THERMAL DESIGN

Pipe Heat Loss Calculations

Note: All thermal and electrical design information provided here is based upon a "standard" installation; i.e., with heating cable installed on insulated pipes. For any other method of installation, consult your nVent representative for design assistance.

Note: Heat loss calculation is based on a nonflowing pipe.

To select the proper heating cable you must first calculate the pipe heat loss, as outlined in the following four steps:

1. Gather the necessary information.
   - T_M: Maintain temperature
   - T_A: Minimum expected ambient temperature
   - Pipe or tubing size and material
   - Thermal insulation type and thickness
2. Calculate the temperature differential between the pipe maintain temperature and the minimum ambient temperature.
3. Calculate the pipe heat loss.
4. Adjust the heat loss to compensate for specific insulation type.

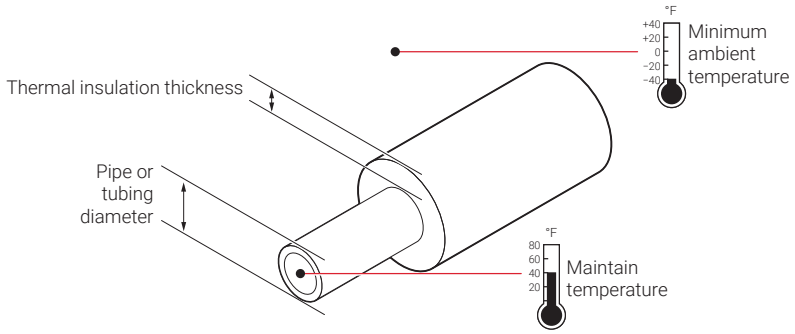

Fig. 4 Pipe heat loss

Thermal Design
1. Gather information
2. Calculate temperature differential
3. Calculate heat loss
4. Compensate for insulation type

Step 1 Gather the necessary information

To select the heating cable, gather and record the following information:

- T_M: Maintain temperature _____
- T_A: Minimum expected ambient temperature _____
- Pipe or tubing size and material _____
- Thermal insulation type and thickness _____

Example: Gather information

Maintain temperature	Water freeze protection at 40°F
Minimum ambient temperature	–40°F
Pipe size and material	6-inch diameter, steel
Insulation thickness and type	2-1/2 inch, calcium silicate

Thermal Design
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Step 2 Calculate temperature differential ΔT

To calculate the temperature differential (ΔT), use the formula below:

Formula ΔT $T_M - T_A$

Example: Calculate temperature differential

Input T_M 40°F (from Step 1)

Input T_A −40°F (from Step 1)

Calculation ΔT = 40°F – (−40°F) = 80°F

ΔT = 80°F

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Step 3 Calculate the pipe heat loss

From "Table 1" match the pipe size and insulation thickness with the temperature differential, ΔT, to find the base heat loss of the pipe (Q_B).

Example: Calculate pipe heat loss

Input Pipe size = 6 inch (from Step 1)

Input Insulation thickness = 2-1/2 inch (from Step 1)

Input ΔT = 80°F (from Step 2)

Input Pipe heat loss = 3.6 W/ft (from "Table 1")

From "Table 1", Q_B must be calculated through interpolation. For this example, 80°F is 3/5 of the difference between the ΔT of 50°F and the ΔT of 100°F:

Q_B = 3.6 W/ft + [3/5 x (7.4 – 3.6)] (7.4 is the ΔT of 100°F; 3.6 is the ΔT of 50°F)

Calculation Q_B = 3.6 + 2.3 = 5.9 W/ft

Pipe heat loss Q_B= 5.9 W/ft @ 40°F

Thermal Design
1. Gather information
2. Calculate temperature differential
3. Calculate heat loss
4. Compensate for insulation type

Step 4 Compensate for insulation type

Multiply the base heat loss of the pipe (Q_B) from Step 3 by the insulation compensation factor (f) from "Table 2" to get the total heat loss per foot of pipe (Q_T).

Formula $Q_T = Q_B$ x f

Example: Insulation type compensation

Input Insulation type = calcium silicate (from Step 1)

Input f = 1.50 for calcium silicate (from "Table 2")

Input Q_B = 5.9 W/ft (from Step 3)

Calculation Q_T = 5.9 W/ft x 1.50 = 8.85 W/ft

Q_T = 8.85 W/ft at 40°F

Now proceed to the Heating Cable Selection section, page 10, to determine the heating cable that will compensate for this heat loss.

Note: Heat loss calculations are based on IEEE Standards.

TABLE 1 PIPE HEAT LOSS (W/FT)

			Pipe diameter (IPS) in inches							
			1/4	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
	(ΔT)		Tubing size (inches)							
Insulation thickness	°F	°C		3/4	1	1-1/4	1-1/2	2		
0.5"	50	28	1.9	2.5	2.9	3.5	4.1	4.6	5.5	6.5
	100	56	3.9	5.2	6.1	7.2	8.6	9.6	11.5	13.5
	150	84	6.1	8.1	9.5	11.2	13.4	14.9	17.9	21.1
	200	111	8.5	11.3	13.2	15.6	18.6	20.7	24.9	29.2
1.0"	50	28	1.3	1.6	1.9	2.2	2.5	2.8	3.2	3.8
	100	56	2.7	3.4	3.9	4.5	5.2	5.8	6.8	7.8
	150	84	4.2	5.3	6.1	7.0	8.2	9.0	10.6	12.2
	200	111	5.8	7.4	8.4	9.7	11.3	12.4	14.6	16.9
	250	139	7.6	9.7	11.0	12.7	14.8	16.3	19.1	22.1
1.5"	50	28	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.8
	100	56	2.2	2.8	3.1	3.5	4.0	4.4	5.1	5.8
	150	84	3.5	4.3	4.8	5.5	6.3	6.9	8.0	9.1
	200	111	4.8	5.9	6.7	7.6	8.7	9.5	11.0	12.6
	250	139	6.3	7.8	8.7	9.9	11.4	12.4	14.4	16.5
	300	167	7.9	9.7	11.0	12.4	14.3	15.6	18.1	20.6
	350	194	9.6	11.9	13.3	15.1	17.4	19.0	22.0	25.1
2.0"	50	28	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.3
	100	56	2.0	2.4	2.7	3.0	3.4	3.7	4.2	4.8
	150	84	3.1	3.7	4.2	4.7	5.3	5.8	6.6	7.5
	200	111	4.3	5.2	5.8	6.5	7.4	8.0	9.2	10.4
	250	139	5.6	6.8	7.5	8.5	9.6	10.4	12.0	13.5
	300	167	7.0	8.5	9.4	10.6	12.1	13.1	15.0	17.0
	350	194	8.5	10.3	11.5	12.9	14.7	15.9	18.2	20.6
2.5"	50	28	0.9	1.0	1.2	1.3	1.4	1.6	1.8	2.0
	100	56	1.8	2.2	2.4	2.7	3.0	3.3	3.7	4.2
	150	84	2.8	3.4	3.7	4.2	4.7	5.1	5.8	6.5
	200	111	3.9	4.7	5.2	5.8	6.5	7.0	8.0	9.0
	250	139	5.1	6.1	6.8	7.6	8.5	9.2	10.5	11.7
	300	167	6.4	7.7	8.5	9.5	10.7	11.5	13.1	14.7
	350	194	7.8	9.3	10.3	11.5	13.0	14.0	15.9	17.9
3.0"	50	28	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1.8
	100	56	1.7	2.0	2.2	2.4	2.7	2.9	3.3	3.7
	150	84	2.6	3.1	3.4	3.8	4.3	4.6	5.2	5.8
	200	111	3.6	4.3	4.8	5.3	5.9	6.4	7.2	8.0
	250	139	4.8	5.7	6.2	6.9	7.8	8.3	9.4	10.5
	300	167	6.0	7.1	7.8	8.7	9.7	10.4	11.8	13.2
	350	194	7.3	8.6	9.5	10.5	11.8	12.7	14.3	16.0
4.0"	50	28	0.7	0.9	0.9	1.0	1.1	1.2	1.4	1.5
	100	56	1.5	1.8	2.0	2.1	2.4	2.5	2.9	3.2
	150	84	2.4	2.8	3.0	3.4	3.7	4.0	4.4	4.9
	200	111	3.3	3.9	4.2	4.6	5.2	5.5	6.2	6.8
	250	139	4.3	5.1	5.5	6.1	6.7	7.2	8.1	8.9
	300	167	5.4	6.3	6.9	7.6	8.5	9.0	10.1	11.2
	350	194	6.6	7.7	8.4	9.3	10.3	11.0	12.3	13.6

Note: Pipe heat loss (Q_B) is shown in watts per foot. Heat loss calculations are based on IEEE Standards with the following provisions:

- Pipes insulated with glass fiber in accordance with ASTM C547
- Pipes located outdoors in a 20-mph wind
- No insulating air space assumed between pipe and insulation
- No insulating air space assumed between the insulation and outer cladding
- Includes a 10% safety factor

TABLE 1 PIPE HEAT LOSS (W/FT)

Pipe diameter (IPS) in inches											
3	3-1/2	4	6	8	10	12	14	16	18	20	24
7.7	8.6	9.6	13.6	17.4	21.4	25.2	27.5	31.3	35.0	38.8	46.2
16.0	18.0	20.0	28.4	36.3	44.6	52.5	57.4	65.2	73.0	80.8	96.3
25.0	28.1	31.2	44.3	56.6	69.6	81.9	89.5	101.7	113.8	126.0	150.2
34.6	39.0	43.3	61.5	78.5	96.6	113.6	124.2	141.1	158.0	174.8	208.5
4.4	4.9	5.4	7.5	9.4	11.5	13.5	14.7	16.6	18.6	20.5	24.4
9.1	10.2	11.2	15.6	19.7	24.0	28.1	30.6	34.7	38.7	42.8	50.9
14.2	15.9	17.5	24.3	30.7	37.4	43.8	47.8	54.1	60.4	66.7	79.4
19.7	22.0	24.2	33.7	42.5	51.9	60.7	66.2	75.0	83.8	92.5	110.0
25.8	28.7	31.7	44.0	55.6	67.9	79.4	86.6	98.1	109.6	121.0	143.9
3.2	3.6	3.9	5.3	6.7	8.1	9.4	10.2	11.5	12.9	14.2	16.8
6.7	7.4	8.1	11.1	13.9	16.8	19.6	21.3	24.0	26.8	29.5	35.0
10.5	11.6	12.7	17.3	21.6	26.2	30.5	33.2	37.5	41.8	46.1	54.6
14.5	16.1	17.6	24.0	30.0	36.3	42.3	46.0	52.0	57.9	63.8	75.7
19.0	21.0	23.0	31.4	39.2	47.5	55.3	60.2	68.0	75.7	83.5	99.0
23.8	26.3	28.8	39.3	49.2	59.6	69.3	75.4	85.1	94.9	104.6	124.0
28.9	32.0	35.0	47.8	59.8	72.4	84.3	91.7	103.5	115.4	127.2	150.8
2.6	2.9	3.1	4.2	5.2	6.3	7.3	7.9	8.9	9.9	10.9	12.9
5.5	6.0	6.6	8.8	10.9	13.1	15.2	16.5	18.6	20.7	22.8	26.9
8.5	9.4	10.2	13.8	17.0	20.5	23.8	25.8	29.0	32.3	35.5	42.0
11.8	13.0	14.2	19.1	23.6	28.4	32.9	35.7	40.2	44.7	49.2	58.2
15.5	17.0	18.5	24.9	30.9	37.2	43.1	46.7	52.6	58.5	64.3	76.1
19.4	21.3	23.2	31.2	38.7	46.6	54.0	58.6	65.9	73.3	80.6	95.3
23.6	25.9	28.3	38.0	47.1	56.6	65.6	71.2	80.2	89.1	98.1	115.9
2.3	2.5	2.7	3.6	4.4	5.2	6.1	6.6	7.4	8.2	9.0	10.6
4.7	5.2	5.6	7.4	9.1	10.9	12.6	13.7	15.3	17.0	18.7	22.0
7.4	8.1	8.7	11.6	14.2	17.0	19.7	21.3	23.9	26.5	29.1	34.3
10.2	11.2	12.1	16.1	19.7	23.6	27.2	29.5	33.1	36.7	40.3	47.5
13.3	14.6	15.8	21.0	25.8	30.9	35.6	38.6	43.3	48.0	52.8	62.2
16.7	18.3	19.8	26.3	32.3	38.7	44.6	48.4	54.3	60.2	66.1	77.9
20.3	22.2	24.1	32.0	39.3	47.1	54.3	58.8	66.0	73.2	80.4	94.7
2.0	2.2	2.4	3.1	3.8	4.5	5.2	5.6	6.3	7.0	7.6	9.0
4.2	4.6	4.9	6.5	7.9	9.4	10.8	11.7	13.1	14.5	15.9	18.7
6.6	7.1	7.7	10.1	12.4	14.7	16.9	18.3	20.5	22.6	24.8	29.2
9.1	9.9	10.7	14.0	17.1	20.4	23.4	25.3	28.3	31.4	34.4	40.4
11.9	12.9	14.0	18.3	22.4	26.6	30.6	33.1	37.1	41.0	45.0	52.8
14.9	16.2	17.5	23.0	28.1	33.4	38.4	41.5	46.5	51.4	56.3	66.2
18.1	19.7	21.3	28.0	34.1	40.6	46.7	50.5	56.5	62.5	68.5	80.5
1.7	1.8	2.0	2.5	3.1	3.6	4.1	4.4	5.0	5.5	6.0	7.0
3.5	3.8	4.1	5.3	6.4	7.5	8.6	9.3	10.3	11.4	12.4	14.5
5.5	6.0	6.4	8.3	10.0	11.8	13.4	14.5	16.1	17.8	19.4	22.7
7.6	8.3	8.9	11.4	13.8	16.3	18.6	20.0	22.3	24.6	26.9	31.4
10.0	10.8	11.6	15.0	18.1	21.3	24.3	26.2	29.2	32.2	35.2	41.1
12.5	13.5	14.6	18.8	22.6	26.7	30.5	32.8	36.6	40.3	44.1	51.5
15.2	16.5	17.7	22.8	27.5	32.4	37.1	39.9	44.5	49.0	53.6	62.6

TABLE 2 INSULATION FACTORS

Preformed pipe insulation	Insulation factor (f)	k factor at 50°F (10°C) (BTU/hr–°F–ft^2/in)
Glass fiber (ASTM C547)	1.00	0.25
Calcium silicate (ASTM C533)	1.50	0.37
Cellular glass (ASTM C552)	1.60	0.40
Rigid cellular urethane (ASTM C591)	0.64	0.16
Foamed elastomer (ASTM C534)	1.16	0.29
Mineral fiber blanket (ASTM C553)	1.20	0.30
Expanded perlite (ASTM C610)	1.90	0.48