Engineering Information

Before selecting a standard circulation heater from the catalog listings, or customizing a design with any of the options and accessories, check the engineering information to assure proper heater design and performance for your application.

Calculating KW Requirements

When calculating the power required to heat a material flowing through the circulation heater, the KW equation shown below can be applied. This equation is based on the criteria that there is no vaporization occurring in the heater. The KW equation incorporates a 20% safety factor, allowing for heat losses of the jacket and piping, variation in voltage and wattage tolerance of the elements.

$$KW = \frac{M \times \$T \times Cp \times S.F.}{3412}$$

Where:
KW = power in kilowatts
M = flow rate in Lbs/Hr
$\$T$ = temperature rise in °F
(The difference between the minimum inlet temperature and maximum outlet temperature.)
Cp = specific heat in BTU/Lb °F
S.F. = safety factor, 1.2
3412 = conversion of BTU to KWH

Water Heating Example:

Application data: 8 GPM flow with an inlet temperature of 65° F and an outlet temperature of 95° F. First, convert the flow rate to Lbs/Hr.

$$\frac{8\ Gal}{Min} \times \frac{1\ Ft^3}{7.48\ Gal} \times \frac{60\ Min}{1\ Hr} = 64.17\ Ft^3/Hr$$

Obtain the specific heat (Cp) and density from Table III, page 7.

$$64.17\ Ft^3/Hr \times 62.4\ Lbs/Ft^3 = 4004\ Lbs/H$$

Now calculate KW:

$$KW = \frac{4004\ Lbs/Hr \times (95-65)°F \times 1\ BTU/Lbs°F \times 1.2}{3412}$$

KW = 42

Oil Heating Example:

Application data: SAE 30 lubrication oil with a flow rate of 135 GPM, an inlet temperature of 45° F and an outlet temperature of 55° F. First, convert the flow rate to Lbs/Hr.

$$\frac{135\ Gal}{Min} \times \frac{1\ Ft^3}{7.48\ Gal} \times \frac{60\ Min}{1\ Hr} = 1083\ Ft^3/Hr$$

Obtain the specific heat (Cp) and density from Table III.

$$1083\ Ft^3/Hr \times 55.4\ Lbs/Ft^3 = 60{,}000\ Lbs/Hr$$

Now calculate KW:

$$KW = \frac{60{,}000\ Lbs/Hr \times (55-45)°F \times .45\ BTU/Lbs°F \times 1.2}{3412}$$

KW = 95

Gas Heating Example:

Application data: Air is flowing at 187 ACFM and 5 PSIG pressure. The inlet temperature of the air is 90° F and the outlet temperature is 250° F. First, convert the flow rate to SCFM.

$$SCFM = ACFM \times \frac{PSIA}{14.7\ PSIA} \times \frac{530°R}{(T°F+460°R)}$$

Where:
T = Inlet temperature in °F
ACFM = Actual cubic feet per minute (This is the actual volume flow rate value at inlet temperature and operating pressure, PSIA.)
SCFM = Standard cubic feet per minute (This is the volume flow rate value at 70° F and atmospheric pressure, 14.7 PSIA.)
PSIA = Pounds per square inch, absolute
PSIG = Pounds per square inch, gauge
PSIA = PSIG + 14.7 (Note: If value is given as psi, it is implied to be PSIG.)

$$187\ ACFM \times \frac{19.7\ PSIA}{14.7\ PSIA} \times \frac{530°R}{(90°F+460°R)} = SCFM$$

241.5 = SCFM

Now convert to Lbs/Hr.

$$241.5\ SCFM \times \frac{60\ Min}{1\ Hr} \times \frac{.073\ Lbs}{Ft^3} = 1057.7\ Lbs/Hr$$

Reference Table I for the density and specific heat (Cp) of air.

Engineering Information (continued)

Properties for Gases
Table I

Gas	Density (Lbs/Ft³)	Specific Heat (BTU/Lb °F)
Air	0.073	0.24
Nitrogen	0.073	0.25
Steam	0.037	0.49

Densities and specific heats are at atmospheric pressure (14.7 PSIA) and 70° F, except the temperature for steam is 212° F.

Now calculate KW: (Specific heat of air at average temperature of 170° F is also .24.)

$$KW = \frac{1057.7 \text{ Lbs/Hr} \times (250-90)°F \times 0.24 \text{ BTU/Lbs°F} \times 1.2}{3412}$$

KW = 14.3

Pressure Drop

Pressure drop through the heater is a function of many variables, including type of liquid or gas, flow rate, temperature and vessel size. Use the information on this page as a guideline for common applications where water, lube oil, fuel oil, or ethylene glycol are heated from 60° F. For other applications, including heating gases, contact Heatrex, and we will determine the pressure drop for you.

The curves on Chart A indicate the pressure drop for the different diameters of catalog listed heaters. The curves are based on water at 60° F, and the heaters having the standard inlet and outlet sizes as listed on page 10.

Table II gives correction factors for Chart A when these other liquids are being heated from 60° F.

Pressure Drop Correction Factors
Table II

Liquid	Correction Factor
SAE 30 Lubrication Oil	1.6
No. 2 Fuel Oil	1.4
Ethylene Glycol (50% Solution)	1.7

Example:

Flow rate: 100 GPM

Liquid: SAE 30 lubrication oil

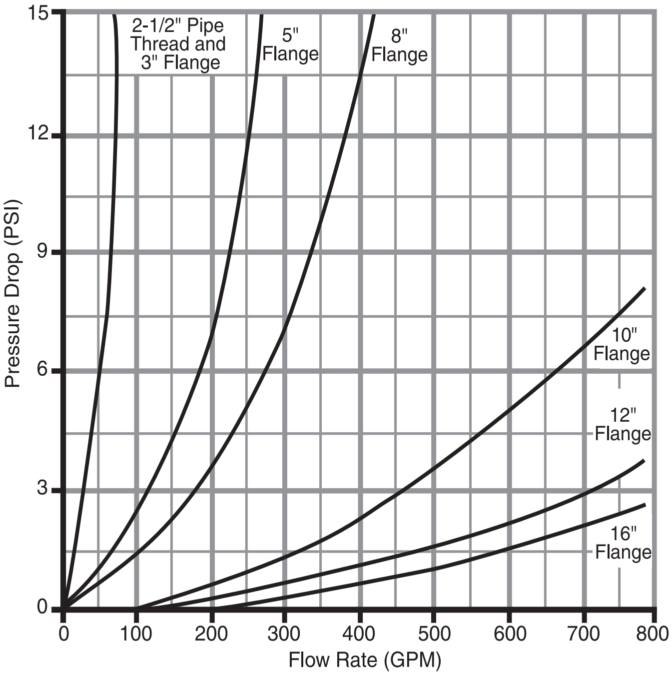
Inlet Temperature: 60° F

First, select the vessel size by determining the KW rating and watt density and referring to the oil heater listings. For this example, we will select a 5" flange heater.

From the water pressure drop curves, we get a 2 psi pressure drop, then we multiply that value by the correction factor for SAE 30 lubrication oil. This gives a 3.2 psi pressure drop through the heater for this application.

The viscosity of oil can change dramatically with a 30° F change in temperature. If your inlet temperature is different than 60° F, or the graphs indicate a pressure drop is too high for your system, please contact Heatrex. We can evaluate your exact requirements and offer alternatives to meet your needs.

Chart A



Watt Density and Element Sheath Material Selection

Selecting the proper watt density (watts per square inch of element surface area) and the proper sheath material is critical to heater life and fluid integrity. If the watt density is too high, the fluid may carbonize, break down chemically, or the elements may burn out. If the sheath material selection is incorrect, it will corrode, destroying the element.

In general, watt density is determined by three factors: 1) maximum outlet temperature 2) type of fluid heated and 3) fluid flow rate.

Sheath material depends on the type of fluid and maximum temperature.

The standard vessel material is carbon steel. A stainless steel vessel may be required at higher temperatures or for better corrosion resistance.

Table III gives watt densities and sheath material guidelines for a variety of liquids.

The watt density and sheath material guidelines shown in this table should not be interpreted as a recommendation for all applications because there are many other factors that can affect the selection of the appropriate watt density or sheath material. Use this information as an initial guide along with knowledge of the actual conditions which exist in the heating application.

Maximum Watt Densities, Sheath Materials and Properties for Liquids
Table III

Liquid	Max. Fluid Temp. (°F)	Max. Watt Density (W/In²)	Density (1) (Lbs/Ft³)	Specific (1) Heat, Cp (BTU/ Lbs °F)	Sheath Materials			
					Copper	Steel	Stainless Steel	Incoloy
Acetic Acid (2)	221	40	65.4	0.51			C	C
Alkaline Solutions	212	50	62.0	1.00			B	
Asphalt	500	6	132.0	0.22		A	A	A
Ethylene Glycol-50% Solution	300	50	65.8	0.76	A	B	A	A
Fuel Oils								
No. 1*	575	20	50.5	0.50		A	A	A
No. 2	375	20	53.9	0.47		A	A	A
No. 5	375	12	58.9	0.45		A	A	A
No. 6	375	8	58.9	0.44		A	A	A
Heat Transfer Oils								
Caloria HT 43	475	12	52.0	0.43		A	A	A
Chemtherm 660	675	20	63.7	0.38		A	A	A
Dowtherm A	725	20	66.0	0.38		A	A	A
Dowtherm G	675	20	68.6	0.37		A	A	A
Dowtherm HT	625	20	60.6	0.37		A	A	A
Dowtherm J	575	20	54.1	0.43		A	A	A
Dowtherm LF	575	20	63.0	0.40		A	A	A
Hitec	875	20	126.2	0.37		A	A	A
Marlotherm L	675	20	58.7	0.45		A	A	A
Marlotherm S	675	12	60.8	0.43		A	A	A
Mobiltherm 600	550	20	58.4	0.43		A	A	A
Mobiltherm 603	550	20	53.9	0.44		A	A	A
Mobiltherm 605	550	20	53.9	0.44		A	A	A
Mobiltherm Light	550	20	61.3	0.42		A	A	A
Multitherm PG-1	565	12	54.2	0.45		A	A	A
Multitherm IG-2	575	20	54.8	0.47		A	A	A

* Kerosene

Liquid	Max. Fluid Temp. (°F)	Max. Watt Density (W/In²)	Density (1) (Lbs/Ft³)	Specific (1) Heat, Cp (BTU/ Lbs °F)	Sheath Materials			
					Copper	Steel	Stainless Steel	Incoloy
Heat Transfer Oils								
Syltherm XLT	475	12	52.6	0.40		A	A	A
Syltherm 800	725	12	58.7	0.38		A	A	A
Thermalane 600	575	12	50.7	0.52		A	A	A
Thermalane 800	675	12	50.1	0.57		A	A	A
Therminol 44	400	12	57.8	0.47		A	A	A
Therminol 55	560	12	55.2	0.46		A	A	A
Therminol 59	575	20	60.6	0.41		A	A	A
Therminol 60	560	20	62.6	0.39		A	A	A
Therminol 66	630	20	63.0	0.38		A	A	A
Therminol 75	675	20	68.8	0.38		A	A	A
Therminol FR-1	575	20	85.5	0.28		A	A	A
Therminol LT	475	20	53.7	0.43		A	A	A
Therminol VP-1	725	20	66.7	0.37		A	A	A
UCON 500	475	12	64.8	0.47		A	A	A
Machine or Lubrication Oils								
SAE 10	275	20	55.4	0.45		A	A	A
SAE 20	280	20	55.4	0.45		A	A	A
SAE 30	285	20	55.4	0.45		A	A	A
SAE 40	290	12	55.4	0.45		A	A	A
SAE 50	295	12	55.4	0.45		A	A	A
Vegetable Oil	380	30	50.6	0.58			A	A
Water								
Process	212	50-80	62.4	1.00	A		A	A
Deionized (2)	212	50-80	62.4	1.00			B	

(1) Densities and specific heats are at or near room temperature.
(2) Stainless steel vessel may be required.

Rating legend:
A – Good
B – Fair
C – Conditional, solution concentration and temperature will affect suitability.