15055
Motors

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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.
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.
A. Summary

This section contains design criteria for mechanical systems identification. See Section 13915 for fire suppression system 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.
Yale University Design Standards
Section 15075: Mechanical Identification

Table 1. Pipe Marker Color Coding

<table>
<thead>
<tr>
<th>Service</th>
<th>Legend</th>
<th>Background Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold water</td>
<td>Cold water</td>
<td>Green</td>
</tr>
<tr>
<td>Hot water</td>
<td>Domestic hot water</td>
<td>Yellow</td>
</tr>
<tr>
<td>Hot water return</td>
<td>Domestic hot water return</td>
<td>Yellow</td>
</tr>
<tr>
<td>Protected cold water</td>
<td>Protected cold water</td>
<td>Yellow</td>
</tr>
<tr>
<td>Protected hot water</td>
<td>Protected hot water</td>
<td>Yellow</td>
</tr>
<tr>
<td>Protected hot water return</td>
<td>Protected hot water return</td>
<td>Yellow</td>
</tr>
<tr>
<td>Non-potable water</td>
<td>Non-potable</td>
<td>Yellow</td>
</tr>
<tr>
<td>Compressed air</td>
<td>Compressed air</td>
<td>Green</td>
</tr>
<tr>
<td>Sanitary</td>
<td>Sanitary Sewer</td>
<td>Green</td>
</tr>
<tr>
<td>Vent</td>
<td>Vent</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rainwater</td>
<td>Storm Sewer</td>
<td>Green</td>
</tr>
<tr>
<td>Pump discharge</td>
<td>Pump discharge</td>
<td>Green</td>
</tr>
<tr>
<td>Pure water</td>
<td>Pure water</td>
<td>Green</td>
</tr>
<tr>
<td>Vacuum</td>
<td>Vacuum</td>
<td>Green</td>
</tr>
<tr>
<td>Central vacuum</td>
<td>Vacuum</td>
<td>Yellow</td>
</tr>
<tr>
<td>Lab waste</td>
<td>Lab waste</td>
<td>Yellow</td>
</tr>
<tr>
<td>Lab vent</td>
<td>Lab vent</td>
<td>Yellow</td>
</tr>
<tr>
<td>Gray water</td>
<td>Gray water</td>
<td>Green</td>
</tr>
<tr>
<td>Tempered water</td>
<td>Tempered water</td>
<td>Green</td>
</tr>
<tr>
<td>Tempered water return</td>
<td>Tempered water</td>
<td>Green</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Piping System (and Legend)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable Cold Water</td>
<td>Green, Blue, ______</td>
</tr>
<tr>
<td>Potable Hot Water</td>
<td>Green, Blue, ______</td>
</tr>
<tr>
<td>Non-Potable Cold Water</td>
<td>Yellow, Gray, ______</td>
</tr>
<tr>
<td>Non-Potable Hot Water</td>
<td>Yellow, Gray, ______</td>
</tr>
<tr>
<td>Storm Drain</td>
<td>Green, Blue, ______</td>
</tr>
<tr>
<td>RODI Water</td>
<td>Yellow, White, ______</td>
</tr>
<tr>
<td>Gray Water</td>
<td>Green, Blue ______</td>
</tr>
<tr>
<td>Tempered Water</td>
<td>Green, Blue ______</td>
</tr>
</tbody>
</table>

e. Plastic jackets include fitting and piping covers.

f. Insulate and finish the piping to be covered with plastic jackets, per this section, then apply the plastic jackets.

2. **Tags, Valves, Equipment, and Instruments**

   a. Upon completion of work, attach engraved laminated plastic tags to all valves and instrumentation. In every mechanical space, tags must be seen when hung with valve/riser charts.

   b. Equipment must bear stamped, stainless steel tags.

   c. Tags must be numbered consecutively with black characters on a white face. Tags for general valves must be prefixed with the letter P. Tags must bear the number used in the P&IDs for those items so marked. Numerals must be at least 3/8" high.

   d. Embossed or engraved aluminum or brass tags may be substituted for stainless steel or laminated tags, if desired.
Yale University Design Standards

Section 15075: Mechanical Identification

e. Tags must be at least 1” in diameter, at least 1/8” thick, and attached by S-hooks and chains.

3. HVAC Systems Identification

a. Stencil ductwork at each junction or branch takeoff, at least once in each room, and at intervals not longer than 20 feet. Stencils must clearly identify the duct service area (S for supply, R for return, X for exhaust) served by the branch, and must include an arrow indicating the direction of flow.

b. Provide color-coded pipe identification markers on piping installed per this section. Use snap-on, laminated, plastic pipe markers protected with a clear acrylic coating. Apply pipe markers after architectural painting where such painting is required.

c. Provide an arrow marker with each pipe content marker to indicate the direction of flow. If flow can be in either direction, use a double-headed arrow marker.

d. Label mains:
   - At points of entrance and exit from mechanical rooms
   - Adjacent to each valve
   - On each riser
   - At each tee fitting
   - At points of entrance and exit from building
   - At least once in each room
   - At intervals no longer than 20 ft

e. The size of legend letters on markers and the length of the color field must be per the latest edition of ANSI.

f. Use the color-coding in Table 3, with names in black letters on a white background and white letters on a green background.
Table 3. Pipe Marker Color Coding

<table>
<thead>
<tr>
<th>Service</th>
<th>Legend</th>
<th>Background Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled water supply</td>
<td>CHWS</td>
<td>Dk Blue</td>
</tr>
<tr>
<td>Chilled water return</td>
<td>CHWR</td>
<td>Lt Blue</td>
</tr>
<tr>
<td>Hot water supply</td>
<td>HWS</td>
<td>Yellow</td>
</tr>
<tr>
<td>Hot water return</td>
<td>HWR</td>
<td>Yellow</td>
</tr>
<tr>
<td>Cold water</td>
<td>Cold water supply</td>
<td>Green</td>
</tr>
<tr>
<td>Low pressure condensate return</td>
<td>LPR</td>
<td>Tan</td>
</tr>
<tr>
<td>Medium pressure condensate return</td>
<td>MPR</td>
<td>Tan</td>
</tr>
<tr>
<td>High pressure condensate return</td>
<td>HPR</td>
<td>Tan</td>
</tr>
<tr>
<td>High pressure steam</td>
<td>HPS</td>
<td>Orange</td>
</tr>
<tr>
<td>Low pressure steam</td>
<td>LPS</td>
<td>Orange</td>
</tr>
<tr>
<td>Medium pressure steam</td>
<td>MPS</td>
<td>Orange</td>
</tr>
<tr>
<td>Pumped condensate</td>
<td>PC</td>
<td>Tan</td>
</tr>
<tr>
<td>Steam</td>
<td>Steam</td>
<td>Orange</td>
</tr>
<tr>
<td>Glycol supply</td>
<td>GS</td>
<td>Yellow</td>
</tr>
<tr>
<td>Glycol return</td>
<td>GR</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

C. **Product Standards**

Color banding must meet the latest ANSI and OSHA requirements.

D. **Manufacturers**

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

E. **Materials**

Use Setmark markers by the Seton Name Plate Corporation, or approved equal.
F. Installation Guidelines

1. Mains shall be labeled at points of entrance and exit from mechanical room, adjacent to each valve, on each riser, at each tee fitting, at points of entrance and exit from building, at least once in each room, and at intervals no longer than 20'.

2. In general, use 2” high legends for 4” and larger diameter pipe lines, and 3/4” high legends for pipe lines 3” diameter and smaller pipe lines.

3. Use screws or rivets to securely attach nameplates, catalog numbers, and rating identifications to mechanical and electrical equipment. The use of adhesives or cements is not permitted.

4. Identify non-potable water outlets with permanently attached, yellow color-coding or 4” high triangle tags that read “Water unsafe.”

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

End of Section
15081
Duct Insulation

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A. Summary

This section contains duct insulation design criteria, including internal lining.

B. System Design and Performance Requirements

1. Kitchen Exhaust Ducts
   Insulated kitchen exhaust ducts per NFPA, local code, and Fire Department requirements.

2. Concealed Rectangular, Flat Oval, and Circular Ductwork
   Insulate supply and fresh air ducts and plena in concealed spaces and return ducts not in the ceiling plenum. Refer to the wrap requirements under Materials.

3. Exposed Rectangular Ductwork
   Insulate exposed supply, return, and fresh air ducts and exposed plena.

4. Exposed Round and Flat Oval Ductwork
   Insulate exposed supply and fresh air ducts and exposed plena located in mechanical and electrical rooms, storage rooms, unoccupied areas, unconditioned areas, and/or as indicated on plans.
5. **Internal Duct Insulation**

Sound traps in ductwork are required over internal duct insulation. Use internal duct insulation only with the prior approval of Yale University Facilities Group. Duct lining of the first 15 feet of ductwork leaving the air handler is **Not** acceptable.

C. **Manufacturers**

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

2. Subject to compliance with the design requirements, provide unicellular, elastomeric, foam rubber sheet insulation by one of the following manufacturers:
   - Armstrong (Armaflex)
   - Manville
   - Owens Corning
   - Halstead-Nomaco

3. Provide kitchen exhaust duct wrap by Thermal Ceramics (or other comparable manufacturer).

D. **Materials**

- Materials must meet Adhesive and Sealant Council Standards and SMACNA requirements.
- ASTM E-84 minimum fire hazard ratings must be 25 flame spread, 50 fuel contributed, and 50 smoke developed.
- Transmission rates of vapor barriers cannot exceed 0.02 perms.
1. **Concealed Rectangular, Flat Oval, and Circular Ductwork**
   Use at least 1-1/2” thick, fibrous glass duct wrap with a foil-kraft flame-resistant vapor barrier. Insulation density must be 3/4 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 valve of 6 with factory-applied fire retardant, foil-reinforced kraft vapor barrier facing. Insulation density must be 3 lb/cf. The maximum K-factor must be 0.23 at a mean temperature of 75°F.

3. **Exposed Round and Flat Oval Ductwork**
   Use 1-1/2” fibrous glass ductwrap with a foil-kraft flame-resistant vapor barrier. Insulation density must be 3/4 lb/cf. the maximum K-factor must be 0.30 at a mean temperature of 75°F.

4. **Outdoor Round or Rectangular Duct External Rubber Steel Insulation and Waterproofing**
   Use a 2” thickness of flexible unicellular elastomeric foam rubber sheet insulation with a maximum K-factor of 0.27

5. Any exposed ductwork subject to personnel traffic should be protected with an approved walking surface. Approval shall be on a case by case basis and Yale Facilities shall sign off.

E. **Installation Guidelines**
   - Install insulation, mastics, adhesives, coatings, covers, weather-protection, and other materials exactly as required by the manufacturer’s recommendations.
   - Apply insulation after systems have been tested, proven tight, and approved by Yale 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. Apply aluminum jacketing per E-4 specifications.
15083
Pipe Insulation

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A. Summary
This section contains design criteria for piping insulation and jacketing.

B. System Design and Performance Requirements
1. Verify with the Yale University Facilities group that information related to insulation and jacketing is the most recent.

2. Insulation must be fibrous glass insulation with a factory-applied, fire retardant, vapor barrier jacket and a K factor of at least 0.23 at a mean temperature of 75°F. ASTM E-84 fire hazard ratings must be 25 flame spread, 50 smoke developed and 50 fuel contributed.

3. Refer to Table 1 for Yale University pipe insulation thicknesses.

4. For 125-250 psi steam, use calcium silicate block with 11 lbs per cubic foot density with a maximum K factor of 0.42 at a mean temperature of 200°F. Insulation shall be securely wired in place with galvanized steel wire or galvanized steel bands on 12 inch centers. Calcium silicate pipe insulation shall have 1” galvanized wire netting and 1 coat of insulating and finishing cement trowelled to a smooth finish. Exposed pipe shall be finished by applying a pre-sized glass cloth over the insulating and finishing cement.
Table 1. Pipe Insulation Thicknesses for Yale University Insulations

<table>
<thead>
<tr>
<th>Hrs. of Operation &amp; Bldg. Types</th>
<th>10 psi</th>
<th>Steam 30-125 psi</th>
<th>125-250 psi</th>
<th>Condensate</th>
<th>Chilled Water</th>
<th>Domestic Hot Water</th>
<th>Hot Water Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>8700 hrs./yr. Distr. systems &amp; lab bldgs.</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>1.5”</td>
<td>4”</td>
<td>1”</td>
<td>1.5”</td>
</tr>
<tr>
<td>4000 hrs./yr. Non-lab bldgs.</td>
<td>1”</td>
<td>3”</td>
<td>4”</td>
<td>1”</td>
<td>2”</td>
<td>1”</td>
<td>1.5”</td>
</tr>
</tbody>
</table>

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. For 30 psi steam and above, provide removable insulating jacketing for steam traps, PRV stations, valve bonnets and strainers.

C. Manufacturers

Subject to compliance with the design requirements, provide products by one of the following manufacturers:

1. Insulation
   - Owens
   - Corning
   - Certain-Teed
   - Manville
   - Knauf
2. **Insulation Jacketing**

   Subject to compliance with the design requirements, provide products by one of the following manufacturers:
   
   - Advanced Thermal Corporation, represented by:
     Powers & Process, Inc., 1168 Farmington Avenue, Kensington, CT 06037
   - D&N Insulation Company, 88 Farwell Street, West Haven, CT 06516
   - Shannon Enterprises of WNY, Inc., represented by:
     Components & Controls, Inc., 256 Oakwood Drive, Glastonbury, CT 06033

D. **Materials**

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

E. **Installation Guidelines**

   Install pipe insulation as required by the manufacturer.

End of Section