Watt Density Ratings And Calculations

Heater Wattage Determination

The procedures used to establish cartridge wattage are outlined below. Please note that the required equations, as well as typical application examples, are detailed in the catalog section “Application Data”.

1 Establish an acceptable heat up time and desired operating temperature.

2 Calculate the total wattage required to meet the application requirements.

3 Determine the cartridge diameter and length most suitable to the dimensions of your application.

4 Establish the quantity of heaters required to maintain temperature uniformity.

5 Calculate heater wattage by dividing total wattage required by heater quantity.

6 Calculate cartridge heater watt density. (See column “Watt Density Calculations”.)

7 Select the graph or table appropriate to your application and insure that the calculated watt density of the cartridge does not exceed the recommended maximum watt density. Additional graphs are contained in the catalog section titled “Application Data”.

8 If the calculated watt density is found to be excessive, implement a correction method from the list below and repeat the calculation process.

* Increase either the cartridge heater diameter or length, or both.
* Increase the quantity of cartridge heaters used in the application.
* Increase the heat up time allowed to lower the total wattage required.

Watt Density Calculations

The calculation of heater watt density consists of a simple, three step procedure.

1 Determine actual heated length by subtracting all cold lengths from the cartridge overall length. Minimum cold lengths include 1/4" at both disc and lead end with additional cold length required for certain lead and construction options.

2 Calculate heated area.

Cartridge Heated Area = Cartridge Heated Length x Actual Cartridge Diameter x 3.14

3 Calculate Watt Density

Cartridge Watt Density = Total Cartridge Watts ÷ Cartridge Heated Area

Watt Density Recommendations For Heating Solids

Using The Graph To Establish Appropriate Watt Density Based On Cartridge Fit.

Heater to hole fit is critical. Subtract minimum diameter of the heater (actual diameter minus tolerance) from maximum hole diameter to determine fit.

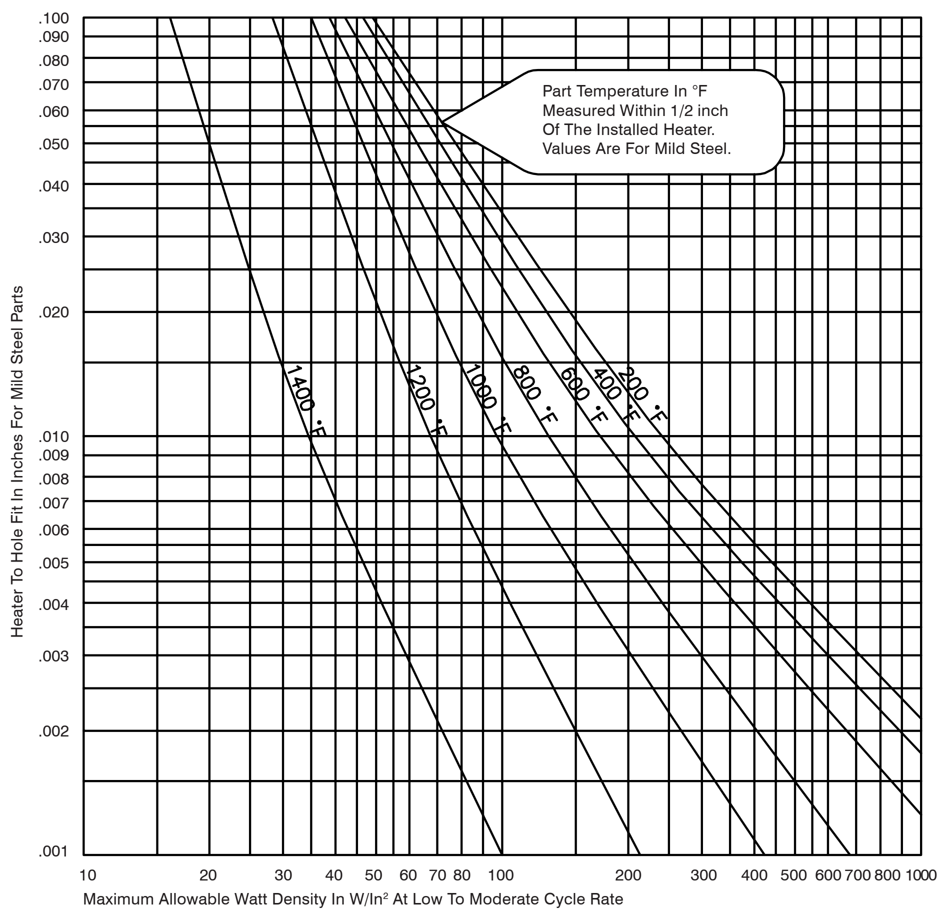
To determine maximum watt density when operating temperature and fit are known:

* Locate the intersection point of operating temperature curve and planned scale fit value. Read recommended watt density on scale directly below this point.

To determine maximum fit value when part temperature and watt density are known:

* Locate the intersection point of operating temperature curve and known watt density scale value. Read maximum fit value on scale directly across from this point.

Adjustment Factors:
* For stainless steel parts enter graph with a .002 greater than actual fit value.
* For brass and aluminum enter graph with 100 °F greater part temperature.
* For on-off cycles more frequent than once an hour multiply maximum recommended watt density by .8.
* For on-off cycles more frequent than once a minute multiply maximum recommended watt density by .7.



Watt Density Recommendations For Heating Liquids

Immersion Application Notes

Swaged cartridges satisfy the need for compact, high capacity heat sources in the heating of liquids. Watt density ratings as high as 150-300 watts per square inch are available for water applications. Refer to the table for watt density recommendations for various liquids.

For best performance in liquid heating applications:

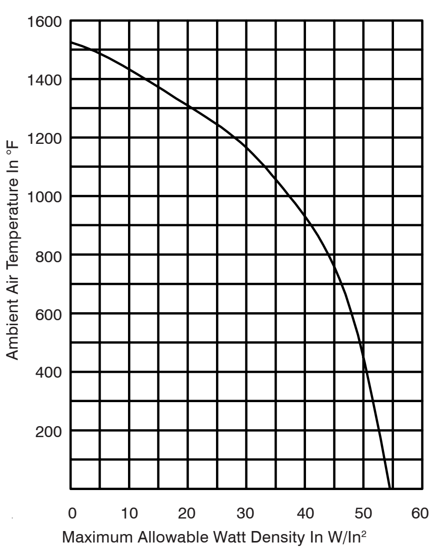
* Insure that the cartridge is in the main body of the liquid.
* Keep the cartridge totally immersed in liquid at all times.
* Prevent mineral deposits and scale from forming on the heater surface.
* Avoid frequent on and off cycling of the heater cartridge.
* Do not allow viscous, organic materials to carbonize on the heater sheath.
* Insure that sludge at the bottom of the tank is removed at periodic intervals.
* Sheath must be compatible with liquid to minimize corrosion.

Material Or Liquid Being Heated	Temperature	Max. Watt Density
Water and minimum 80% water solutions including acid and alkali cleaning baths.	210 °F	150-300 watts/sq. in.
Liquid metals including lead, solder, sodium and potassium.	500 °F 700 °F 900 °F 1100 °F 1300 °F	600 watts/sq. in. 500 watts/sq. in. 400 watts/sq. in. 300 watts/sq. in. 200 watts/sq. in.
Vegetable Oil @ Velocity of 1 fps.	400 °F	30 watts/sq. in.
Dowtherm A @ Velocity of 1 fps.	500 °F	20 watts/sq. in.
Machine Oil @ Velocity of 1 fps.	250 °F	18 watts/sq. in.
Therminol FR-2 @ Velocity of 1 fps.	500 °F	12 watts/sq. in.
Bunker C Fuel Oil @ Velocity of 1 fps.	160 °F	10 watts/sq. in.
Asphalt @ Velocity of 1 fps.	300 °F	8 watts/sq. in.
Molasses @ Velocity of 1 fps.	100 °F	5 watts/sq. in.

Watt Density Recommendations For Heating Gases

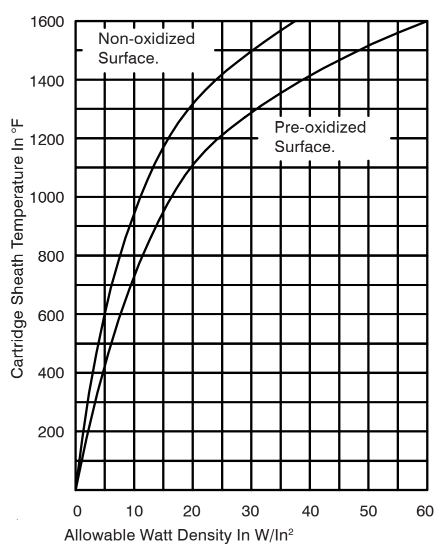
Maximum Watt Density
Versus
Ambient Air Temperature
(Natural Convection)

The graph values below are for one cartridge in air or similar gas environment. When using multiple cartridges and spacing between heaters is less than one diameter multiply .95 times graph value. If a reflector is placed behind the cartridge multiply .85 times the graph value.



Cartridge Sheath Temperature
Versus
Watt Density
(70 °F Ambient Air With Natural Convection)

The watt density required to obtain various cartridge sheath temperatures is shown in the graph below. Note that the values given are for typical pre-oxidized and non-oxidized sheath surfaces. A sheath temperature of 1450 °F with infrequent cycling would give approximately one year heater life.



Maximum Watt Density
Versus
Forced Convection Air Velocity
(Entering Air Between 0 °F and 200 °F)

The maximum watt density values in the graph below are based on air movement expressed in feet per minute (FPM). If air quantity is known in cubic feet per minute (CFM) divide the CFM value by the total free area around the heater. Total free area is container area minus the heater area.