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 $\Delta T = T_M - T_A$
  Where:
  T_M = Desired maintenance temperature °F
  T_A = Minimum expected ambient temperature °F
- 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 W/ft of pipe per °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 (ΔT) times heat loss rate in Watts/ft/°F.

   ΔT = 100°F - 0°F = 100°F
   Q = (ΔT)(heat loss rate per °F)
   Q = (100°F) (0.038 W/ft) = 3.80 W/ft

3. **Insulation Factor —** Table 1 is based on Fiberglas® insulation and a 50°F ΔT. Adjust Q for thermal conductivity (*k* factor) and temperature as necessary, using adjustment factors from Table 2.

   Adjusted Q = (Q)(1.08) = 3.80 W/ft x 1.08
   Q = 4.10 W/ft

4. **Wind Factor —** Table 1 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.

   Adjusted Q = (Q)(1.15) = 4.10 W/ft x 1.15
   Design heat loss per linear foot
   ***Q* = 4.72 W/ft**

Note — For indoor installations, multiply Q by 0.9.

Table 1 — Heat Losses from Insulated Metal Pipes (Watts per foot of pipe per °F temperature differential [1])

Pipe Size (IPS)	Insul. I.D. (In.)	Insulation Thickness (In.)							
		1/2	3/4	1	1-1/2	2	2-1/2	3	4
1/2	0.840	0.054	0.041	0.035	0.028	0.024	0.022	0.020	0.018
3/4	1.050	0.063	0.048	0.040	0.031	0.027	0.024	0.022	0.020
1	1.315	0.075	0.055	0.046	0.036	0.030	0.027	0.025	0.022
1-1/4	1.660	0.090	0.066	0.053	0.041	0.034	0.030	0.028	0.024
1-1/2	1.990	0.104	0.075	0.061	0.046	0.038	0.034	0.030	0.026
2	2.375	0.120	0.086	0.069	0.052	0.043	0.037	0.033	0.029
2-1/2	2.875	0.141	0.101	0.080	0.059	0.048	0.042	0.037	0.032
3	3.500	0.168	0.118	0.093	0.068	0.055	0.048	0.042	0.035
3-1/2	4.000	0.189	0.133	0.104	0.075	0.061	0.052	0.046	0.038
4	4.500	0.210	0.147	0.115	0.083	0.066	0.056	0.050	0.041
—	5.000	0.231	0.161	0.125	0.090	0.072	0.061	0.054	0.044
5	5.563	0.255	0.177	0.137	0.098	0.078	0.066	0.058	0.047
6	6.625	0.300	0.207	0.160	0.113	0.089	0.075	0.065	0.053
—	7.625	0.342	0.235	0.181	0.127	0.100	0.084	0.073	0.059
8	8.625	0.385	0.263	0.202	0.141	0.111	0.092	0.080	0.064
—	9.625	0.427	0.291	0.224	0.156	0.121	0.101	0.087	0.070
10	10.75	0.474	0.323	0.247	0.171	0.133	0.110	0.095	0.076
12	12.75	0.559	0.379	0.290	0.200	0.155	0.128	0.109	0.087
14	14.00	0.612	0.415	0.316	0.217	0.168	0.138	0.118	0.093
16	16.00	0.696	0.471	0.358	0.246	0.189	0.155	0.133	0.104
18	18.00	0.781	0.527	0.401	0.274	0.210	0.172	0.147	0.115
20	20.00	0.865	0.584	0.443	0.302	0.231	0.189	0.161	0.125
24	24.00	1.034	0.696	0.527	0.358	0.274	0.223	0.189	0.147

1. Values in Table 1 are based on a pipe temperature of 50°F, an ambient of 0°F, a wind velocity of 20 mph and a "*k*" factor of 0.25 (Fiberglas®). Values are calculated using the following formula plus a 10% safety margin:
   Watts/ft of pipe = $2 \varpi k (\Delta T) \div (Z) \ln (D_0/D_1)$
   Where: k = Thermal conductivity (Btu/in./hr/ft²/°F)
   ΔT = Temperature differential (°F)
   D_0 = Outside diameter of insulation (in.)
   D_1 = Inside dia. of insulation (in.)
   Z = 40.944 Btu/in/W/hr/ft
   ln = Natural Log of D_0/D_1 Quotient

Table 2 — Thermal Conductivity (k) Factor of Typical Pipe Insulation Materials (Btu/in./hr/ft²/°F)

Insulation Type		Pipe Maintenance Temperature (°F)							
		0	50	100	150	200	300	400	500
Fiberglas® or Mineral Fiber Based on ASTM C-547	*k* value Adjustment factor	0.23 (0.92)	0.25 (1.00)	0.27 (1.08)	0.30 (1.20)	0.32 (1.28)	0.37 (1.48)	0.41 (1.64)	0.45 (1.80)
Calcium Silicate[2] Based on ASTMC-533	*k* value Adjustment factor	0.35 (1.52)	0.37 (1.48)	0.40 (1.60)	0.43 (1.72)	0.45 (1.80)	0.50 (2.00)	0.55 (2.20)	0.60 (2.40)
Foamed Glass[2] Based on ASTMC-552	*k* value Adjustment factor	0.38 (1.52)	0.40 (1.60)	0.43 (1.72)	0.47 (1.88)	0.51 (2.04)	0.60 (2.40)	0.70 (2.8)	0.81 (3.24)
Foamed Urethane Based on ASTMC-591	*k* value Adjustment factor	0.18 (0.72)	0.17 (0.68)	0.18 (0.72)	0.21 (0.84)	0.25 (1.00)	Not Recommended		

2. When using rigid insulation, select an inside diameter one size larger than the pipe on pipe sizes through 9 in. IPS. Over 9 in. IPS, use same size insulation.

Table 3 — Heat Losses from Insulated Metal Tanks (W/ft²/°F)[3]

Insulation Thickness (In.)										
1/2	3/4	1	1-1/2	2	2-1/2	3	3-1/2	4	5	6
0.161	0.107	0.081	0.054	0.040	0.032	0.027	0.023	0.020	0.016	0.013

3. Values in Table 3 are based on a tank temperature of 50°F, an ambient of 0°F, a wind velocity of 20 mph and a "k" factor of 0.25 (Fiberglas®). Values are calculated using the following formula plus a 10% safety margin:
   Watts/ft² = $Y\, k(\Delta T) \div X$
   Where: Y = 0.293W/hr/btu
   k = Thermal conductivity
   X = Thickness of insulation (in.)
   Δ = Temperature differential (°F)

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.

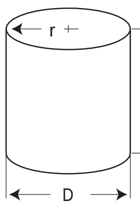
Technical Information

Determining Heat Energy Requirements

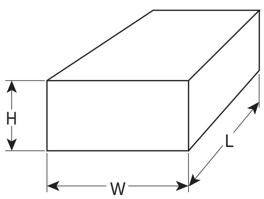
Pipe & Tank Tracing (cont'd.)

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

Cylindrical Tanks —
Area = $2 \varpi r^2 + \varpi DH$
$A = \varpi D (r + H)$



Horizontal Tanks —
Area = 2[(W x L) + (L x H) + (H x 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.
   $A = \varpi D (r + H)$
   $A = \varpi 4 (2 + 12)$
   $A = 175.9 \text{ ft}^2$

2. Temperature Differential (ΔT)

   $\Delta T = T_M - T_A = 50°F - 0°F = 50°F$

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 ΔT. 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.

   $Q = 0.04 \text{ W/ft}^2/°F \times 50°F\ \Delta T = 2 \text{ W/ft}^2$
   Q = Adjusted W/ft² x 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.

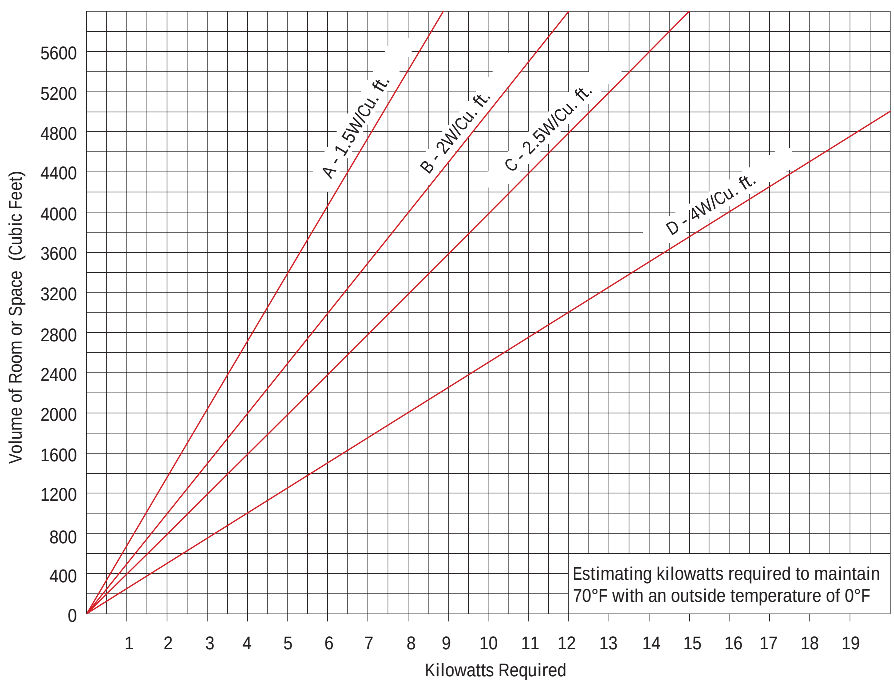
   20 ft x 13 ft x 9 ft = 2,340 ft³

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.

Comfort Heating Chart



Curve A — Rooms with little or no outside exposure. No roof or floor with outside exposure; only 1 wall exposed with not over 15% door and window area.

Curve B — Rooms with average exposure. Roof and 2 or 3 walls exposed, up to 30% door and window area. But with roof, walls and floor insulated if exposed to outside temperatures.

Curve C — Rooms with roof, walls and floor uninsulated but with inside facing on walls and ceiling.

Curve D — Exposed guard houses, pump houses, cabins and poorly constructed rooms with reasonably tight joints but no insulation. Typical construction of corrugated metal or plywood siding, single layer roofs.