

Raychem SELF-REGULATING CABLES



This step-by-step design guide provides the tools necessary to design a self-regulating heat-tracing system for insulated pipes and tubing. For other applications or for design assistance, contact your Pentair Thermal Management representative or phone (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

Pentair Thermal Management invented self-regulating heating cable technology more than 40 years ago and today has over a billion feet of Raychem brand self-regulating heating cable installed worldwide.

Self-regulating systems are the preferred choice for most complex pipe-tracing applications. This is due to their parallel construction, which allows them to be cut to length and spliced in the field, and their self-regulating output, which provides more heat where it is needed.

Pentair Thermal Management self-regulating heating cables are certified for use in hazardous locations and have been tested and approved for unconditional temperature classifications by worldwide approval agencies.

Conductive-Polymer Technology

Pentair Thermal Management uses innovative conductive-polymer technology in both monolithic (solid core) and fiber (polymeric fiber wrap) heating cables, as seen in Figures 1 and 2. The heating element is made of polymers mixed with conductive carbon black. This special blend of materials creates electrical paths for conducting current between the parallel bus wires along the entire cable length.

Pentair Thermal Management invented self-regulating heating cable technology more than 40 years ago and today has over a billion feet of Raychem brand self-regulating heating cable installed worldwide.

In each heating cable the number of electrical paths between the bus wires changes in response to temperature fluctuations. As the ambient temperature surrounding the heating cable decreases, the conductive core or fiber contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core or fiber.

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As the temperature rises, the core or fiber expands microscopically. This expansion increases electrical resistance, and the number of electrical paths decreases. As a result, the heating cable automatically begins to reduce its power output.

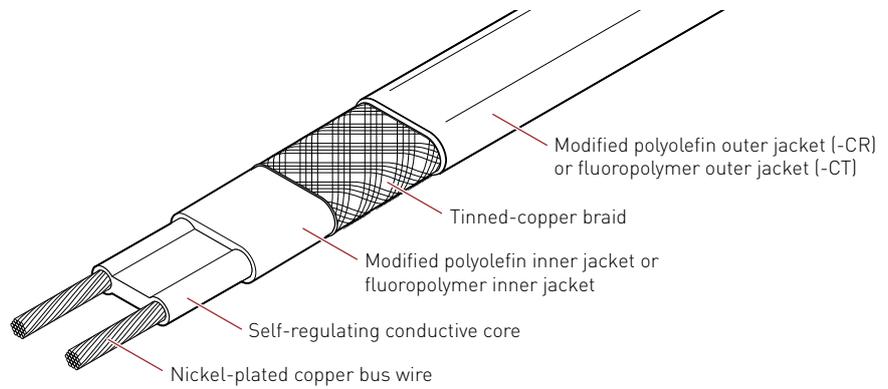


Fig. 1 Monolithic heating cable (BTV, QTVR, HBTV, and HQTV)

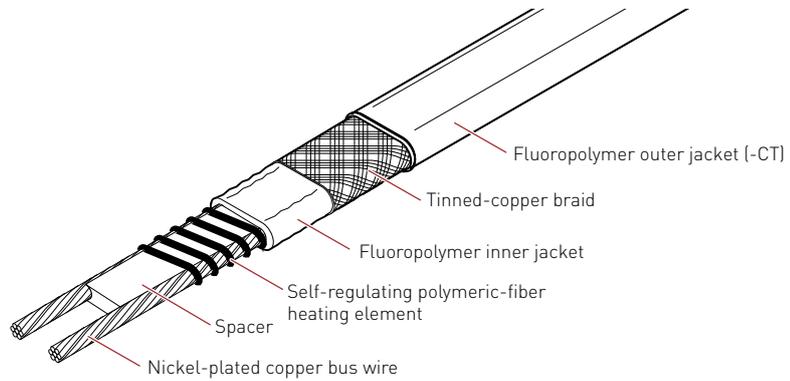


Fig. 2 Fiber-wrap heating cable (XTV, KTV and HXTV)

SYSTEM OVERVIEW

Typical Self-Regulating System

A typical self-regulating heating cable system is shown in Figure 3. The heating cable is cut to length at the job site and attached to the pipe with glass tape. A power connection kit connects the heating cable bus wires to power in a junction box. Tees and splices accommodate pipe branches to connect two or three heating cables together. An end seal kit is used to terminate the end of the heating cable. These required connection kits are designed and approved to provide a safe and reliable heat-tracing system. For applications requiring tight temperature control, electrical system monitoring, or remote operation, consider a control and monitoring system.

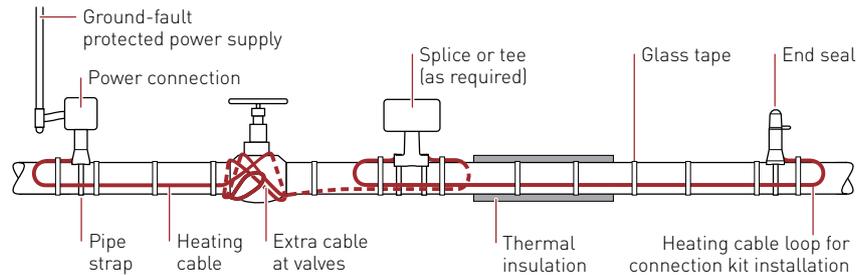


Fig. 3 Typical self-regulating heating cable system

Approvals and Certifications

Pentair Thermal Management self-regulating systems are approved and certified for use in nonhazardous and hazardous locations by many agencies. Please refer to technical data sheets for more details.



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 Pentair Thermal Management 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.

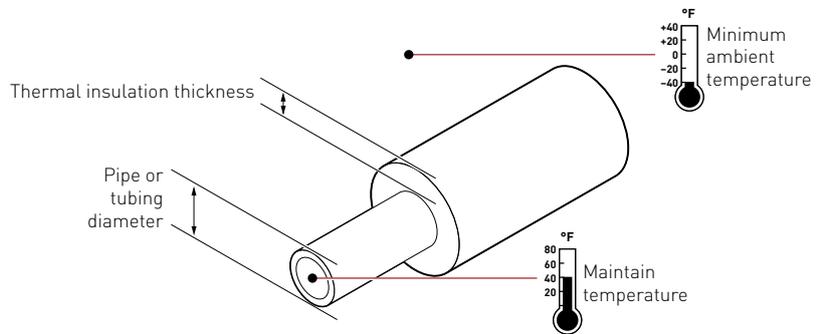


Fig. 4 Pipe heat loss

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

Step 2 Calculate temperature differential ΔT

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

$$\text{Formula} \quad \Delta T = T_M - T_A$$

Example: Calculate temperature differential

Input $T_M = 40^\circ\text{F}$ (from Step 1)

Input $T_A = -40^\circ\text{F}$ (from Step 1)

Calculation $\Delta T = 40^\circ\text{F} - (-40^\circ\text{F}) = 80^\circ\text{F}$

$\Delta T = 80^\circ\text{F}$

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

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 $\Delta T = 80^\circ\text{F}$ (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 :

$$Q_B = 3.6 \text{ W/ft} + [3/5 \times (7.4 - 3.6)] \text{ [7.4 is the } \Delta T \text{ of } 100^\circ\text{F}; 3.6 \text{ is the } \Delta T \text{ of } 50^\circ\text{F}]$$

Calculation $Q_B = 3.6 + 2.3 = 5.9 \text{ W/ft}$

Pipe heat loss $Q_B = 5.9 \text{ W/ft @ } 40^\circ\text{F}$

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).

$$\text{Formula} \quad Q_T = Q_B \times f$$

Example: Insulation type compensation

Input Insulation type = calcium silicate (from Step 1)

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

Input $Q_B = 5.9 \text{ W/ft}$ (from Step 3)

Calculation $Q_T = 5.9 \text{ W/ft} \times 1.50 = 8.85 \text{ W/ft}$

$Q_T = 8.85 \text{ W/ft at } 40^\circ\text{F}$

Now proceed to the Heating Cable Selection section, page 8, to determine the heating cable that will compensate for this heat loss.

Note: Heat loss calculations are based on IEEE Standards.

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TABLE 1 PIPE HEAT LOSS (W/FT)

Insulation thickness	Pipe diameter (IPS) in inches									
	(ΔT)		1/4	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
	°F	°C	Tubing size (inches)							
			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
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
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
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
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
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
4.0"	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_p) 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

SELF-REGULATING CABLES

HEATING CABLE SELECTION

Note: The data presented here are nominal and conservative. Additional engineering analysis at specific voltages may allow optimization that could extend circuit lengths and/or available power output. Consult Pentair Thermal Management for more information.

If your application is freeze protection of water piping, follow the five-step heating cable selection process outlined below.

- 1** Gather the following information:
 - Pipe size and material
 - Insulation type and thickness
 - Maintain temperature (T_M)
 - Minimum ambient temperature (T_A)
 - Minimum start-up temperature
 - Service voltage
 - Chemical environment
 - Maximum intermittent exposure temperature*
 - Electrical area classification**
- 2** Select the heating cable family.
- 3** Select the service voltage.
- 4** Determine the heating cable power output rating.
- 5** Select the jacket type.

* Determines whether a higher exposure temperature heating cable is needed.
** Determines whether special design requirements and connection kits must be used.

If your application is maintenance of another fluid at a temperature other than 40°F (5°C) or is temperature-sensitive, you will need the information above plus the following data:

	Example data
• Process temperature	70°F
• Maximum ambient temperature	105°F
• Fluid degradation temperature***	150°F

***Determines whether thermostatic control is necessary.

HEATING CABLE CATALOG NUMBER

Before beginning, take a moment to understand the structure underlying heating cable catalog numbers. You will refer to this numbering convention throughout the product selection process. Your goal is to determine the catalog number for the product that best suits your needs.

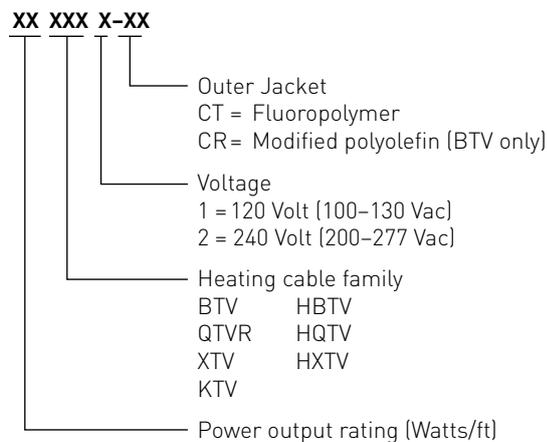


Fig. 5 Heating cable catalog number

Heating Cable Selection
1. Gather information
2. Select heating cable family
3. Select service voltage
4. Determine power output rating
5. Select jacket type

Step 1 Gather the necessary information

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

- Pipe size and material _____
- Insulation type and thickness _____
- Maintain temperature (T_M) _____
- Minimum ambient temperature (T_A) _____
- Minimum start-up temperature _____
- Service voltage _____
- Chemical environment _____
- Maximum intermittent exposure temperature _____
- Electrical area classification _____

Example: Gather necessary information

- Pipe size and material* 6 inches in diameter, steel
- Insulation type and thickness* 2-1/2 inch, calcium silicate
- Maintain temperature (T_M)* Water freeze protection at 40°F
- Minimum ambient temperature (T_A)* -40°F
- Minimum start-up temperature 0°F
- Service voltage 120 Vac
- Chemical environment Organic chemicals
- Maximum intermittent exposure temperature** 366°F
- Electrical area classification*** Nonhazardous

* From Thermal Design, Step 1
 ** Determines whether a higher exposure temperature heating cable is needed.
 *** Determines whether special design requirements and connection kits must be used.

Heating Cable Selection
1. Gather information
2. Select heating cable family
3. Select service voltage
4. Determine power output rating
5. Select jacket type

Step 2 Select the heating cable family

Based on your application’s maintain temperature, pipe material, maximum exposure temperature, and T-rating, select the appropriate heating cable.

For nonhazardous locations, use Table 3 to select the heating cable family. Base your selection on your application’s maintain temperature, pipe material, and maximum intermittent exposure temperature.

For Class I, Division 1 or 2 hazardous locations, also use Table 3 or Table 4, but first determine the required T-rating for the area.

Temperature identification numbers (T-ratings) are defined by the National Electrical Code (NFPA 70), Articles 500 and 505; and the Canadian Electrical Code Part I, Section 18. If the T-rating of the area has been defined, then select a heating cable from Table 3 or 4 having a T-rating equivalent to or less than the T-rating of this location (for example, T6 is a lower T-rating than T3).

The purpose of the T-rating is to ensure that electrical equipment does not exceed the auto-ignition temperatures (AIT) of flammables handled in a hazardous location.

If the T-rating for the area has not been defined, use one of the following methods.

SELF-REGULATING CABLES

FOR CSA CERTIFICATION

- Select the material with the lowest AIT in °C.
This temperature is the maximum allowable heating cable sheath temperature.

FOR FM APPROVAL

- Select material with the lowest AIT in °C.
This temperature is the maximum allowable heating cable sheath temperature.

FOR FM APPROVAL, DIVISION 1 HAZARDOUS LOCATIONS

- Select material with the lowest AIT in °C.
- Multiply the ignition temperature by 0.8.

This temperature is the maximum allowable heating cable sheath temperature. Use Table 4 to select the heating cable family.

TABLE 3 HEATING CABLE PRODUCT PERFORMANCE DATA

Heating cable family	Maximum maintain temperature		Maximum continuous exposure temperature*		Maximum intermittent exposure temperature**		T-rating/ maximum sheath temperature		Pipe material
	°F	(°C)	°F	(°C)	°F	(°C)	T-rating	°F (°C)	
BTV	150°F	(65°C)	150°F	(65°C)	185°F	(85°C)	T6	185°F (85°C)	plastic/metal
QTVR	225°F	(110°C)	225°F	(110°C)	225°F	(110°C)	T4	275°F (135°C)	plastic/metal only
KTV	300°F	(150°C)	300°F	(150°C)	482°F	(250°C) ²	T2C	446°F (230°C)	plastic/metal
5XTV1,2	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T3	392°F (200°C)	metal only
10XTV1,2	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T3	392°F (200°C)	metal only
15XTV2	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T3	392°F (200°C)	metal only
15XTV1	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T2D	419°F (215°C)	metal only
20XTV1	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T2C	446°F (230°C)	metal only
20XTV2	250°F	(121°C)	250°F	(121°C)	482°F	(250°C) ²	T2C	446°F (230°C)	metal only

* With the heating cable power on

** 1000 hours (power on/power off)

¹ For plastic pipes please consult TraceCalc Pro design software or contact the Customer Service Center.

² The 250°C rating applies to all products printed "MAX INTERMITTENT EXPOSURE 250C"

Example: Nonhazardous location

Input 40°F maintain temperature (from Thermal Design, Step 1)

Input 366°F intermittent exposure temperature (from Step 1)

Input Heating cable family XTV (from Table 3)

Catalog number xx**XTV**x-xx

TABLE 4 HEATING CABLE PRODUCT PERFORMANCE DATA (FM-CID1 HAZARDOUS LOCATIONS)

Heating cable family	Maximum maintain temperature	Maximum continuous exposure temperature*	Maximum intermittent exposure temperature**	T-rating/ maximum sheath temperature	Pipe material
HBTV-CT	150°F (65°C)	150°F (65°C)	185°F (85°C)	T6 185°F (85°C)	plastic/ metal
HQTV-CT	225°F (110°C)	225°F (110°C)	225°F (110°C)	T4 275°F (135°C)	plastic/ metal only
5HXTV1,2-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T3 392°F (200°C)	metal only
10HXTV1,2-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T3 392°F (200°C)	metal only
15HXTV2-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T3 392°F (200°C)	metal only
15HXTV1-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T2D 419°F (215°C)	metal only
20HXTV1-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T2C 446°F (230°C)	metal only
20HXTV2-CT	250°F (121°C)	250°F (121°C)	482°F (250°C) ²	T2C 446°F (230°C)	metal only

* With the heating cable power on
 ** 1000 hours (power on/power off)
 1 For plastic pipes please consult TraceCalc Pro design software or contact the Customer Service Center.
 2 The 250°C rating applies to all products printed "MAX INTERMITTENT EXPOSURE 250°C"

Example: CID1 hazardous location

For the same inputs, the heating cable family is HXTV from Table 4 on page 11.

FOR FM APPROVED SYSTEMS IN CID1 HAZARDOUS LOCATIONS

Due to the potentially hazardous nature of Division 1 locations, the requirements below must be followed at all times.

- Use only Raychem brand HBTV-CT, HQTV-CT, and HXTV-CT heating cables and HAK-C-100 connection kits specifically approved by FM.
- Complete and send the field information form found in the Approval for Class I, Division 1 Hazardous Locations in USA form (H56987), available on www.pentairthermal.com, to the Pentair Thermal Management Customer Service Center — phone (800) 545-6258, fax (800) 527-5703 — for design verification.
- Be sure the installer completes and returns the Required Installation Record for Class I, Division 1 Hazardous Locations in USA form (H57426), available on www.pentairthermal.com, or the one in the back of the installation manual shipped with the product.

FOR CSA CERTIFIED SYSTEMS IN CID1 HAZARDOUS LOCATIONS

Due to the potentially hazardous nature of Division 1 locations, use only Raychem brand BTV-CT, QTVR-CT, KTV-CT and XTV-CT heating cables and HAK-C-100 connection kits specifically certified by CSA.

Heating Cable Selection
1. Gather information
2. Select heating cable family
3. Select service voltage
4. Determine power output rating
5. Select jacket type

Step 3 Select the service voltage

Service voltage options: 1 = 120 volts (100–130 Vac)
 2 = 240 volts (200–277 Vac)

Example: Service voltage selection

Input XTV heating cable (from Step 2)
 Input 120 volts (from Step 1)
 Voltage option 1
 Catalog number x**XTV1**-xx

Heating Cable Selection
1. Gather information
2. Select heating cable family
3. Select service voltage
4. Determine power output rating
5. Select jacket type

Step 4 Determine the heating cable power output rating

To select the heating cable power output, use Table 5 to determine the appropriate power output graph based on the heating cable family and voltage already determined.

TABLE 5 HEATING CABLE POWER OUTPUT GRAPH SELECTION

Pipe material	Heating cable	Voltage	Graph number
Metal pipe	BTV, QTVR, HBTV, HQTV	120	1
		208	2
		240	3
		277	4
Metal pipe	KTV, XTV and HXTV	120	5
		208	6
		240	7
		277	8
Plastic pipe*	BTV and HBTV	120	9
		208	10
		240	11
		277	12

* Graphs assume the use of aluminum tape over the heating cable.

Using the selected graph, locate the heating cable with thermal output greater than the heat loss (Q_T) at the pipe maintenance temperature (T_M).

If the pipe heat loss, Q_T , is between the two heating cable power output curves, select the higher-rated heating cable. If Q_T is greater than the power output of the highest-rated heating cable, you can:

- Use two or more heating cables run in parallel.
- Spiral the heating cable.
- Use thicker insulation to reduce heat loss.
- Use insulation material with a lower k factor.

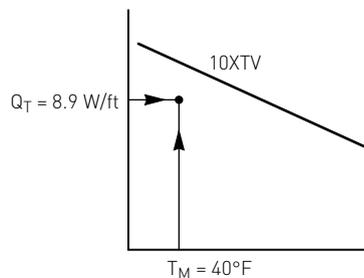


Fig. 6 Heating cable thermal output

Spiraling

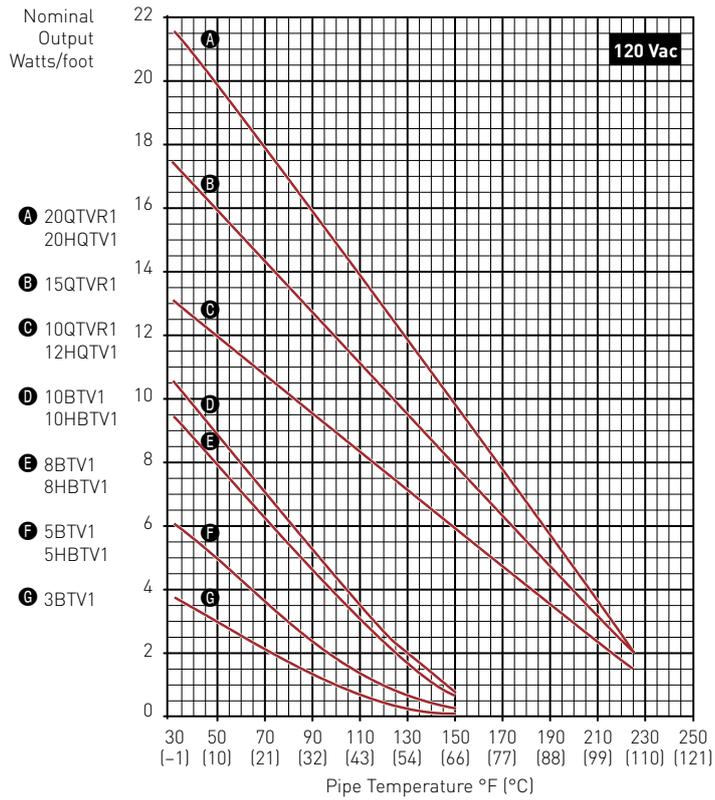
If spiraling is elected, use the formula below to determine the spiral factor (length of heating cable per foot of pipe):

$$\text{Spiral factor} = Q_T / \text{Heater power output at } T_M$$

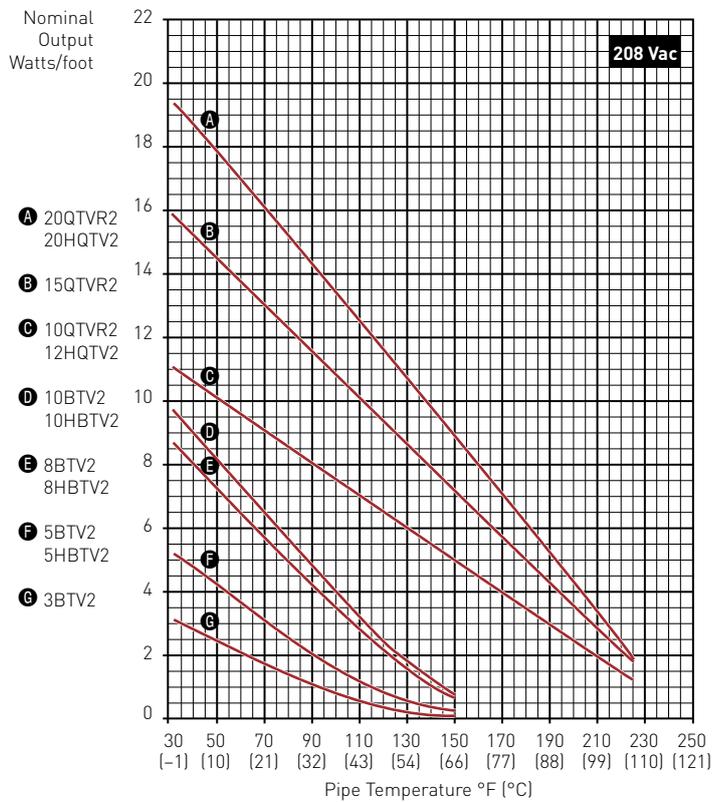
When the spiral factor exceeds 6 or the pipe size is less than three inches, consider using two or more heating cables run in parallel rather than spiraling.

Example: Determine power output rating

Input	XTV heating cable (from Step 3)
Input	Heat loss is 8.7 W/ft (from Thermal Design, Step 4 and Table 1)
Input	10XTV output of 10.2 W/ft exceeds 8.7 W/ft at 40°F (from Graph 5)
Power output rating	10
Catalog number	10XTV1-xx

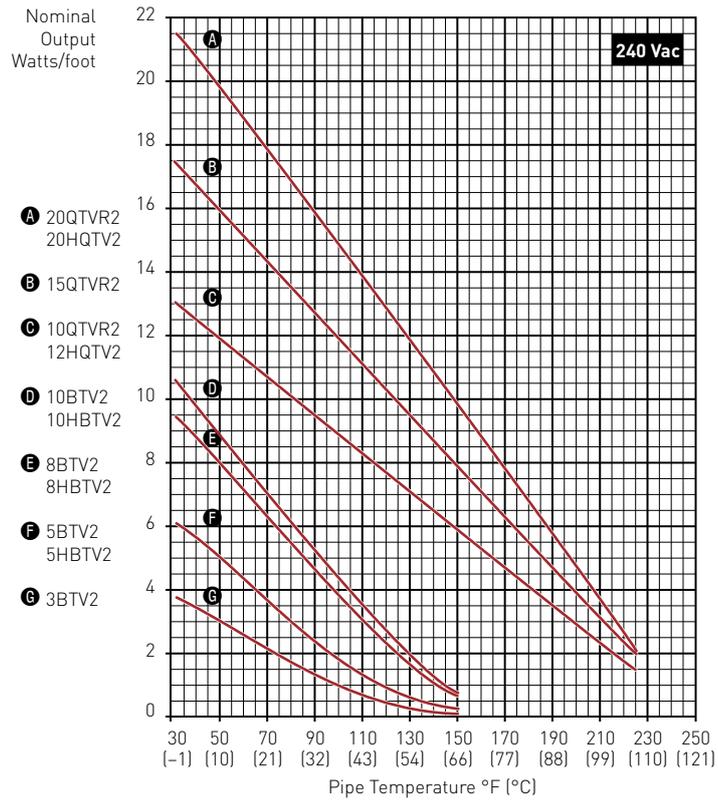


Graph 1 BTV, HBTV, QTVR, and HQTV nominal power output on metal pipes at 120 volts

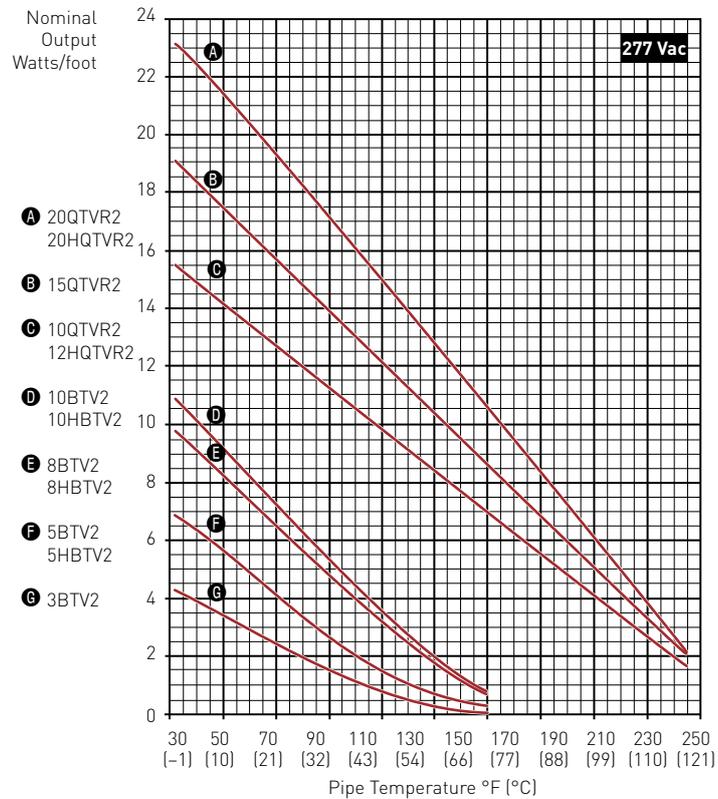


Graph 2 BTV, HBTV, QTVR, and HQTV nominal power output on metal pipes at 208 volts

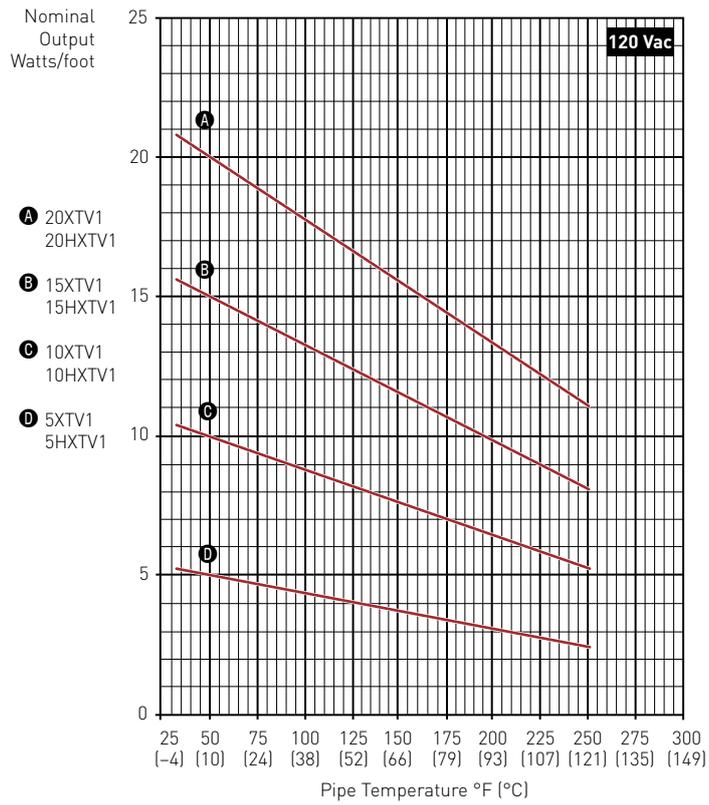
SELF-REGULATING CABLES



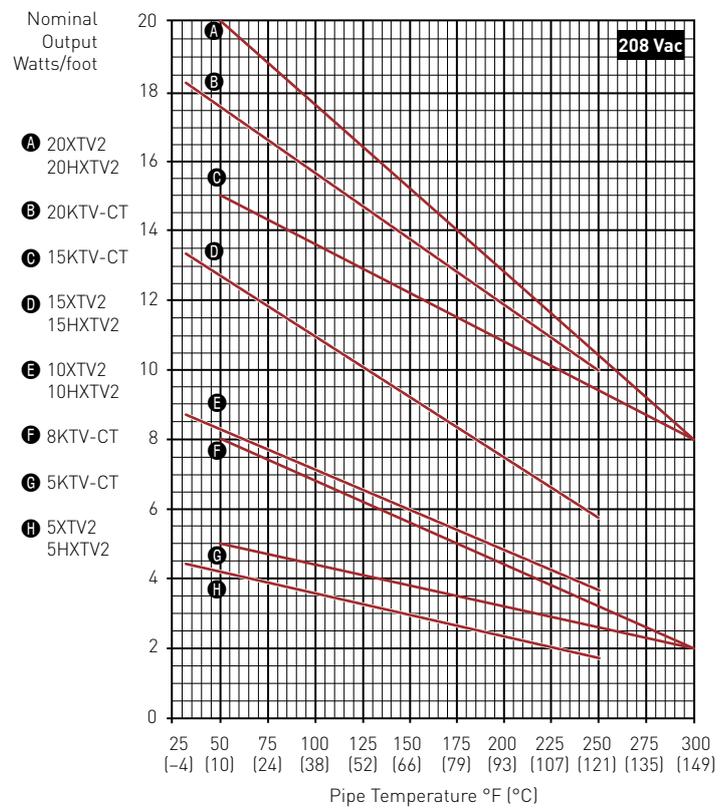
Graph 3 BTV, HBTV, QTVR, and HQTV nominal power output on metal pipes at 240 volts



Graph 4 BTV, HBTV, QTVR, and HQTV nominal power output on metal pipes at 277 volts

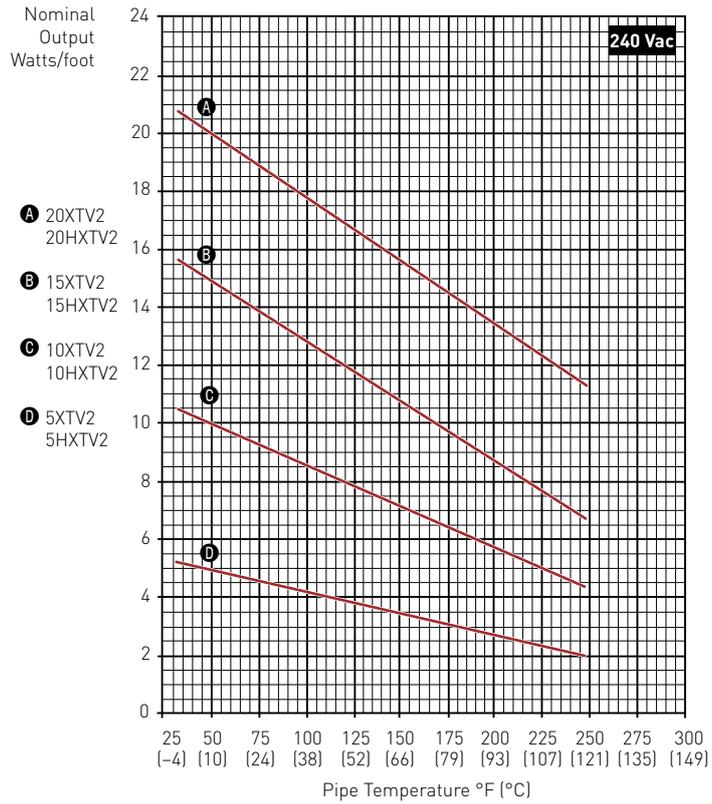


Graph 5 XTV and HXTV nominal power output on metal pipes at 120 volts

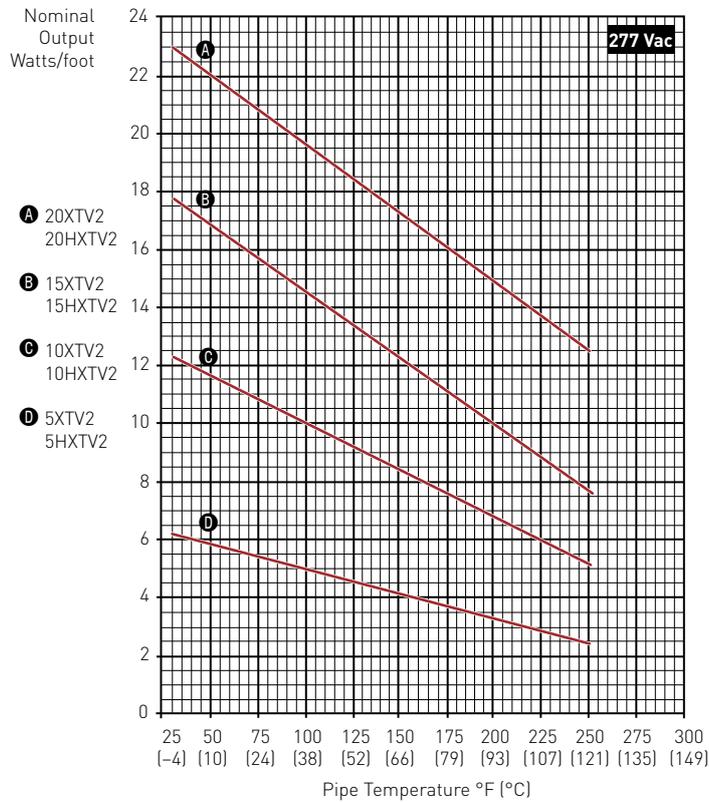


Graph 6 XTV and HXTV nominal power output on metal pipes at 208 volts

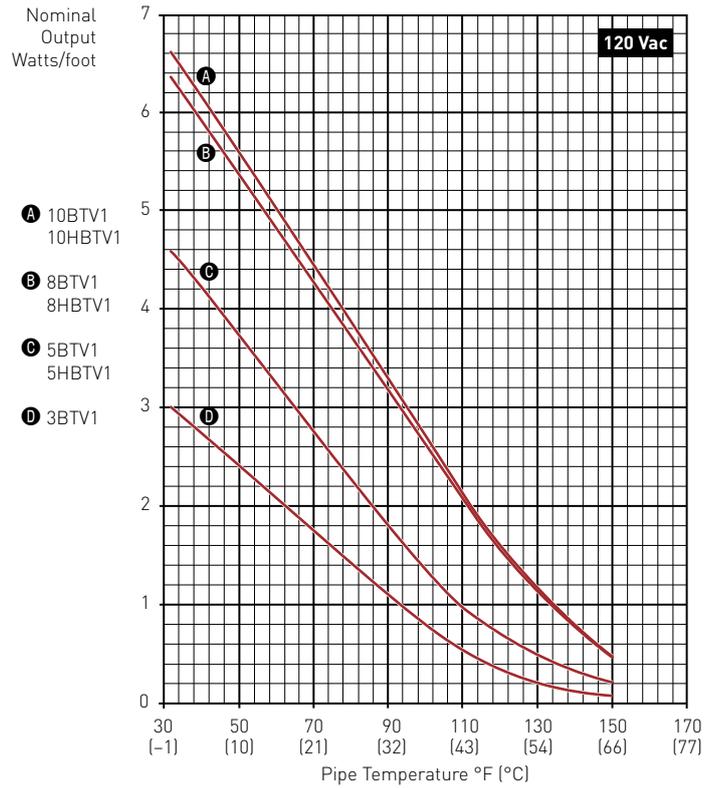
SELF-REGULATING CABLES



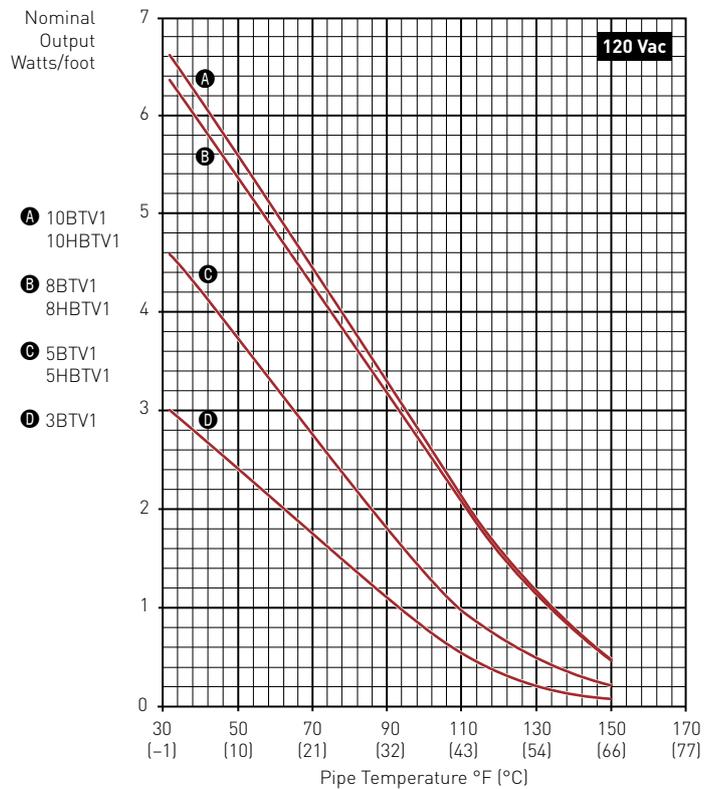
Graph 7 XTV and HXTV nominal power output on metal pipes at 240 volts



Graph 8 XTV and HXTV nominal power output on metal pipes at 277 volts

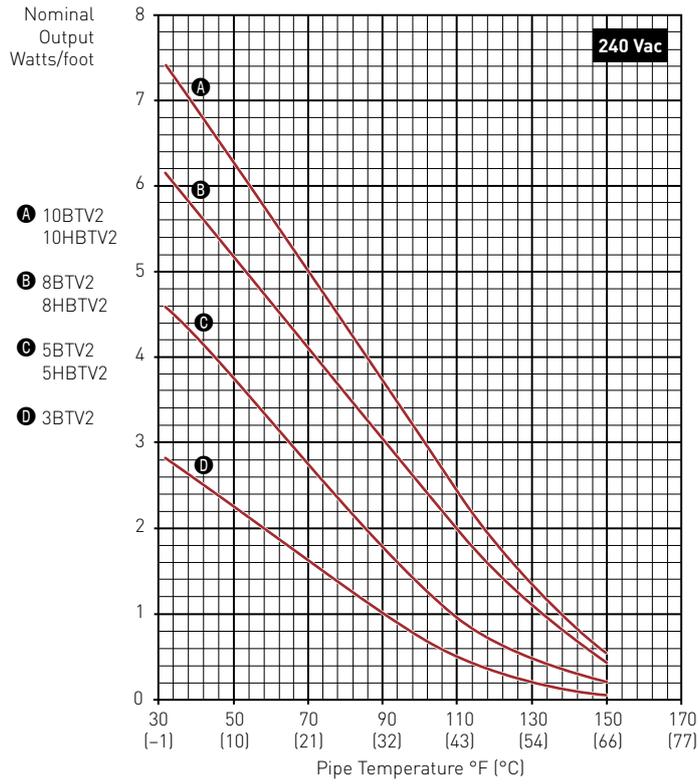


Graph 9 BTV and HBTV nominal power output on plastic pipes at 120 volts

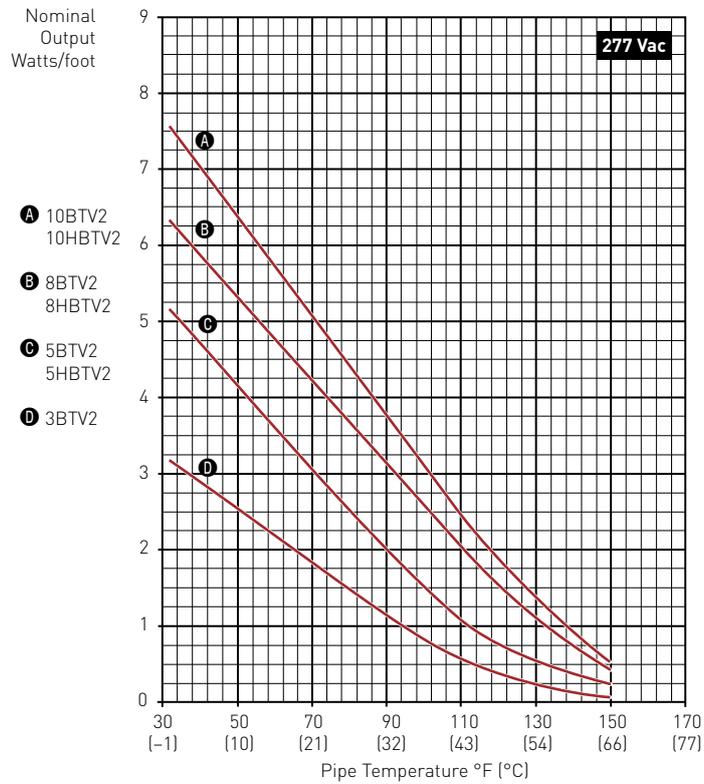


Graph 10 BTV and HBTV nominal power output on plastic pipes at 208 volts

SELF-REGULATING CABLES



Graph 11 BTV and HBTv nominal power output on plastic pipes at 240 volts



Graph 12 BTV and HBTv nominal power output on plastic pipes at 277 volts

Heating Cable Selection
1. Gather information
2. Select heating cable family
3. Select service voltage
4. Determine power output rating
5. Select jacket type

Step 5 Select the jacket type

While QTVR, KTV and XTV heating cables are only available with a CT outer jacket, the BTV heating cables are also available in a CR version.

TABLE 6 HEATING CABLE OUTER JACKET OPTIONS

Option	Material	Application
CT	Fluoropolymer	Exposure to organic chemicals or corrosives
CR	Modified polyolefin	Exposure to aqueous inorganic chemicals

If you are unsure about the correct jacket for your application, select the CT version or contact your Pentair Thermal Management representative for assistance.

Example: Jacket type selection

Input	10XTV1-xx heating cable (from Step 4)
Input	Organic chemicals
Jacket type	CT
Catalog number	10XTV1-CT

BILL OF MATERIALS

Now that you have selected the correct heating cable for your application, this section helps you to determine:

- Total length of heating cable required
- Electrical design, including circuit breaker sizing and selection
- Quantity and type of connection kits and accessories

Determining the Total Length of Heating Cable

To determine the total length of heating cable, follow these six steps:

- 1** Gather the necessary information:
 - Pipe length and diameter
 - Type and number of valves
 - Type and number of pipe supports
 - Start-up temperature
 - Number of circuits and tees in the piping
- 2** Calculate the total length of heating cable for the piping.
- 3** Calculate the total length of heating cable for the valves.
- 4** Calculate the total length of heating cable for the pipe supports.
- 5** Calculate additional heating cable for connection kit installation.
- 6** Add all the lengths together.

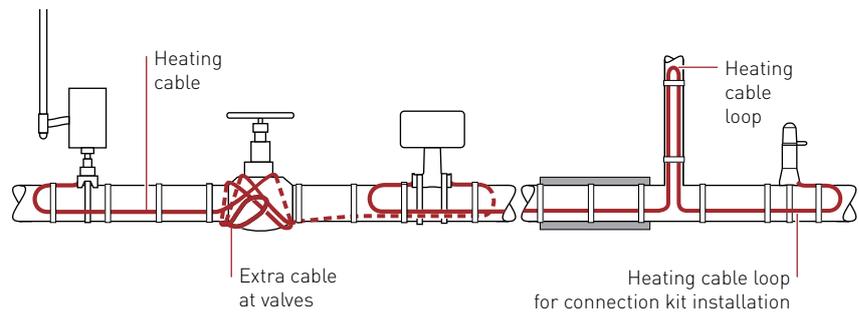


Fig. 7 Typical heating cable layout

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 1 Gather the necessary information

To determine the total length of heating cable, gather and record the following information:

- Pipe length and diameter
- Type and number of valves
- Type and number of pipe supports
- Start-up temperature
- Number of circuits and tees in piping

Example: Gather necessary information

Pipe length and diameter	100 feet of 6-inch pipe
Type and number of valves	Three 6-inch gate valves
Type and number of pipe supports	Support shoes, 10 each, 1-foot length
Start-up temperature	0°F
Number of circuits and tees in piping	Power connections: 1
	End seals: 3
	Pipe tees: 2

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 2 Calculate the total length of heating cable for the piping

Example: Total length of cable for piping calculation

100 ft of pipe (from Step 1) = 100 ft of cable for single tracing

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 3 Calculate the total length of heating cable for the valves

Table 7 contains guidelines to determine the amount of additional heating cable required to compensate for heat loss on valves. For a more detailed analysis, use TraceCalc Pro design software or consult Pentair Thermal Management.

Multiply the number of valves to arrive at the total additional footage of heating cable.

TABLE 7 RECOMMENDED VALVE ALLOWANCE

Pipe diameter (IPS) (inches)	Heating cable feet (meters)	Comments*
1/4	0.3 (0.09)	These recommendations are limited by the amount of heating cable that can physically be installed on small valves. Heat loss may not be fully compensated under extreme conditions.
1/2	0.8 (0.24)	
3/4	1.3 (0.4)	
1	2.0 (0.6)	
1-1/4	3.3 (1.1)	
1-1/2	4.3 (1.3)	
2	4.3 (1.3)	
3	4.3 (1.3)	These numbers represent the minimum amount of heating cable required for a service loop. Additional cable may be required to compensate for total heat loss.
4	4.3 (1.3)	
6	5.0 (1.5)	
8	5.0 (1.5)	
10	5.6 (1.7)	
14	7.3 (2.2)	
18	9.4 (2.9)	
24	12.6 (3.8)	

* Use TraceCalc Pro design software to calculate the exact quantity required for the valve.

Example: Heating cable length for valves calculation

From Table 7 for a 6-inch diameter pipe,

Each valve requires: 5.0 ft

Cable needed for three valves: 3 x 5.0 ft

Total cable length needed for valves: 15.0 ft

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 4 Calculate the total length of heating cable for the pipe supports

SUPPORT SHOES

For each pipe support shoe, calculate the additional heating cable required as follows:

Determine the heat loss for one support.

- Formula: $Q_{SUPPORT} = 0.7L \times (T_M - T_A)$, where L = Support length (ft) (assumes a 0.25-inch steel welded shoe partially shielded from winds)
- Multiply that heat loss by the total number of supports.
- Add 10 percent to the total heat loss for added safety.
- Obtain the heating cable power output per foot from Graph 5.
- Divide the total support heat loss by the heating cable power output per foot to get the number of feet of heating cable needed.

Example: Total length of cable for pipe supports calculation

Input	10XTV1-CT heating cable (from Cable Selection, Step 5)
Input	10 one-foot welded steel shoe supports (from Step 1)
Heat loss for one support	$0.7 \times 1 \times (40 - (-40)) = 56 \text{ W}$
Heat loss for all supports	$10 \times 56 \text{ W} = 560 \text{ W}$
Add safety factor	$560 \text{ W} + 10\% = 616 \text{ W}$
Heating cable power output	10.2 W/ft (from Step 3 of Cable Selection)
Heating cable required	$616 \text{ W} / 10.2 \text{ W/ft} = 60 \text{ ft of heating cable}$

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 5 Calculate additional heating cable for connection kit installation

Estimate the number of power connections, tees, and splices for the system. Allow an additional three feet for each connection kit.

Example: Include additional cable

Input	1 power connection, 3 end seals, 2 tees (from Step 1)
Total number of connection kits	6 (from Step 1)
Cable needed for 6 connection kits	$6 \times 3 \text{ ft of additional cable}$
Total cable length for 6 connection kits	18 ft of cable

Heating Cable Length
1. Gather information
2. Calculate cable length for piping
3. Calculate cable length for valves
4. Calculate cable length for supports
5. Calculate cable length for connection kits
6. Add all lengths

Step 6 Add all lengths together

Example: Final addition

Cable for piping	100 ft (from Step 1)
Cable for valves	15 ft (from Step 3)
Cable for supports	60 ft (from Step 4)
Cable for connection kits	18 ft (from Step 5)
Sum of all lengths	$100 + 15 + 60 + 18 = 193 \text{ ft}$
Total length of heating cable	193 ft

Now that you have the total length of heating cable, you can determine the number of electrical circuits you will need.

Electrical Design

⚠ WARNING: Fire hazard

There is a danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed. To comply with Pentair Thermal Management requirements, certifications, and national electrical codes, and to protect against the risk of fire, ground-fault equipment protection must be used on each heating cable circuit. Arcing may not be stopped by conventional circuit breakers.

DETERMINING MAXIMUM LENGTH OF HEATING CABLE ON ONE CIRCUIT BREAKER

Using Table 8 and Table 9, match the heating cable catalog number at the expected minimum start-up temperature with the total heating cable length and select a circuit breaker trip rating. The circuit breaker trip rating should not exceed the maximum trip rating shown for heating cables of that product family. For example, the trip rating of a circuit breaker protecting several 10XTV circuits should not exceed 50 amps. To maximize fault current protection, use the lowest allowable circuit breaker.

Maximum circuit length per breaker depends on four factors:

1. Heating cable family and catalog number
2. Minimum start-up temperature
3. Service voltage
4. Circuit breaker trip rating

TABLE 8 MAXIMUM CIRCUIT LENGTH (FEET) VS. CIRCUIT BREAKER TRIP RATING (AMPS)

120- and 240-volt heating cables applied to metal pipe with glass tape

Heating cable	Start-up temperature	120-volt cable					240-volt cable				
		15 A	20 A	30 A	40 A	50 A	15 A	20 A	30 A	40 A	50 A
3BTV	50°F (10°C)	330	330	330	330	+	660	660	660	660	+
	0°F (-18°C)	200	265	330	330	+	395	530	660	660	+
	-20°F (-29°C)	175	235	330	330	+	350	465	660	660	+
	-40°F (-40°C)	155	205	310	330	+	310	410	620	660	+
5BTV	50°F (10°C)	230	270	270	270	+	460	540	540	540	+
5HBTV	0°F (-18°C)	140	190	270	270	+	285	380	540	540	+
	-20°F (-29°C)	125	165	250	270	+	250	330	500	540	+
	-40°F (-40°C)	110	145	220	270	+	220	295	440	540	+
8BTV	50°F (10°C)	150	200	210	210	+	300	400	420	420	+
8HBTV	0°F (-18°C)	100	130	200	210	+	200	265	400	420	+
	-20°F (-29°C)	85	115	175	210	+	175	235	350	420	+
	-40°F (-40°C)	80	105	155	210	+	155	210	315	420	+
10BTV	50°F (10°C)	120	160	180	180	+	240	315	360	360	+
10HBTV	0°F (-18°C)	80	110	160	180	+	160	215	325	360	+
	-20°F (-29°C)	70	95	140	180	+	145	190	285	360	+
	-40°F (-40°C)	65	85	125	170	+	125	170	255	340	+
10QTVR	50°F (10°C)	100	130	195	195	+	200	265	390	390	+
12HQTV	0°F (-18°C)	80	105	160	195	+	160	210	320	390	+
	-20°F (-29°C)	70	95	145	195	+	145	195	295	390	+
	-40°F (-40°C)	65	90	135	180	+	135	180	275	365	+
15QTVR	50°F (10°C)	75	100	150	200	220	160	210	320	340	+
	0°F (-18°C)	60	80	120	160	200	125	170	255	340	+
	-20°F (-29°C)	55	70	110	145	185	115	155	235	315	+
	-40°F (-40°C)	50	65	100	135	170	110	145	220	290	+
20QTVR	50°F (10°C)	60	80	120	160	195	120	160	240	320	390
20HQTV	0°F (-18°C)	45	60	95	125	160	95	125	190	255	320
	-20°F (-29°C)	40	55	85	115	145	85	115	175	235	295
	-40°F (-40°C)	40	55	80	110	135	80	110	165	220	275
5XTV	50°F (10°C)	180	240	360	385	385	360	480	720	765	765
5HXTV	0°F (-18°C)	160	210	320	385	385	315	420	625	765	765
	-20°F (-29°C)	150	200	305	385	385	295	395	595	765	765
	-40°F (-40°C)	145	195	290	385	385	285	380	570	760	765

SELF-REGULATING CABLES

TABLE 8 MAXIMUM CIRCUIT LENGTH (FEET) VS. CIRCUIT BREAKER TRIP RATING (AMPS)

120- and 240-volt heating cables applied to metal pipe with glass tape

Heating cable	Start-up temperature		120-volt cable					240-volt cable				
			15 A	20 A	30 A	40 A	50 A	15 A	20 A	30 A	40 A	50 A
10XTV	50°F	(10°C)	110	145	220	270	270	220	295	440	540	540
10HXTV	0°F	(-18°C)	95	130	195	260	270	195	260	385	515	540
	-20°F	(-29°C)	95	125	190	250	270	185	245	370	495	540
	-40°F	(-40°C)	90	120	180	240	270	175	235	355	470	540
15XTV	50°F	(10°C)	75	100	150	200	220	150	200	300	400	445
15HXTV	0°F	(-18°C)	65	90	135	180	220	130	175	265	355	440
	-20°F	(-29°C)	65	85	130	170	215	125	165	250	335	420
	-40°F	(-40°C)	60	80	125	165	205	120	160	240	320	405
20XTV	50°F	(10°C)	60	80	120	160	190	115	150	230	305	380
20HXTV	0°F	(-18°C)	50	70	105	140	180	100	135	205	275	345
	-20°F	(-29°C)	50	65	100	135	170	100	130	200	265	330
	-40°F	(-40°C)	50	65	100	130	165	95	125	190	255	320
5KTV	50°F	(10°C)	180	240	360	385	385	360	480	720	765	765
	0°F	(-18°C)	160	215	320	385	385	320	430	640	765	765
	-20°F	(-29°C)	155	205	305	385	385	310	415	620	765	765
	-40°F	(-40°C)	145	195	290	385	385	300	400	600	765	765
8KTV	50°F	(10°C)	130	170	260	300	300	260	345	515	600	600
	0°F	(-18°C)	115	150	225	300	300	230	310	465	600	600
	-20°F	(-29°C)	110	145	215	290	300	225	295	445	595	600
	-40°F	(-40°C)	105	140	205	275	300	215	285	430	570	600
15KTV	50°F	(10°C)	80	105	160	215	220	160	215	320	425	440
	0°F	(-18°C)	75	95	145	195	220	145	190	285	385	440
	-20°F	(-29°C)	70	95	140	185	220	140	185	275	370	440
	-40°F	(-40°C)	65	90	135	180	220	135	180	265	355	440
20KTV	50°F	(10°C)	55	75	115	155	185	115	155	230	305	375
	0°F	(-18°C)	50	70	105	140	175	105	140	210	280	350
	-20°F	(-29°C)	50	65	100	135	165	100	135	200	270	335
	-40°F	(-40°C)	50	65	95	130	160	95	130	195	260	325

† Not permitted

For a fully optimized design, use TraceCalc Pro design software or contact your Pentair Thermal Management representative.

⚠ Note: Pentair Thermal Management and the U.S. National Electrical Code require both ground-fault protection of equipment and a grounded metallic covering (usually braid) on all heating cables. All Raychem products meet the metallic covering requirement. Following are some of the ground-fault breakers that satisfy this equipment protection requirement: Square D Type QOB-EPD or QO-EPD; Raychem/Square D Type GFPD EHB-EPD (277 Vac); Cutler Hammer (Westinghouse) Type QBGFEP.

TABLE 9 MAXIMUM CIRCUIT LENGTH (FEET) VS. CIRCUIT BREAKER TRIP RATING (AMPS)

208- and 277-volt heating cables applied to metal pipe with glass tape

Heating cable	Start-up temperature		208-volt cable					277-volt cable				
			15 A	20 A	30 A	40 A	50 A	15 A	20 A	30 A	40 A	50 A
3BTV	50°F	(10°C)	635	635	635	635	†	690	710	710	710	†
	0°F	(-18°C)	390	520	635	635	†	405	540	710	710	†
	-20°F	(-29°C)	345	460	635	635	†	360	480	710	710	†
	-40°F	(-40°C)	305	405	610	635	†	315	425	635	710	†
5BTV	50°F	(10°C)	435	505	505	505	†	490	590	590	590	†
5HBTV	0°F	(-18°C)	270	360	505	505	†	303	404	590	590	†
	-20°F	(-29°C)	235	315	475	505	†	265	355	530	590	†
	-40°F	(-40°C)	210	280	420	505	†	235	315	470	590	†

TABLE 9 MAXIMUM CIRCUIT LENGTH (FEET) VS. CIRCUIT BREAKER TRIP RATING (AMPS)

208- and 277-volt heating cables applied to metal pipe with glass tape

Heating cable	Start-up temperature	208-volt cable					277-volt cable				
		15 A	20 A	30 A	40 A	50 A	15 A	20 A	30 A	40 A	50 A
8BTV	50°F (10°C)	280	370	385	385	+	330	440	465	465	+
8HBTV	0°F (-18°C)	185	250	370	385	+	220	290	440	465	+
	-20°F (-29°C)	165	220	330	385	+	195	255	385	465	+
	-40°F (-40°C)	145	195	295	385	+	170	230	346	460	+
10BTV	50°F (10°C)	220	290	330	330	+	260	350	400	400	+
10HBTV	0°F (-18°C)	150	200	295	330	+	180	240	355	400	+
	-20°F (-29°C)	130	175	260	330	+	155	210	315	400	+
	-40°F (-40°C)	115	155	235	310	+	140	185	280	375	+
10QTVR	50°F (10°C)	195	260	365	365	+	190	255	385	410	+
12HQTV	0°F (-18°C)	155	205	310	365	+	150	205	305	410	+
	-20°F (-29°C)	145	190	290	365	+	140	190	285	380	+
	-40°F (-40°C)	135	180	270	360	+	130	175	265	350	+
15QTVR	50°F (10°C)	150	205	305	305	+	175	230	350	370	+
	0°F (-18°C)	120	160	245	305	+	140	185	280	370	+
	-20°F (-29°C)	110	150	225	300	+	130	170	260	345	+
	-40°F (-40°C)	105	140	210	280	+	120	160	240	320	+
20QTVR	50°F (10°C)	110	145	220	290	355	125	170	255	340	426
20HQTV	0°F (-18°C)	85	115	175	235	290	100	135	200	270	340
	-20°F (-29°C)	80	105	160	215	270	95	125	185	250	315
	-40°F (-40°C)	75	100	150	200	250	85	115	175	235	290
5XTV	50°F (10°C)	355	475	715	720	720	390	520	750	750	750
5HXTV	0°F (-18°C)	310	415	625	720	720	340	450	680	750	750
	-20°F (-29°C)	295	395	595	720	720	325	430	645	750	750
	-40°F (-40°C)	285	380	565	720	720	310	410	615	750	750
10XTV	50°F (10°C)	220	290	435	515	515	235	315	470	580	580
10HXTV	0°F (-18°C)	190	255	385	515	515	205	275	415	550	580
	-20°F (-29°C)	185	245	365	490	515	195	260	395	525	580
	-40°F (-40°C)	185	235	350	470	515	190	250	380	500	580
15XTV	50°F (10°C)	145	195	295	395	420	160	215	320	430	480
15HXTV	0°F (-18°C)	130	175	260	345	420	140	190	280	375	470
	-20°F (-29°C)	125	165	250	330	415	135	180	270	360	450
	-40°F (-40°C)	120	160	235	315	395	130	170	260	345	430
20XTV	50°F (10°C)	110	150	220	295	355	125	165	250	330	415
20HXTV	0°F (-18°C)	100	135	200	270	335	110	150	225	300	375
	-20°F (-29°C)	95	130	195	260	320	105	145	215	290	360
	-40°F (-40°C)	90	125	185	250	310	105	140	210	280	345
5KTV	50°F (10°C)	380	505	730	730	730	350	465	700	810	810
	0°F (-18°C)	340	450	675	730	730	310	415	625	810	810
	-20°F (-29°C)	325	435	655	730	730	300	400	600	800	810
	-40°F (-40°C)	315	420	630	730	730	290	390	580	775	810
8KTV	50°F (10°C)	270	360	540	575	575	250	335	500	635	635
	0°F (-18°C)	245	325	485	575	575	225	300	450	600	635
	-20°F (-29°C)	235	310	470	575	575	215	290	430	575	635
	-40°F (-40°C)	225	300	450	575	575	210	275	415	555	635

TABLE 9 MAXIMUM CIRCUIT LENGTH (FEET) VS. CIRCUIT BREAKER TRIP RATING (AMPS)

208- and 277-volt heating cables applied to metal pipe with glass tape

Heating cable	Start-up temperature	208-volt cable					277-volt cable				
		15 A	20 A	30 A	40 A	50 A	15 A	20 A	30 A	40 A	50 A
15KTV	50°F (10°C)	170	225	335	420	420	155	205	310	415	470
	0°F (-18°C)	150	200	300	405	420	140	185	280	370	465
	-20°F (-29°C)	145	195	290	390	420	135	180	270	360	445
	-40°F (-40°C)	140	185	280	375	420	130	175	260	345	430
20KTV	50°F (10°C)	120	160	240	320	360	110	150	225	295	370
	0°F (-18°C)	110	145	220	290	360	100	135	200	270	335
	-20°F (-29°C)	105	140	210	280	350	95	130	195	260	325
	-40°F (-40°C)	100	135	205	270	340	95	125	190	250	315

† Not permitted

⚠ Note: Pentair Thermal Management and the U.S. National Electrical Code require both ground-fault protection of equipment and a grounded metallic covering (usually braid) on all heating cables. All Raychem products meet the metallic covering requirement. Following are some of the ground-fault breakers that satisfy this equipment protection requirement: Square D Type QOB-EPD or QO-EPD; Raychem/Square D Type GFPD EHB-EPD (277 Vac); Cutler Hammer (Westinghouse) Type QBGFEP.

Example: Determine maximum length of heating cable on one circuit breaker

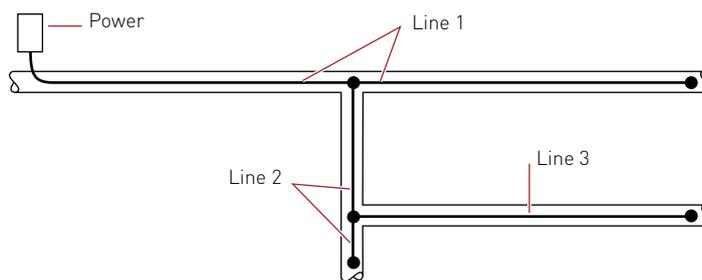
Input 10XTV1 heating cable (from Cable Selection, Step 3)
 Input 120 volts (from Cable Selection Step 1)
 Input 0°F start-up temperature (from Cable Selection, Step 1)
 Input Maximum circuit length = 195 feet on a 30-amp breaker (from Table 8)
 If the total length of cable exceeds 195 feet, you must use a 40-amp circuit breaker, which allows up to 260 feet.

DETERMINE MINIMUM NUMBER OF CIRCUITS

Example: Minimum number of circuits calculation

Input 195 ft allowed per 30-amp circuit (from Table 8)
 Input Total circuit length = 193 ft (from Bill of Materials, Step 6)
 Number of circuits 1 circuit

If the total length of heating cable required exceeded 195 ft, you would need to split the total length into two separate circuits or use a larger circuit breaker size.



Line 1 + Line 2 + Line 3 ≤ Maximum circuit length

Fig. 8 Maximum heating cable circuit length

Ground-fault protection

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Pentair Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Connection Kit Selection and Accessories

⚠ WARNING: Fire hazard

To prevent fire or shock, Raychem brand specified connection kits must be used. Do not substitute parts or use vinyl electrical tape.

OVERVIEW

Pentair Thermal Management offers a full range of connection kits for power connections, splices, and end seals on self-regulating cable systems. These connection kits must be used to ensure proper functioning of the product and compliance with warranty, code, and approvals requirements.

Different power connection, end seal, splice, and tee kits are required depending on the area classification. Data sheets can be found on the Pentair Thermal Management web site, www.pentairthermal.com, or the Technical data sheet section of the Advanced Industrial Solutions Heat-Tracing Products & Services Catalog (H56550).

NONHAZARDOUS AND HAZARDOUS LOCATION CONNECTION KITS

Figure 9 shows the connection kits and accessories available for self-regulating heating systems.

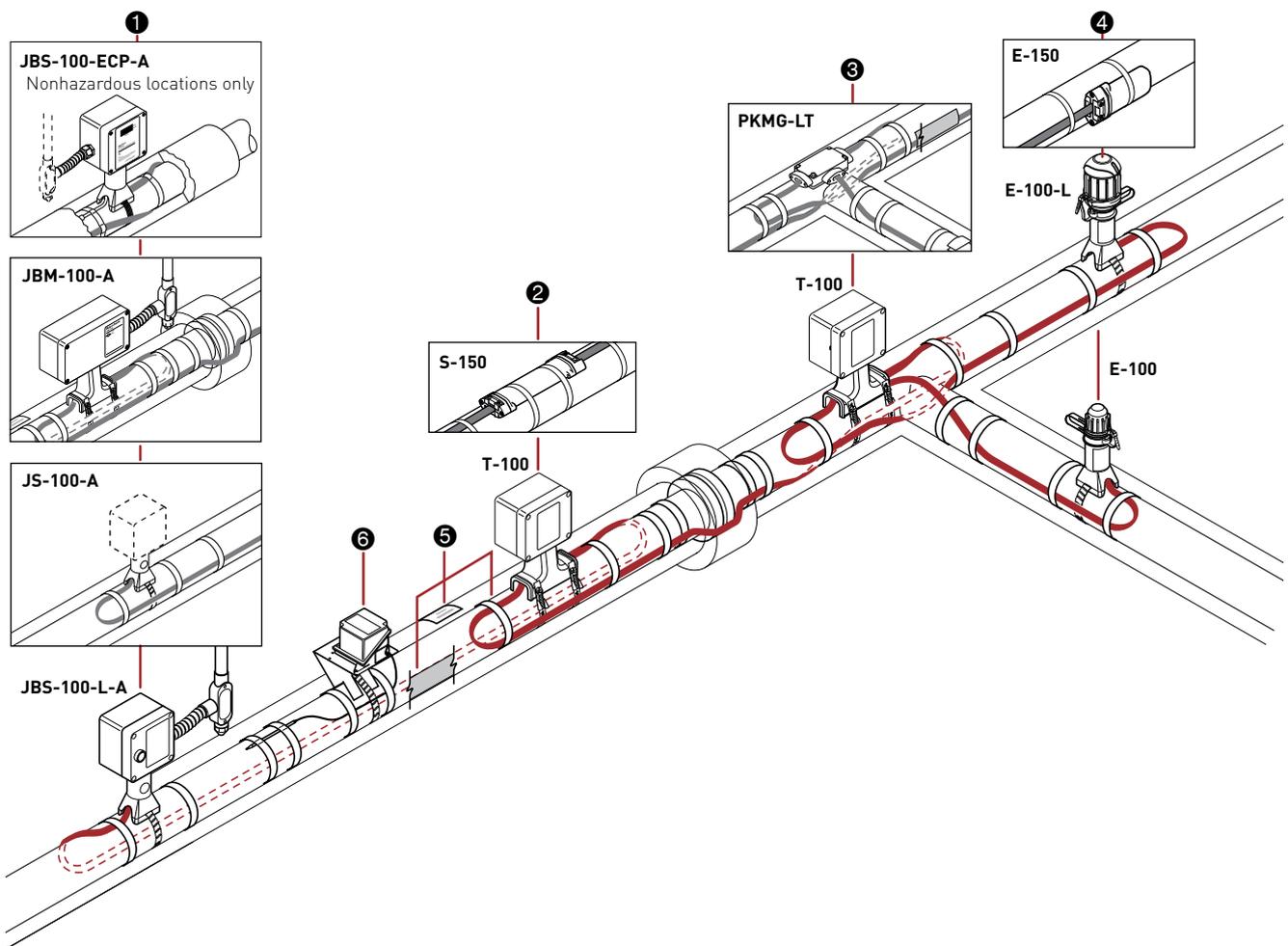


Fig. 9 Self-regulating heating system connection kits and accessories

SELF-REGULATING CABLES

TABLE 10 NONHAZARDOUS AND HAZARDOUS CONNECTION KITS AND ACCESSORY SELECTION

Description	Catalog number	Quantity
Connection Kits		
① Power connection		1 per circuit
Single heating cable	JBS-100-A	
Single heating cable with light	JBS-100-L-A	
Single heating cable with digital electronic controller	JBS-100-ECP-A (nonhazardous locations only)	
Single heating cable (user-supplied junction box)	JS-100-A	
Multiple heating cables (1, 2, or 3)	JBM-100-A	
Multiple heating cable with light	JBM-100-L-A	
② Splice connection		1 per splice
Above insulation	T-100	
Below insulation	S-150	
③ Tee connection		1 per tee
Above insulation	T-100	
Below insulation	PMKG-LT (BTV and QTVR only)	
④ End seal		1 per power connection plus 1 per tee
Above insulation	E-100	
Above insulation with light	E-100-L-A	
Below insulation	E-150	
Accessories		
⑤ Attachment tape, labels, and pipe straps		
Controls (optional)		
⑥ Thermostat — Control and Monitoring design guide (H56889)		

CID1 HAZARDOUS LOCATION CONNECTION KITS

All power connections, splices, tees, and end seals in a Division 1 location must use the HAK-C-100 connection kit and an HAK-JB3-100 or a Division 1 Nationally Recognized Testing Lab (NRTL) approved junction box.

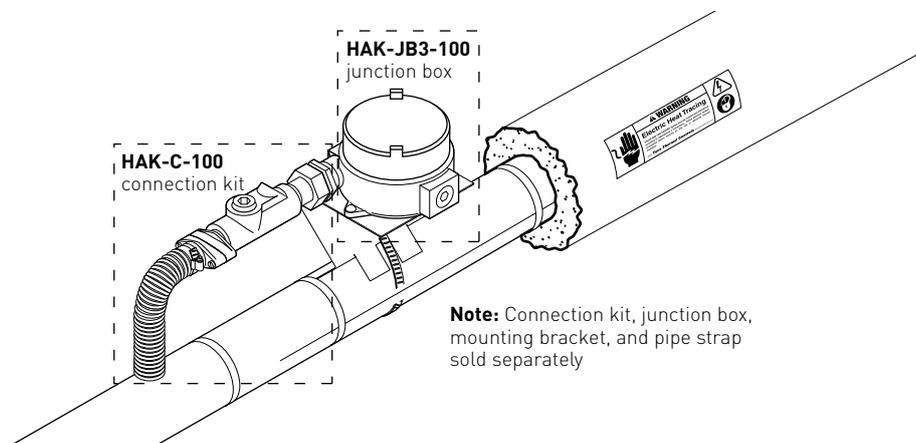


Fig. 10 CID1 hazardous location connection kits

TABLE 11 CID1 CONNECTION KIT SELECTION

Connection type	Number of HAK-C-100 kits required	Number of holes required on the junction box	Junction box catalog number	Additional materials required	
				Mounting brackets*	Pipe straps
Power	1	2	HAK-JB3-100	1	1
Splice	2	2	HAK-JB3-100	1	1
Tee	3	3	HAK-JB3-100	1	1
End seal	1	1	HAK-JB3-100	1	1

* Catalog number UMB

The HAK-C-100 kit is FM approved and CSA certified to be used for all power connections, splices, tees, and end seals in Division 1 locations.

SYSTEM CONNECTION KITS



JBS-100-A

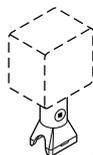
JBS-100-A Power connection for one heating cable in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal. Requires one pipe strap to be ordered separately.

With red indicator light, order JBS-100-L-A



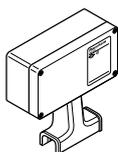
JBS-100-ECP-A

JBS-100-ECP-A Power connection and digital electronic controller. Requires one pipe strap to be ordered separately. Nonhazardous locations only.



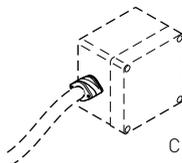
JS-100-A

JS-100-A Junction box stand for one heating cable in nonhazardous and hazardous locations. A separate customer-supplied NEMA 4X junction box is required. Includes cold-applied heating cable core seal. Requires one pipe strap to be ordered separately.



JBM-100-A

JBM-100-A Multiple-entry power connection for up to three heating cables. Can also be used as a splice or tee connection. For use in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal. Requires two pipe straps to be ordered separately. With red indicator light, order JBM-100-L-A.



C75-100-A

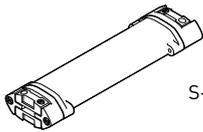
C75-100-A A NEMA 4X-rated gland kit (3/4" NPT) used to transition heating cables into a junction box in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal. A terminal block (3 x 12 AWG) is included. This kit does not include the junction box or the conduit.



T-100

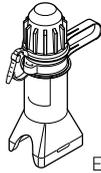
T-100 Tee or splice connection for up to three heating cables in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal. Requires two pipe straps to be ordered separately.

SELF-REGULATING CABLES



S-150

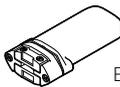
S-150 Splice kit for heating cables in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal.



E-100-A

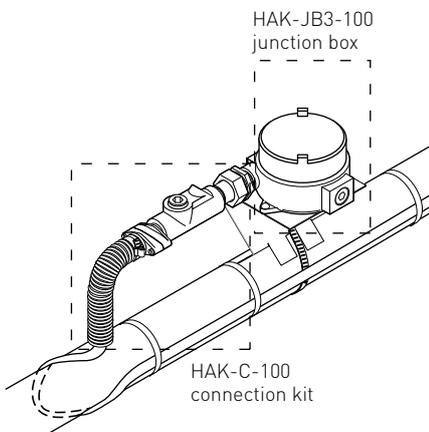
E-100-A End seal for heating cable in nonhazardous and hazardous locations. Reenterable. Includes cold-applied heating cable core seal. Requires one pipe strap to be ordered separately.

E-100-L-A Lighted version



E-150

E-150 Low-profile end seal for heating cable in nonhazardous and hazardous locations. Includes cold-applied heating cable core seal.



HAK-C-100 CID1 hazardous location connection kit for one heating cable. Junction box ordered separately.

HAK-JB3-100 CID1 hazardous location junction box for up to three entries. Requires one pipe strap and a universal mounting bracket (UMB) to be ordered separately.

ACCESSORIES

GT-66 Glass Installation Tape

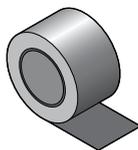
- For use on pipes other than stainless steel
- 1/2" x 66' roll
- Strap at 1-foot intervals at minimum application temperature of 40°F (5°C)



GT-66
GS-54

GS-54 Glass Installation Tape

- For use on all pipes, particularly stainless steel
- 1/2" x 54' roll
- Strap at 1-foot intervals at minimum application temperature of -40°F (-40°C)



AT-180

AT-180 Aluminum Tape

- For use on all pipe materials
- 2-1/2" x 180' roll
- Temperature class: 300°F (150°C)
- Minimum installation temperature: 32°F (0°C)

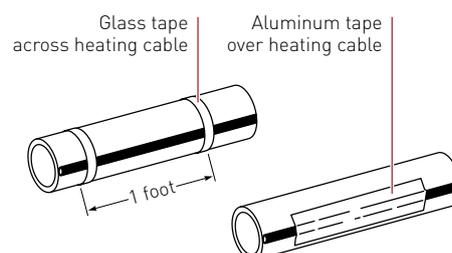


Fig. 11 Tape installation

TABLE 12 ATTACHMENT TAPE REQUIREMENTS

Tape type	Rolls needed per 100 ft of cable						
	Pipe diameter (IPS) in inches						
	1/2	1	2	3	4	6	8
GT-66	0.6	1.2	4	4	6	8	10
GS-54	0.6	1.2	4	6	6	10	12
AT-180	Use one foot of tape per foot of heating cable						



ETL

ETL (Electric Traced Label)

Attach the label to the outside of the thermal insulation weather barrier to indicate presence of electrical heat tracing. Use one label for every 10 feet (3 m) of pipe, alternating on either side of the pipe.



Pipe strap

Pipe Straps

Stainless steel pipe straps to attach connection kit to the heat-traced pipe. Use Table 13 below to assist with pipe strap selection.

TABLE 13 PIPE STRAP SELECTION

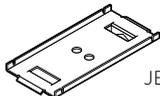
Catalog number	Pipe size
PS-01	For conduit $\leq 1"$
PS-03	For connection kits on pipes with dimensions $< 2"$
PS-10	For connection kits on pipes with dimensions $2" - 10"$
PS-20	For connection kits on pipes with dimensions $10" - 19.5"$



JBS-SPA

Small Pipe Adapters

JBS-SPA Adapter for mounting E-100, JBS-100, and JS-100-A to small pipe. ($\leq 1"$ diameter)



JBM-SPA

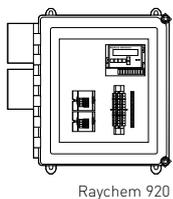
JBM-SPA Adapter for mounting JBM-100 and T-100 to small pipe. ($\leq 1"$ diameter)



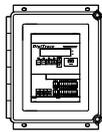
JB-DRAIN-PLUG-3/4IN

Conduit Drain

JB-DRAIN-PLUG-3/4IN Conduit drain for JBS-100, JBM-100, and JS-100-A.



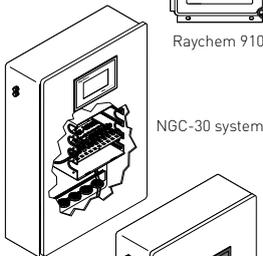
Raychem 920



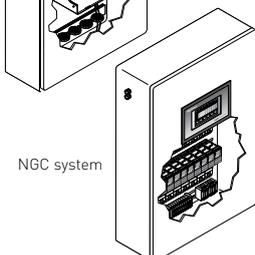
Raychem 910

Controls

For a complete selection of control and monitoring products, including thermostats, see Control and Monitoring design guide (H56889)



NGC-30 system



NGC system



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