



Recommendations for Improving the Life of Tempco Hi-Density Metric Cartridge Heaters

Tempco Hi-Density Metric Cartridge Heaters have been widely used in many demanding and diverse applications since 1972. The commonly used basic applications are platen, plastic mold and die heating, liquid immersion and air heating.



Note: Selection of the wrong termination for the particular application is the major reason for all heater failures. However, failure to consider other important criteria can also have a negative effect on the life of the heater. To get the best performance and assure long life, it is important to carefully evaluate the following factors.

Operating Temperature

Operating temperature of a heater is a major factor in determining the life expectancy of a heating element. The heater life depends on the actual temperature of the resistance wire within the heater and not on the process operating temperature. The graph in Fig. 1 demonstrates the proper relationship between operating temperature and watt density; the higher the operating temperature, the lower the maximum recommended watt density.

Heater Watt Density

Cartridge heater watt density is defined as the wattage dissipated per square centimeter of the heated sheath surface. For a particular application a heater's watt density governs internal resistance wire temperature, which determines the outer sheath temperature. These factors are critical to the proper heating of the application and to the life expectancy of the heater. Special construction features that promote excellent heat transfer permit Hi-Density cartridge heaters to operate at higher watt densities while maintaining the lowest possible resistance wire temperatures of any style cartridge heater.

Heater watt density (w/cm^2) is calculated using the following formula:

$$\text{Watt Density} = \frac{\text{Heater wattage}}{\text{Heated length} \times \text{Heater diameter} \times 3.1416}$$

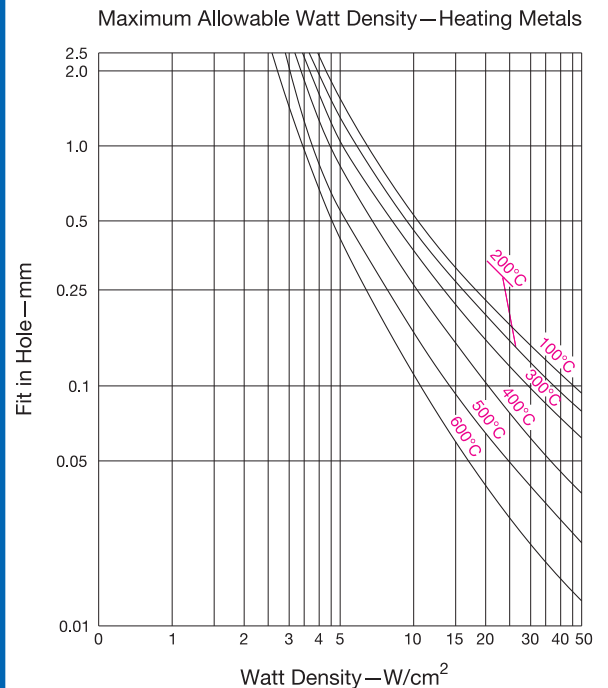
Heated length is the overall length of the heater minus any unheated (cold) sections. Standard Type N, Hi-Density Metric Cartridge Heaters have 9.5 mm at the lead end and 6.4 mm at the disc end unheated. This would mean a 100 mm long heater would have 84.1 mm effective heated length. Unheated sections vary with type of heater termination. For descriptions of terminations and options, see pages 2-39 through 2-60.

The graph in Fig. 1 shows the maximum recommended watt density for Hi-Density Metric Cartridge Heaters when used in a steel platen. Watt density limitations for various materials are given in the engineering section of this catalog. For liquid immersion heaters the maximum watt density depends on the type of liquid being heated. The more viscous, or thicker the liquid, the lower the maximum watt density. Higher watt density can cause the liquid to carbonize and accumulate on the heater sheath, which will cause premature heater failure. It is advisable to use heaters that have watt densities below the maximum recommended watt density to get the longest heater life. If the actual heater watt density is close to the maximum recommended watt density, you can correct the problem by:

1. Increasing the number, diameter and length of heaters.
2. Lowering the total wattage; however, this may increase the heat-up time.
3. Obtaining tighter fit (see Fig. 2 — Determining Fit).

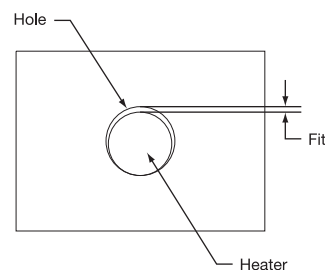
A Hi-Density cartridge heater designed at the maximum recommended watt density allows the smallest heater to be used to obtain the required wattage with good service life. All things being equal, using a lower watt density heater will typically provide optimized service life.

FIG. 1 Recommended Watt Density for Heating Metal Parts



The graph shows the recommended maximum watt density for Tempco Hi-Density Metric Cartridge Heaters at different operating temperatures and fit, when the heater is installed in an oxidized mild steel block. The thermocouple is located 12.5 mm from the heater. When heating other materials, the data needs to be extrapolated based on the thermal conductivity of the material. Consult Tempco with your requirements.

FIG. 2 Determining Fit



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Determining Fit

When heating a platen, mold, die or hot runner probe with Hi-Density Metric Cartridge Heaters inserted into drilled holes, fit is an important factor in determining the life expectancy of the heater. Fit is the difference between the minimum diameter of the cartridge heater and the maximum diameter of the hole. Unheated sections on a Hi-Density cartridge may be smaller in diameter due to swaging. To determine fit, use the smallest diameter on the heated length only.

Example: A 10 mm nominal OD Hi-Density cartridge heater has an actual diameter of 9.95 ± 0.03 mm, which translates to a minimum diameter of 9.92 mm. If used in a $10.01 \text{ mm} \pm 0.02$ mm hole, the fit would be .11 mm ($10.03 \text{ mm} - 9.92 \text{ mm} = 0.11 \text{ mm}$).

When medium watt density heaters (less than 9.30 watts per square centimeter) are used in low temperature applications (less than 600°F [315°C]) general purpose drills are commonly used to drill holes. The typical hole size may be 0.07 mm to 0.20 mm over the drill size. For higher watt density and/or higher temperature applications, we recommend that the holes are drilled and reamed for the tightest possible fit. In applications where precise temperature control and heat transfer properties are required, Hi-Density cartridge heaters can be centerless ground to ± 0.01 mm.

Although a tighter fit is desirable to efficiently transfer heat and to get long heater life, a looser fit will aid in installing and removing heaters, especially long heaters. We recommend that you apply Tempco's BNS anti-seize cartridge heater coating as it will improve heat transfer and will make the removal of heaters easier.

The graph in Fig 1. (page 2-29) shows the effect of fit in determining the maximum recommended watt density on a steel platen. As it is indicated in the graph, the tighter the fit, the higher the maximum recommended watt density.

Temperature Control and Location of Temperature Sensing Device

In order to better control the heater temperature and hence the resistance wire temperature, use of an appropriate temperature control and the proximity of the heater to the sensor is very important. The graph in Fig 1. (page 2-29) shows the effect of operating temperature in determining the maximum recommended watt density on a steel platen where the sensor is located 12.5 mm from the heater. Higher watt density heaters can generate heat faster than the surrounding area's ability to dissipate heat. This creates a thermal lag between the heater and the sensor. The closer the sensor to the heater, the better you can control the heater temperature. By keeping the sensor further from the heater, temperature gradients of several hundred degrees can be observed in many applications, especially during initial start-up and heavy thermal cycling. Although the set operating temperature may be low, the heater may be running at a very high temperature. This is a common cause of heater failure. This can be minimized using time proportional and PID functions of the temperature controllers. See Section 13 for temperature controllers and Section 14 for thermocouples and sensors.

Power Control

Power control methods affect the life expectancy of heating elements. In general, although economical, on-off controls increase thermal fatigue and oxidation rate on heating elements by causing wide temperature swings of the internal heating element. Silicon Controlled Rectifiers (SCRs), Mercury Relays and Solid State Power Controls can increase the life expectancy of heating elements by reducing the temperature swings of the internal heating element. See Section 13 for power controls.

Important Installation Considerations

1. For closest fit and best heat transfer, use reamed holes.
2. When possible, drill holes through the object being heated. This will make heater removal easier.
3. When using an anti-seize coating like Tempco's BNS spray or paste, **do not apply** over lead wires or any other current carrying conductors.
4. When using insulated tape or sleeving, check to make sure it is rated for the temperature of the application. Lower temperature rated materials can contain an adhesive or binder that can carbonize and become electrically conductive.
5. When using heaters near their maximum recommended watt density, it is recommended that the temperature sensing probes be located approximately 12.5 mm from the heater sheath.
6. Lead wires should not be located in the hole containing the cartridge heater during operation. This may cause the lead wires to be exposed to temperatures above their rated temperature.
7. When used in a vacuum application, make sure the lead end of the heater is outside the vacuum. If the lead has to be in the vacuum, consult Tempco for specific recommendations.
8. Many applications will subject a heater's electrical terminations to one or more of the following potentially damaging conditions:

- Moisture
- Flexing
- Oil and other contaminants
- Abrasion
- High temperature

Note: To protect the heater from damage in these harsh environments, Tempco has a wide selection of terminations and options available. See pages 2-39 through 2-60 for details.



CALCULATING WATTAGE REQUIREMENTS

Formulas and related data to calculate wattage requirements are detailed in the Engineering Section located at the back of this catalog. For new applications it is recommended that testing under actual operating conditions be performed to confirm wattage and watt density calculations.

An excellent evaluation method is to power up a heater with the calculated wattage and watt density through a variable voltage transformer. By changing the voltage and therefore the heater output, thermocouples sensing heater and process temperature can verify the design.



Standard (Non-Stock) Hi-Density Metric Cartridge Heaters

6.5 mm Diameter Actual 6.45 mm (.254")

Sheath Length (mm)	Watts	Watt Density (W/cm ²)	Part Number 220V
40	50	9	HDM00001
40	75	13	HDM00002
40	100	18	HDM00003
40	125	22	HDM00004
40	150	27	HDM00005
60	50	5	HDM00006
60	100	10	HDM00007
60	150	15	HDM00008
60	200	21	HDM00009
60	250	26	HDM00010

Sheath Length (mm)	Watts	Watt Density (W/cm ²)	Part Number 220V
80	100	7	HDM00011
80	150	11	HDM00012
80	200	15	HDM00013
80	300	22	HDM00014
80	400	29	HDM00015
100	100	6	HDM00016
100	200	11	HDM00017
100	300	17	HDM00018
100	400	22	HDM00019
100	500	28	HDM00020
130	100	4	HDM00021
130	250	10	HDM00022
130	400	17	HDM00023
130	500	21	HDM00024
130	600	25	HDM00025

8 mm Diameter Actual 7.95 mm (.313")

Sheath Length (mm)	Watts	Watt Density (W/cm ²)	Part Number 220V
40	50	7	HDM00026
40	75	11	HDM00027
40	100	14	HDM00028
40	150	22	HDM00029
40	200	29	HDM00030
60	75	6	HDM00031
60	150	13	HDM00032
60	200	17	HDM00033
60	250	21	HDM00034
60	300	25	HDM00035
80	100	6	HDM00036
80	200	12	HDM00037
80	300	18	HDM00038
80	400	24	HDM00039
80	500	29	HDM00040
100	100	5	HDM00041
100	250	11	HDM00042
100	400	18	HDM00043
100	500	23	HDM00044
100	600	27	HDM00045

Sheath Length (mm)	Watts	Watt Density (W/cm ²)	Part Number 220V
130	200	7	HDM00046
130	350	12	HDM00047
130	500	17	HDM00048
130	600	20	HDM00049
130	700	24	HDM00050
160	200	5	HDM00051
160	400	11	HDM00052
160	600	16	HDM00053
160	700	19	HDM00054
160	900	24	HDM00055
200	300	6	HDM00056
200	500	11	HDM00057
200	700	15	HDM00058
200	900	19	HDM00059



Note: Part Numbers above are for Hi-Density Cartridge Heaters terminated with Type N leads, 250 mm (10") long. See pages 2-39 through 2-57 for other terminations.

Metric Size Cartridge Heaters are made-to-order only. **Standard lead time is 3 weeks.**

Custom Engineered/Manufactured Hi-Density Metric Cartridge Heaters

Refer to ordering information on page 2-33.