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KW Calculations

Calculating KW Requirements for Heating Liquids and Gases

When calculating the required KW, always use the maximum flow of the medium to be heated, the minimum temperature at the heater inlet, and the maximum desired outlet temperature. Also include a 20% Safety Factor to allow for heat losses to jacket and piping, voltage variation and wattage tolerance.

For specific heat and density values see Properties of Materials Tables on page 16-4.

Safe element watt density and sheath material charts are located on pages 16-12 through 16-20.

Formula for Heating Liquids

$$KW = \frac{\text{Flow} \times \text{60 minute/hour} \times \text{Density} \times \text{Specific heat} \times \Delta T \times \text{Safety factor}}{\text{3412 BTU/KWH}}$$

Flow = Flow in gallons/minute

Density = Density of liquid in pounds/gallon

Specific Heat = Specific heat of liquid in BTU/pound °F

ΔT = Temperature rise in °F

Sample problem for heating water:

Calculate KW required to heat 5 gallons/minute of water from 50 to 100°F.

$$KW = \frac{\text{5 gal/min} \times \text{60 min/hr} \times \text{8.34 lb/gal} \times \text{1.0 BTU/lb°F} \times \text{50°F} \times 1.2}{\text{3412 BTU/KWH}}$$

Total KW required = 44

Water Flow Chart for Tempco 3" and 5" Flanged Circulation Heaters

Maximum water flow per hour through selected heaters at specified temperature rise.

Part Number	KW	20°F	30°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F	110°F	120°F	130°F
CHF01891	6	123	82	61	49	41	35	31	27	25	22	20	19
CHF01895	9	184	123	92	74	61	53	46	41	37	33	31	28
CHF01898	12	245	164	123	98	82	70	61	55	49	45	41	38
CHF01901	15	307	205	153	123	102	88	77	68	61	56	51	47
CHF01904	18	368	245	184	147	123	105	92	82	74	67	61	57
CHF01928	24	491	327	245	196	164	140	123	109	98	89	82	76
CHF01931	30	614	409	307	245	205	175	153	136	123	112	102	94
CHF01934	36	736	491	368	295	245	210	184	164	147	134	123	113
CHF01935	50	1023	682	511	409	341	292	256	227	205	186	170	157
CHF01936	60	1227	818	614	491	409	351	307	273	245	223	205	189

$$\text{(Gallons) HR} = \frac{(KW)\ (3412)}{(8.34)\ (\Delta T)}$$

NOTE: ***Safety factor not included. Add to suit application.***

Formula for Heating Gases

$$KW = \frac{\text{Flow} \times \text{60 minute/hour} \times \text{Density} \times \text{Specific heat} \times \Delta T \times \text{Safety factor}}{\text{3412 BTU/KWH}}$$

Flow = Flow in SCFM (standard cubic feet per minute measured at 14.7 PSIA and 70°F)

Density = Density of gas in pounds/cubic foot at standard conditions.

Specific Heat = Specific heat of gas in BTU/pound °F at standard conditions.

ΔT = Temperature rise in °F

NOTE: If air flow is given in CFM at operating temperature and pressure it can be converted to SCFM (Standard Cubic Feet per Minute) with the following formula:

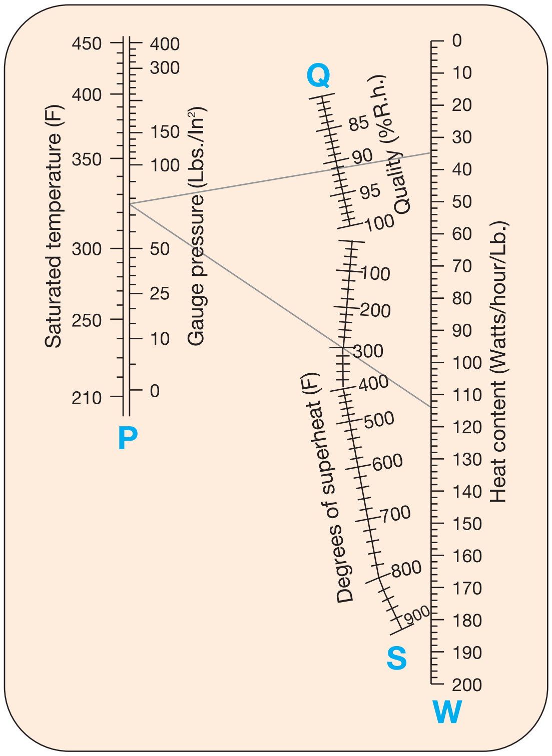
$$SCFM = CFM \times \frac{PSIG + 14.7}{T + 460} \times 35.37$$

PSIG = operating pressure (gauge pressure in lbs/sq.in.)

T = operating temperature in °F

SCFM = flow rate in CFM at standard conditions of 60°F and 14.7 PSIA.

Calculating KW Requirements to Superheat Steam



Superheated Steam Graph

Problem: ***Heat 420 lbs/hr of 90% quality steam to 620°F @ 75PSIG***

1. Plot the pressure on graph **P** and the steam quality on graph **Q**. Draw a straight line from **P** through **Q** and read **W1**.
2. Plot the degrees of superheat on graph **S**. The degrees of superheat equals operating temperature minus saturated temperature. Saturated temperature is read beside gauge pressure on graph **P**.

   620°F – 320°F = 300°F

   Draw a straight line from **P** through **S** and read **W2**.
3. Determine the required KW using the following equation:

$$\begin{aligned} KW &= LBS/HR \times (W2 - W1) / 1000 \times \text{Safety factor} \\ &= 420 \times (114 - 36) / 1000 \times 1.2 = 39.3\ KW \end{aligned}$$

CAUTION

Note: Element watt density is critical in choosing the correct circulation heater and is dependent upon maximum operating temperature and steam velocity.

Standard Pipe Data

Nominal Pipe Size	Threads Per Inch	Inside Diameter (inches)	Outside Diameter (inches)	Weight Pipe (lbs/ft)	Length in Feet Containing One Cubic Foot	Gallons in One Linear Foot	Weight Water (lbs/ft of Pipe)
⅛	27	0.269	0.405	0.244	2526.000	0.0030	0.025
¼	18	0.364	0.540	0.424	1383.800	0.0054	0.045
⅜	18	0.493	0.675	0.567	754.360	0.0099	0.083
½	14	0.622	0.840	0.850	473.910	0.0158	0.132
¾	14	0.824	1.050	1.130	270.030	0.0277	0.231
1	11½	1.049	1.315	1.678	166.620	0.0449	0.374
1¼	11½	1.380	1.660	2.272	96.275	0.0777	0.648
1½	11½	1.610	1.900	2.717	70.733	0.1058	0.882
2	11½	2.067	2.375	3.652	49.913	0.1743	1.453
2½	8	2.469	2.875	5.793	30.077	0.2487	2.073
3	8	3.068	3.500	7.575	19.479	0.3840	3.200
3½	8	3.548	4.000	9.109	14.565	0.5136	4.280
4	8	4.026	4.500	10.790	11.312	0.6613	5.510
5	8	5.047	5.563	14.617	7.198	1.0393	8.660
6	8	6.065	6.625	18.974	4.984	1.5008	12.510
8	8	7.981	8.625	28.551	2.878	2.5988	21.680
10	8	10.020	10.750	40.483	1.826	4.0963	34.100
12	8	12.000	12.750	49.560	1.274	5.9036	49.000
14	8	13.250	14.000	54.570	1.046	7.1928	59.700
16	8	15.250	16.000	62.580	0.789	9.5301	79.100
18	8	17.250	18.000	70.590	0.617	12.1928	101.200

Barlow's Formula

Pressure ratings of fluid vessels depend mainly on the tensile strength of the material being used at the process temperature, and the wall thickness of the vessel. Normally, the safety factor ratio should be at least 4 to 1 in determining the maximum pressure a vessel may see.

$$\text{Minimum wall thickness (in)} = \frac{\text{Maximum Pressure (PSI)} \times \text{OD of vessel (in)}}{2 \times \text{Tensile Strength (PSI) at process temperature}}$$