National Plastic Heater
Technical Brief

Extending Miniature Heater Life

Designing cartridge heaters with reduced watt-density multiplies service life.

The industry-standard warrantee for electric cartridge heaters is 2000 hours, or one year on single shift. This is a reasonable life expectancy for many applications.

But some applications demand much more. Life expectancies of five, seven or even ten years are not unreasonable for some mission-critical applications:

- Blood warmers used in medical theaters must never fail;
- Battery conditioners for EVA spacesuits on the International Space Station must last ten years before replacement, due to payload costs;
- Here on earth, high throughput semiconductor chip testers must operate without significant downtime for the 5 year life of the equipment.

For these applications, a service life of 50000 to 90000 hours is a requirement that is both reasonable and attainable.

How can it be done?
For every heater power loading (See "Calculating Watt-Density", at bottom) there is a maximum operating temperature that will guarantee 2000 hours life. This is the "Critical Temperature" for that power loading. (See chart below).

Power Chart – System Temperature versus Maximum Watt-Density

Critical Temperature (F)	200	300	400	500	600	700	800	900	1000
Maximum Watt-Density	365	345	310	275	245	225	170	150	130

Go above the Critical Temperature by 100 degrees and life will be cut to a third, to 666 hours. But go *below* it by 100 degrees and heater life will be tripled, to 6000 hours! We can use this relationship to determine the watt-density at a given system temperature that will yield thousands of hours of extra life.

For Example…
Let's suppose that your system requires a processing temperature of 500 degrees F with an input power of 80 watts. A 1/8" by 1" cartridge heater could provide the necessary wattage, and would have a power density of 270 watts-per-square-inch. As can be seen from the power chart, a heater with a power loading up to 275 watts per square inch would be acceptable. Heater life would be a respectable 2000 hours.

Processing Temperature ↓

Critical Temperature (F)	200	300	400	500	600	700	800	900	1000
Maximum Watt-Density	365	345	310	275	245	225	170	150	130

Maximum Watt-Density ↑

But what happens if we use a utilize a 1 ¼" heater, just a ¼" longer? The heater's power loading is lowered to 210 watts-per-square-inch. The Critical Temperature is raised by 200 degrees. The heater is now operating 200 degrees *below* the new Critical Temperature and heater life is increased to 18000 hours (2000 hours x 3 to the 2nd)!

Processing Temperature ← ***- 200 F*** ← ***New* Critical Temperature**

Critical Temperature (F)	200	300	400	500	600	700	800	900	1000
Maximum Watt-Density	365	345	310	275	245	225	170	150	130

Maximum Watt-Density **Lowered Watt-Density**

How Do You Reduce Watt-Density? (First, the Good News…)

Your heater watt density may not have to be reduced. Many miniature heating applications inherently require relatively little wattage, due to their small mass. This often results in a minimal power loading on a 1/8" miniature heater. In these cases, miniature cartridge heaters are often under-loaded by 200 to 400 degrees, relative to the Critical Temperature. Their 2000 hour life expectancy* may be multiplied up to 81 times!

Increasing Surface Area to Reduce Watt-Density

1. Maximize your heater length. Increasing the length of a 1" heater to 1 ¼" (just a ¼") can increase the active area* by 33%, reducing power loading by 25%.
2. Consider using more heaters. Two heaters dividing the load will reduce watt-density by 50%.
3. Take advantage of any available space to install a supplemental heater. Adding a ½" long heater to an existing 1" heater can reduce power loading by 25%.

Calculating Watt-Density

Watt-density is the power loading of the heater, expressed in watts-per-square-inch of active heater surface.

The formula for active heater surface is: (Heater Length – Cold End Length) x Diameter x Pi.
For a 1/8" diameter by 1" long heater it is: (1.00 - 0.25) x .38, or .285 square inches.

The formula for watt-density is: Wattage / Active Heater Surface
For 1/8" diameter by 1" heater at 80 watts, this is: 80 watts / .285 in sq or 270 watts/sq inch.