



HEAT TRACE DESIGN GUIDE



PIPE HEAT LOSS CALCULATIONS

- Basic Heat Loss:** After determining the difference between the ambient and desired pipe maintenance temperature, T_m , use **Table 1** to figure the basic heat loss for the pipe size and insulation thickness.
- Insulation Adjustment:** Using **Table 2**, find the type of insulation being used and its insulation factor.

Table 1 Pipe Heat Loss Q_b in W/ft Based on Temperature Differential and Insulation Thickness

Nominal Pipe Size, in. (ID)	Temperature Difference Between Pipe and Ambient															
	Deg°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F	220°F	240°F	260°F
1" Insulation Thickness																
1/2"	W/ft	1.4	1.8	2.1	2.5	2.8	3.2	3.5	4.2	5.1	5.9	6.6	7.7	8.5	9.2	10.0
3/4"	W/ft	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.8	5.9	6.7	7.6	8.8	9.7	10.6	11.4
1"	W/ft	1.8	2.3	2.8	3.2	3.7	4.1	4.6	5.5	6.8	7.7	8.7	10.1	11.1	12.1	13.2
1 1/2"	W/ft	2.4	3.1	3.7	4.3	4.9	5.5	6.1	7.3	9.0	10.2	11.5	13.4	14.8	16.1	17.4
2"	W/ft	2.8	3.5	4.1	4.8	5.5	6.2	6.9	8.3	10.1	11.6	13.0	15.2	16.7	18.2	19.7
2 1/2"	W/ft	3.2	4.0	4.8	5.6	6.4	7.2	8.0	9.6	11.8	13.4	15.1	17.6	19.4	21.1	22.9
3"	W/ft	3.7	4.7	5.6	6.5	7.4	8.4	9.3	11.2	13.7	15.6	17.6	20.5	22.5	24.6	26.6
4"	W/ft	4.6	5.8	6.9	8.1	9.2	10.4	11.5	13.8	16.9	19.3	21.7	25.3	27.8	30.4	32.9
6"	W/ft	6.4	8.0	9.6	11.2	12.8	14.4	16.0	19.2	23.5	26.9	30.2	35.2	38.7	42.2	45.8
8"	W/ft	8.1	10.1	12.1	14.1	16.2	18.2	20.2	24.2	29.7	33.9	38.2	44.4	48.9	53.3	57.8
10"	W/ft	9.9	12.4	14.8	17.3	19.8	22.2	24.7	29.6	36.3	41.5	46.7	54.3	59.8	65.2	70.6
12"	W/ft	11.6	14.5	17.4	20.3	23.2	26.1	29.0	34.8	42.6	48.7	54.8	63.8	70.2	76.6	82.9
14"	W/ft	12.6	15.8	19.0	22.1	25.3	28.4	31.6	37.9	46.5	53.1	59.7	69.5	76.5	83.4	90.4
16"	W/ft	14.3	17.9	21.5	25.1	28.7	32.3	35.9	43.0	52.7	60.2	67.8	78.9	86.8	94.6	102.5
18"	W/ft	16.0	20.1	24.1	28.1	32.1	36.1	40.1	48.1	58.9	67.4	75.8	88.2	97.0	105.9	114.7
20"	W/ft	17.7	22.2	26.6	31.0	35.4	39.9	44.3	53.2	65.1	74.4	83.7	97.5	107.2	117.0	126.7
22"	W/ft	19.4	24.3	29.1	34.0	38.8	43.7	48.5	58.2	71.3	81.5	91.7	106.7	117.4	128.0	138.7
24"	W/ft	21.1	26.4	31.6	36.9	42.2	47.4	52.7	63.2	77.5	88.5	99.6	115.9	127.5	139.1	150.7
1.5" Insulation Thickness																
1/2"	W/ft	1.1	1.4	1.7	2.0	2.2	2.5	2.8	3.5	4.1	4.7	5.5	6.2	6.8	7.4	8.0
3/4"	W/ft	1.2	1.6	1.9	2.2	2.5	2.8	3.1	3.9	4.6	5.2	6.1	6.8	7.5	8.2	8.9
1"	W/ft	1.4	1.8	2.2	2.5	2.9	3.2	3.6	4.5	5.3	6.0	7.1	7.9	8.7	9.5	10.3
1 1/2"	W/ft	1.8	2.3	2.8	3.2	3.7	4.1	4.6	5.8	6.8	7.7	9.1	10.1	11.1	12.1	13.2
2"	W/ft	2.1	2.6	3.1	3.6	4.2	4.7	5.2	6.6	7.6	8.7	10.3	11.4	12.6	13.7	14.9
2 1/2"	W/ft	2.4	3.0	3.5	4.1	4.7	5.3	5.9	7.4	8.7	9.9	11.7	13.0	14.3	15.6	16.9
3"	W/ft	2.7	3.4	4.1	4.8	5.4	6.1	6.8	8.6	10.0	11.4	13.5	15.0	16.5	18.0	19.4
4"	W/ft	3.3	4.2	5.0	5.8	6.6	7.5	8.3	10.5	12.2	13.9	16.4	18.3	20.1	21.9	23.7
6"	W/ft	4.5	5.7	6.8	7.9	9.0	10.2	11.3	14.2	16.6	19.0	22.4	24.9	27.3	29.8	32.3
8"	W/ft	5.6	7.1	8.5	9.9	11.3	12.7	14.1	17.8	20.7	23.7	27.9	31.0	34.1	37.2	40.3
10"	W/ft	6.8	8.0	10.3	12.0	13.7	15.4	17.1	21.5	25.1	28.7	33.9	37.6	41.4	45.1	48.9
12"	W/ft	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.2	29.4	33.6	39.6	44.0	48.4	52.8	57.2
14"	W/ft	8.7	10.9	13.0	15.2	17.4	19.5	21.7	27.3	31.9	36.5	43.0	47.7	52.5	57.3	62.1
16"	W/ft	9.8	12.3	14.8	17.2	19.7	22.1	24.6	31.0	36.2	41.3	48.7	54.1	59.5	64.9	70.4
18"	W/ft	11.0	13.7	16.4	19.2	21.9	24.7	27.4	34.5	40.3	46.0	54.3	60.3	66.3	72.3	78.4
20"	W/ft	12.1	15.1	18.1	21.1	24.2	27.2	30.2	38.1	44.4	50.7	59.8	66.4	73.1	79.7	86.4
22"	W/ft	13.2	16.5	19.8	23.1	26.4	29.7	33.0	41.6	48.5	55.4	65.3	72.6	79.9	87.1	94.4
24"	W/ft	14.3	17.9	21.5	25.1	28.6	32.2	35.8	45.1	52.6	60.1	70.9	78.8	86.6	94.5	102.4

Table 2 Insulation Adjustment Factors

Pipe Insulation Type	Insulation Factor
Glass fiber (ASTM C547)	1.00
Calcium silicate (ASTM C533)	1.48
Cellular glass (ASTM C552)	1.48
Rigid cellular urethane (ASTM C591)	0.64

Pipe Insulation Type	Insulation Factor
Foamed elastomer (ASTM C534)	1.16
Mineral fiber blanket (ASTM C553)	1.16
Expanded perlite (ASTM C610)	1.90

- Calculate Q_b :** Multiply the basic heat loss figure from **Table 1** by the adjustment factor from **Table 2** to calculate the estimated heat loss, Q_e , in watts per foot of pipe length.
- Correct for Indoor Location/ Wind Speed:** If location is indoors, multiply Q_e by 0.9. **Table 1** is based on 10% safety factor and 20 mph wind speed; add 5% margin for each 5 mph over 20 mph wind speed.

Nominal Pipe Size, in. (ID)	Temperature Difference Between Pipe and Ambient															
	Deg°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F	220°F	240°F	260°F
2" Insulation Thickness																
1/2"	W/ft	1.0	1.2	1.4	1.7	1.9	2.2	2.4	3.0	3.5	4.0	4.8	5.3	5.8	6.3	7.2
3/4"	W/ft	1.1	1.4	1.6	1.9	2.2	2.4	2.7	3.4	4.0	4.5	5.3	5.9	6.5	7.1	8.1
1"	W/ft	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.8	4.4	5.0	5.9	6.6	7.3	7.9	9.0
1 1/2"	W/ft	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.8	5.6	6.4	7.5	8.4	9.2	10.0	11.4
2"	W/ft	1.7	2.2	2.6	3.0	3.4	3.9	4.3	5.4	6.3	7.2	8.5	9.5	10.4	11.4	12.9
2 1/2"	W/ft	1.9	2.4	2.9	3.4	3.8	4.3	4.8	6.0	7.1	8.1	9.5	10.6	11.6	12.7	14.4
3"	W/ft	2.2	2.8	3.3	3.9	4.4	5.0	5.5	6.9	8.1	9.2	10.9	12.1	13.3	14.5	16.4
4"	W/ft	2.6	3.3	4.0	4.6	5.3	5.9	6.6	8.3	9.7	11.1	13.1	14.5	16.0	17.4	19.7
6"	W/ft	3.6	4.5	5.3	6.2	7.1	8.0	8.9	11.2	13.1	15.0	17.6	19.6	21.5	23.5	26.6
8"	W/ft	4.4	5.6	6.7	7.8	8.9	10.0	11.1	14.0	16.3	18.6	22.0	24.4	26.9	29.3	33.2
10"	W/ft	5.3	6.7	8.0	9.3	10.6	12.0	13.3	16.8	19.6	22.3	26.3	29.3	32.2	35.1	39.8
12"	W/ft	6.2	7.8	9.3	10.9	12.4	14.0	15.5	19.5	22.8	26.0	30.7	34.1	37.5	40.9	46.3
14"	W/ft	6.7	8.4	10.1	11.8	13.4	15.1	16.8	21.2	24.7	28.2	33.3	37.0	40.7	44.4	50.2
16"	W/ft	7.6	9.5	11.3	13.2	15.1	17.0	18.9	23.8	27.8	31.8	37.4	41.6	45.7	49.9	56.5
18"	W/ft	8.4	10.5	12.6	14.7	16.8	18.9	21.0	26.5	30.9	35.3	41.6	46.2	50.8	55.4	62.8
20"	W/ft	9.2	11.6	13.9	16.2	18.5	20.8	23.1	29.1	34.0	38.8	45.7	50.8	55.9	61.0	69.1
22"	W/ft	10.1	12.6	15.2	17.7	20.2	22.7	25.3	31.8	37.1	42.4	50.0	55.6	61.1	66.7	75.5
24"	W/ft	11.0	13.7	16.4	19.2	21.9	24.7	27.4	34.5	40.3	46.0	54.3	60.3	66.3	72.3	81.9
3" Insulation Thickness																
1/2"	W/ft	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	2.9	3.4	4.0	4.4	4.8	5.5	6.0
3/4"	W/ft	0.9	1.1	1.3	1.5	1.8	2.0	2.2	2.8	3.2	3.7	4.4	4.8	5.3	6.1	6.67
1"	W/ft	1.0	1.3	1.5	1.8	2.0	2.3	2.5	3.2	3.7	4.2	5.0	5.5	6.1	6.9	7.5
1 1/2"	W/ft	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.8	4.4	5.0	5.9	6.6	7.3	8.3	9.0
2"	W/ft	1.3	1.7	2.0	2.3	2.6	3.0	3.3	4.2	4.9	5.5	6.5	7.3	8.0	9.1	9.9
2 1/2"	W/ft	1.5	1.9	2.2	2.6	3.0	3.3	3.7	4.7	5.4	6.2	7.3	8.1	9.0	10.2	11.1
3"	W/ft	1.7	2.1	2.5	2.9	3.4	3.8	4.2	5.3	6.2	7.1	8.3	9.2	10.2	11.6	12.6
4"	W/ft	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.3	7.4	8.4	9.9	11.0	12.1	13.8	15.0
6"	W/ft	2.6	3.3	3.9	4.6	5.2	5.9	6.5	8.2	9.6	10.9	12.9	14.3	15.7	17.9	19.4
8"	W/ft	3.2	4.0	4.8	5.6	6.4	7.2	8.0	10.1	11.8	13.4	15.8	17.6	19.4	22.1	23.9
10"	W/ft	3.8	4.8	5.7	6.7	7.6	8.6	9.5	12.0	14.0	16.0	18.8	20.9	23.0	26.2	28.4
12"	W/ft	4.4	5.5	6.5	7.6	8.7	9.8	10.9	13.7	16.0	18.3	21.6	24.0	26.4	30.1	32.6
14"	W/ft	4.7	5.9	7.1	8.3	9.4	10.6	11.8	14.9	17.3	19.8	23.4	26.0	28.6	32.6	35.3
16"	W/ft	5.3	6.7	8.0	9.3	10.6	12.0	13.3	16.8	19.6	22.3	26.3	29.3	32.2	36.7	39.8
18"	W/ft	5.9	7.4	8.8	10.3	11.8	13.2	14.7	18.5	21.6	24.7	29.1	32.3	35.6	40.6	44.0
20"	W/ft	6.4	8.1	9.7	11.3	12.9	14.5	16.1	20.3	23.7	27.0	31.9	35.4	39.0	44.4	48.1
22"	W/ft	7.0	8.8	10.5	12.3	14.0	15.8	17.5	22.1	25.7	29.4	34.7	38.5	42.4	48.3	52.3
24"	W/ft	7.6	9.5	11.3	13.2	15.1	17.0	18.9	23.8	27.8	31.8	37.4	41.6	45.7	52.2	56.5

1. Select Heating Cable Family: Based on the maximum maintenance temperature rating, maximum exposure temperature rating, and area classification, select the heating cable family from **Table 3**. (See Chromalox Heat Trace Cable Product Information Sheets for cable construction options, voltage ratings, and wattage outputs available.)

2. Select Thermal Output Rating:

- (a) For Metal Pipes – Use Figures 1, 2 or 4
 (b) For Plastic Pipes – Use Figure 3 by finding the intersection of the calculated heat loss, Q_r , and pipe maintenance temperature, T_m . Select the cable with a thermal output that equals or exceeds Q_r at T_m .

Table 3 Heating Cable Families

Heating Cable Family	Area Classification	Pipe Material	Maximum Maintenance Temperature	Maximum Exposure Temperature (Power Off)	Approvals	
					U.S.	Other
SRL (Self-Regulating Low Temperature)	Ordinary	Plastic/Metal	150°F / 65°C	185°F / 85°C	UL, CSA, FM	GOST, Cenelec, CE, ATEX
	Class I, Div.2, Gr. B, C, D				CSA, FM, (Gr. A, CSA Only)	GOST, Cenelec, CE, ATEX
	Class II, Div.2, Gr. E, F, G				CSA, FM, (Gr. E, CSA Only)	GOST, Cenelec, CE
	Class III, Div.2				FM Only	GOST, Cenelec, CE, ATEX
SRM/E (Self-Regulating Medium Temperature)	Ordinary	Metal Only	302°F / 150°C	420°F / 215°C	UL, CSA, FM	GOST, Cenelec, CE, ATEX
	Class I, Div.2, Gr. A, B, C, D				CSA, FM, (Gr. A, CSA Only)	GOST, Cenelec, CE, ATEX
	Class II, Div.2, Gr. F, G				CSA Only	GOST, Cenelec, CE, ATEX
	Class III				UL, CSA, FM Pending	GOST, Cenelec, CE, ATEX Pending
HSRL (H-Self-Regulating Low Temperature)	Ordinary	Plastic/Metal	150°F / 65°C	185°F / 85°C	CSA, FM	
	Class I, Div.1, Gr. B, C, D				CSA, FM	
	Class II, Div.1, Gr. E, F, G				CSA, FM	
	Class III, Div.1				CSA, FM	
HSRM (H-Self-Regulating Medium Temperature)	Ordinary	Metal Only	302°F / 150°C	420°F / 215°C	CSA, FM	
	Class I, Div.1, Gr. B, C, D				CSA, FM	
	Class II, Div.1, Gr. E, F, G				CSA, FM	
	Class III, Div.1				CSA, FM	
CWM (Constant Wattage)	Ordinary	Metal Only	Consult Factory	392°F / 200°C	UL, CSA	
	Hazardous Area, Consult Factory					
MI (Mineral Insulated)	Ordinary	Metal Only	Consult Factory	1,100°F / 595°C	CSA, FM	
	Class I, Div.2, Gr. B, C, D				CSA, FM	
	Class II, Div.2, Gr. E, F, G				CSA, FM	
	Class III				CSA, FM	

NOTE: It is the responsibility of the facility manager or engineer to determine the classification of an area where heat trace will be installed. The factory can help determine a suitable cable based on the information provided.

3. Determine Total Cable Length: In addition to pipe length, in-line components such as valves, flanges, and pipe supports require additional heat tracing to maintain T_m . See **Table 4**. Calculate the total cable length required by combining the pipe length with the additional lengths needed for all the other components.

Table 4 Additional Cable Lengths Required for In-Line Components Based on Pipe IPS (Iron Pipe Size)

Piping Size	Gate Valve	Globe Valve	Ball Valve	Butterfly Valve	Shoe Support	Hanger Support	Sleeper Support	Flange Pair
	ft							
1/2 in.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.30
3/4 in.	1.50	1.00	1.00	1.00	1.50	1.00	1.00	0.30
1 in.	2.00	1.00	1.00	1.00	1.50	1.00	1.00	0.30
1 1/2 in.	2.50	1.50	1.50	1.50	2.00	2.00	2.00	0.30
2 in.	2.50	2.00	2.00	2.00	2.00	2.00	2.00	0.30
2 1/2 in.	2.50	2.00	2.00	2.00	2.00	2.00	2.00	0.30
3 in.	3.00	2.50	2.50	2.50	2.00	2.00	2.00	0.50
4 in.	4.00	3.00	3.00	3.00	2.50	2.50	2.50	0.50
6 in.	5.00	3.50	3.50	3.50	2.50	2.50	2.50	0.80
8 in.	7.00	4.00	4.00	4.00	2.50	2.50	2.50	0.80
10 in.	8.00	4.50	4.50	4.50	3.00	3.00	3.00	0.80
12 in.	9.00	5.00	5.00	5.00	3.00	3.00	3.00	0.80
14 in.	10.00	5.50	5.50	5.50	3.00	3.00	3.00	1.00
16 in.	11.00	6.00	6.00	6.00	3.50	3.50	3.50	1.00
18 in.	12.00	7.00	7.00	7.00	3.50	3.50	3.50	1.00
20 in.	13.00	7.50	7.50	7.50	3.50	3.50	3.50	1.00
22 in.	13.00	7.50	7.50	7.50	3.50	3.50	3.50	1.00
24 in.	15.00	8.00	8.00	8.00	4.00	4.00	4.00	1.00

Figure 1 SRL & HSRL – Thermal Output Ratings on Insulated Metal Pipe

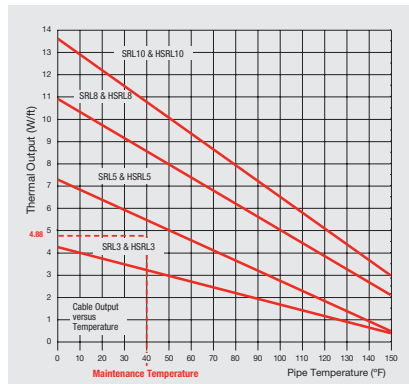


Figure 2 SRM/E & HSRM – Thermal Output Ratings on Insulated Metal Pipe

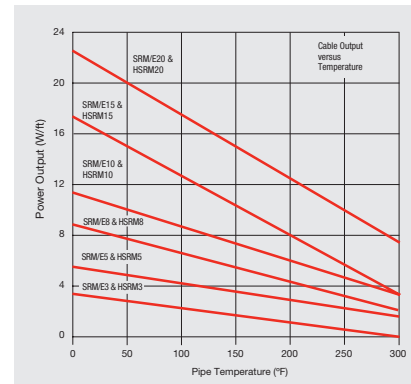


Figure 3 SRL & HSRL – Thermal Output Ratings on Plastic Pipe with Aluminum Tape

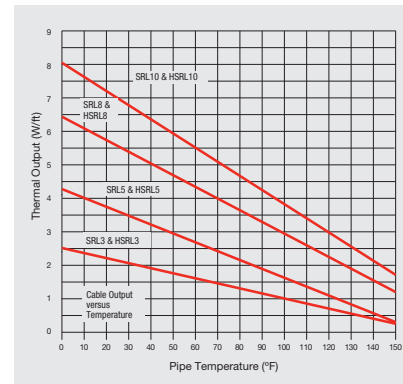
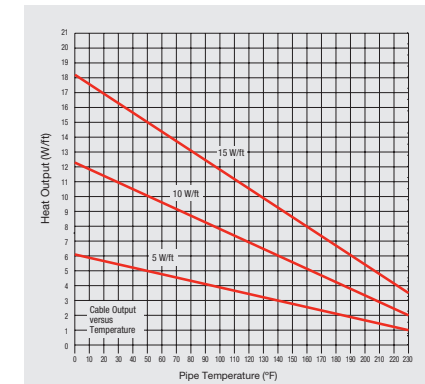


Figure 4 SRP – Thermal Output Ratings on Insulated Metal Pipe



CONTROL SYSTEMS

IntelliTrace



- Up to 72 Loops at 40 A/circuit
- Full monitoring, powerful sensor mapping, Modbus RS485 or Ethernet communications & supervisory control
- Extremely intuitive programming via large touch screen HMI, ordinary or hazardous (Division 2) areas

WeatherTrace



- Up to 40 loops
- Pre-wired and assembled monitoring and distribution (saves time on installation)
- Includes the Sentinel monitoring system

ITC Controller



- 1 or 2 circuits, 40 A/circuit, SSR control
- Full monitoring, RS485 or Ethernet communications, up to 2 RTD inputs/circuit, soft start, alarms
- Bright display & easy to program, only 8x10x8 in./203x254x203 mm, Division 2 hazardous area

Combination Single Point Temperature Controls & Power Connection Boxes

UAS Ambient-Sensing



- 0° to 225°F / 0° to 107°C temperature rating
- 120 to 480 Vac, 22 A switching capability
- Freeze protection applications

UBC Line-Sensing



- 0° to 400°F / 0° to 205°C set points
- 120 to 480 Vac, 22 A switching capability
- Freeze protection applications

DTS-HAZ Digital ThermoStat / Power Connection Line- or Ambient-Sensing



- 30 A/120 to 277 Vac, SSR control, large LED display
- Programmable with soft start, alarm contact, Class I, Division 2 & ATEX
- Applications: freeze protection/process temperature maintenance

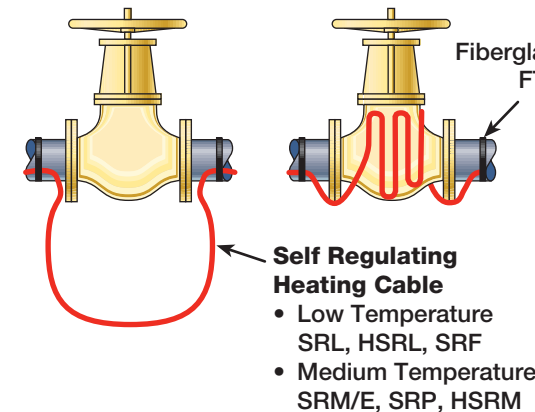
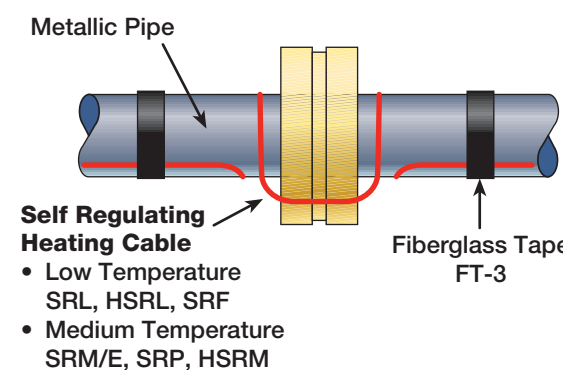
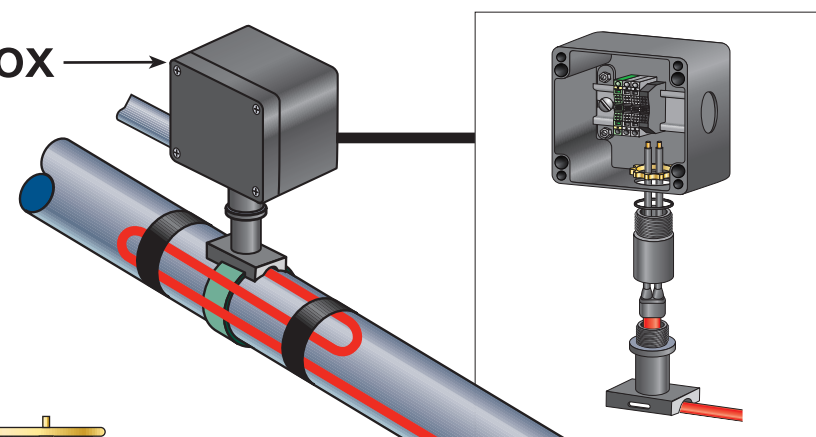


Electric Heat Trace Quick Install Guide

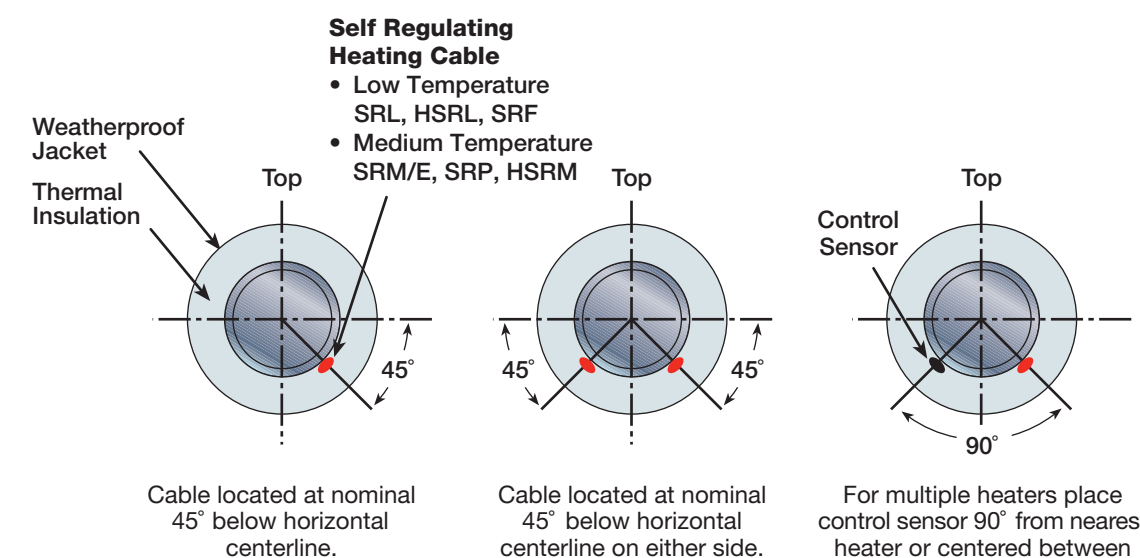
Quick Install Guide is a specification tool only. Always refer to proper installation instructions when installing heat trace cable.

Now Approved for Division 2 Hazardous Area Use.

Power Connection Box (UPC)



Heating Cable/Sensor Location

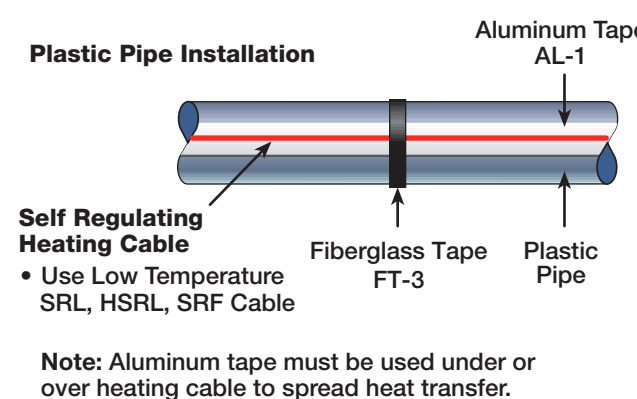
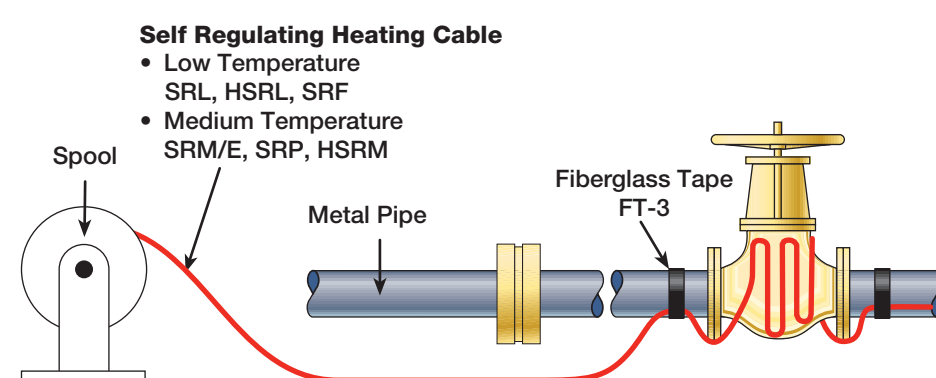


Installation Tips

- Temporarily position cable on pipe and equipment to ensure proper distribution.
- Leave a loop of cable at heat sinks such as valves, pipe supports, and flange sets. Use FT-3 fiberglass tape to secure cable to pipe at 18 in. / 455 mm (nom) intervals using recommended method.
- Always observe minimum bend radius.

Step 1

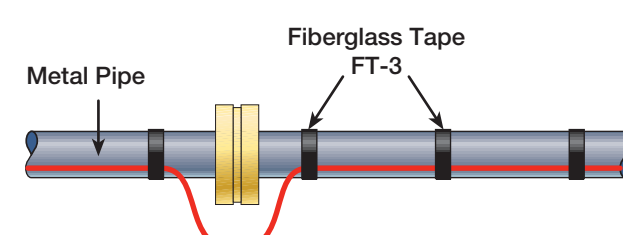
Start tracing at the end of the pipe and work your way back to spool.



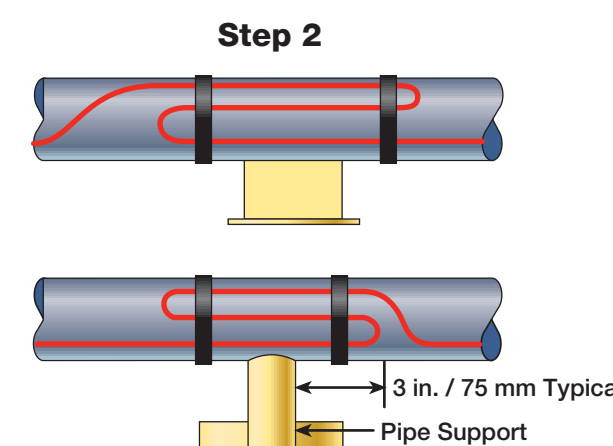
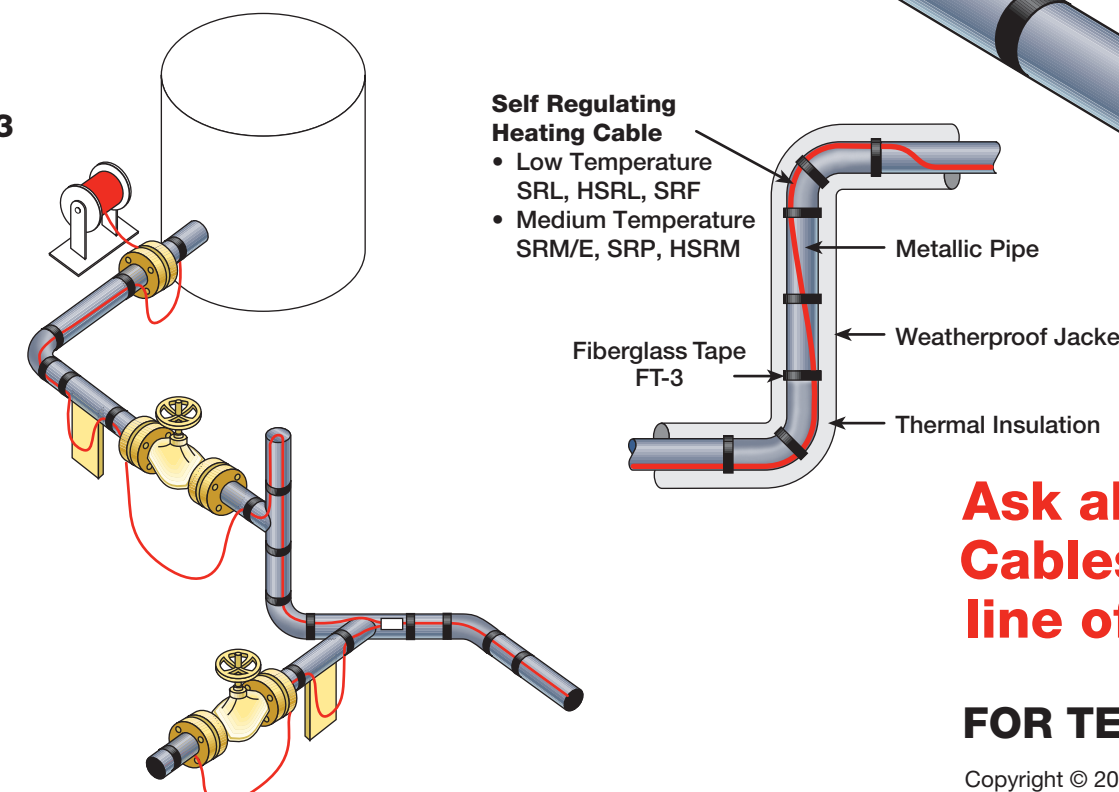
Note: Aluminum tape must be used under or over heating cable to spread heat transfer.

Step 2

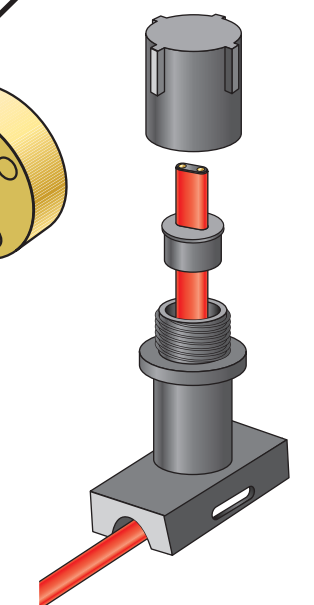
Leave a loop of cable at heat sinks such as valves, pipe supports and flange sets. Use FT-3 fiberglass tape to secure cable to pipe at 18 in. / 455 mm intervals.



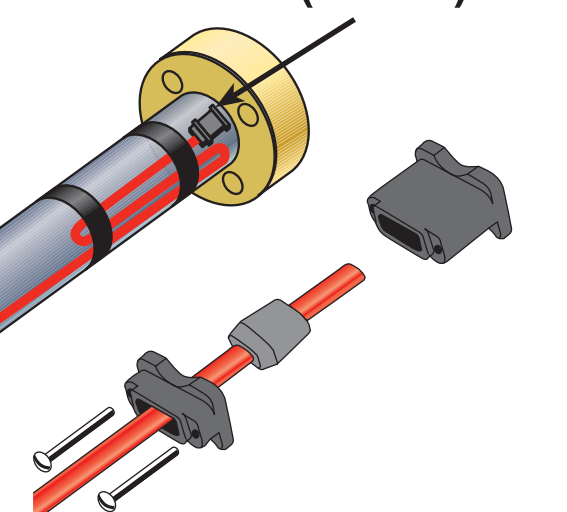
Step 3



Above Insulation Cable End Seal (UES)



Below Insulation Cable End Seal (RTES)



Ask about Chromalox Class 1 Division 1. Cables & Accessories as well as a full line of High-Temperature Cables.

FOR TECHNICAL SUPPORT CALL 888-996-9258.

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Installation Tips

- Do not twist buss wires together at end of circuit
- Insulate all conductive parts
- Seal all electrical connections against moisture
- Seal ends of exposed cable during installation
- Do not expose cables to temperatures above their maximum ratings
- Install cable with aluminum tape for use on plastic pipes
- Locate ambient temperature sensors in coldest expected area
- Locate pipe temperature sensors at lowest expected line temperature
- Use sufficient cable to trace additional heat sinks
- Install cable so that valves can be removed without removing cable



SRL Cable

- 150°F / 65°C Maximum Maintenance
- 185°F / 85°C Maximum Exposure
- 3 to 10 W/ft / 10 to 33 W/m
- 16 AWG with Optional TPE or Fluoropolymer Jacket



SRP Cable

- 225°F / 110°C Maintenance Temperature
- 275°F / 135°C Maximum Exposure Temperature
- 5 to 15 W/ft / 16 to 49 W/m
- 16 AWG with Optional Fluoropolymer Jacket



SRM Cable

- 302°F / 150°C Maximum Maintenance
- 420°F / 215°C Maximum Exposure
- 5 to 20 W/ft / 16 to 66 W/m
- 16 AWG with Optional Fluoropolymer Jacket

Important Safeguards

Mechanical Inspection

- Inspect all insulation and weatherproofing
- Inspect all junction box, connection box, and sensor connections
- Verify all circuits have been properly grounded
- Verify all circuits are connected in proper panel locations
- Verify proper circuit breakers are in place (always use 30 mA trip GFI-type breakers)
- Verify all circuit lengths are within manufacturer's specified limits
- Verify all proper safety warnings are in place
- Verify all end seal, splice/tee locations are marked on lagging

Electrical Tests

- Insulation Resistance (Megger)
 - ✓ Before tracing pipes
 - ✓ After installing terminations
 - ✓ Before insulating pipes
 - ✓ After insulating pipes
 - ✓ Before energizing system
- Circuit Voltage
- Initial Current
 - ✓ Note ambient temp and pipe temp
- Stabilized Current (15 minutes of operation)
 - ✓ Note ambient temp and pipe temp
- Always use ground fault circuit breakers (30 mA trip level)

Tools Needed

- Wire Cutters/Strippers
- Megger
- Phillips Head Screwdriver
- Standard Screwdriver
- Voltmeter
- Utility Knife
- Hammer