BSR/ASHRAE/IES Addendum aq
to ANSI/ASHRAE/IES Standard 90.1-2019

Public Review Draft

Proposed Addendum aq to
Standard 90.1-2019, Energy Standard
for Buildings Except Low-Rise Residential Buildings

First Public Review (August 2021)
(Draft Shows Proposed Changes to Current Standard)

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FOREWORD

The piping insulation thickness requirements in Table 6.8.3-1 were developed primarily for space heating. This addendum creates new tables for service water heating piping insulation in Section 7.4. The proposed changes are based on typical Service Water Heating (SWH) operation and operating temperatures.

There is also a reorganization of Section 6.8.3 - Piping Insulation Tables. Two items that were in the footnotes have been moved to the body of the standard to make them easier to read. The first is the equation for calculating the minimum required insulation thickness when the insulation’s thermal conductivity is outside the range in the table. The second is the language that allows designers to calculate an alternative minimum thickness for non-steel pipe that is thicker than schedule 80. This reorganization does not change the requirements of the standard.

Cost Justification

The values reflect 2021 utility rates, fiberglass pipe insulation cost from 2020 RS Means data and scalar compliance based on a service water heating pipe insulation lifetime of 30 years.

Addendum aq to 90.1-2019

Modify the standard as follows (IP and SI Units)

6.8.3 Piping Insulation Tables

Hot water heating, steam heating, and steam condensate piping shall be insulated to the minimum thickness required in the tables of this section and shall either utilize insulation within the thermal conductivity ranges in the table, or when the insulation thermal conductivity is not within the range in the table, the following equation shall be used to calculate the minimum insulation thickness:

\[ t_{alt} = r \cdot \left( \frac{1}{r} + \frac{t_{table}}{r} \right) \frac{k_{alt}}{k_{upper}} - 1 \]

Where:
- \( t_{alt} \) = minimum insulation thickness of the alternate material (in.) (mm)
- \( r \) = actual outside radius of pipe (in.) (mm)
- \( t_{table} \) = insulation thickness listed in this table for applicable fluid temperature and pipe size
- \( k_{alt} \) = thermal conductivity of the alternate material at mean rating temperature indicated for the
applicable fluid temperature $[\text{Btu} \cdot \text{in} / \text{h} \cdot \text{ft}^2 \cdot \circ \text{F}] [\text{W} (\text{m} \cdot \circ \text{C})]$ 

$k_{\text{upper}}$ = the upper value of the thermal conductivity range listed in this table for the applicable fluid temperature $[\text{Btu} \cdot \text{in} / \text{h} \cdot \text{ft}^2 \cdot \circ \text{F}] [\text{W} (\text{m} \cdot \circ \text{C})]$

**Exception to 6.8.3**

For nonmetallic piping thicker than Schedule 80 and having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot (meter) than a steel pipe of the same size with the insulation thickness shown in the tables.

Table 6.8.3-1 Minimum Piping Insulation Thickness for Heating and Hot Water Systems$^{a,b,c,d,e}$ (Steam, Steam Condensate, and Hot-Water Heating and Domestic Water Systems)

<table>
<thead>
<tr>
<th>Fluid Operating Temperature Range (°F) and Usage</th>
<th>Insulation Thermal Conductivity, Mean Rating Temperature, °F</th>
<th>Insulation Thickness, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5]&lt;1</td>
<td>1 to &lt;1-1/2</td>
<td>1-1/2 to &lt;4</td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 to 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 to 350</td>
<td>0.29 to 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 to 250</td>
<td>0.27 to 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 to 200</td>
<td>0.25 to 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 to 140</td>
<td>0.22 to 0.28</td>
<td>100</td>
</tr>
</tbody>
</table>

(For Service Water Heating Systems: See Table 7.4)

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r \left[(1 + t/r)K/k - 1\right]$, where $T =$ minimum insulation thickness (in.), $r =$ actual outside radius of pipe (in.), $t =$ insulation thickness listed in this table for applicable fluid temperature and pipe size, $K =$ thermal conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature ($[\text{Btu} \cdot \text{in} / \text{h} \cdot \text{ft}^2 \cdot \circ \text{F}]$); and $k =$ the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c. For piping smaller than 1.5 in. and located in partitions within conditioned spaces, reduction of these thicknesses by 1 in. shall be permitted (before thickness adjustment required in the equation in Section 6.8.3 footnote[a]) but not to thicknesses below 1 in.

d. For direct-buried heating and hot-water system piping, reduction of these thicknesses by 1.5 in. shall be permitted (before thickness adjustment required in footnote[a]the equation in Section 6.8.3) but not to thicknesses below 1 in.

e. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

d. Piping that also serves service water heating systems shall comply with Section 7.4.
Table 6.8.3-2 Minimum Piping Insulation Thickness Cooling Systems (Chilled Water, Brine, and Refrigerant)\textsuperscript{a,b,c,d}

<table>
<thead>
<tr>
<th>Temperature Range (°F) and Usage</th>
<th>Insulation Thermal Conductivity Mean Rating Temperature, °F</th>
<th>0.21 to 0.27</th>
<th>0.20 to 0.26</th>
<th>&lt;40</th>
<th>40 to 60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal Pipe or Tube Size, in.</td>
<td>4 to &lt;8</td>
<td>≥8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;1</td>
<td>1 to &lt;1/2</td>
<td>1-1/2 to &lt;4</td>
<td>4 to &lt;8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insulation Thickness, in.</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a} For insulation outside the stated conductivity range, the minimum thickness ($T$) shall be determined as follows: $T = r[(1 + t/r)K/k - 1]$, where $T$ = minimum insulation thickness (in.), $r$ = actual outside radius of pipe (in.), $t$ = insulation thickness listed in this table for applicable fluid temperature and pipe size, $K$ = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F]; and $k$ = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

\textsuperscript{b} These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

\textsuperscript{c} For direct-buried cooling system piping, insulation is not required.

\textsuperscript{d} The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

Make the following changes to Section 7.4.3 (I-P and SI):

### 7.4.3 Service Hot-Water Heating System Piping Insulation

The following Service water heating system piping shall be insulated to levels surrounded by uncompressed insulation of the thickness shown in Section 6, Table 6.8.1-3 Table 7.4. When the insulation thermal conductivity is not within the range in the table, the following equation shall be used to calculate the minimum insulation thickness:

$$t_{\text{alt}} = r \left[ \frac{(1 + t_{\text{table}}/r)}{k_{\text{alt}}/k_{\text{upper}} - 1} \right]$$

Where:

- $t_{\text{alt}}$ = minimum insulation thickness of the alternate material (in.) (mm)
- $r$ = actual outside radius of pipe (in.) (mm)
- $t_{\text{table}}$ = insulation thickness listed in this table for applicable fluid temperature and pipe size
- $k_{\text{alt}}$ = thermal conductivity of the alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F] [W (m·°C)]
- $k_{\text{upper}}$ = the upper value of the thermal conductivity range listed in this table for the applicable fluid temperature [Btu·in/h·ft²·°F] [W (m·°C)]

For nonmetallic piping thicker than Schedule 80 and having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided.
showing that the pipe with the proposed insulation has no more heat transfer per foot (meter) than a steel pipe of the same size with the insulation thickness shown in the table.

7.4.3.1 The following piping shall be insulated per the requirements of this section:

a. Recirculating system piping, including the supply and return piping of a circulating tank type water heater.

b. The first 8 ft (2.4m) of outlet piping for from: a constant-temperature nonrecirculating storage system.
   1. storage water heaters
   2. hot water storage tanks
   3. any water heater and hot water supply boiler containing 10 or more gallons of water heated by a direct heat source, an indirect heat source, or both a direct heat source and an indirect heat source.

c. The first 8 ft (2.4m) of branch piping connecting to recirculated, heat-traced heat traced, or impedance heated piping.

d. The make-up water inlet piping between heat traps (see 7.4.6 Heat Traps) and the storage water heaters and the storage tanks they are serving, and a heat trap in a nonrecirculating nonrecirculating service water heating storage system.

e. Hot water piping between multiple water heaters, between multiple hot water storage tanks, and between water heaters and hot water storage tanks.

e-f. Piping that is externally heated (such as heat trace or impedance heating).

Exceptions to 7.4.3.1

1. Factory-installed piping within water heaters and hot water storage tanks tested and rated in accordance with Section 6.4.1.

2. Piping that conveys hot water that has not been heated through the use of fossil fuels or electricity.

3. For piping 1 in. (25 mm) or less, insulation is not required for valves or strainers.

4. Piping in existing buildings where alterations are made to existing service water heating systems where there is insufficient space or access to meet the requirements.
Modify the standard as follows (I-P Units)

Table 7.4 Minimum Piping Insulation Thickness for Service Water Heating Systems\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Service Hot-Water Temperature Range</th>
<th>Insulation Thermal Conductivity</th>
<th>Nominal Pipe or Tube Size, in.</th>
<th>&lt;1</th>
<th>1 to &lt;1-1/2</th>
<th>1-1/2 to &lt;4</th>
<th>4 to &lt;8</th>
<th>≥8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Water Heating System Piping Not Located in Partitions Within Conditioned Spaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105°F to 140°F</td>
<td>0.22 to 0.28</td>
<td>100</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>&gt;140°F to 200°F</td>
<td>0.25 to 0.29</td>
<td>125</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>&gt;200°F</td>
<td>0.27 to 0.30</td>
<td>150</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

| Service Water Heating System Piping Located in Partitions Within Conditioned Spaces | | | | | | | |
| 105°F to 140°F                     | 0.22 to 0.28                  | 100                            | 1.0 | 1.0         | 1.5         | 1.5    | 1.5 |
| >140°F to 200°F                    | 0.25 to 0.29                  | 125                            | 1.0 | 1.0         | 2.0         | 2.0    | 2.0 |
| >200°F                             | 0.27 to 0.30                  | 150                            | 1.5 | 1.5         | 2.5         | 3.0    | 3.0 |

\textsuperscript{a} These thicknesses are based on energy efficiency considerations only. Additional insulation may be necessary for safety.

\textsuperscript{b} For direct-buried service water heating system piping, reduction of these thicknesses by 1.5 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses less than 1 in.

Modify the standard as follows (SI Units):

Table 7.4 Minimum Piping Insulation Thickness for Service Water Heating Systems\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Service Hot-Water Temperature Range</th>
<th>Insulation Thermal Conductivity</th>
<th>Nominal Pipe or Tube Size, mm</th>
<th>&lt;25</th>
<th>25 to &lt;40</th>
<th>40 to &lt;100</th>
<th>100 to &lt;200</th>
<th>≥200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Water Heating System Piping Not Located in Partitions Within Conditioned Spaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41°C to 60°C</td>
<td>0.032 to 0.040</td>
<td>38</td>
<td>25</td>
<td>25</td>
<td>40</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>&gt;60°C to 121°C</td>
<td>0.036 to 0.042</td>
<td>52</td>
<td>40</td>
<td>40</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>&gt;121°C</td>
<td>0.039 to 0.043</td>
<td>66</td>
<td>65</td>
<td>65</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

| Service Water Heating System Piping Located in Partitions Within Conditioned Spaces | | | | | | | |
| 41°C to 60°C                       | 0.032 to 0.040                | 38                             | 25  | 25        | 40         | 40          | 40   |
| >60°C to 121°C                     | 0.036 to 0.042                | 52                             | 25  | 25        | 50         | 50          | 50   |
| >121°C                             | 0.039 to 0.043                | 66                             | 40  | 40        | 65         | 75          | 75   |

\textsuperscript{a} These thicknesses are based on energy efficiency considerations only. Additional insulation may be necessary for safety.

\textsuperscript{b} For direct-buried service water heating system piping, reduction of these thicknesses by 35 mm shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses less than 25 mm.