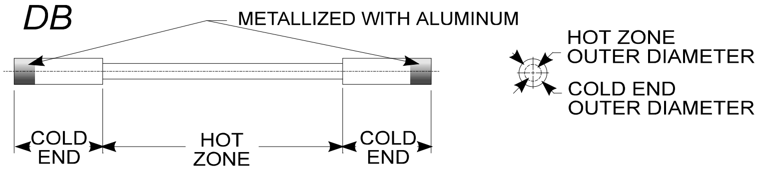
TYPE DB DUMBBELL and TDB TUBULAR DUMBBELL - (ENLARGED COLD END) - SILICON CARBIDE HEATING ELEMENTS

GENERAL DESCRIPTION

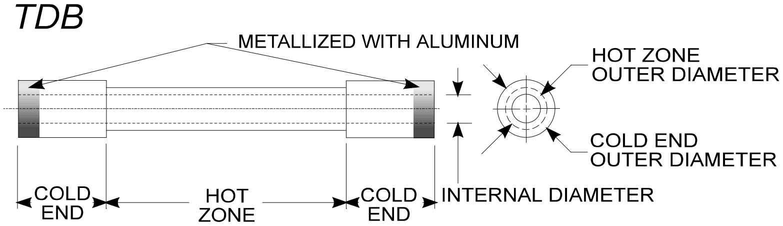
One of the earliest heating element designs, the enlarged cold ends of the Dumbbell style element were originally made oversized to increase cold end cross section, lowering electrical resistance, thereby lowering cold end operating temperature. Modern Dumbbell Starbars, by contrast, employ an advanced technology to keep the terminal ends cool by virtue of the decreased resistivity of the lower resistance cold end material used in the manufacturing process. Oversize cold ends are therefore no longer necessary. Non-dumbbell (RR Starbars) can be substituted for Dumbbell Starbars. Improvements in the cold-end-to-hot-zone resistance ratio between the original DB and new DB Starbar have been dramatic. The old style resistance ratio was 1:3, whereas the new DB and RR resistance ratio is a minimum of 1:15.

The first several inches of the cold ends are metalized with aluminum to provide a low-resistance contact surface. Electrical connections are made using flat aluminum braids, held in compression to the cold end circumference by stainless steel spring clamps.

DB



TDB



DB Starbars are described by giving the overall length, the heating section length, the hot zone outer diameter and the cold end outer diameter.

As an example, DB 22 x 15 x .31/.50 is a Dumbbell Starbar 22 inches long, 15 inch hot zone, .31 hot zone OD and .50 cold end OD. In millimeters the part number would be DB 560 x 380 x 8/14.

For sizes available, please refer to Table B on page 3, DB Starbar Dimensions.

With a larger diameter, thinner wall, and clear inner diameter (ID) the TDB are used as tube heaters. An electrically insulative load tube, usually made of mullite, can be used to isolate the product from the TDB Starbar. The surface of Starbars are electrically live. See Table B, page 3 for the ID dimensions and recommended load tube diameters.

SUPERIOR PERFORMANCE

A 2.4 gm-cc density helps prevent the crystalline lattice structure from being oxidized, resulting in a very slow aging characteristic.

INTERCHANGEABILITY

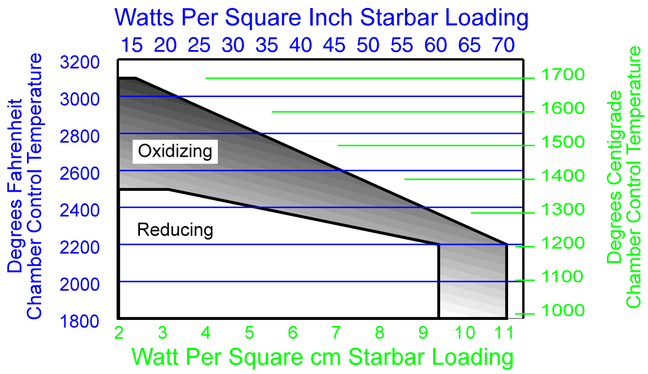
Starbars are interchangeable with all dumbbell silicon carbide heating elements manufactured in the United States as well as higher resistance heating elements manufactured for the Asian and European markets. It is important to provide the nominal electrical resistance when ordering Starbars.

Starbar®

Silicon Carbide Heating Elements

I SQUARED R ELEMENT CO., INC.

Recommended Maximum Watt Loading (Figure 1)



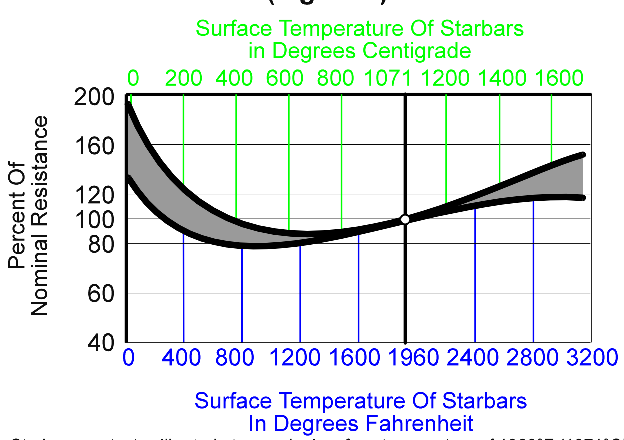
OPERATING TEMPERATURES

DB Starbars can operate to furnace temperatures up to 2730ºF (1500ºC). If the furnace temperature is to be 2600ºF (1425ºC) or above, the terminal end or cold end should be well protected within the refractory wall of the furnace. The hot zone material is rated to furnace temperatures up to 3100ºF (1700ºC).

The maximum operating temperature should be reduced for non-air applications with the exception of argon and helium that can be used without any reduction. Reducing atmospheres, such as hydrogen or disassociated ammonia, particularly with low dew-points, may remove the protective silicon oxide protection that forms on silicon carbide. In such atmospheres, temperature reductions are required as shown in Figure 1.

The maximum furnace temperature for a nitrogen atmosphere is 2500ºF (1370ºC) with a watt loading of 20 w/in² to 30 w/in² (3.1 w/cm² to 4.6 w/cm²) maximum watt surface watt loading. Too high a surface temperature will result in formation of silicon nitride causing a thermally insulative layer to form around the Starbar resulting in over-temperature damage.

Resistance Temperature Characteristics (Figure 2)



Starbars are test calibrated at a nominal surface temperature of 1960°F (1071°C).

ELECTRICAL CHARACTERISTICS

The silicon carbide Starbar is a linear type resistance heater that converts electrical energy to heat energy -- Joule's Law $W = I^2 \times R$, (W = power in watts, I = current in amperes, R = resistance on ohms).

DB Starbars have a negative resistance temperature characteristic from room temperature to approximately 1200°F (650°C). At this temperature it turns positive and remains so through-out its normal operating temperature range. See Typical Resistance/Temperature characteristics graph (Figure 2).

Nominal Starbar resistance is measured at the calibrating temperature of 1960ºF (1071ºC). Nominal resistance values of Starbars in ohms, per unit of length are shown in Table A, page 3.

ELECTRICAL LOADING

Starbars are not sized to a specific wattage output like metallic heating elements. The amount of energy that a Starbar is capable of converting from electrical to heat energy depends on the ambient furnace temperature and atmosphere in which the Starbar is operating.

When calculating the wattage capabilities of a Starbar, the unit of watts output per unit of radiating surface area is used. Figure 1 shows the recommended watt loading for a square inch or square centimeter of radiating surface as a function of furnace temperature.

To determine the recommended wattage capabilities of the Starbars start with Figure 1. Knowing the furnace temperature and atmosphere in which the Starbars will be operated, follow the temperature line until you intersect the heavy black line (choosing the appropriate line according to the atmosphere in which the Starbar will be operating). Read the loading in watts per square unit of radiating surface that can be applied to the Starbar. To find the total amount of power one Starbar could supply under these conditions, multiply this value by the radiating surface of the Starbar.

The radiating surface area is calculated by multiplying the hot zone diameter times the hot zone length times pi (3.14). Example of radiating area:

The DB 22 x 15 x .31/.50 has a hot zone length of 15 inches and a hot zone diameter of .31 inches. The radiating surface area is 15 x .31 x 3.14, or 15 square inches.

(In millimeters, the DB 559 x 381 x 8 has a hot zone length of 381mm and a diameter of 8mm. The radiating surface area is 381 x 8 x 3.14, or 9571 square millimeters, converted to centimeters is 96 square centimeters.)

EASE OF REPLACEMENT

DB Starbars can be replaced while the furnace is at operating temperature. The power to the Starbars being changed should be shut off, the spring clips and aluminum braid released, and the old Starbar removed. The new Starbar should be inserted smoothly through the hot furnace with sufficient speed to insure that the aluminum is not melted off the terminal end but not so fast as to cause thermal shock.

SERVICE LIFE

Starbars increase gradually in resistance with use. This characteristic of increasing in resistance is called aging. Aging is a function of the following:

(1) Operating temperature
(2) Electrical loading - usually expressed in watts per square inch or watts per square centimeter of Starbar radiating surface
(3) Atmosphere
(4) Type of operation (continuous or intermittent)
(5) Operating and maintenance techniques

MOUNTING

DB Starbars can be mounted in any orientation. Holes through refractory walls or in ceramic lead-in sleeves, if used, must be large enough to ensure no physical binding of the Starbars. The alignment of the support holes through refractory walls should also guarantee that no physical binding occurs.

If ceramic fiber bulk is used to help reduce radiant energy losses around the Starbars, it must be tucked gently around the diameter of the cold end for a distance of only 12mm (1/2 inch). The ceramic fiber should never be packed so tightly that it restricts the thermal expansion differences between the Starbar and furnace components. Aluminum braid should be kept slack so that there is no physical stress being applied to the Starbars.

AVAILABILITY

Starbars can be shipped from stock or two to three weeks after receipt of an order.

SPECIFICATIONS AND MATCHING

Starbars have a manufactured tolerance of plus or minus 20% on the nominal resistance. All Starbars are calibrated at least twice prior to shipping to ensure their being within specifications. The calibrated amperage of each Starbar is marked on the carton and right hand end of each Starbar. When installing, arrange Starbars with amperage values as close to each other as available. Longer service life will be obtained when series connected Starbars are matched in resistance. Starbars are shipped as closely matched as possible.

FURNACE HEATING CHAMBER

The furnace heated chamber dimension, which the Starbar spans, can be the same as the Starbar (as shown by the Starbars under the load in Figure 3). Recommended terminal hole diameters for various refractory walls and Starbar sizes are shown in Table C.

Table A
DB Electrical Resistance

Hot Zone OD		Cold End OD		*Hot Zone resistance		*Cold End Resistance	
MM	Inch	MM	Inch	Ohms/ MM	Ohms/ Inch	Ohms/ MM	Ohms/ Inch
8	.31	14	.56	.02157	.5480	.00038	.00959
12	.44	18	.75	.01372	.3486	.00016	.00406
14	.56	22	.88	.00773	.1963	.00012	.00308
18	.75	28	1.10	.00340	.0865	.00008	.00200
25	1.00	38	1.50	.00197	.0501	.00004	.00104
30	1.12	45	1.75	.00134	.0341	.00003	.00085
TDB Electrical Resistance							
30	1.12	38	1.50	.00452	.115	.00003	.00068
40	1.63	50	2.00	.00271	.069	.00002	.00056
50	2.00	60	2.38	.00208	.053	.00001	.00038

* All Resistance values are +/- 20%.

Table B
DB Starbar Dimensions

Hot Zone Outer Diameter		Cold End Outer Diameter		Maximum Heating Length		Maximum Overall Length		* Maximum Recommended Load Tube OD		Starbar Inner Diameter (ID)		T-Clamp & strap *or* D-Strap: **T-Clamp	***D-Strap
MM	Inch	MM	Inch	MM	Inch	MM	Inch	MM	Inch	MM	Inch		
8	.31	14	.56	305	12	559	22	--	--	--	--	T-13	D-14
12	.44	18	.75	610	24	787	31	--	--	--	--	T-19	D-19
14	.56	22	.88	610	24	1295	51	--	--	--	--	T-25	D-22
18	.75	28	1.10	813	32	1498	59	--	--	--	--	T-25	D-28
25	1.00	38	1.50	914	36	1803	71	--	--	--	--	T-38	D-38
30	1.18	45	1.75	1219	48	2286	90	--	--	--	--	T-44	D-44
TDB Starbar Dimensions													
30	1.12	38	1.50	610	24	1016	40	*12	*0.50	22	0.88	T-38	D-38
40	1.63	50	2.00	610	24	1016	40	*18	*0.75	30	1.12	T-54	D-52
50	2.00	60	2.38	610	24	1016	40	*28	*1.10	40	1.50	N/A	D-60

* The maximum load tube diameter is based on the overall length of the DB Starbar. For overall lengths other than the maximum length listed above, use the following formula: Starbar ID - (0.01 x overall length in inches), but no greater than Starbar ID - 0.12". Starbar ID - (0.0254 x overall length in mm), but no greater than Starbar ID - 3mm.

** The T-Clamp requires an A-type or B-type strap to be used with the clamp. Please refer to our Starbar accessory brochure for additional information on T-clamps and straps.

*** The D Strap is a strap/clamp combination. Please refer to our Starbar accessory brochure for D strap information.

Starbars should not be placed closer than two Starbar diameters to each other or one and one half Starbar diameter to a wall or other reflecting body. If the Starbar is not able to dissipate heat energy equally in all directions, it may cause local overheating and possible failure.

The formula for computing the recommended Starbar spacing to obtain an even temperature gradient on the product being heated is shown in Figure 3.

ELECTRICAL CONNECTORS

Held in place by clamps, braided aluminum terminal straps in 25, 50, 100, and 200 ampere ratings, are available in two primary styles: Single Loop (for connecting binding post to element) and Double Loop (for connecting element to element). Post to Post straps are also available. Detailed descriptions and part numbers can be found in our accessory literature.

TERMINAL CLAMPS

There are two type of clamps: Type "M" (derives its name from its similarity to the letter M) and Type "T" (used with a tool). Please refer to our accessory literature for a detailed part number and description.

RECOMMENDED DB STARBAR SPACING

X = 2 x Starbar hot zone diameter is the minimum, 1.5 x Starbar hot zone diameter is the absolute minimum and requires a reduced Starbar Surface Watt Loading.

Z = S ÷ 1.73 minimum for moving loads

S = 2 x Starbar hot zone diameter minimum

X - distance from the centerline of Starbar to any reflecting surface, such as a refractory wall or product

Z - distance from the centerline of the Starbar to a moving or stationary load

S - distance from centerline of the Starbar to the centerline of an adjacent Starbar

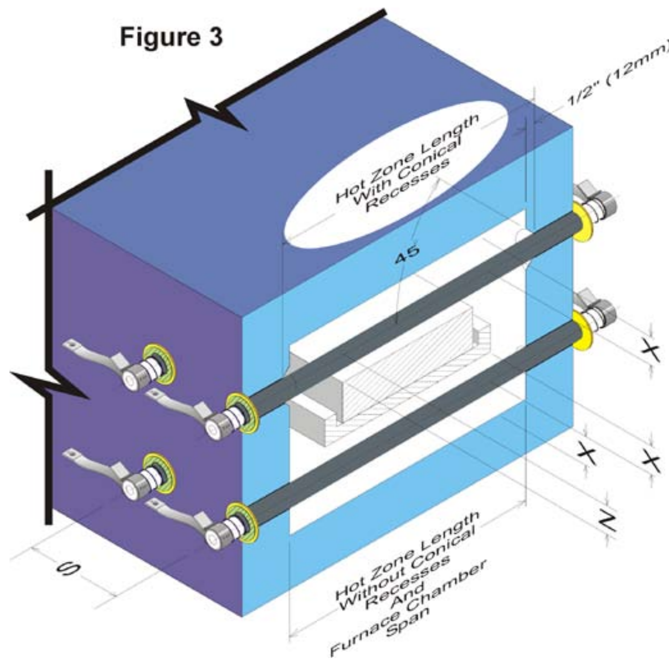


Figure 3

Table C Recommended Minimum Refractory Hole Size											
		Minimum Hole Diameter Based on Refractory Wall Thickness									
Cold End Outer Diameter		*100*	*150*	*200*	*300*	*400*	*3*	*5*	*6.5*	*9*	*13.5*
MM	Inch	MM	MM	MM	MM	MM	Inch	Inch	Inch	Inch	Inch
14	.56	20	20	21	23	--	3/4	13/16	13/16	7/8	--
18	.75	25	25	26	28	--	15/16	1	1	1-1/16	--
22	.88	28	29	30	32	34	1-1/16	1-1/8	1-1/8	1-3/16	1-1/4
28	1.10	34	35	36	38	40	1-5/16	1-3/8	1-3/8	1-7/16	1-1/2
38	1.50	45	45	46	48	50	1-3/4	1-3/4	1-13/16	1-7/8	1-15/16
45	1.75	51	52	53	55	57	2	2-1/16	2-1/16	2-1/8	2-3/16
50	2.00	58	59	60	62	64	2-1/4	2-5/16	2-5/16	2-3/8	2-7/16
60	2.38	68	69	70	72	74	2-5/8	2-11/16	2-3/4	2-3/4	2-7/8