Power-Limiting Cables

This section provides general design guidelines for power-limiting heat-tracing systems installed on insulated metal pipes. For other applications or design assistance, contact your Tyco Thermal Controls representative or phone Tyco Thermal Controls at (800) 545-6258. Also, visit our Web site at www.tycothermal.com.

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Introduction

Tyco Thermal Controls power-limiting heating cables are the preferred technology for applications requiring high power output at elevated temperatures. Raychem brand VPL can be used for high maintain temperatures ranging up to 455°F (235°C), depending on cable selection, and exposure temperatures to 500°F (260°C).

VPL also can provide a cost-effective alternative to self-regulating heating cables when more than a single run of cable is required (trace ratio > 1).

Tyco Thermal Controls power-limiting cables have been certified for use in hazardous and nonhazardous locations.

Power-Limiting Technology

Tyco Thermal Controls power-limiting cables are parallel heating cables formed by a coiled resistor alloy heating element wrapped around two parallel bus wires. At a fixed distance, the insulation is removed from one of the bus wires. The process is repeated, removing the insulation from the other bus wire. This distance between contact points forms the heating zone length.
The positive temperature coefficient (PTC) of the heating element reduces power output as ambient temperature increases. This effect allows the power-limiting cable to be crossed over itself since the temperature of the heating element is reduced at the cross over points.

**System Overview**

**Typical Power-Limiting System**

A typical power-limiting heating cable system is shown in Figure 2. 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.

**Approvals and Certifications**

Tyco Thermal Controls 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

The thermal design of a power-limiting heat-tracing system follows the same steps as for a self-regulating system. Refer to Self-Regulating Cables: Thermal Design, to determine the pipe heat loss for your application.

The example below can be used to follow the steps for a manual design with VPL power-limiting heating cables.

For an optimized design, use our TraceCalc Pro design software or contact your Tyco Thermal Controls representative.

Heating Cable Selection

*If your application requires a high maintain temperature up to 455°F (235°C)*, the heating cable selection process involves three basic steps:

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 service voltage.

3. Determine the heating cable power output rating.

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

For higher maintain temperatures or where more power is required, refer to Mineral Insulated Cables for product selection, or contact your Tyco Thermal Controls representative.

If your application is in a hazardous location, you must determine the maximum sheath temperature. Power-limiting heating cables do not have an unconditional T-rating as do self-regulating cables. The maximum sheath temperature of the cable must be calculated to ensure that it is compatible with the hazardous location requirements. Use TraceCalc Pro design software or contact your Tyco Thermal Controls representative.
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.

XX VPL X-CT
- Outer Jacket
- CT = Fluoropolymer
- Voltage
- 1 = 120 Volt (100–120 Vac)
- 2 = 240 Volt (200–277 Vac*)
- 4 = 480 Volt (400–480 Vac)
- Heating cable family
- VPL
- Power output rating (Watts/ft)

* 20VPL limited to 240 Vac

Fig. 3 Heating cable catalog number

<table>
<thead>
<tr>
<th>Heating Cable Selection</th>
<th>1. Gather information</th>
<th>2. Select service voltage</th>
<th>3. Determine power output rating</th>
</tr>
</thead>
</table>

**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       2 inch, carbon steel
Insulation type and thickness Fiberglass, 3 inch
Maintain temperature ($T_m$) 280°F
Minimum ambient temperature ($T_a$) –40°F
Minimum start-up temperature 0°F
Service voltage               120 Vac
Chemical environment         Chlorides
Maximum intermittent exposure temperature* 450°F
Electrical area classification** Nonhazardous

* 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 service voltage
3. Determine power output rating

---

**Step 2: Select the heating cable service voltage**

Service voltage options:  
1 = 120 volts (100–120 Vac)  
2 = 240 volts (200–277 Vac*)  
4 = 480 volts (400–480 Vac)

*Example: Service voltage selection*

Input 120 volts *(from Step 1)*

Catalog number xVPL1-CT

* 20VPL limited to 240 Vac

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**Step 3: Determine the heating cable power output rating**

Using Graphs 1 and 2 on page 6 or Graph 3 on page 7, locate the heating cable with thermal output greater than the heat loss (QT) at the pipe maintain temperature (TM).

If the pipe heat loss, QT, is in between the two heating cable power output curves, select the higher-rated heating cable. If QT 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. 4 Heating cable thermal output](image)

Following the thermal design steps described in the Self-Regulating Cables publication:

\[
Q_T = 11.8 \text{ W/ft} + \left[ \frac{2}{5} \times (14.3 - 11.8) \right]
\]

\[
Q_T = 12.8 \text{ W/ft}
\]

**Spiraling**

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

\[
\text{Spiral factor} = \frac{Q_T}{\text{Heater power output at } T_M}
\]

When the spiral factor exceeds 1.6 or the pipe size is less than three inches, consider using two or more heating cables run in parallel rather than spiraling.

*Example: Power output selection*

Input VPL heating cable *(determined earlier in this step)*

Input Power output rating = 20 *(determined earlier in this step)*

Input Heat loss is 12.8 W/ft *(from Table 1, Self Regulating Systems, Self-Regulating Cables)*

Input 20VPL output of 15.3 W/ft exceeds 12.8 W/ft at 280°F *(Graph 1, pg. 6)*

Catalog number 20VPL1-CT
Select one of the following graphs based on the voltage determined in Step 1.

Graph 2.1 VPL nominal power output at 120 V, 240 V and 480 V

Graph 2.2 VPL nominal power output at 208 V
1. Self-Regulating Cables
2. Power-Limiting Cables
3. Mineral Insulated Cables
4. Longline Heating
5. Tubing Bundles
6. Tank Heating
7. Snow and Ice
8. Control and Monitoring
9. Heat-Trace Panels
10. Engineered Products
11. Steam-Tracing Systems
12. Technical Data Sheets
13. Appendixes
14. Index

Graph 2.3  VPL nominal power output at 277 V

Graph 2.4  VPL nominal power output at 400 V
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 the six steps outlined below.

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. Include additional heating cable for connection kit installation.

6. Add all the lengths together.

---

### Step 1 Gather the necessary information

- Pipe size 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 size and diameter: 120 feet of 2-inch pipe
Type and number of valves: Three 2-inch gate valves
Type and number of pipe supports: Support shoes, thermally insulated: 10
Start-up temperature: \( 0^\circ \text{F} \)
Number of circuits and tees in piping:
End seals: 3
Pipe tees: 2
Step 2 Calculate the total length of heating cable for the piping

Example: Total length of cable for piping calculation
120 ft of pipe (from Step 1) = 120 ft of cable for single tracing

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

Use Table 1 to determine the amount of heating cable required for each valve. Multiply by the number of valves to get the total additional footage of heating cable.

<table>
<thead>
<tr>
<th>Pipe diameter (IPS)</th>
<th>Heating cable feet (meters)</th>
<th>Comments*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>0.3 (0.09)</td>
<td>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.</td>
</tr>
<tr>
<td>1/2</td>
<td>0.8 (0.2)</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>1.3 (0.4)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.0 (0.6)</td>
<td></td>
</tr>
<tr>
<td>1-1/4</td>
<td>3.3 (1)</td>
<td></td>
</tr>
<tr>
<td>1-1/2</td>
<td>4.3 (1.3)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4.3 (1.3)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.3 (1.3)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.3 (1.3)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5.0 (1.5)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5.0 (1.5)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5.6 (1.7)</td>
<td>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.</td>
</tr>
<tr>
<td>14</td>
<td>7.3 (2.2)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>9.4 (2.9)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>12.6 (3.8)</td>
<td></td>
</tr>
</tbody>
</table>

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

Example: Total length of cable for valves calculation
From Table 1 for a 2-inch diameter pipe,
Each valve requires: 4.3 ft
Total cable length needed for valves: 3 x 4.3 ft = 12.9 ft

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: \( Q_{\text{SUPPORT}} = 0.7L \times (T_M - T_A) \), 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 1 or 2.
- 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 20VPL1-CT heating cable (from Product Selection, Step 3)
Input 10 thermally-insulated shoe supports (from Bill of Materials, Step 1)
As the pipe supports are thermally insulated, no additional heating cable is required for this example.
Step 5 Include 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*

<table>
<thead>
<tr>
<th>Total number of connection kits</th>
<th>6 <em>from Step 1</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable needed for 6 connection kits</td>
<td>6 x 3 ft of additional cable</td>
</tr>
<tr>
<td>Total cable length for 6 connection kits</td>
<td>18 ft of cable</td>
</tr>
</tbody>
</table>

Step 6 Add all the lengths

**Example: Final addition**

<table>
<thead>
<tr>
<th>Cable for piping</th>
<th>120 ft <em>from Step 1</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable for valves</td>
<td>12.9 ft <em>from Step 3</em></td>
</tr>
<tr>
<td>Cable for supports</td>
<td>0 ft <em>from Step 4</em></td>
</tr>
<tr>
<td>Cable for connection kits</td>
<td>18 ft <em>from Step 5</em></td>
</tr>
<tr>
<td>Sum of all lengths</td>
<td>120 + 12.9 + 18 = 150.9 ft</td>
</tr>
<tr>
<td>Total length of heating cable</td>
<td>151 ft (rounded)</td>
</tr>
</tbody>
</table>

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 Tyco Thermal Controls 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 Tables 2, 3, and 4 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. For example, the trip rating of a circuit breaker protecting several circuits should not exceed 50 amps. To maximize fault current protection, use the lowest allowable circuit breaker sizing.

Maximum circuit length per breaker depends on four factors:
1. Heating cable and catalog number
2. Minimum start-up temperature
3. Service voltage
4. Circuit breaker trip rating

**Table 2 Maximum Circuit Length (feet) vs. Circuit Breaker Trip Rating (Amps)**

<table>
<thead>
<tr>
<th>Heating cable</th>
<th>Start-up temperature</th>
<th>120-volt cable</th>
<th>240-volt cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td></td>
</tr>
<tr>
<td>5VPL-CT</td>
<td>50°F (10°C)</td>
<td>260 350 370 370</td>
<td>525 665 740 740</td>
</tr>
<tr>
<td></td>
<td>0°F (−18°C)</td>
<td>240 325 370 370</td>
<td>485 645 740 740</td>
</tr>
<tr>
<td></td>
<td>−20°F (−29°C)</td>
<td>235 315 370 370</td>
<td>470 625 740 740</td>
</tr>
<tr>
<td></td>
<td>−40°F (−40°C)</td>
<td>225 305 370 370</td>
<td>455 610 740 740</td>
</tr>
<tr>
<td>10VPL-CT</td>
<td>50°F (10°C)</td>
<td>130 175 260 260</td>
<td>260 350 525 525</td>
</tr>
<tr>
<td></td>
<td>0°F (−18°C)</td>
<td>120 165 245 260</td>
<td>245 325 490 525</td>
</tr>
<tr>
<td></td>
<td>−20°F (−29°C)</td>
<td>120 160 240 260</td>
<td>235 315 475 525</td>
</tr>
<tr>
<td></td>
<td>−40°F (−40°C)</td>
<td>115 155 230 260</td>
<td>230 310 465 525</td>
</tr>
<tr>
<td>15VPL-CT</td>
<td>50°F (10°C)</td>
<td>85 115 175 215</td>
<td>175 230 350 430</td>
</tr>
<tr>
<td></td>
<td>0°F (−18°C)</td>
<td>80 110 165 215</td>
<td>165 220 325 430</td>
</tr>
<tr>
<td></td>
<td>−20°F (−29°C)</td>
<td>80 105 160 215</td>
<td>160 215 320 425</td>
</tr>
<tr>
<td></td>
<td>−40°F (−40°C)</td>
<td>75 100 155 210</td>
<td>155 210 310 415</td>
</tr>
<tr>
<td>20VPL-CT</td>
<td>50°F (10°C)</td>
<td>65 85 130 175</td>
<td>130 175 260 350</td>
</tr>
<tr>
<td></td>
<td>0°F (−18°C)</td>
<td>60 85 125 165</td>
<td>125 165 250 330</td>
</tr>
<tr>
<td></td>
<td>−20°F (−29°C)</td>
<td>60 80 120 160</td>
<td>120 160 245 325</td>
</tr>
<tr>
<td></td>
<td>−40°F (−40°C)</td>
<td>60 80 120 160</td>
<td>115 155 240 320</td>
</tr>
</tbody>
</table>
### Table 3  Maximum Circuit Length (feet) vs. Circuit Breaker Trip Rating (Amps)

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

<table>
<thead>
<tr>
<th>Heating cable</th>
<th>Start-up temperature</th>
<th>208-volt cable</th>
<th>277-volt cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td></td>
</tr>
<tr>
<td>5VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>589 700 700 700 700</td>
<td>465 620 720 720 720</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>589 700 700 700 700</td>
<td>430 574 720 720 720</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>530 700 700 700 700</td>
<td>418 557 720 720 720</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>515 686 700 700 700</td>
<td>406 541 720 720 720</td>
<td></td>
</tr>
<tr>
<td>10VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>291 388 490 490 490</td>
<td>236 315 472 515 515</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>272 362 490 490 490</td>
<td>221 294 441 515 515</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>265 353 490 490 490</td>
<td>215 286 430 515 515</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>258 344 490 490 490</td>
<td>209 279 419 515 515</td>
<td></td>
</tr>
<tr>
<td>15VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>191 255 383 400 400</td>
<td>160 213 320 420 420</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>180 240 360 400 400</td>
<td>150 200 300 401 420</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>176 234 351 400 400</td>
<td>147 196 293 391 420</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>172 229 343 400 400</td>
<td>143 191 287 382 420</td>
<td></td>
</tr>
<tr>
<td>20VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>142 189 284 340 340</td>
<td>††† †† †† ††</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>135 180 269 340 340</td>
<td>††† †† †† ††</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>132 176 264 340 340</td>
<td>††† †† †† ††</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>129 173 249 340 340</td>
<td>††† †† †† ††</td>
<td></td>
</tr>
</tbody>
</table>

† Not permitted (20 VPL must not be powered at 277 V)

### Table 4  Maximum Circuit Length (feet) vs. Circuit Breaker Trip Rating (Amps)

400- and 480-volt heating cables applied to metal pipe with glass tape

<table>
<thead>
<tr>
<th>Heating cable</th>
<th>Start-up temperature</th>
<th>400-volt cable</th>
<th>480-volt cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td>15 A 20 A 30 A 40 A 50 A</td>
<td></td>
</tr>
<tr>
<td>5VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>756 986 1066 1066 1066</td>
<td>1050 1370 1480 1480 1480</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>698 929 1066 1066 1066</td>
<td>970 1290 1480 1480 1480</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>677 900 1066 1066 1066</td>
<td>940 1250 1480 1480 1480</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>655 878 1066 1066 1066</td>
<td>910 1220 1480 1480 1480</td>
<td></td>
</tr>
<tr>
<td>10VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>380 511 767 767 767</td>
<td>520 700 1050 1050 1050</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>358 475 715 767 767</td>
<td>490 650 980 1050 1050</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>343 460 694 767 767</td>
<td>470 630 950 1050 1050</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>336 453 679 767 767</td>
<td>460 620 930 1050 1050</td>
<td></td>
</tr>
<tr>
<td>15VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>259 340 518 636 636</td>
<td>350 460 700 860 860</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>244 326 481 636 636</td>
<td>330 440 650 860 860</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>237 318 474 629 636</td>
<td>320 430 640 850 860</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>229 311 459 614 636</td>
<td>310 420 620 830 860</td>
<td></td>
</tr>
<tr>
<td>20VPL-CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>195 263 390 525 555</td>
<td>260 350 520 700 740</td>
<td></td>
</tr>
<tr>
<td>0°F (–18°C)</td>
<td>188 248 375 495 555</td>
<td>250 330 500 660 740</td>
<td></td>
</tr>
<tr>
<td>–20°F (–29°C)</td>
<td>180 176 368 488 555</td>
<td>240 320 490 650 740</td>
<td></td>
</tr>
<tr>
<td>–40°F (–40°C)</td>
<td>173 173 360 480 555</td>
<td>230 310 480 640 740</td>
<td></td>
</tr>
</tbody>
</table>

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

Input 20VPL1-CT heating cable (from Product Selection, Step 3)
Input 120 volts (from Product Selection, Step 1)
Input 0°F start-up temperature (from Product Selection, Step 1)
Input Maximum circuit length = 165 feet on a 40-amp breaker (from Table 2)
If the total length of cable exceeds 165 feet, you must use a 50-amp circuit breaker, which allows up to 185 feet.

DETERMINE MINIMUM NUMBER OF CIRCUITS
The number of circuits you need depends on the total length of heating cable you will be using and the maximum circuit length for the heating cable you selected.

Example: Calculating the minimum number of circuits
Input 165 ft allowed per 40-amp circuit (from Table 2)
Input Total circuit length = 151 ft (from Bill of Materials, Step 6)
Number of circuits 1 circuit
If the total length of heating cable required exceeded 165 feet, you would need to split the total length into two separate circuits (or use a larger circuit-breaker size).

**Fig. 6 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 Tyco Thermal Controls, 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 DigiTrace control and monitoring systems meet the ground-fault protection requirement.

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**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**
Tyco Thermal Controls offers a full range of connection kits for power connections, splices, and end seals. 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. The data sheets for these connection kits can be found on the Tyco Thermal Controls Web site, www.tycothermal.com.
NONHAZARDOUS AND HAZARDOUS LOCATION CONNECTION KITS

Figure 7 shows the connection kits and accessories available for typical power-limiting systems.

Table 5  Nonhazardous and Hazardous Connection Kit and Accessory Selection

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog number</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connection Kits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Power connection</td>
<td>JBS-100-A</td>
<td>1 per circuit</td>
</tr>
<tr>
<td>Single heating cable</td>
<td>JBS-100-L-A</td>
<td></td>
</tr>
<tr>
<td>Single heating cable with light</td>
<td>JBS-100-ECP-A</td>
<td>(nonhazardous locations only)</td>
</tr>
<tr>
<td>Single heating cable with digital electronic controller</td>
<td>JBS-100-ECP-A</td>
<td>(nonhazardous locations only)</td>
</tr>
<tr>
<td>Single heating cable (user-supplied junction box)</td>
<td>JS-100-A</td>
<td></td>
</tr>
<tr>
<td>Multiple heating cables (1, 2, or 3)</td>
<td>JBM-100-A</td>
<td></td>
</tr>
<tr>
<td>Multiple heating cable with light</td>
<td>JBM-100-L-A</td>
<td></td>
</tr>
<tr>
<td>2. Splice connection</td>
<td>JBM-100-A</td>
<td>1 per splice</td>
</tr>
<tr>
<td>Above insulation</td>
<td>T-100</td>
<td></td>
</tr>
<tr>
<td>3. Tee connection</td>
<td>JBM-100-L-A</td>
<td>1 per tee</td>
</tr>
<tr>
<td>Above insulation</td>
<td>T-100</td>
<td></td>
</tr>
<tr>
<td>4. End seal</td>
<td>E-100</td>
<td>1 per power connection plus 1 per tee</td>
</tr>
<tr>
<td>Above insulation</td>
<td>E-100-L1-A (100–120 V)</td>
<td></td>
</tr>
<tr>
<td>Above insulation with light</td>
<td>E-100-L2-A (200–277 V)</td>
<td></td>
</tr>
<tr>
<td><strong>Accessories</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Attachment tape, labels, and pipe straps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Controls (optional)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Thermostat — see Control and Monitoring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SYSTEM CONNECTION KITS

Power Connection Kits for Heating Cable

**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**  Power connection and digital electronic controller. Requires one pipe strap to be ordered separately. Nonhazardous locations only.

**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**  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**  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**  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.

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

Lighted versions:  E-100-L1-A (100–120 V)  
E-100-L2-A (200–277 V)
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)

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 Aluminum Tape
- For use on all pipe materials
- 2-1/2” x 180’ roll
- Minimum installation temperature: 32°F (0°C)

Table 6  Attachment Tape Requirements

<table>
<thead>
<tr>
<th>Tape type</th>
<th>Rolls needed per 100 ft of cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pipe diameter (IPS) in inches</td>
</tr>
<tr>
<td>GT-66</td>
<td>0.6</td>
</tr>
<tr>
<td>GS-54</td>
<td>0.6</td>
</tr>
<tr>
<td>AT-180</td>
<td>Use one foot of tape per foot of heating</td>
</tr>
</tbody>
</table>

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 Straps
Stainless steel pipe straps to attach connection kits to the heat-traced pipe. Use Table 7 below to assist with pipe strap selection.

### Table 7  Pipe Strap Selection

<table>
<thead>
<tr>
<th>Catalog number</th>
<th>Pipe size</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-01</td>
<td>For conduit ≤ 1”</td>
</tr>
<tr>
<td>PS-03</td>
<td>For connection kits on pipes with dimensions &lt;2”</td>
</tr>
<tr>
<td>PS-10</td>
<td>For connection kits on pipes with dimensions 2” – 10”</td>
</tr>
<tr>
<td>PS-20</td>
<td>For connection kits on pipes with dimensions 10” – 19.5”</td>
</tr>
</tbody>
</table>

Small Pipe Adapters

**JBS-SPA**  Adapter for mounting E-100, JBS-100, and JS-100-A to small pipe.

**JBM-SPA**  Adapter for mounting JBM-100 and T-100 to small pipe.

Conduit Drain

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

Controls
For a complete selection of control and monitoring products, including thermostats, see Control and Monitoring.
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