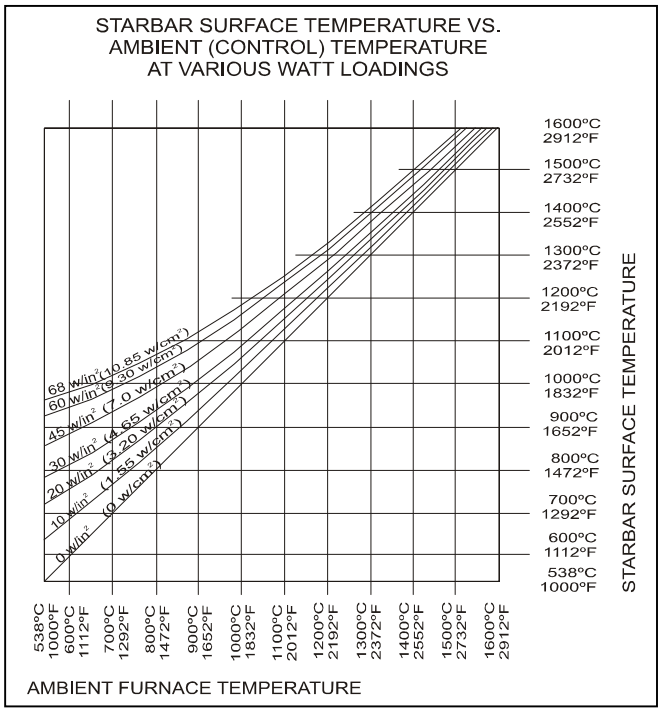
I SQUARED R ELEMENT CO., INC.
12600 Clarence Center Road, P.O. Box 390, Akron, New York 14001, Phone (716)542-5511, Fax (716)542-2100
e-mail: sales@isquaredrelement.com www.isquaredrelement.com

Starbar® Moly-D®

FACTORS THAT AFFECT STARBAR SERVICE LIFE

Silicon Carbide heating elements increase in resistance during their service life. The rate at which aging occurs is affected by many factors such as element watt loading, operating temperature, atmosphere, mode of operation--continuous or intermittent and power control methods. Element life depends on many factors. The elements can last several years if operated in a favorable atmosphere at a favorable watt loading.

- **Watt Loading and Operating Temperature** A heating element with a higher watt loading will operate hotter, as shown on the adjacent chart. This higher temperature is directly related to the rate at which the element increases in resistance. For optimum element life, the lowest possible watt loading should be considered, in the range of 20 to 50 watts per square inch (3-8 watts per square centimeter).



- **Atmosphere** - In clean, dry air atmosphere SE, SER and one-piece Starbars can be operated at furnace control temperatures up to 2912°F (1600°C). The maximum element temperature is 2957°F (1625°C) The three-piece RR or U type Starbars are limited to 2600°F (1425°C).

  In inert atmospheres of argon or helium elements may be operated to 3092°F (1700°C.)

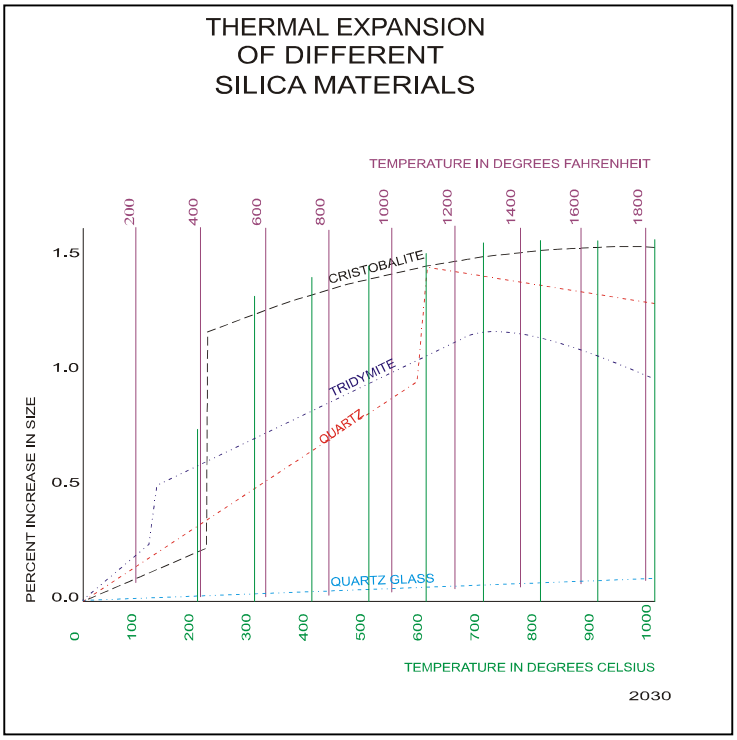
  For atmospheres containing water vapor, alkali metal vapors, flux vapors or oxygen enrichment, we recommend LMA infusion glaze coated elements or elements of type TW, SE, SER or SEU. Please contact us for recommendations.

  In reducing atmospheres the maximum operating temperature is 2500°F (1370°C).

  There is a protective coating of silicon dioxide on the silicon carbide. Hydrogen reduces this coating and causes the Starbar to deteriorate. Very dry or very wet hydrogen is detrimental to long service life.

  Nitrogen atmosphere applications are limited to 2500°F (1370°C) and 30 watts per square inch (5 watts per square centimeter) maximum surface watt loading. Too high of a surface temperature will result in a silicon nitride reaction. A thermally insulative layer forms around the Starbar resulting in very high surface temperatures which damage the Starbars.

- **Mode of Operation** – Starbar heating elements can be used in both continuous and intermittent operations. For maximum service life above 2372°F (1300°C) continuous operation is recommended. The reason for this is that a new element is essentially 100% pure silicon carbide with very little silicon oxide. As it is used, the silicon carbide oxidizes and forms more silicon oxide and silicon dioxide. This is what causes the element to increase in resistance over its life.



The chart entitled THERMAL EXPANSION OF DIFFERENT SILICA MATERIALS show that these various forms of silica - quartz, cristobalite and tridymite have considerable size changes as they go through these phase phases.

When the silicon dioxide in the element is cooled or cycled, it goes through several phase transformations. The high-low quartz transformation at 1060°F (570°C) involves a substantial volumetric change, which can lead to the fracture of bodies containing large amounts of quartz.

As the Starbars go through these temperature ranges, the expansion and contracting of the silica can fracture the silicon carbide lattice structure which increases the electrical resistance and can cause element failure.

The 1060°F (571°C) temperature is theoretical and the exact element temperature can vary somewhat. For these reasons, we recommend a minimum idling temperature of 1300°F (704°C), to remain well above this inversion temperature.

There are those customers who feel it is more economical to conserve on energy and suffer a shorter element life. There are other customers who prefer the longer element life at the expense of the energy used during idling. Since each application is different, the choice remains with the customer.

- **Power Supply** – The resistance of Starbars increases gradually during their useful life. Therefore, some means of maintaining the power input to the furnace at a level sufficiently high to maintain the desired temperature, is required. Historically this involved the use of mechanical contactors and multiple tap transformers with up to 16 taps to be able to adjust the voltage upwards in steps, to maintain the desired power output as the elements aged. In more recent times, the use of SCR's (silicon controlled rectifiers, also known as thyristors) have become more popular as they are less bulky, and enable very precise control of the voltage and power input to the heating elements. To provide a large voltage reserve to enable maximum life of the element elements when designing higher temperature and more industrial furnaces, the use of a combination of step down transformers with only 3 or 4 output tappings in combination with SCRs, is the most common system today.

Starbars can be used directly on the line (fixed voltages) at temperatures up to 2400°F (1300°C). To compensate for the reduced output as the Starbars gradually age or increase in resistance, the furnace or kiln is typically initially overpowered by 25% to 50%. This type of arrangement has proven very satisfactory in many applications.