Technical Information

Determining Heat Energy Requirements

Pipe & Tank Tracing

The following tables can be used to determine the heat losses from insulated pipes and tanks for heat tracing applications. To use these tables, determine the following design factors:

- Temperature differential $\Delta T = T_m - T_a$
- Type and thickness of insulation
- Diameter of pipe or surface area of tank
- Outdoor or indoor application
- Maximum expected wind velocity (if outdoors).

Pipe Tracing Example — Maintain a 1-1/2 inch IPS pipe at 100°F to keep a process fluid flowing. The pipe is located outdoors and is insulated with 2 inch thick Fiberglas® insulation. The minimum expected ambient temperature is 0°F and the maximum expected wind velocity is 35 mph. Determine heat losses per foot of pipe.

1. Heat Loss Rate — Using Table 1, determine the heat loss rate in Watts/ft of pipe for °F temperature differential. Enter table with insulation ID or IPS pipe size (1-1/2 in.) and insulation thickness (2 in.). Rate = 0.038 Watts/ft/°F.

2. Heat Loss per Foot — Calculated heat loss per foot of pipe equals the maximum temperature differential $(\Delta T)$ times heat loss rate in Watts/ft/°F.

3. Insulation Factor — Table 1 is based on Fiberglas® insulation and a 50°F $\Delta T$. Adjust $Q_{\text{f}}$ for thermal conductivity ($k$ factor) and temperature as necessary, using adjustment factors from Table 2.

4. Wind Factor — Table 1 is based on 20 mph wind velocity. Adjust $Q_{\text{f}}$ for wind velocity as necessary by adding 5% for each 5 mph over 20 mph. Do not add more than 15% regardless of wind speed.

Note — For indoor installations, multiply $Q_{\text{f}}$ by 0.9.

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Table 1 — Heat Losses from Insulated Metal Pipes

(Watts per foot of pipe per °F temperature differential)

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Insul. I.D.</th>
<th>Insulation Thickness (In.)</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1-1/2</th>
<th>2</th>
<th>2-1/2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.840</td>
<td>0.054</td>
<td>0.041</td>
<td>0.035</td>
<td>0.028</td>
<td>0.024</td>
<td>0.022</td>
<td>0.020</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>1.050</td>
<td>0.063</td>
<td>0.048</td>
<td>0.040</td>
<td>0.031</td>
<td>0.027</td>
<td>0.024</td>
<td>0.022</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.315</td>
<td>0.075</td>
<td>0.055</td>
<td>0.046</td>
<td>0.036</td>
<td>0.030</td>
<td>0.027</td>
<td>0.025</td>
<td>0.022</td>
<td></td>
</tr>
<tr>
<td>1-1/4</td>
<td>1.660</td>
<td>0.090</td>
<td>0.066</td>
<td>0.053</td>
<td>0.041</td>
<td>0.034</td>
<td>0.030</td>
<td>0.028</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.990</td>
<td>0.104</td>
<td>0.075</td>
<td>0.061</td>
<td>0.046</td>
<td>0.038</td>
<td>0.034</td>
<td>0.030</td>
<td>0.026</td>
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<tr>
<td>2-1/2</td>
<td>2.375</td>
<td>0.120</td>
<td>0.086</td>
<td>0.069</td>
<td>0.052</td>
<td>0.043</td>
<td>0.037</td>
<td>0.033</td>
<td>0.029</td>
<td></td>
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<tr>
<td>3</td>
<td>2.875</td>
<td>0.141</td>
<td>0.101</td>
<td>0.080</td>
<td>0.059</td>
<td>0.048</td>
<td>0.042</td>
<td>0.037</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td>3-1/2</td>
<td>3.500</td>
<td>0.168</td>
<td>0.118</td>
<td>0.093</td>
<td>0.068</td>
<td>0.055</td>
<td>0.048</td>
<td>0.042</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.000</td>
<td>0.189</td>
<td>0.133</td>
<td>0.104</td>
<td>0.075</td>
<td>0.061</td>
<td>0.052</td>
<td>0.046</td>
<td>0.038</td>
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<td>4-1/2</td>
<td>5.000</td>
<td>0.210</td>
<td>0.147</td>
<td>0.115</td>
<td>0.083</td>
<td>0.066</td>
<td>0.056</td>
<td>0.050</td>
<td>0.041</td>
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<td>5</td>
<td>5.563</td>
<td>0.231</td>
<td>0.161</td>
<td>0.125</td>
<td>0.090</td>
<td>0.072</td>
<td>0.061</td>
<td>0.054</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>0.265</td>
<td>0.177</td>
<td>0.137</td>
<td>0.098</td>
<td>0.078</td>
<td>0.068</td>
<td>0.061</td>
<td>0.047</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7.625</td>
<td>0.300</td>
<td>0.207</td>
<td>0.160</td>
<td>0.113</td>
<td>0.089</td>
<td>0.075</td>
<td>0.065</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8.625</td>
<td>0.335</td>
<td>0.235</td>
<td>0.181</td>
<td>0.127</td>
<td>0.100</td>
<td>0.084</td>
<td>0.073</td>
<td>0.059</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9.625</td>
<td>0.385</td>
<td>0.263</td>
<td>0.202</td>
<td>0.141</td>
<td>0.111</td>
<td>0.092</td>
<td>0.080</td>
<td>0.064</td>
<td></td>
</tr>
</tbody>
</table>

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Table 2 — Thermal Conductivity ($k$) Factor of Typical Pipe Insulation Materials

(Btu/hr/ft²/°F)

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Pipe Maintenance Temperature (°F)</th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglas® or Mineral Fiber Based on ASTM C-547</td>
<td>k value</td>
<td>0.23</td>
<td>0.25</td>
<td>0.27</td>
<td>0.30</td>
<td>0.32</td>
<td>0.37</td>
<td>0.41</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Calcium Silicate</td>
<td>k value</td>
<td>0.35</td>
<td>0.37</td>
<td>0.40</td>
<td>0.43</td>
<td>0.45</td>
<td>0.50</td>
<td>0.55</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>Foamed Glass</td>
<td>k value</td>
<td>0.38</td>
<td>0.40</td>
<td>0.43</td>
<td>0.47</td>
<td>0.51</td>
<td>0.60</td>
<td>0.70</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Foamed Urethane Based on ASTM C-591</td>
<td>k value</td>
<td>0.18</td>
<td>0.17</td>
<td>0.18</td>
<td>0.21</td>
<td>0.25</td>
<td>Not</td>
<td>Not</td>
<td>Not</td>
<td>Not</td>
</tr>
</tbody>
</table>

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Table 3 — Heat Losses from Insulated Metal Tanks

(Watts/ft²/°F)

<table>
<thead>
<tr>
<th>Insulation Thickness (In.)</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1-1/2</th>
<th>2</th>
<th>2-1/2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.161</td>
<td>0.107</td>
<td>0.081</td>
<td>0.054</td>
<td>0.040</td>
<td>0.032</td>
<td>0.027</td>
<td>0.023</td>
<td>0.020</td>
</tr>
</tbody>
</table>

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Note — The above information is presented as a guide for solving typical heat tracing applications. Contact your Local Chromalox Sales office for assistance in heater selection and for pipes made of materials other than metal.
Technological Information

Determining Heat Energy Requirements

Pipe & Tank Tracing (cont’d.)

Tank tracing requires an additional calculation of the total exposed surface area. To calculate the surface area:

Cylindrical Tanks —

\[ A = \pi D (r + H) \]

Horizontal Tanks —

\[ A = 2 [(W \times L) + (L \times H) + (H \times W)] \]

Tank Tracing Example — Maintain a metal tank with 2 inch thick Fiberglas® insulation at 50°F. The tank is located outdoors, is 4 feet in diameter, 12 feet long and is exposed at both ends. The minimum ambient temperature is 0°F and the maximum expected wind speed is 15 mph.

1. Surface Area — Calculate the surface area of the tank.
   \[ A = \pi D (r + H) \]
   \[ A = \pi 4 (2 + 12) \]
   \[ A = 175.9 \text{ ft}^2 \]

2. Temperature Differential (\( \Delta T \))
   \[ \Delta T = T_m - T_a = 50°F - 0°F = 50°F \]

3. Heat Loss Per Foot² — Obtain the heat loss per square foot per degree from Table 3.
   Heat loss/ft²/°F = 0.04 W/ft²/°F

4. Insulation Factor — Table 3 is based on Fiberglas® insulation and a 50°F \( \Delta T \).
   Adjust Q for thermal conductivity (k factor) and temperature as necessary, using factors from Table 2.

5. Wind Factor — Table 3 is based on 20 mph wind velocity. Adjust Q for wind velocity as necessary, by adding 5% for each 5 mph over 20 mph. Do not add more than 15% regardless of wind speed.
   Note — For indoor installations, multiply Q by 0.9.

6. Calculate Total Heat Loss for Tank — Multiply the adjusted heat loss per square foot per °F figure by the temperature differential. Multiply the loss per square foot by the area.
   \[ Q = 0.04 \text{ W/ft}^2/°F \times 50°F = 2 \text{ W/ft}^2 \]
   \[ Q = \text{Adjusted W/ft}^2 \times \text{tank surface area} \]
   \[ Q = 2 \text{ W/ft}^2 \times 175.9 \text{ ft}^2 \]
   Heat Loss from Tank = 351.8 Watts

Comfort Heating

For complete building and space heating applications, it is recommended that a detailed analysis of the building construction heat losses (walls, ceilings, floors, windows, etc.) be performed using ASHRAE guidelines. This is the most accurate and cost effective estimating procedure. However, a quick estimate of the kW requirements for room and supplemental heating or freeze protection can be obtained using the chart to the right.

Problem — A warehouse extension measures 20 ft long x 13 ft wide x 9 ft high. The building is not insulated. Construction is bare concrete block walls and an open ceiling with a plywood deck and built-up roof. Determine the kW required to maintain the warehouse at 70°F when the outside temperature is 0°F.

Solution —

1. Calculate the volume of the room.
   \[ 20 \text{ ft} \times 13 \text{ ft} \times 9 \text{ ft} = 2,340 \text{ ft}^3 \]

2. Refer to the chart, use Curve D which corresponds to the building construction.

3. Find the intersection of 2,340 ft³ with curve D. The kilowatts required are 9.3 kW. Suggest using a 10 kW unit blower heater.

Note — If the volume of the room is larger than the chart values, divide by 2, 3, 4, etc. until the trial volume fits the curve. Then select heater from this volume. Multiply heaters selected by the number used to select the trial volume.