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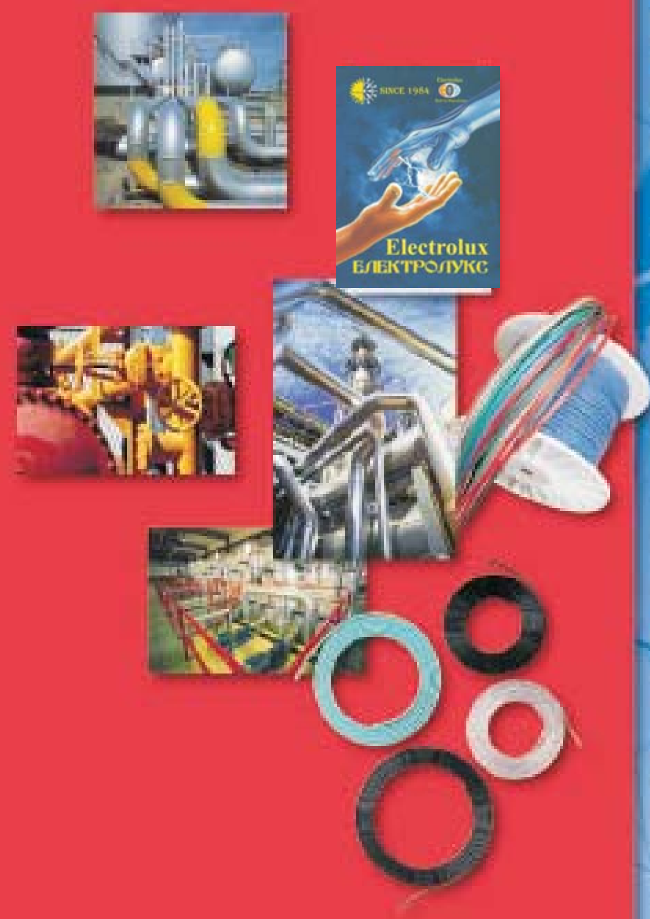
PRECISION HEAT AND CONTROL

Electrical Heat Tracing Systems
Design Guide

ELECTRIC HEAT TRACING SYSTEMS



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INTRODUCTION

This design guide provides a step-by-step approach for the design, specification, and selection of a bill of materials for an electric heat tracing system. Electric heat tracing systems are designed to make up for the heat lost from process system equipment through the thermal insulation. In some cases, the heat tracing system can be used for system heat-up at initial startup or after a power shutdown.

The information in this design guide will allow the user to design, specify and select a complete bill of materials for freeze protection or process maintenance applications for a piping system or tank. By following the steps in this guide the user can easily select a complete bill of materials for the system, including heating cable, connection accessories, and temperature controls.

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THERMAL DESIGN-TANKS

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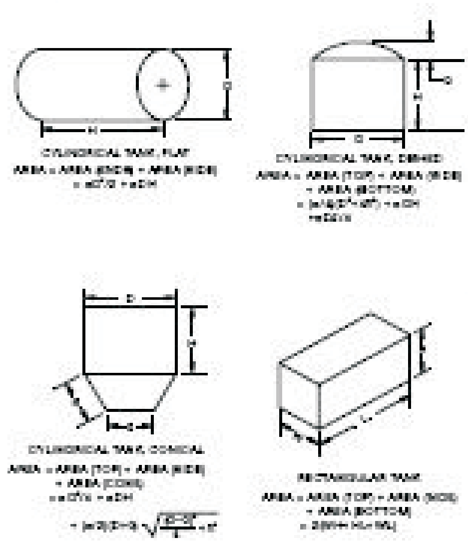
THERMAL DESIGN—TANKS



Collect the following information for each tank.

Maintenance Temperature, T_m: ______

Minimum Ambient Temperature, T_a: ______

Location, Indoor/Outdoor: ______

Wind Speed, if applicable: ______

Tank Shape and Surface Area: ______

Additional Safety Factor, if required: ______

Thermal Insulation Type and Thickness: ______

Example:

English

Maintenance Temperature, T_m:	40°F
Minimum Ambient Temperature, T_a:	-20°F
Location, Indoor/Outdoor:	Outdoor
Wind Speed, if applicable:	20 mph
Tank Shape and Surface Area:	Steel Horizontal Cylinder 3 ft dia. 6 ft long
Additional Safety Factor, if required:	None
Thermal Insulation Type and Thickness:	2" Cellular Glass

Example:

Metric

Maintenance Temperature, T_m:	4.4°C
Minimum Ambient Temperature, T_a:	-28.9°C
Location, Indoor/Outdoor:	Outdoor
Wind Speed, if applicable:	32 kph
Tank Shape and Surface Area:	Steel Horizontal Cylinder 0.92 m dia. 1.83 m long
Additional Safety Factor, if required:	None
Thermal Insulation Type and Thickness:	51 mm Cellular Glass

Step 1. Calculate ΔT

$\Delta T = T_m - T_a$

English

$= 40°F - (-20°F)$

$= 60°F$

Metric:

$= 4.4°C - (-28.9°C)$

$= 33.3°C$

Table 3

Heat Loss (Q_B) for Various Insulation Thicknesses

Insulation Thickness		Heat Loss (Q_B)	
in.	mm	W/ft²/°F	W/m²/°C
½	12.7	0.161	3.120
1	25.4	0.081	1.569
1½	38.1	0.054	1.046
2	50.8	0.040	0.775
3	76.2	0.027	0.523
4	101.6	0.020	0.388
5	127.0	0.016	0.130
6	152.4	0.013	0.252

NOTE: Heat loss values based on 20 mph (32 kph) wind, 10% safety factor, and Fiberglas® insulation at 50°F (10°C).

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THERMAL DESIGN-TANKS

Step 2. Determine Total Surface Area of Tank

Most tanks are a combination of shapes. Determine the surface area of each section and then add the areas for each section to determine the overall surface area, A.

$A = \pi D^2/2 + \pi DH$

English
$= (3.14)(3\ ft)^2/2 + (3.14)(3\ ft)(6\ ft)$
$= 70.7\ ft^2$

Metric
$= (3.14)(0.92\ m)^2/2 + (3.14)(0.92\ m)(1.83\ m)$
$= 6.6\ m^2$

Step 3. Determine Q_T

Find Q_T in Table 3 for the corresponding insulation thickness.

Step 4. Calculate Heat Loss, Q

$Q = (Q_T)(\Delta T)(A)$

English
$= (0.040\ W/ft^2/°F)(60°F)(70.7\ ft^2)$
$= 170\ W$

Metric
$= (0.775\ W/m^2/°C)(33.3°C)(6.6 m^2)$
$= 170\ W$

Step 5. Adjust for Insulation

Q, as found in the step above, must be adjusted for the insulation type. Multiply your heat loss by I_B, the Insulation Adjustment Factor, from the values in Table 2.

Using the Insulation Adjustment Factor (I_B) for cellular glass (1.48):
$Q_F = Q \times I_B$
$= 170\ W \times 1.48$
$= 252\ W$

Step 6. Correct for Indoor Location/Windspeed

If the application is indoors, multiply Q_F by 0.9. Since Table 3 is based on 20 mph (32 kph) windspeed, add 5% margin for each additional 5 mph (8 kph) over 20 mph (32 kph).

Step 7. Correct for Additional Safety Factors

Step 8. Additional Equipment Heat Losses

Equipment such as ladders, manways, and support legs act as heat sinks and increase the overall heat loss of the tanks. For each piece of equipment, use Table 4 to calculate equipment heat loss and add to the heat loss calculated above.

For example, additional heat loss for 4 support legs:
$Q_A = (Q_E)\ (\Delta T) \times$ number of legs

English
$= (0.5\ W/°F)(60°F) \times 4$
$= 120\ W$

Metric
$= (0.9\ W/°C)(33.3°C) \times 4$
$= 120\ W$

Step 9. Calculate the Cable Length Required

To determine the length required, take the total heat loss as calculated in the previous steps and divide by the chosen cable output at the maintenance temperature. (See Figures 1-4.)

$Q = Q_F + Q_A$
$= 252\ W + 120\ W$
$= 372\ W$

SRL5-CT Output @ 40°F = 4.8 W/ft
$L = 372\ W \div 4.8\ W/ft$
$L = 78\ ft$

Table 4
Tank Equipment Heat Loss Calculation (Q_E)

Support Legs	0.5 W/°F (0.9 W/°C) x number of legs
Ladder	2.5 W/°F (4.5 W/°C) x number of ladders
Manways	10.0 W/°F (18.0 W/°C) x number of manways

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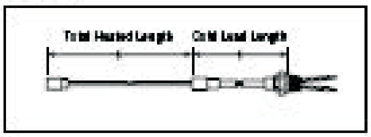
TEHNICKA PRESMETKA NA EL.GREEN KABEL

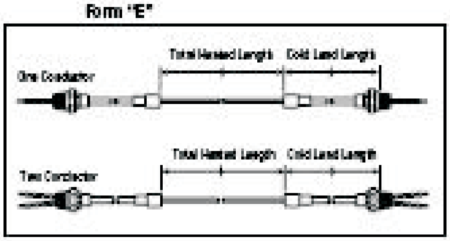
MINERAL INSULATED CABLE DESIGN

Mineral Insulated Cable can be manufactured into the heater designs shown below as Form "A" and Form "E". The following information is required to properly design mineral insulated cable units. Determine the following information and contact the Chromalox Application Group for assistance (see back cover).

Form "A"



Form "E"



For Pipe
- Length: ____________
- Diameter: ____________
- Material: ____________

For Tank
- Length: ____________
- Width: ____________
- Height: ____________
- Radius: ____________
- Diameter: ____________
- Surface Area: ____________
- Material: ____________

Type of Insulation: ____________
Insulation Thickness: ____________
Voltage: ____________
Maintenance Temperature: ____________
Minimum Ambient Temperature: ____________
Minimum Startup Temperature: ____________
Maximum Exposure Temperature: ____________
Area Classification: ____________
Indoor or Outdoor: ____________
Maximum Wind Speed: ____________
Corrosive(s) Present: ____________
Safety Factor: ____________

Equipment and Quantity:
- Flange Pair: ____________
- Pipe Support: ____________
- Butterfly Valve: ____________
- Ball Valve: ____________
- Glove Valve: ____________
- Gate Valve: ____________

Desired Cable Form:
- Form A: ____________
- Form E:
  - One-Conductor: ____________
  - Two-Conductor: ____________

Desired Cold Lead Length: ____________

MINERAL INSULATED CABLE DESIGN

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HEATING CABLE SELECTION

Figure 3

SRL & HSRL – Thermal Output Ratings on Plastic Pipes with Aluminum Tape Over Cable

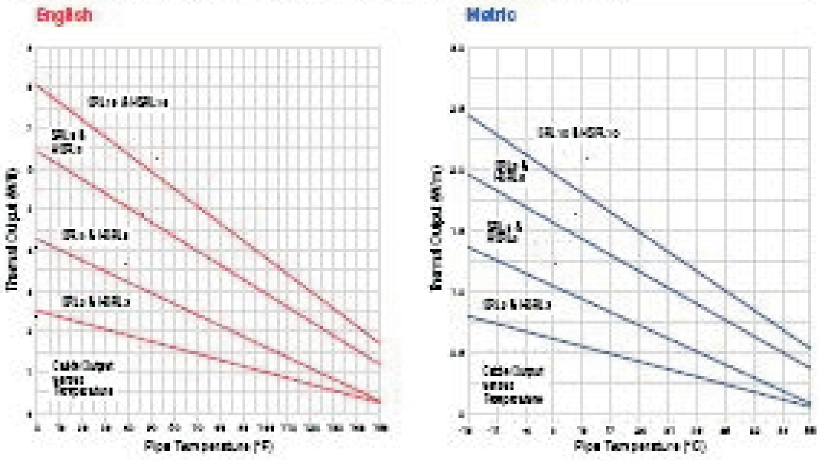
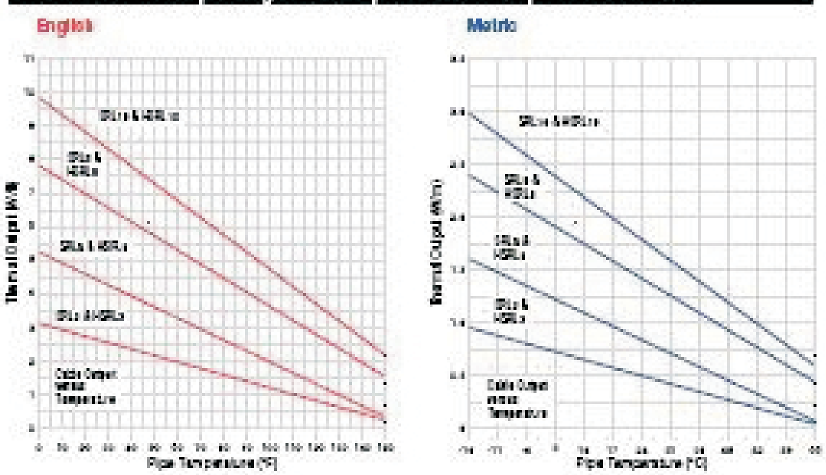


Figure 4

SRL & HSRL – Thermal Output Ratings on Plastic Pipes with Aluminum Tape Under and Over Cable



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THERMAL DESIGN—PIPES

The first step in designing a heat trace system is to determine the heat loss from each pipe or tank to be traced. Collect the following data for each pipe (for tank applications go to page 6). Then follow the steps below to determine the heat loss.

Maintenance Temperature, T_M:	________
Minimum Ambient Temperature, T_A:	________
Location, Indoor/Outdoor:	________
Wind Speed, if applicable:	________
Nominal Pipe/Tubing Size, D_P:	________
Additional Safety Factor, if required:	________
Thermal Insulation Type and Thickness:	________

Example:

English

Maintenance Temperature, T_M:	40°F
Minimum Ambient Temperature, T_A:	-20°F
Location, Indoor/Outdoor:	Outdoor
Wind Speed, if applicable:	10 mph
Nominal Pipe/Tubing Size, D_P:	3" Steel
Additional Safety Factor, if required:	None
Thermal Insulation Type and Thickness:	2" Cellular Glass

Example:

Metric

Maintenance Temperature, T_M:	4.4°C
Minimum Ambient Temperature, T_A:	-28.9°C
Location, Indoor/Outdoor:	Outdoor
Wind Speed, if applicable:	16 kph
Nominal Pipe/Tubing Size, D_P:	76mm Steel
Additional Safety Factor, if required:	None
Thermal Insulation Type and Thickness:	51 mm Cellular Glass

Step 1. Calculate ΔT

$\Delta T = T_M - T_A$

English

$= 40°F - (-20°F)$

$= 60°F$

Metric

$= 4.4°C - (-28.9°C)$

$= 33.3°C$

Step 2. Determine Pipe Heat Loss

Find Q_P in Table 1 (page 2) for the nominal pipe size and insulation thickness based on ΔT.

For example, for a 3" (76 mm) pipe with 2" (51 mm) insulation and ΔT = 60°F (33.3°C), the value for Q_P is 5.5 W/ft (10.8 W/m).

Step 3. Adjust for Insulation

Table 1 (page 2) is based on ASTM C547 Fiberglas® insulation.

Q_P, as found in the step above, must be adjusted for the insulation type. Multiply your heat loss by I_B, the Insulation Adjustment Factor, from the values in Table 2 (page 5).

$Q_T = Q_P \times I_B$

For Cellular Glass, $I_B = 1.48$

English

$Q_T = 3.3$ W/ft x 1.48

$= 4.88$ W/ft

Metric

$Q_T = 10.8$ W/m x 1.48

$= 15.98$ W/m

Step 4. Correct for Indoor Location/Windspeed

If location is indoors multiply Q_T by 0.9.

Step 5. Correct for Additional Safety Factor

Table 1 is based on 10% safety factor and 20 mph (32 kph) windspeed, add 5% margin for each 5 mph (8 kph) over 20 mph (32 kph).

THERMAL DESIGN-PIPES

THERMAL DESIGN-PIPES

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HEATING CABLE SELECTION

Figure 1

SRL & HSRL – Thermal Output Ratings on Insulated Metal Pipe

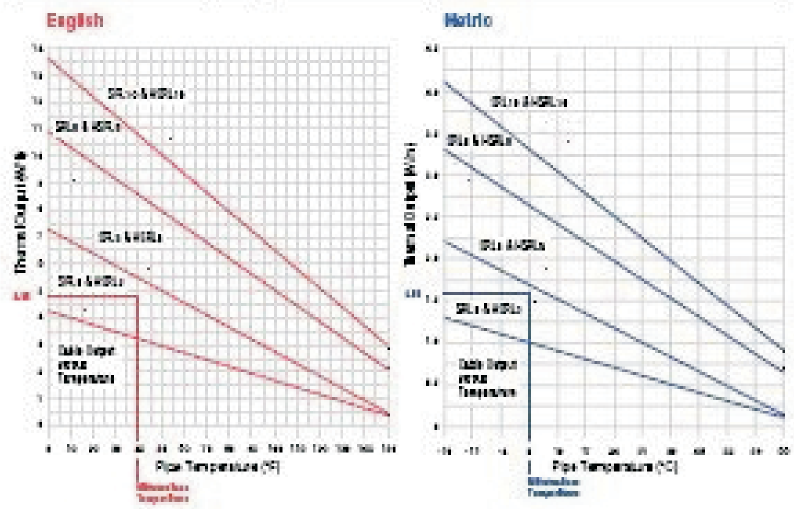
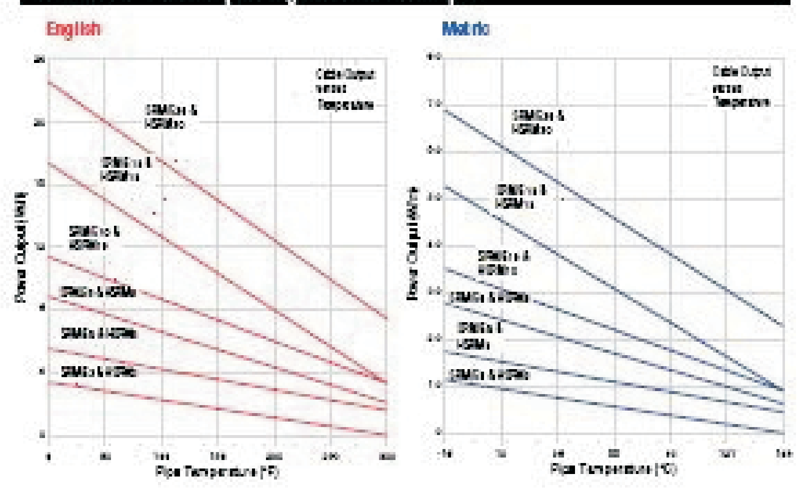


Figure 2

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



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HEATING CABLE SELECTION

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To determine the correct cable for your application, determine the following information:

Maintenance Temperature =	
Max. Exposure Temperature =	
Pipe Material =	
Service Voltage =	
Chemical Environment =	
Area Classification =	
Heat Requirement (from Thermal Design Section) =	

Example:
English

Maintenance Temperature =	40°F
Max. Exposure Temperature =	100°F
Pipe Material =	Stainless Steel
Service Voltage =	120V
Chemical Environment =	Organic
Area Classification =	C1D2 Group B
Heat Requirement (from Thermal Design Section) =	4.83 W/ft

Example:
Metric

Maintenance Temperature =	4.4°C
Max. Exposure Temperature =	37.8°C
Pipe Material =	Stainless Steel
Service Voltage =	120V
Chemical Environment =	Organic
Area Classification =	C1D2 Group B
Heat Requirement (from Thermal Design Section) =	15.98 W/m

Step 1. Select Heating Cable Family

Based on the maximum maintainance temperature, maximum exposure temperature, and area classification, select the heating cable family from Table 5.

Note: Maximum maintenance temperatures for constant wattage cables (CWM) are dependent upon cable wattage rating and the use of aluminum foil tape. See Table 6 (page 10).

Example:

Based on information, select the SRL (Self-Regulating Low Temperature) Cable Family.

Selection: SRL * - * *

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ELECTRICAL DESIGN

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Circuit Breaker Selection

To select the circuit breaker size, determine the following information:

Maintenance Temperature:	
Heat Loss per Foot of Pipe, Q_T:	
Pipe or Tubing Size:	
Pipe Length:	
Type and Number of Valves & Supports:	
Heating Cable Catalog Number:	
Minimum Start-Up Temperature:	

Example:
English

Maintenance Temperature:	40°F
Heat Loss per Foot of Pipe, Q_T:	4.38 W/ft
Pipe or Tubing Size:	3" steel
Pipe Length:	124 ft
Type and Number of Valves & Supports:	2 Butterfly Valves, 12 Pipe Hanger Supports
Heating Cable Catalog Number:	SRL 5-1CT
Minimum Start-Up Temperature:	-20°F

Example:
Metric

Maintenance Temperature:	4.4°C
Heat Loss per Foot of Pipe, Q_T:	15.98 W/m
Pipe or Tubing Size:	76 mm steel
Pipe Length:	38 m
Type and Number of Valves & Supports:	2 Butterfly Valves, 12 Pipe Hanger Supports
Heating Cable Catalog Number:	SRL 5-1CT
Minimum Start-Up Temperature:	-28.9°C

Step 1. Determine the Total Cable Length

In addition to piping, in-line equipment such as valves, flanges, and pipe supports require additional heat tracing to maintain the system operating temperatures.

See Table 11 (page 19) for additional cable lengths required for each type of in-line equipment based on piping size.

Calculate the total length of heating cable required by combining lengths from each component of the piping system.

Example:

Pipe length of 124 ft (38 m) single pass application	=	124 ft (38 m) SRL 5-1CT
2 Butterfly Valves, additional cable 2.5 ft (0.76 m) each valve	=	5.0 ft (1.52 m) SRL 5-1CT
12 Pipe Hanger Supports, additional cable per support is 2.0 ft (0.61 m)	=	24.0 ft (7.3 m) SRL 5-1CT
Total length required	=	153 ft (46.82 m) SRL 5-1CT

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