symbols, letter size and color coding for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards: Not applicable.

I. Installation Standards:
   1. Install identification systems in accordance with manufacturer's instructions.
   2. Direct the installation and locations of mechanical identification systems to provide adequate coverage and to be easily read from a normal standing position.

J. Application Standards:
   1. Plastic nameplates shall be used to identify large equipment.
   2. Plastic pipe markers shall be used to identify piping systems. Marker shall be color coded and clearly identify pipe service, pressure and flow direction.
   3. Tags shall be used for small equipment and piping systems.
   4. HVAC controls labeling shall be keyed to the controls schematic. Use plastic nameplates to identify panels and control components. Tags may be used to identify control devices such as control valves.
   5. Ductwork and associated systems shall be identified by stenciled painting and shall indicate service and associated AHU.

SECTION 15260—PIPING INSULATION

A. Description:
   1. This Section covers the requirements associated with the design, application, construction and installation of Pipe Insulation and Jacket Systems.

B. References: Not applicable.

C. General Requirements:
   1. Design piping insulation systems following the appropriate codes, best recommended practices and University standards.
   2. Materials used shall not exceed a flame spread/smoke developed rating of 25/50.
   3. Installers of insulation systems shall be by a company specializing in performing this type of work for a minimum of three years.
   4. Materials listed in this section are intended for use with pipe insulation systems associated with building applications.

D. Design Document Requirements:
   1. In design documents, clearly identify the design insulation type, density and thickness for all applications.

E. Delivery, Handling and Storage:
   1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
   2. Store insulation in original wrapping and protect from weather and construction activities, including dirt, water, chemical and mechanical damage.
   3. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

F. Certification and Testing:
   1. All pipe testing shall be completed and accepted prior to applying insulation materials.

G. Submittals:
   1. Direct contractors to provide product data and installation instructions for review and approval by Owner and/or Owner’s Representative as required to assure project compliance.

H. Product Standards:
   1. Insulation:
      a. Glass fiber, rigid molded, non-combustible. K value of 0.24 at 75ºF. Maximum moisture absorption of 0.2 percent by volume.

   2. Jackets:
      a. White kraft paper reinforced with glass fiber and bonded to aluminized film. Maximum moisture vapor transmission of 0.02 perm inches. Secure with self-sealing longitudinal laps and butt strips.
      b. PVC plastic one-piece molded type fitting covers and sheet material. Maximum moisture vapor transmission of 0.012 perm inches. Secure with brush on welding adhesive.
      c. Aluminum, embossed type, thickness of 0.020 inch sheet. Fitting covers

to be 0.016 inch thick die shaped with factory attached protective liner. Secure with brush-on welding adhesive. Metal jacket bands to be 1/2 inch wide, 0.015 inch thick aluminum.

d. Stainless steel, embossed, type 304, thickness of 0.016 inch sheet. Fitting covers to be 0.010 inch thick die shaped with factory attached protective liner. Metal jacket bands to be 1/2 inch wide, 0.010 inch thick stainless steel.

I. Installation Standards:

1. Install in accordance with manufacturer's instructions. Maintain ambient temperatures and conditions required by manufacturers during and after installation for minimum period of 24 hours.
2. Locate insulation and jacket seams in least visible locations for exposed piping.
3. Inserts and/or shields are to be provided for all insulated piping systems. Shields shall be galvanized steel and may be used alone for piping systems below 2 inches. For pipe sizes above 2 inches, inserts shall be used in combination with shields. Inserts shall be located between the pipe and the support shield, under the finish jacket.
4. Exterior applications are to be provided with a vapor barrier jacket. Insulate fittings, joints and valves with insulation of like material and thickness of adjoining pipe.

J. Application Standards:

1. Provide vapor barrier jackets for all services conveying fluids which may be below ambient temperatures at any time. Continue insulation through walls, sleeves and other pipe penetrations. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections and other system components.
2. Hot piping systems conveying fluids above ambient temperatures but below 140ºF, do not insulate flanges and unions, but bevel and seal ends of insulation. Piping systems above 140ºF shall be completely insulated including flanges and unions.
3. Exposed piping, mechanical rooms, finished spaces, etc. shall be finished with a PVC type jacket.
4. Exterior applications are to be provided with a stainless steel or aluminum jacket.
5. Insulation Schedule:

PIPING SYSTEM	PIPE SIZE (IN)	THICKNESS (IN)
Plumbing Systems	All	1"
Hydronic Systems		
Heating Water	All	1-1/2"
Glycol	All	1-1/2"
Chilled Water	All	1"
Steam/Condensate Systems		
Low/Med. Pressure	2" and smaller	1-1/2"
Low/Med. Pressure	Above 2"	2"
High Pressure	2" and smaller	2"
High Pressure	Above 2"	2-1/2"
Condensate	All	1-1/2"

Provide insulation on all other system where a significant heat transfer may occur.

SECTION 15280 - EQUIPMENT INSULATION

A. Description:
   1. This Section covers the requirements associated with the design, application, construction and installation of Equipment Insulation and Jacket Systems.

B. References: Not applicable.

C. General Requirements:
   1. Design equipment insulation systems following the appropriate codes, best recommended practices and University standards.
   2. Materials used shall not exceed a flame spread/smoke developed rating of 25/50.
   3. Installers of insulation systems shall be by a company specializing in performing this type of work for a minimum of three years.

D. Design Document Requirements:
   1. Clearly identify in design documents the design insulation type, density and thickness for all applications.

E. Delivery, Handling and Storage:
   1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
   2. Store insulation in original wrapping and protect from weather and construction activities, including dirt, water, chemical and mechanical damage.
   3. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

F. Certification and Testing:
   1. All equipment testing shall be completed and accepted prior to applying insulation materials.

G. Submittals:
   1. Direct contractors to provide product data and installation instructions for review and approval by Owner and/or Owner’s Representative as required to assure project compliance.

H. Product Standards:
   1. Insulation:
      a. Glass fiber, rigid/semi-rigid, non-combustible. K value of 0.24 at 75ºF, 3.0 pounds/cubic feet density. Maximum moisture absorption of 0.2 percent by volume. Vapor barrier jacket, kraft paper reinforced with glass fiber and bonded to aluminized film.

   2. Jackets:
      a. White kraft paper reinforced with glass fiber and bonded to aluminized film. Maximum moisture vapor transmission of 0.02 perm inches.
      b. PVC plastic one piece molded type fitting covers and sheet material. Maximum moisture vapor transmission of 0.012 perm inches. Secure

with brush on welding adhesive.

c. Aluminum, embossed type, thickness of 0.020 inch sheet. Secure with brush on welding adhesive. Metal jacket bands to be 1/2 inch wide, 0.015 inch thick aluminum.

I. Installation Standards:
1. Install in accordance with manufacturer's instructions. Maintain ambient temperatures and conditions required by manufacturers during and after installation for minimum period of 24 hours.
2. Locate insulation and jacket seams in least visible locations.
3. Apply insulation close to equipment by grooving, scoring and beveling insulation as appropriate. Insulate fittings, joints and valves with insulation of like material and thickness.
4. Seal joints with vapor barrier adhesive or tape to match jacket. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
5. Stop and point insulation around access doors, operators and similar devices to allow operation without disturbing insulation. For applications below ambient temperatures, install insulation to allow easy removal and replacement to provide access to equipment devices requiring inspection or maintenance.
6. Do not insulate over nameplates or ASME stamps. Bevel and seal insulation around such locations.

J. Application Standards:
1. Provide vapor barrier jackets for all services which may be below ambient temperatures at any time.
2. Equipment exposed in mechanical rooms, finished spaces, etc. shall be finished with a PVC or aluminum jacket.
3. Exterior applications are to be provided with vapor barrier and caulked aluminum jacket.
4. Insulate steam equipment with 2 inch thick insulation, heating hot water with 1-1/2 inch thick, chilled water with 1 inch thick and plumbing equipment with 1 inch thick insulation.

SECTION 15290 - DUCTWORK INSULATION

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Duct Insulation and Jacket Systems.

B. References: Not applicable.

C. General Requirements:
1. Design duct insulation systems following the appropriate codes, best recommended practices and University standards.
2. Materials used shall not exceed a flame spread/smoke developed rating of 25/50.
3. Installers of insulation systems shall be by a company specializing in performing this type of work for a minimum of three years.

D. Design Document Requirements:
1. Clearly identify in design documents the design insulation type, density and

thickness for all applications.

2. On the construction plans, clearly identify the locations where the use of duct liner is allowed.

E. Delivery, Handling and Storage:
   1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
   2. Store insulation in original wrapping and protect from weather and construction activities, including dirt, water, chemical and mechanical damage.
   3. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

F. Certification and Testing:
   1. All duct testing shall be completed and accepted prior to applying insulation materials.

G. Submittals:
   1. Direct contractors to provide product data and installation instructions for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards:
   1. Insulation:
      a. Glass fiber, flexible blanket, non-combustible. K value of 0.24 at 75ºF, 1.5 pounds/cubic feet density. Maximum moisture absorption of 0.2 percent by volume. Vapor barrier jacket, kraft paper reinforced with glass fiber and bonded to aluminized film.
      b. Glass fiber, rigid board, non-combustible. K value of 0.24 at 75ºF, 3.0 pounds/cubic feet density. Maximum moisture absorption of 0.2 percent by volume. Vapor barrier jacket, kraft paper reinforced with glass fiber and bonded to aluminized film.
      c. Glass fiber, rigid duct liner, non-combustible. K value of 0.23 at 75ºF, 2.0 pounds/cubic feet density. Maximum moisture absorption of 0.2 percent by volume. Vapor barrier jacket, kraft paper reinforced with glass fiber and bonded to aluminized film.

   2. Jackets:
      a. White kraft paper reinforced with glass fiber and bonded to aluminized film. Maximum moisture vapor transmission of 0.02 perm inches.
      b. Aluminum, embossed type, thickness of 0.020 inch sheet. Fitting covers to be 0.016 inch thick die shaped with factory attached protective liner. Secure with brush-on welding adhesive. Metal jacket bands to be 1/2 inch wide, 0.015 in thick aluminum.

I. Installation Standards:
   1. Install in accordance with manufacturer's instructions. Maintain ambient temperatures and conditions required by manufacturers during and after installation for minimum period of 24 hours.
   2. Locate insulation and jacket seams in least visible locations for exposed ductwork.
   3. Exterior applications are to be provided with a vapor barrier jacket. Insulate

fittings, joints and valves with insulation of like material and thickness of adjoining pipe.

4. Seal joints with vapor barrier adhesive or tape to match jacket. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Use adhesives and mechanical fasteners to prevent sagging on underside of ductwork.
5. Stop and point insulation around access doors, damper operators and similar devices to allow operation without disturbing insulation.

J. Application Standards:
1. Provide vapor barrier jackets for all services conveying air which may be below ambient temperatures at any time. Continue insulation through walls, sleeves and other penetrations. Insulate entire duct and other system components.
2. Exposed ductwork in mechanical rooms, finished spaces, etc. shall be finished to allow for painting.
3. Exterior applications are to be provided with vapor barrier and caulked aluminum jacket.
4. Flexible duct insulation shall be used for concealed locations and rigid insulation for exposed locations. Thickness to 1-1/2 inches minimum.
5. Refer to Section 15890 - Ductwork for duct liner application requirements.

SECTION 15310 - FIRE PROTECTION PIPING

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Fire Protection Piping systems.

B. References:
1. NFPA 13 - Sprinkler Systems.
2. NFPA 14 - Standpipe and Hose Systems.
3. NFPA 24 - Service Mains.

C. General Requirements:
1. Design Fire Protection Piping systems following the appropriate codes, best recommended practices and University standards.
2. Installers of Fire Protection Piping systems shall be by a company specializing in performing this type of work for a minimum of three years.

D. Design Document Requirements: Not applicable.

E. Delivery, Handling and Storage:
1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification.
2. Caps shall be provided on pipe openings until installed.

F. Certification and Testing:
1. In accordance with the requirements of NFPA.

G. Submittals:
1. Direct contractors to provide product data, installation instructions and shop

drawings indicating installation layout, pipe materials, jointing methods, supports, floor and wall penetration seals.

H. Product Standards:
1. Double check valve to be Watts, Series 709.

I. Installation Standards:
1. Install piping in accordance with Factory Mutual, NFPA 13 for sprinkler systems, NFPA 14 for standpipe and hose systems and NFPA 24 for service mains.
2. Connect Fire Protection Piping to domestic water system using a double check backflow device installed horizontally. Provide adequate clearance on all sides of backflow assembly, (12 inches below, 24 inches front, 12 inches back and 36 inches above). Assembly installations higher than 60 inches will need to include a permanent platform for maintenance procedures.
3. Slope piping and arrange systems to drain at low points and provide a drain at all low points. Use eccentric reducers to maintain top of pipe level.
4. Install valves with stems upright or horizontal, not inverted.
5. Provide test drains and shut-off valves for each floor/zone of system. Locate a floor drain near test station to facilitate testing.

J. Application Standards: Not applicable.

SECTION 15410 - PLUMBING PIPING

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Plumbing Piping Systems, including sanitary sewer/vent, acid waste, storm sewer, condensate drains, domestic water, natural gas, vacuum, compressed air, process cooling water, deionized water, reverse osmosis water and distilled water piping.

B. References: Not applicable.

C. General Requirements:
1. Design plumbing systems following the appropriate codes, best recommended practices and University standards.
2. Installers of plumbing piping systems shall be by a company specializing in performing this type of work for a minimum of three years.
3. Specific plumbing requirements associated with project shall be determined and compared with services available within the existing facility if applicable.
4. Materials listed in this Section are intended for use with plumbing systems associated with building applications.

D. Design Document Requirements:
1. Provide a legend of all piping symbols to be use on the plans.
2. Provide a clear indication of plumbing requirements and intended routing locations. Utilize sectional views of critical and congested areas such as corridors. Provide an indication of pipe elevation by breaking line for lower pipe runs and clearly show where pipe turns up or down.
3. Provide piping isometrics and details for plumbing systems as appropriate.

4. Indicate the installation of isolation valves in all branch plumbing lines.
5. All plumbing fixtures for lab applications to be manufactured by Chicago Faucet Company.
6. Designer shall determine domestic water disinfection design requirements, with input from the University Water Plant personnel to allow the University to complete the disinfection process. Design documents shall include connection taps and indicate desired location for taps.
    a. Contractor is not allowed to use new plumbing system prior to being tested and accepted. New piping shall not be attached to the existing system and is to be designed such that it can be capped and isolated during the disinfection process. When filling the system the contractor is to provide a backflow preventor to prevent the potential for cross contamination. When required the University will provide a backflow preventor and meter to be used for temporary water service during construction.

E. Delivery, Handling and Storage:
1. Caps shall be provided on pipe openings until installed.
2. Valves to be maintained in shipping containers with label in place until installed.

F. Certification and Testing:
1. An appropriate pressure test shall be specified for all plumbing systems. Test shall be conducted using a non-flammable liquid or gas compatible with the final service for which the system is intended. Drain, clean and purge all piping after testing has been completed.
2. The University of Iowa Water Plant personnel will perform the disinfection and water treatment process associated with new/renovated domestic water systems. The contractor will be required to provide notification when the system is 100% complete, including fixtures, and ready for testing. Contractor will be required to assist University personnel during the disinfection process and to flush the system.

G. Submittals:
1. Direct contractor to provide detailed shop drawings and product data for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards:
1. Sanitary Sewer Piping, Above Grade:
    a. Cast iron pipe and fittings.
    b. Design Pressure: Gravity.

2. Acid Waste Piping:
    a. Polypropylene pipe and fittings with a two quart bottle trap, similar to Orion BT-1.
    b. Glass pipe and fittings, borosilicate glass, UL classified Type 1, beaded ends. Traps to be interceptor type with borosilicate glass partition tray and bottom cleanout.
    c. Design Pressure: Gravity.
    (NOTE: Verify the specific requirements for acid waste piping for the building associated with project.)

3. Storm Sewer Piping, Above Grade:
   a. Cast iron pipe and fittings.
   b. Design Pressure: Gravity.

4. Condensate Drain Piping:
   a. Copper tubing, Type L. Joints to be soldered.
   b. Design Pressure: Gravity.

5. Domestic Water Piping:
   a. Copper tubing (4 inch and under), Type L, hard drawn. Joints to be soldered.
   b. Valves to be full port ball type for sizes up to 2 inches and butterfly type for sizes above 2-1/2 inches. Butterfly valves to be lug end, bubble tight shutoff design.
   c. Design Pressure: 125 psig.
   d. Design Temperature: 250ºF

6. Natural Gas Piping:
   a. Steel pipe, Schedule 40 black. Fittings to be welded for sizes 2-1/2 inches and above. All concealed pipe to be welded.
   b. Design Pressure: 125 psig.
   c. Design Temperature: 350ºF

7. Vacuum and Compressed Air Piping:
   a. Copper tubing, Type L, hard drawn. Joints to be soldered.
   b. Design Pressure:
      1) Vacuum: 29 inches of mercury.
      2) Compressed Air: 125 psig.

8. Process Cooling Water Piping:
   a. Copper tubing (4 inch and under), Type L, hard drawn. Joints to be soldered.
   b. Steel pipe (above 4 inches), Schedule 40 black. Fittings to be welded.
   c. Valves to be full port ball type for sizes up to 2 inches and butterfly type for sizes above 2-1/2 inches. Butterfly valves to be lug end, bubble tight shutoff design.
   d. Design Pressure: 150 psig.

9. Distilled, Deionized and Reverse Osmosis Water Piping:
   a. Pipe, fittings and valves to be polypropylene, fire retardant, Schedule 80. Joints to be mechanical type.
   b. Faucet to be tin plated interior with chrome plated exterior, Chicago Faucet Co., Model 969.
   c. Design Pressure: 100 psig.

10. Backflow Preventers:
    a. Acceptable Manufacturer: Watts

I. Installation Standards:
   1. Install piping to conserve building space, generally locate piping close to structure.

2. Locate valves and other plumbing specialties to provide easy access, install access doors where required to provide the required accessibility.
3. Gas and air branch connections shall be taken from the top of horizontal pipe runs.
4. Clean all piping systems as required for that specific system.

J. Application Standards:
1. Ball and/or butterfly valves shall be used for isolation and shutoff requirements of domestic water, process cooling water, vacuum, compressed air and pure water services.
2. Globe valves shall be used for throttling, bypass and manual flow control applications.
3. Plug valves shall be used for shutoff requirements of natural gas piping systems.
4. Dielectric unions are **NOT** to be used to separate dissimilar materials.

SECTION 15510 - HYDRONIC PIPING

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Hydronic Piping Systems, including heating hot water, glycol, chilled water and condenser water piping systems.

B. References:
1. ASME - Section 9, Qualification Standard for Welding and Brazing Procedures.

C. General Requirements:
1. Design hydronic piping systems following the appropriate codes, best recommended practices and University standards.
2. Installers of hydronic piping systems shall be by a company specializing in performing this type of work for a minimum of three years.
3. Materials listed in this section is intended for use with piping systems associated with building applications.

D. Design Document Requirements:
1. Provide a legend of all piping symbols to be use on the plans.
2. Indicated hydronic piping requirements on plans clearly indicating how piping is intended to be run. Provide an indication of pipe elevation by breaking line for lower pipe runs and clearly show where pipe turns up or down.
3. Provide piping isometrics and details for hydronic systems as appropriate.
4. For renovation projects, the existing building hydronic piping systems shall be evaluated to determined if sufficient capacity exists within the existing systems or a new service is required.

E. Delivery, Handling and Storage:
1. Caps shall be provided on pipe openings until installed.
2. Valves to be maintained in shipping containers with label in place until installed.

F. Certification and Testing:
1. A welder's certificate shall be provided in compliance with ASME Section 9.
2. An appropriate pressure test shall be specified for all plumbing systems. Test

shall be conducted using a non-flammable liquid or gas compatible with the final service for which the system is intended. Drain and clean all piping after testing has been completed.

G. Submittals:
1. Direct contractor to provide detailed shop drawings and product data for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards:
1. Heating Hot Water, Glycol, Chilled Water and Condenser Water Piping:
   a. 2-1/2 inches and Smaller:
      1) Copper tubing, Type L, hard drawn. Joints to be silver soldered. Fittings to be cast brass.
      2) Valves to be full port ball type.

   b. 3 inches and Larger:
      1) Steel pipe, Schedule 40, black. Fittings to be forged steel, Class 125. Pipe and to be flanged/welded for sizes.
      2) Valves to be butterfly type, bubble tight shutoff, Class 125, flanged ends for sizes 2 1/2 inches and above.

2. Backflow Preventers:
   a. Acceptable Manufacturer: Watts

I. Installation Standards:
1. Install piping to conserve building space, locate piping close to structure.
2. Locate valves and other plumbing specialties to provide easy access, install access doors where required to provide the required accessibility.
3. Isolation valves are to be provided on all branch lines.
4. Branch connections for water lines shall be taken from the bottom of horizontal pipe runs.
5. Provide drain assemblies at all low points in hydronic systems and vent assemblies at high points.
6. Clean all piping systems as required for that specific system.

J. Application Standards:
1. Ball and/or butterfly valves shall be used for isolation and shutoff requirements of hydronic water systems.
2. Calibrated balancing valves shall be used for throttling, bypass and manual flow control applications. Calibrated balancing valves shall be used for balancing purposes only. A separate valve is to be provided for isolation and shutoff requirements. Do NOT use triple duty valves.
3. Dielectric unions are **NOT** to be used to separate dissimilar materials. Avoid using dissimilar materials to the extent possible.

SECTION 15520—STEAM AND STEAM CONDENSATE PIPING

A. Description:
   1. This Section covers the requirements associated with the design, application, construction and installation of Steam and Steam Condensate Piping Systems and includes pipe, valves and fitting associated with low (0-20 psig), medium (20-60 psig) and high (60-155 psig) pressure steam/steam condensate and pumped condensate piping systems.

B. References:
   1. ASME - Section 9, Qualification Standard for Welding and Brazing Procedures.

C. General Requirements:
   1. Design of steam and steam condensate systems shall follow the appropriate codes, best recommended practices and University standards.
   2. Installers of steam and steam condensate piping systems shall be by a company specializing in performing this type of work for a minimum of three years.
   3. High pressure steam piping shall be limited to mechanical spaces within the building and is not to be routed through occupied regions of the building.
   4. Condensate piping system shall be design to allow for gravity drainage to the nearest condensate receiver. Do NOT lift condensate. At the discharge of steam coils allow a minimum of 12 inch drop in the condensate to the level of the steam trap plus an additional 6 inches for a dirt leg.
   5. For renovation projects, the existing building steam and steam condensate systems shall be evaluated to determined if sufficient capacity exists within the existing systems or a new service is required.
   6. Materials listed in this Section is intended for use with steam systems associated with building applications.

D. Design Document Requirements:
   1. Provide a legend of all piping symbols to be use on the plans.
   2. Indicated piping requirements on plans clearly indicating how piping is intended to be run. Provide an indication of pipe elevation by breaking line for lower pipe runs and clearly show where pipe turns up or down.
   3. Provide piping isometrics and details for piping systems as appropriate.

E. Delivery, Handling and Storage:
   1. Caps shall be provided on pipe openings until installed.
   2. Valves to be maintained in shipping containers with label in place until installed.

F. Certification and Testing:
   1. A welder's certificate shall be provided in compliance with ASME Section 9.
   2. An appropriate pressure test shall be specified for all piping systems, Test shall be conducted using a non-flammable liquid compatible with the final service for which the system is intended. Drain and clean all piping after testing has been completed.

G. Submittals:
   1. Direct contractors to provide detailed shop drawings and product data for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards:

1. Low Pressure Steam Piping:
   a. Steel pipe, Schedule 40, black. Fittings to be forged steel, Class 125. Pipe and fittings may be threaded for sizes 2 inch and smaller and to be flanged/welded for sizes 2-1/2 inches and above.
   b. Valves to be Class 125, flanged ends for sizes 2-1/2 inches and above.
   c. Design Pressure: 125 psig.
   d. Design Temperature: 310ºF.

2. Medium/High Pressure Steam Piping:
   a. Steel pipe, Schedule 80, black. Fittings to be forged steel, Class 300. Pipe and fittings to be flanged/welded.
   b. Valves to be Class 300, flanged ends.
   c. Design Pressure: 155 psig.
   d. Design Temperature: 410ºF.

3. Steam Condensate (Gravity/Pumped) Piping:
   a. Steel pipe, Schedule 80, black. Fittings to be forged steel, Class 125. Pipe and fittings to be flanged/welded.
   b. Valves to be Class 125, flanged ends.
   c. Design Pressure: 125 psig.
   d. Design Temperature: 220ºF.

I. Installation Standards:

1. Slope steam/condensate piping one inch in 40 feet in the direction of flow. Use eccentric reducers to maintain a flat bottom of pipe. Condensate lines serving a modulation pressure applications must be designed for gravity drainage back to condensate receiver/pump.
2. Provide condensate drip trap assemblies at all low points and before control valves.
3. Install valves with stems horizontal, angled up or upright; not inverted.
4. Locate valves and other plumbing specialties to provide easy access. Install access doors where required to provide the required accessibility.
5. Clean all piping systems as required for that specific systems.
6. Condensate Receivers
   a. Iowa Statute and Administrative Rules for boilers and unfired pressure vessels, section 875-203.14 (89) states that “condensate return tanks shall be equipped with at least two vents or a vent and overflow pipe to protect against a loose float plugging a single connection”
   b. Section 875-203.5 (89) states that vents and their outlets shall be arranged so that there is no danger of scalding personnel. Also, discharge piping should be designed to properly drain.
   c. Section 875-203.6 (89) prohibits the use of galvanized pipe and gives further guidance into piping design
   d. A condensate pit does not fall under the 2-vent rule as a pit cover would not normally fit tight enough to develop pressure in the event of a plugged vent line.
   e. Condensate receivers 4 cubic feet in capacity and below are exempt from Iowa Code and the 2-vent rule. However, when possible, it is still a good idea.
   f. Existing condensate receivers with only one vent fitting might well be

capable of a second vent plumbed in to the inlet line adjacent to the receiver with no valve in between.

g. Venting receiver outdoors is not a first choice option nor is it required by code. First, it is susceptible to freezing in the winter thus negating one of the vents. Second, outside venting is not as easy to monitor for excess steam venting (indicating a trap failure). Third, it can be unsightly to building exteriors.

J. Application Standards:
1. Gate valves shall be used for isolation and shutoff requirements of steam, steam condensate and pumped condensate services.
2. Globe valves shall be used for throttling, bypass and manual flow control applications.

SECTION 15525—STEAM AND STEAM CONDENSATE SPECIALTIES

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Steam and Steam Condensate Specialties.

B. References: Not applicable.

C. General Requirements:
1. Design Steam and Steam Condensate systems following the appropriate codes, best recommended practices and University standards.
2. Manufactures of Steam and Steam Condensate Specialties shall be a company specializing in the manufacture of such products for a minimum of three years.
3. Equipment listed in this Section is intended for use with steam systems associated with building applications.
4. Design condensate piping systems to provide gravity drainage from all equipment and coils to the condensate receiver.

D. Design Document Requirements:
1. Locations for all specialties shall be clearly shown on drawings. Symbols used to locate specialties on plans shall be identified by a legend.

E. Delivery, Handling and Storage:
1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification.

F. Certification and Testing: Not applicable.

G. Submittals:
1. Direct contractor to provide shop drawings, product data and installation instructions for review and approval by Owner and/or Owner’s Representative as required to assure project compliance.

H. Product Standards:
1. Steam Traps:
a. Float and Thermostatic Traps: Cast iron or semi-steel body and bolted

cover, heliarc welded stainless steel metal float device, with renewable stainless steel valve and seat. Built-in thermostatic air vent for balanced pressure.

b. Inverted Bucket Traps: Cast iron or semi-steel body and bolted cover. Stainless steel construction to be provided for bucket, valve, seat and lever mechanism.

2. Steam Pressure Reducing Valves: Pilot operated regulator with hardened 416 Stainless Steel pilot and main valve trim. Cast steel body, thread connections for sizes up to 1-1/2 inch and flanged connections 2 inches and larger.
3. Relief Valves: Cast steel body, with stainless steel diaphragm, stem and springs. Direct pressure actuated.
4. Steam Grid Humidifiers: Steam jacketed dry steam type. Separator to be stainless steel or cast iron, design to ensure dry steam enters manifold tube. Distribution manifold to be continuously welded stainless steel with replaceable nozzles sized for scheduled capacity and absorption distances required. Multiple tubes to be provided as necessary. Control valve to be stainless steel construction with linear flow characteristics. Valve to be normally closed upon loss of power.

I. Installation Standards:
1. Install specialties in accordance with manufacturer's instructions. Locate in accessible locations providing for maintenance and inspection.
2. Install steam traps as per University standards. Traps shall be a minimum of 12 inches below equipment served with a dirt leg ahead of trap. A vacuum breaker shall be provided between equipment and associated steam trap. Basis of Design: Hoffman No. 62.
3. Provide condensate drip trap assemblies at all low points and ahead of control valves.
4. Install pressure reducing valve and relief valve as per University standards.
5. Steam relief valves to be set at 10 psi higher that the associated pressure reducing valve. Vent relief valves to outside of building in a safe location. Provide a drip pan elbow with a drain line to nearest floor drain when a vertical discharge is required.

J. Application Standards:
1. Inverted bucket traps are to be used for end of main drips and constant pressure applications. Float and thermostatic traps are to be used for all modulation pressure applications. A safety factor of 2:1 shall be used when selecting steam traps.
2. Steam grid humidifiers shall utilized steam from the central University steam distribution system where available.

SECTION 15545—CHEMICAL WATER TREATMENT

A. Description:
1. This Section covers the requirements associated with the design, application and construction requirements for chemical water treatment of mechanical systems.

B. References: Not applicable.

C. General Requirements:
1. Design for chemical water treatment processes shall following the appropriate codes, best recommended practices and University standards.
2. Manufactures of treatment materials and equipment shall be a company specializing in the manufacture of such products for a minimum of three years.
3. Chemicals required for water treatment applications will be provided by the University Water Plant. The contractor is to provide the required labor to complete the treatment procedures under the direction of a University Water Plant Representative.
4. Materials and processes listed in this section are intended for use with systems associated with building applications.

D. Design Document Requirements:
1. Closely coordinate project chemical treatment system design requirements with the University's project engineer and Water Plant Representative.
2. Clearly identify on construction documents the work and coordination requirements between the contractor and University Water Plant.

E. Delivery, Handling and Storage: Not applicable.

F. Certification and Testing:
1. Water plant personnel will test chemical water treatment systems upon completion to verify treatment levels.

G. Submittals:
1. Direct contractor to provide shop drawings, product data and installation instructions for review and approval by Owner and/or Owner’s Representative as required to assure project compliance.

H. Product Standards: Not applicable.

I. Installation Standards:
1. Chemical water treatment process is to be completed by the contractor under the direction of University Water Plant Representative.

J. Application Standards: Not applicable.

SECTION 15890—DUCTWORK

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation associated with HVAC and exhaust air distribution systems.

B. References:
1. ASHRAE Handbooks.
2. SMACNA Design Manuals.

C. General Requirements:

1. Installers of ductwork systems shall be by a company specializing in performing this type of work for a minimum of three years.
2. HVAC air distribution systems shall be designed following the best recommended practices as indicated by the ASHRAE Handbooks and SMACNA Design Manuals.
    a. HVAC duct systems shall be designed using the following limiting criteria:
        1) Duct Mains: Typically designed for 0.08-0.10 inches/100 feet friction loss and in no cases higher than 2000 fpm duct velocity.
        2) Branch Ducts: Design for 1000-1500 feet/minute duct velocity with critical noise and airflow applications being designed towards the lower end.

3. Exhaust systems shall be designed in a manner consistent with the best practices as indicated by the Industrial Ventilation Manual by the American Conference of Governmental Industrial Hygienists and the ASHRAE Handbooks.
    a. Chemicals and vapors being exhausted from a space shall be carefully evaluated and the materials and equipment specified to provide the corrosive resistance requirements associated with the specific application. Stainless steel, Type 302, with welded seams shall be used as a minimum standard for chemical fume hood exhausts.
    b. Duct velocities associated with exhaust systems shall be designed to maintain minimum levels recommended by the ASHRAE.
    c. Exhaust stacks associated with hazardous exhaust systems shall be designed with an exit velocity, at minimum air flow, of not less than 3000 feet/minute. Stack shall be a vertical no-loss type, extending a minimum of 8 feet above any adjacent building structure and no closer than 50 feet from the nearest air intake. The use of backdraft dampers or rain caps are not allowed. These requirements indicate the minimum acceptable. In all cases, ASHRAE Guidelines for "Airflow Around Buildings" shall be referenced to determine if more stringent requirements are necessary.

4. Duct systems shall be designed for a minimum pressure classification of 1.5 times the maximum anticipated operating pressure.
5. The duct design shall utilize fittings or a combination of fittings which are listed as "best design practice" by the design reference manuals specified and shall include published pressure loss data. The use of high pressure loss fittings is not allowed.
6. Flexible duct shall be designed with regard to the following criteria:
    a. The use of flexible duct shall be limited to lengths no greater that 4 feet for the low pressure side of terminal unit and 18 inches on the high pressure side.
    b. Where flexible duct is intended to provide the final connection to the air device, a detail shall be provided clearly indicating the required support for the duct and a smooth bend with a centerline radius of 1.5 diameters minimum.
    c. Flexible ductwork shall not be allowed for applications with critical air flow and pressure control considerations, such as laboratories, clean rooms, etc.

7. All ducts shall be sealed in accordance with SMACNA Standards.
8. Provide a minimum of three straight duct diameters (or the equivalent) ahead of all VAV terminals and airflow measuring stations.

D. Design Document Requirements:
1. Duct design shall be shown as a double line drawing and whenever possible at a 1/4 inch scale.
2. Locations for all combination smoke/fire dampers, fire dampers, access doors and similar devices shall be clearly shown on drawings.
3. Clearly indicate the extent of internally lined ductwork to be allowed for the project on plans. Dimensions indicated shall indicate clear inside opening with lining in place.

E. Delivery, Handling and Storage:
1. Ductwork shall not stored directly on the ground. Water marked ductwork will not be accepted for installation.
2. Lined ductwork shall have all open ends sealed during delivery and storage periods.

F. Certification and Testing:
1. Duct leakage testing shall be done in accordance with the SMACNA procedures as indicated by the HVAC Air Duct Leakage Test Manual.
   a. Ducts shall be tested at the specified duct classification design pressure. Ducts not meeting the specified leakage class specified by Table 4-1 of the SMACNA HVAC air Duct Leakage Manual shall be repaired and retested until a successful test has been completed.
   b. Low pressure ducts, duct class 2 inches and below, are not normally required to be tested. It shall be indicated, however, that the Owner or Owner's Representative may request a test at the Contractor's expense if it is believed that the duct installation does not meet the appropriate leakage classification.
   c. A percentage of the duct, class 3 inches and above, shall be specified as required to be tested. Duct section to be tested is to be selected by the Owner or the Owner's Representative. If the selected section passes the appropriate leakage classification, the entire system shall be approved. If the selected section does not pass, the entire duct system shall be repaired and a new section of duct tested until the required leakage class is achieved.
   d. Hazardous fume exhaust duct shall be tested to ensure virtually no leakage within the building; typically 8 CFM or less at 7 inch water column.

G. Submittals:
1. Contractors shall be directed to provide detailed shop drawings for review and approval which show the entire air distribution systems prior to the fabrication and installation of the duct system.
2. A welding test shall be submitted for stainless steel exhaust system.

H. Product Standards:
1. Galvanized ductwork shall be constructed using G90 zinc coating for all applications.

2. Flexible duct shall be constructed of an interlocking spiral duct constructed of galvanized or aluminum.

I. Installation Standards:
   1. All ductwork shall be cleaned prior to installation and maintained clean until start-up by keeping open end of duct systems sealed dust tight throughout the construction period.

J. Application Standards:
   1. HVAC Duct, Fittings and Connections:
      a. Branch ducts to air devices shall be bellmouth, conical or a 45 degree to round boot type fitting as a basis. Straight tap-ins shall not be used. Branch ducts are not to be located directly opposite of each other.
      b. Elbows, round and rectangular shall be 1.5 diameter minimum centerline radius. Mitered rectangular elbow with turning vanes with trailing edge are acceptable where required.
      c. Transitions shall be designed with an angle of convergence not exceeding 30º or divergence not exceeding 15º.
      d. The use of cushion heads at the end of a duct run is not allowed.
      e. Duct connections to fan/AHUs shall be designed for proper entering and leaving air conditions at the fan and avoid any adverse system effect fan losses.

   2. Air devices shall be installed to minimize noise transfer from main duct to occupied space. Locate air devices away from mains and install balancing damper near main duct and not at air device.
   3. Splitter dampers and air extractors shall not be used.
   4. Fibrous glass ducts shall not be used.
   5. Flexible duct usage shall be limited to applications where a substantial benefit can be shown with little of no risk associated with the performance and operation of the system being designed.
   6. Flexible duct liner usage is subject to University approval. Usage consideration shall be limited to the following:
      a. Flexible duct liner shall be installed in accordance with SMACNA standards and as indicated below.
      b. Metal nosing shall be used at the fan discharge and at the leading edge of ductliner when the duct velocity may exceed 2000 feet/minute.
      c. Raw edges of liner, resulting from field penetrations as a result of branch connections, access doors, dampers, reheat coils or similar installations, shall be sealed in the field using fiberglass cloth set in adhesive.
      d. All longitudinal seams of the liner shall be coated with adhesive.
      e. Liner shall be designed for 1 inch thickness. The use of multiple layers of liner to meet minimum thickness of insulation is not allowed.
      f. Flexible duct liner shall not be used in the following locations.
         1) Ahead of any coil in all air distribution systems.
         2) Within 20 feet downstream of a humidifier.
         3) In any HVAC system which serves laboratory spaces or any other area having special concerns for dust or airborne contaminants.

   7. Provide duct access doors to all internal devices requiring inspection or maintenance including: fire dampers, combination smoke/fire dampers, coils

(entering air side), humidifiers (with window) and similar devices. Coordinate location of devices and access door to allow proper access to equipment once project has been completed.

SECTION 15910—DUCTWORK ACCESSORIES

A. Description:
   1. This Section covers the requirements associated with the design, application, construction and installation of HVAC air distribution system accessories.

B. References:
   1. ASHRAE Handbooks.
   2. SMACNA Design Manuals.
   3. NFPA 90A and 92A.
   4. Uniform Building Code (UBC).

C. General Requirements:
   1. HVAC air distribution accessories shall be designed following the appropriate codes and the best recommended practices as indicated by the ASHRAE Handbooks and SMACNA Design Manuals.
   2. Manufacturers of ductwork accessories shall be a company specialized in the manufacture of such products with a minimum of three years experience.

D. Design Document Requirements:
   1. Locations for all ductwork accessories shall be clearly shown on drawings. Symbols used to locate accessories on plans shall be identified by a legend.

E. Delivery, Handling and Storage:
   1. Materials to be delivered to site in original factory packaging, labeled with manufacturer's identification.

F. Certification and Testing: Not applicable.

G. Submittals:
   1. Direct contractor to provide shop drawings, product data and installation instructions for review and approval by Owner and/or Owner's Representative as required to assure project compliance.

H. Product Standards:
   1. All accessories which are in contact with hazardous/corrosive exhaust air shall be manufactured of stainless steel or of the appropriate corrosion resistant material.
   2. Combination Fire Smoke Dampers shall meet the requirements of NFPA 90A and NFPA 92A. Basis of Design: Ruskin, Model FSD 36, Class II.
      a. Damper actuator shall be provided with springs internal to actuator motor. Basis of Design: Barber Coleman Company, MA-405, 120 volt.
      b. Damper shall be provided with an optional switch package. Basis of Design: Ruskin, Model SP 100.
      c. Manufacturer shall provide factory assembled sleeve of 16 inch minimum

length. Sleeve shall be factory caulked and constructed of extra heavy galvanized steel.

3. Turning vanes shall be a single vane type with a 1 inch trailing edge and 2 inch vane radius on 1-1/2 inch spacing.

I. Installation Standards:
1. Install all ductwork accessories in accordance with manufacturer's instructions.
2. Combination Fire Smoke Dampers shall be installed in accordance with UBC, Section 713.10 and 713.11. Power and control for dampers shall originate from the same floor as the damper.

J. Application Standards:
1. Combination Fire Smoke Dampers shall be equipped with a remote mounted, position indicating light. Basis of Design: Select-A-Switch, Model SL53413-6-BG or equal. Indicating light is to be located in the closest adjacent corridor at a height of 7'-0" above the finished floor or on the ceiling. Light is to be "on" when the damper is closed.
2. Control of Combination Fire Smoke Dampers shall be from a control module and a relay operated by the Fire Alarm Control Panel. Dampers shall be operated by an individual fire floor or zone during an actual fire alarm. Damper shall be normally open with power on and close automatically with loss of power.
3. Combination Fire Smoke Dampers shall be Ruskin "Style G" when damper is to be flush mounted with a grille.
4. Provide balancing dampers where branch ducts are taken from the main duct and in all runouts to individual air devices. Do not provide balance dampers integral with air device.
5. Turning vanes shall be used in all mitered duct elbows.
6. Flexible duct connections shall be used when connections are made to fans and motorized equipment.
7. Duct access doors shall be provided where required for inspection and access for maintenance. Typical locations shall include coils, fans, automatic dampers, fire dampers and combination fire smoke dampers. Access doors to fire and combination fire smoke dampers shall not require tools of any kind to open. Locate access doors at other similar locations as required. Access doors shall be square and sized 2 inches less than the width of the duct, maximum door size to be 18 x 18 inches. If required, provide multiple doors for adequate access to equipment.

SECTION 15975 - DIRECT DIGITAL CONTROL SYSTEM

A. Description:
1. This Section covers the requirements associated with the design, application, construction and installation of Direct Digital Control (DDC) systems for HVAC and related systems.

B. References:
1. University of Iowa master specification Section 15975 - Direct Digital Control Systems.

C. General Requirements:
   1. During the design development phase, Designer is to consult with the University Engineer to determine the specific requirements associated with the project. Items to be determined shall include the potential to extend existing building systems, controls manufacturer to be used, method of communication, level of user interface and associated software required.
   2. Controls shall be designed in close coordination with the manufacturer to be used on the project.
   3. Control design package shall be included in its entirety within the contract specification and drawings, but shall be indicated as for reference only.
      a. Controls work will be contracted separately by the University directly with the Controls Contractor.

   4. Upon successful completion of the functional performance tests, the Controls Contractor shall provide the University with back-up disks of final accepted control programs.

D. Design Document Requirements:
   1. Project drawings shall include a controls schematic showing all systems and the associated control inputs and outputs and the associated system sequence of operation.
   2. All coordination and support work required by the general, mechanical and electrical contractors shall be clearly identified in the project documents.
   3. The University master specification, Section 15975 - Direct Digital Control System, is included in Section 3.3. This specification is to used on all University project and edited to meet the specific requirements of the project.

E. Delivery, Handling and Storage: Not applicable.

F. Certification and Testing:
   1. All control points shall be field tested, calibrated and operation verified prior to the system being placed on-line.

G. Submittals:
   1. Controls Contractor shall be required to submit manuals which include: controls point lists, control drawings/schematics, piping/wiring diagrams, I/O panel layouts and terminations, valve/damper schedules, data sheets of all control components and controls' Sequence of Operation.

H. Product Standards:
   1. DDC manufacturer shall be determined by the University Engineer along with Operations and Maintenance, considering the specific requirements of each project and existing controls systems within the building/service area.
   2. Temperature sensor shall be thermistor or RTD type. Basis of Design: HY-CAL Engineering, 1000 ohm sensor with integral, matched current transmitter. Other acceptable manufacturers are Honeywell, Johnson Controls, Barber-Coleman and Landis-Gyr Powers.

I. Installation Standards:
   1. Install DDC components in accordance with manufacturer's instructions. Locate in accessible locations providing for maintenance and inspection. Refer to

University of Iowa master specification, Section 15975 - Direct Digital Control System, for specific installation requirements.

2. When locating temperature sensor near doorways, it shall be specified to be within 15" of door jamb. Same height as light switch.

J. Application Standards:
1. HVAC control system to be 100% DDC, including local zone controls.
2. Provide temperature sensors downstream of all coils, including zone reheat coils.

SECTION 15990—TESTING, ADJUSTING AND BALANCING

A. Description:
1. This Section covers the requirements associated with the design and requirements associated with Testing, Adjusting and Balancing procedures for mechanical building systems.

B. References:
1. Associated Air Balance Council (AABC).
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

C. General Requirements:
1. Testing, Adjusting and Balancing (TAB) design package shall be included in its entirety within the contract specification and drawings but shall be indicated as for reference and coordination only. TAB work will be contracted separately by the University directly with the TAB Agency.
2. TAB shall be performed by a AABC certified company specializing in performing this type of work for a minimum of three years. Work to be performed under the direct supervision of an AABC certified Test and Balance Engineer. TAB shall be performed in accordance with AABC National Standards for Total System Balance, Field Measurement and Instrumentation.
3. TAB procedures shall not begin until system to be balanced in 100% complete. Conditions which prevent the system to be properly balanced are to be reported immediately to the Owner's Representative to allow corrective action to be taken prior to the completion of TAB procedures.
4. TAB Agency shall permanently mark the settings of all valves, dampers and other adjustment devices in a manner that will allow the settings to be identified and restored. Balancing devices provided with a memory stop are to be set and locked.

D. Design Document Requirements:
1. Clearly identify coordination efforts required between the contractor and TAB Agency.
2. Systems to be balanced shall be clearly identified with detailed instruction provided identifying specific requirements of the TAB procedures including: preparation activities prior to TAB, measurements to be taken, documentation requirements, acceptable tolerances and systems to be tested.
3. The University Master Specification Section 15990 - Testing, Adjusting and Balancing is included in Section 3.3 for reference.

E. Delivery, Handling and Storage: Not applicable.

F. Certification and Testing: Not applicable.

G. Submittals:
   1. Direct TAB Agency to provide detailed procedures, agenda and sample reports for review and approval by Owner and/or Owner's Representative prior to performing work.
   2. Submit draft copies of preliminary report with comments for review and approval by Owner and/or Owner's Representative prior to submitting final TAB report.
   3. Submit five copies of final approved TAB report. Reports to be letter sized complete with index page and indexing tabs.

H. Product Standards: Not applicable.

I. Installation Standards: Not applicable.

J. Application Standards: Not applicable.