ADDENDA

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

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by ASHRAE and the American National Standards Institute on July 29, 2022, and by the Illuminating Engineering Society on July 26, 2022.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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FOREWORD

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

Section 6.8.3, "Piping Insulation Tables," has been reorganized. Two footnote items were 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 nonsteel pipe that is thicker than schedule 80. This reorganization does not change the requirements of the standard.

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.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum aq to Standard 90.1-2019

Modify Section 6.8.3 and Tables 6.8.3-1 and 6.8.3-2 as shown (I-P and SI).

6.8.3 Piping Insulation Tables. Hot-water heating, steam heating, and steam condensate *piping* shall be insulated to the minimum thickness required in Tables 6.8.3.-1 and 6.8.3-2 and shall either utilize insulation within the *thermal conductivity* ranges in the tables, or, when the insulation *thermal conductivity* is not within the range in the tables, the following equation shall be used to calculate the minimum insulation thickness:

$$t_{alt} = r[(1 + t_{table}/r) \times k_{alt}/k_{upper} - 1]$$

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 Table 6.8.3-1 or Table 6.8.3-2 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, Btu·in/h·ft^2·°F (W/[m·°C])

k_{upper} = upper value of the *thermal conductivity* range listed in this table for the applicable fluid temperature, Btu·in/h·ft^2·°F] (W/[m·°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 (metre) than a steel pipe of the same size with the insulation thickness shown in the tables.

Modify Tables 6.8.3-1 and 6.8.3-2 as shown (I-P).

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*~~)

Fluid Operating Temperature Range, °F, and Usage	Insulation *Thermal Conductivity* ~~Conductivity~~		Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft^2·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
>350	0.32 to 0.34	250	4.5	5.0	5.0	5.0	5.0
251 to 350	0.29 to 0.32	200	3.0	4.0	4.5	4.5	4.5
201 to 250	0.27 to 0.30	150	2.5	2.5	2.5	3.0	3.0
141 to 200	0.25 to 0.29	125	1.5	1.5	2.0	2.0	2.0
105 to 140	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5

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: $T = r\{(1 + t/r)^{K/k} - 1\}$, 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·ft^2·°F), and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.~~

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

b~~e~~. 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 footnote [a]) but not to thicknesses below 1 in.

c~~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]) but not to thicknesses below 1.5 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)[a,b,~~c,d~~]

Fluid Operating Temperature Range, °F, and Usage	Insulation *Thermal Conductivity* ~~Conductivity~~		Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft^2·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
40 to 60	0.21 to 0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20 to 0.26	50	0.5	1.0	1.0	1.0	1.5

~~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.~~

a~~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.

b~~e~~. For direct-buried cooling *system piping*, insulation is not required.

~~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.~~

Modify Tables 6.8.3-1 and 6.8.3-2 as shown (SI).

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*~~)

Fluid Operating Temperature Range, °C, and Usage	Insulation *Thermal Conductivity* ~~Conductivity~~		Nominal Pipe or Tube Size, mm				
	Conductivity, W/(m·°C)	Mean Rating Temperature, °C	<25	25 to <40	40 to <100	100 to <200	≥200
			Insulation Thickness, mm				
>177	0.046 to 0.049	121	115	125	125	125	125
122 to 177	0.042 to 0.046	93	80	100	115	115	115
94 to 121	0.039 to 0.043	66	65	65	80	80	80
61 to 93	0.036 to 0.042	52	40	40	50	50	50
41 to 60	0.032 to 0.040	38	25	25	40	40	40

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: $T = r\{(1 + t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (mm), r = actual outside radius of pipe (mm), 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 (W/[m·°C]), and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.~~

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

b~~e~~. For *piping* smaller than 40 mm and located in partitions within *conditioned spaces*, reduction of these thicknesses by 25 mm shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 25 mm.

c~~d~~. For direct-buried heating and hot-water *system piping*, reduction of these thicknesses by 40 mm shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 25 mm.

~~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 metre 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)[a,b,~~c,d~~]

Fluid Operating Temperature Range, °C, and Usage	Insulation *Thermal Conductivity* ~~Conductivity~~		Nominal Pipe or Tube Size, mm				
	Conductivity, W/(m·°C)	Mean Rating Temperature, °C	<25	25 to <40	40 to <100	100 to <200	≥200
			Insulation Thickness, mm				
4 to 16	0.030 to 0.039	24	13	13	25	25	25
<4	0.029 to 0.037	10	13	25	25	25	40

~~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 (mm), r = actual outside radius of pipe (mm), 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 (W/[m°C]), and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.~~

a~~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.

b~~e~~. For direct-buried cooling *system piping*, insulation is not required.

~~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.~~

Modify Section 7.4.3 as shown (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:

$$t_{alt} = r[(1 + t_{table}/r) \times k_{alt}/k_{upper} - 1]$$

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 Table 7.4 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, Btu·in/h·ft^2·°F (W/[m·°C])

k_{upper} = upper value of the *thermal conductivity* range listed in this table for the applicable fluid temperature, Btu·in/h·ft^2·°F] (W/[m·°C])

Exception to 7.4.3: 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 (metre) 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 ~~to levels shown in Section 6, Table 6.8.1-3~~ 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 (2.4 m) of outlet *piping* ~~for~~ from ~~a constant-temperature nonrecirculating storage *system*~~.

   1. storage *water heaters*,
   2. hot-water storage tanks, and
   3. any *water heater* and hot-water supply *boiler* containing 10 gal (38 L) or more 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 Section 7.4.6) 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).

Exceptionsto 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.
5. Insulation is not required at the point where *piping* passes through a framing member if it requires increasing the size of the framing member.
6. Insulation is not required on *piping* at the point where a vertical support of the *piping* is installed.

Add new Table 7.4 as shown (I-P).

Table 7-4 Minimum *Piping* Insulation Thickness for *Service Water Heating Systems*[a,b]

Service Hot-Water Temperature Range	Insulation *Thermal Conductivity*		Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft^2·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
Service Water Heating System Piping not Located in Partitions within *Conditioned Spaces*							
105°F to 140°F	0.22 to 0.28	100	1.0	1.0	1.5	2.0	2.0
>140°F to 200°F	0.25 to 0.29	125	1.5	1.5	2.5	2.5	2.5
>200°F	0.27 to 0.30	150	2.5	2.5	3.0	3.0	3.0
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

a. These thicknesses are based on *energy efficiency* considerations only. Additional insulation may be necessary for safety.
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 Section 7.4.3 but not to thicknesses less than 1 in.).

Add new Table 7.4 as shown (SI).

Table 7-4 Minimum *Piping* Insulation Thickness for *Service Water Heating Systems*[a,b]

Service Hot-Water Temperature Range	Insulation *Thermal Conductivity*		Nominal Pipe or Tube Size, mm				
	Conductivity, W/(m·°C)	Mean Rating Temperature, °C	<25	25 to <40	40 to <100	100 to <200	≥200
			Insulation Thickness, mm				
Service Water Heating System Piping not Located in Partitions within *Conditioned Spaces*							
41°C to 60°C	0.032 to 0.040	38	25	25	40	50	50
>60°C to 121°C	0.036 to 0.042	52	40	40	65	65	65
>121°C	0.039 to 0.043	66	65	65	75	75	75
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

a. These thicknesses are based on *energy efficiency* considerations only. Additional insulation may be necessary for safety.
b. For direct-buried *service water heating system piping*, reduction of these thicknesses by 35 mm shall be permitted (before thickness adjustment required in Section 7.4.3 but not to thicknesses less than 25 mm).

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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