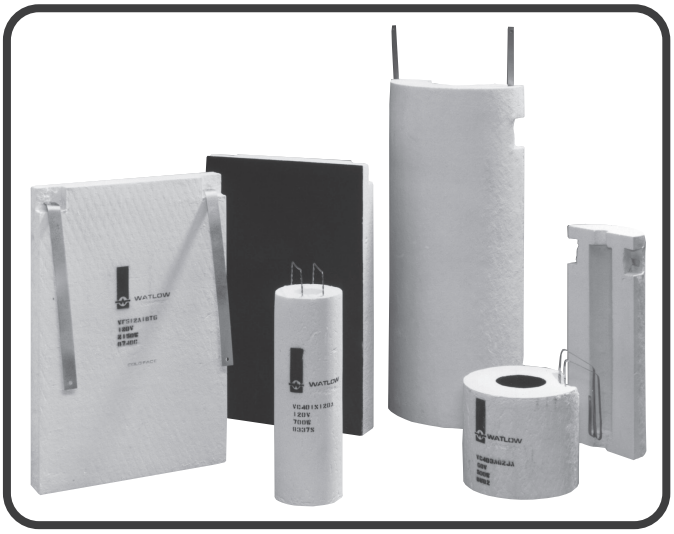
Ceramic Fiber Heaters

Ceramic fiber heaters offer some of the highest temperature heating element capabilities available in the Watlow family of heaters. Heating units constructed of ceramic fiber insulation isolate the heating chamber from the outside. Ceramic fiber heaters are extremely low mass, high insulation value units with self-supported heating elements. Many applications can benefit from the convenience of the heating element and insulation combined into one package. Its lightweight, low-density properties are ideally suited for high temperature applications requiring low thermal mass.



Performance Capabilities

- Operating temperatures up to 2200°F (1204°C)
- Watt densities from 5 up to 30 W/in^2 (0.8 to 4.6 W/cm^2)
- Uses “radiant” heat transfer exclusively

Features and Benefits

High temperature ICA resistance elements

- Bounds integrally into required position
- Allows five element configurations

Lightweight, low-density alumina-silica composition molded into shape

- Acts as insulation to isolate the heating chamber from the outside
- Provides low shrinkage fiber and inorganic binder
- Ensures a firm, thermal shock resistant, self-supporting unit at all operating temperatures

Operating temperatures up to 2200°F (1204°C)

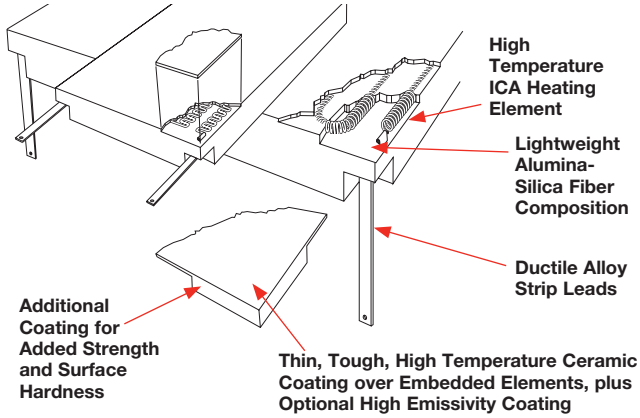
- Provides high temperature performance that is not possible with many other heater types (See page 423 for detailed limits)

Low mass ceramic fiber insulation of 10 to 15 lb/ft^3 (160 to 240 kg/m^3)

- Allows the heater to reach process temperature quickly
- Allows the energy to heat the load instead of wasting energy on itself

Works directly off of common power line voltages

- Eliminates the need for expensive transformers or complex power control systems
- Enables compatibility with the full range of Watlow temperature controllers and power switching devices



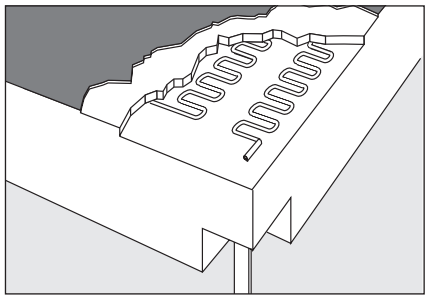
Typical Applications

- High temperature furnaces
- Metal melting, holding and transfer
- Semiconductor processing
- Glass, ceramic and wire processing
- Analytical instrumentation

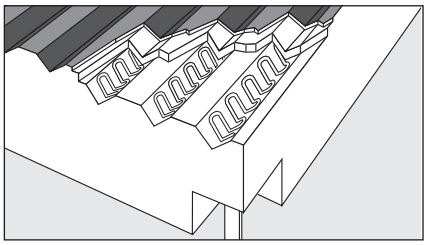
Ceramic Fiber Heaters

Options

Embedded Sinuated Elements



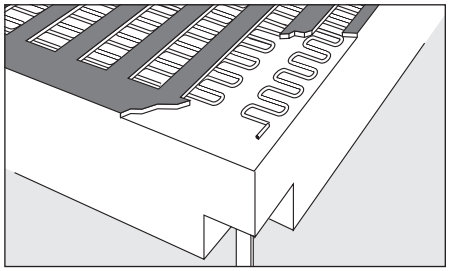
Flat Sinuated



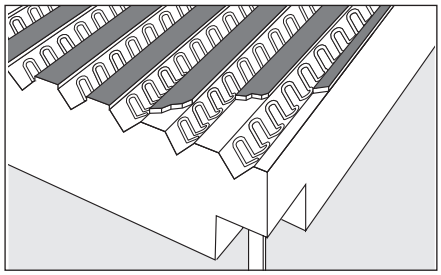
V-Sinuated

- Available in either flat or V-sinuated element configurations
- Advanced V-sinuated element configuration allows up to 27 percent additional watt density over embedded flat sinuated elements
- Performs best at medium to high temperatures at medium watt density power requirements
- Use in partially enclosed to fully enclosed applications
- Especially well suited for large, flat units; semi-cylindrical units above 5 in. (125 mm) I.D.; and full cylinders above 4 in. (100 mm) I.D.
- Offers greater effective insulation thickness than coiled element designs
- Enhances “heated insulation” concept of operational use
- Features high emissivity coating on new high watt density series units. When ordering, refer to charts on pages 438 to 440.

Exposed Sinuated Elements



Flat Sinuated



V-Sinuated

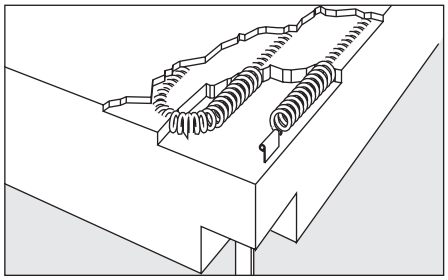
- Available in either flat or V-sinuated element configurations
- Advanced V-sinuated element configuration allows up to 20 percent additional watt density compared to exposed flat sinuated elements
- Offers the lowest possible wire-to-chamber temperature difference for maximum heater life
- Provides optimum heat-up/cool-down and recovery times as well as maximum operational efficiency
- Higher current handling capabilities are possible
- Minimizes the number of circuits and connections in large furnaces
- Especially well suited for large, flat surface area units and large I.D. curved units
- Exposed elements are available on special order as a variation of the embedded sinuated element normally provided on stock and standard units. When ordering, refer to charts on pages 438 to 440.

Ceramic Fiber Heaters

Application Hints

Applications

- High temperature furnaces
- Metal melting, holding and transfer
- Semiconductor processing
- Glass, ceramic and wire processing
- Analytical instrumentation
- Fluidized beds
- Laboratory and R&D
- Other high temperature process applications



Embedded Coil Elements

- Optimum performance for high temperature, enclosed furnace chambers
- Coiled elements readily conform to complex curved surfaces, especially small custom chamber shapes
- Coiled element design works best in higher voltage, lower current situations
- Use where lower watt density requirements and low duty cycle operations are expected
- Available in stock and standard units of medium watt density, rated up to 2000°F (1093°C). When ordering, refer to charts on pages 435 to 437.

- Never use ceramic fiber heaters for conduction heating applications. These heaters are designed for **radiant heat transfer only**.
- Use appropriate mounting methods including pins, washers, clamping straps, overlapping edge clamps, interlocking edges, etc. Generally, these methods work better than cementing ceramic fiber heaters, as cementing will not accommodate the expansion and contraction caused by thermal cycling of surrounding metal structures.
- Keep furnace loads free of oils, lubricants and other contaminants that can vaporize at high temperatures. Ceramic fiber heaters have a porosity exceeding 90 percent and cannot be sealed against contamination infiltration and possible damage to the heating element wire.
- Use low mass thermocouples that are responsive to rapidly changing radiant energy transfer conditions. Without proper temperature control, ceramic fiber heaters can generate sufficient heat for self destruction.
- Mount a thermocouple junction directly above an element and within $^{1}/_{16}$ in. (1.6 mm) of the heated surface. Embedded ceramic mounting tubes are available as an option to position 0.125 in. (3.2 mm) diameter thermocouples inside the fiber, directly behind and between the elements. Heater wire operating temperatures are critical and wires should be monitored at the hottest point within the application.
- Electrical connections made in heated portions of the application must be rated for the appropriate currents and anticipate ambient temperatures. To ensure good electrical connections, use compression-type connection devices located as far away from the hottest area of the application. This minimizes the possibility of electrical connection degradation caused by thermal expansion, contraction and high temperature oxidation.
- Ceramic fiber products shrink at high temperatures. During the first 24 hours of operation at temperatures between 1600 and 2200°F (870 to 1204°C), shrinkage of up to four percent can occur. Fill all gaps between units created by shrinkage with loose ceramic fiber insulation. Watlow offers a “pre-firing” process that pre-shrinks and dimensionally stabilizes units before shipping. Contact your Watlow representative for further details.
- Use additional back-up insulation for maximum energy efficiency and appropriate safety considerations. Use only insulation with inorganic fibers and binders to avoid corrosive fumes that could damage heater elements.
- Handle all units and leads with care. Ceramic fiber heaters are very resistant to thermal cycling and thermal shock, but are easily subject to mechanical damage from careless handling.
- Repair of minor mechanical damage, made with unapproved or unknown cements, could damage the wire elements at high temperatures. If unsure, contact your Watlow representative before making repairs. Several accessory items are available from the factory for repair purposes.

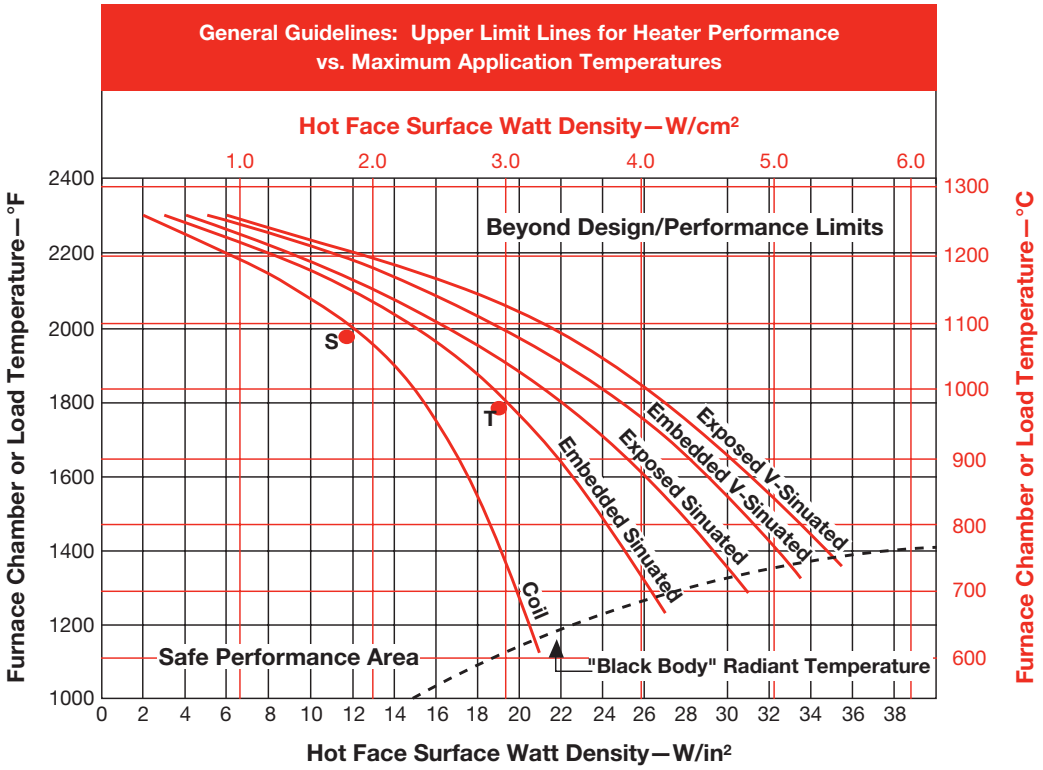
Ceramic Fiber Heaters

Performance Data

Performance Capabilities

The *Performance* graph shown below represents capabilities of the five heater element configurations. The curves compare upper temperature limits versus permissible design watt densities to achieve a standard heater life expectation of 2,000 hours.

As with all Watlow heaters, the major application concern is the heater's surface watt density as it relates to the application temperature, such as with the furnace chamber temperature or the radiant surface temperature. When evaluating an application for temperature and watt density requirements, it should fall to the left of and below the performance limit lines. If the application falls into this area, then it is in the safe performance area. The further into this safe performance area, the higher the life expectancy of the heater. If an application requires temperatures or watt densities that fall into the area to the right of and above the lines, then the application operates beyond the heater's typical design or performance limits. Using a heater required to perform in this area of the graph may result in a shorter life expectancy. For information specific to an application, contact your Watlow representative.



Ceramic Fiber Heaters

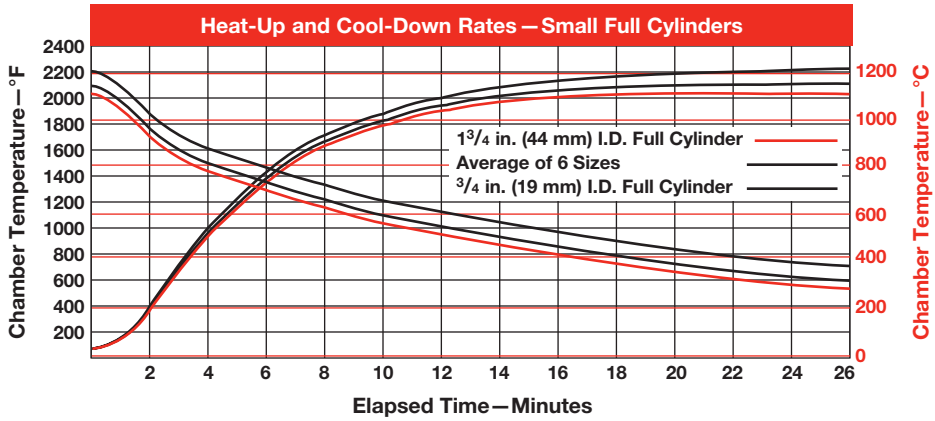
Performance Data *(Continued)*

The following graphs provide technical data to help evaluate performance and select the correct ceramic fiber heater for an application.

The four graphs shown represent performance data for heat-up/cool-down rates and power requirements to maintain furnace temperature. This data averages test results performed for two typical types of furnace chambers, and should not be used for specification purposes.

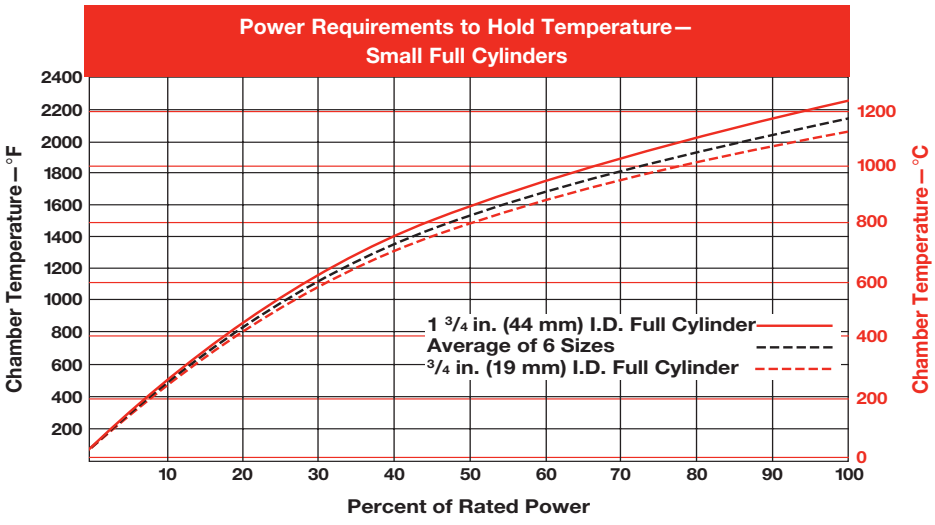
Small, Full Cylinder, Heated Chambers

Test conditions for small, full-cylinder heated chambers are typical of analytical instrumentation furnaces. Several stock sizes are represented. Units tested were 6 in. (150 mm) long, mounted in a vertical orientation. Both ends were capped with 1 in. (25 mm) of ceramic fiber insulation. No additional insulation or metal sheath was added to the outside diameter. Temperature was measured by a thermocouple located in the geometric center of the chamber.



Power Requirements

Shown below are percentages of rated power needed to achieve and hold specific temperatures inside the full cylinder chambers tested. This represents the efficiency of these heaters in this mounting configuration.



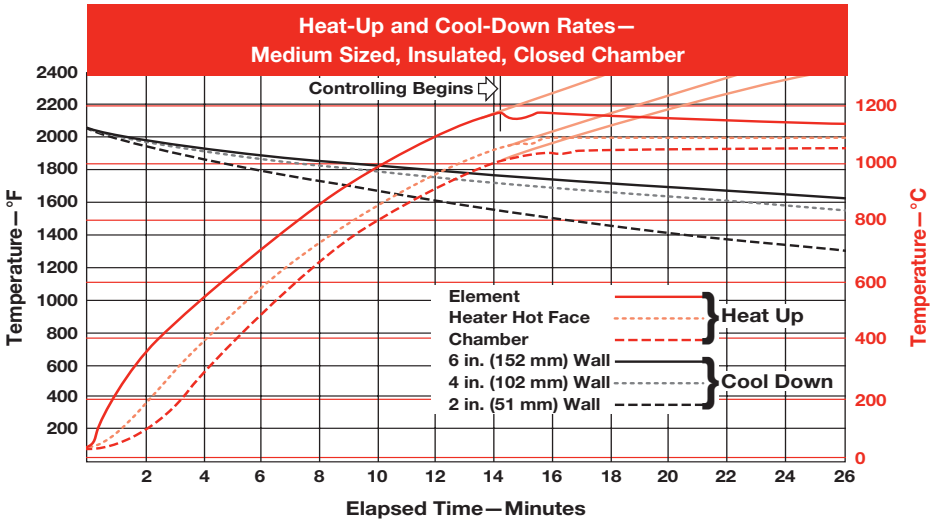
Ceramic Fiber Heaters

Performance Data *(Continued)*

Medium Sized, Insulated Closed Chambers

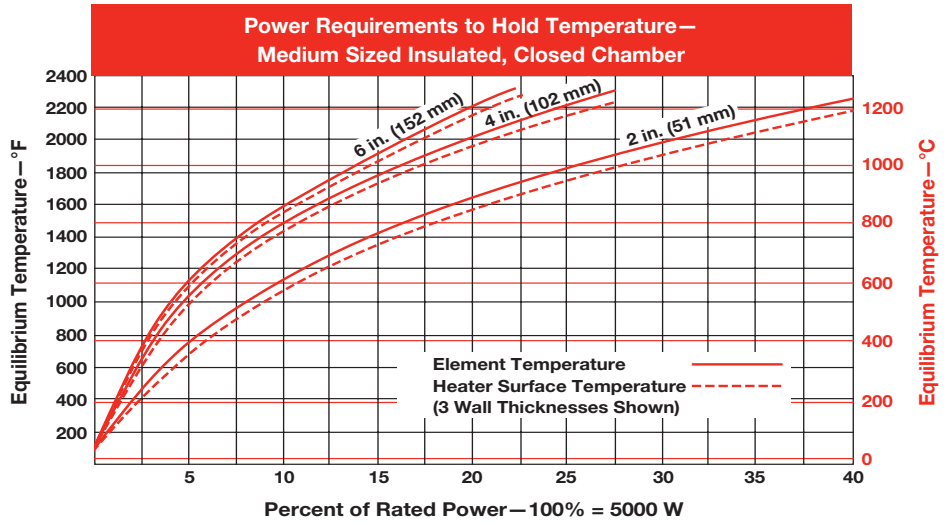
Test conditions for medium-sized, insulated chambers are typical of pit and box furnaces, large tube furnaces and pipe and reactor heating. Standard embedded coil units (Watlow part number **VS412A12S**) were used and rated for 2000°F (1093°C). The test chamber size was 12 in. long and 12 in. I.D. (305 X 305 mm). The volume was approximately 0.75 ft^3 (0.02 m^3).

Temperature heat-up rates were measured by thermocouples in three places: at the element, on the heater surface and at the center-of-chamber. Data for various additional wall thicknesses is also shown. This is typical of how large, flat and semi-cylindrical units are used. The chamber was oriented vertically with top and bottom disks of ceramic fiber insulation equal to wall thickness.



Power Requirements

Shown below are the percentages of rated power needed to achieve and hold specific temperatures inside of medium-sized, insulated chambers. This represents the efficiency of these heaters in this mounting configuration.

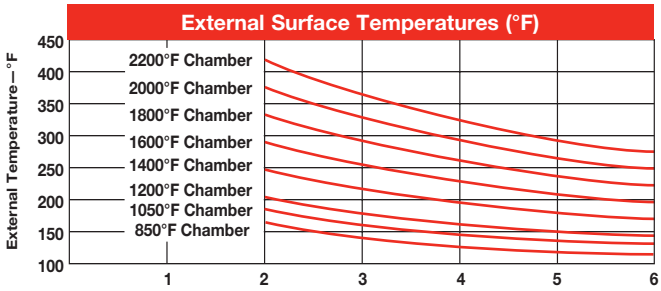


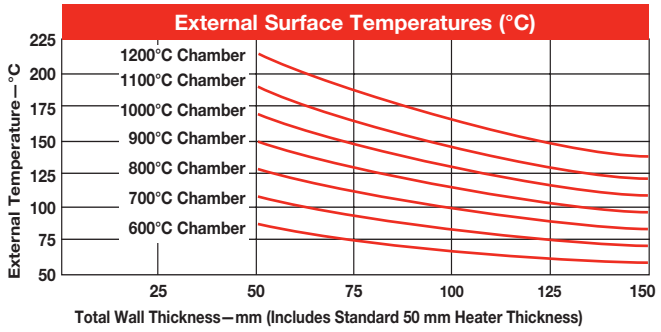
Ceramic Fiber Heaters

Performance Data *(Continued)*

Insulation Effectiveness

The graphs below illustrate the effectiveness of adding 6 lb/ft^3 (96 kg/m^3) blanket insulation to the backside of standard 2 in. (50 mm) thick ceramic fiber heaters. Total wall thickness of up to 6 in. (152 mm) is shown. Data is for vertical sides without metal sheathing. Top and bottom surfaces and surfaces with metal sheaths covering ceramic fiber insulation will vary.

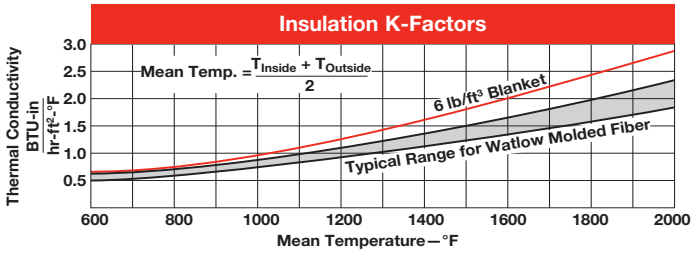


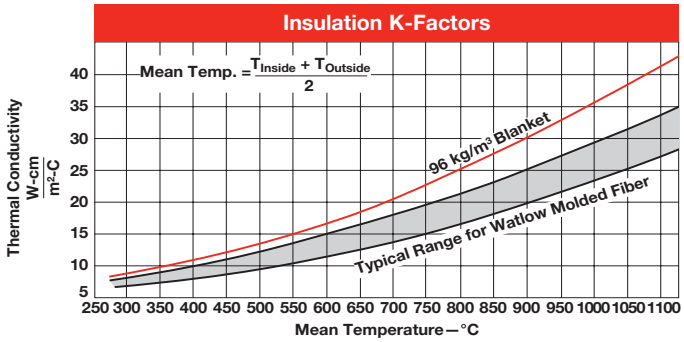


Heat Loss and Energy Transfer

For general calculations of heat loss and energy transfer, the *Insulation K-Factors* and *Emissivity* graphs are helpful.

The *K-Factors* graph is for ceramic fiber heaters and the ceramic fiber insulation blanket typically used with the heaters. This blanket is offered as an accessory by Watlow.





Application Hints

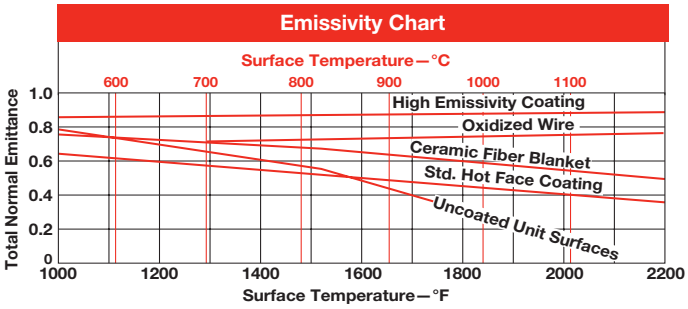
For wall thicknesses (T) in cylindrical situations use the "equivalent thickness" conversion.

$$T_{cyl.} = r_{out} \log_e \left(\frac{r_{out}}{r_{in}}\right)$$

Where r_{out} is outer radius
r_{in} is inner radius

Emissivity of Heater Surface

The *Emissivity* graph details the normalized emittance values for the four surfaces most likely to be encountered when planning Watlow ceramic fiber heater applications.



Ceramic Fiber Heaters

Termination Options

Watlow offers many variations of electric leads to meet particular wiring requirements. To understand termination options available, it is necessary to understand the various methods for applying electrical leads.

Ceramic fiber heater electrical leads are welded to stubs – the metal parts that interface between the heating element wire and the add-on electrical leads. These stubs exit the heater at the lead pockets. Pockets are small cavities below the cold face plane (outside surface) and usually located at or near the corners.

Watlow ceramic fiber heaters are equipped with either strip leads or double twisted wire leads. Strip leads are most commonly used, unless otherwise specified. The various lead styles refer to the lead's exit orientation relative to the pocket used on a given type of heater. See illustrations for specific details.

Strip Leads

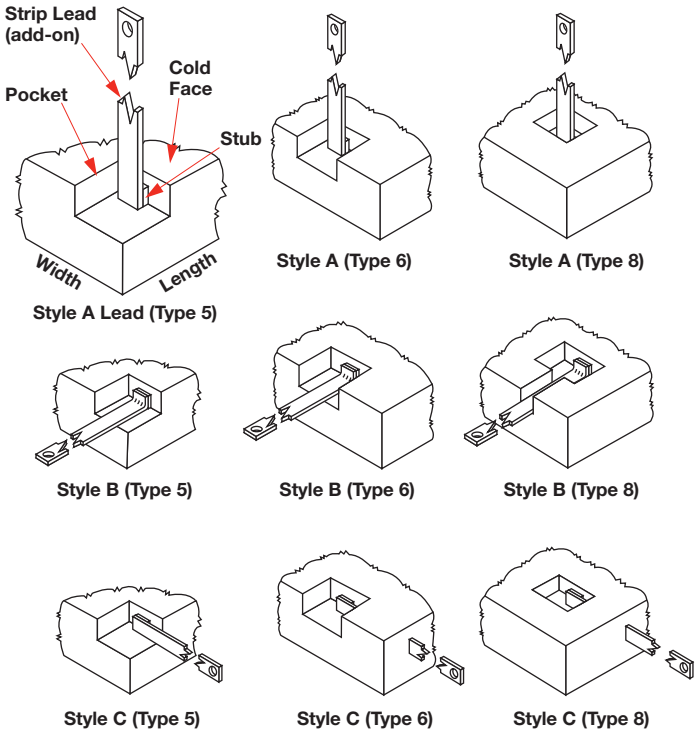
Flat and semi-cylindrical ceramic fiber heaters are available with the termination options shown here. When ordering termination options for catalog units, the specific strip lead **Style** must be specified. To determine the desired style, refer to the following illustrations. If a style is not specified, **Style A** leads, 12 in. (305 mm) in length will be provided. Additional lengths are available using add-on leads which are priced per pair, per inch, for the three different widths. See ordering charts for which lead width is used on a specific heater.

Strip leads are shipped with a $^{13}/_{64}$ in. (5 mm) hole at the end of the lead. Use #10-24 screws, nuts and washers, or other wiring connections. Caution should be exercised when making connections. Leads are susceptible to loosening due to thermal expansion and contraction as the heater cycles.

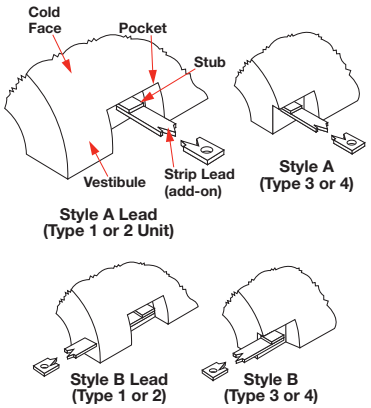
Important

Inspect the carton and its contents for damage prior to discarding packaging material. If there is any damage, contact your Watlow representative immediately for a Returned Material Authorization (RMA) number. All damaged goods are to be returned in the original packaging to reduce the possibility of further damage to the product.

Flat Units



Semi-Cylindrical Units



Ceramic Fiber Heaters

Termination Options *(Continued)*

Special Lead Orientation

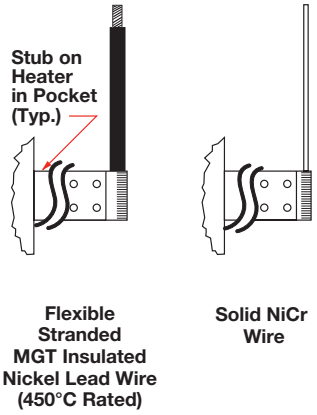
If the various standard strip lead orientations and pocket configurations are not suitable, special designs are available. When ordering, please include drawings that show proposed locations.

Leads Bent 90 Degrees

The double twisted leads of full cylinder heaters can bend 90 degrees to lay into slots and exit to the sides of the unit.

Special Add-On Lead Configurations

The two options illustrated can be welded onto the stub at the heater pocket, or for a better installation, welded to the end of a specified length of the regular strip lead. The strip lead length can vary from zero to the value necessary to distance it from the hot zone. The length of the add-on lead option eliminates the need for a custom product and satisfies a greater range of wiring requirements. Contact your Watlow representative for technical details and price.



Accessories

Ceramic fiber heater orders can include the accessory items described in this section. Please specify the Watlow part number when ordering.

Rigidizer

Rigidizer is primarily used to recoat soft, cut edges of ceramic fiber heaters and ceramic fiber insulation panels. Various degrees of hardening can be achieved with additional applications. Rigidizer can be ordered by the pint (0.47 L) by specifying part number **CFRGDPT** or gallon (3.78 L), part number **CFRGDGAL**.

B.T.E. Closed-End Thermocouple Tubes

A horizontal thermocouple tube between the elements is available in two sizes: 0.140 in. (3.6 mm) and 0.265 in. (6.7 mm), both 6 in. (152 mm) long with closed end.

Black Surface Coat

Black high emissivity coating is used to raise emissivity closer to 1.0. The container size is 4 ounces. Order **CFBSC**.

Ceramic Tubes

Ceramic tubes are available in four nominal sizes: 1/8, 1/4, 3/8 and 1/2 in. (3.2, 6, 9.5 and 13 mm) I.D. and lengths including 0.9 in. (22 mm) and 1.9 in. (48 mm) long. Ceramic tubes have several uses, including thermocouple mounting holes, mounting pin sleeves and lead coverings. The table below lists part numbers and exact sizes.

Inside Diameter		Length		Part Number
in.	(mm)	in.	(mm)	
0.140	(3.6)	0.90	(22)	**CC405-1**
0.265	(6.7)	0.90	(22)	**CC405-2**
0.390	(9.9)	0.74	(19)	**CC405-3**
0.515	(13.1)	0.90	(22)	**CC405-9**
0.140	(3.6)	1.90	(48)	**CC405-4**
0.265	(6.7)	1.90	(48)	**CC405-5**
0.390	(9.9)	1.60	(41)	**CC405-6**
0.515	(13.1)	1.90	(48)	**CC405-8**

Ceramic Fiber Heaters

Accessories *(Continued)*

Dry Heating Surface Mix

Dry heating surface mix is used to make the hot face of all heaters, including those with the high emissivity coating. It can also be used with rigidizer to make a very high temperature paste for touch ups of the hot face area. Order by the pint (0.47 L), part number **CFHTGSURMX**, or gallon (3.78 L), part number **CFHTGMXGAL**.

Patch Kit

To easily repair small breaks or cracks, the patch kit contains one pint (0.47 L) of powdered ceramic fiber and four ounces (0.118 L) of black surface coat. Order **CFPATCHKIT**.

Ceramic Fiber Insulation Blanket

Additional insulation value for ceramic fiber heaters is available with ceramic fiber insulation blanket. This 6 lb/ft³ (96 kg/m³) ceramic fiber blanket contains no organic binders. It is suitable for applications up to 2300°F (1260°C) and sold in full rolls or cut by the square foot. These blankets are available in the following sizes:

Size (U.S.)	Size (metric)	Part No.
24 in. X 25 ft X 1/4 in.	610 mm X 7.6 m X 6 mm	**CFBLKT1/4**①
24 in. X 25 ft X 1/2 in.	610 mm X 7.6 m X 13 mm	**CFBLKT1/2**①
24 in. X 25 ft X 1 in.	610 mm X 7.6 m X 25 mm	**CFBLKT-1**①

① Add ...R to end of part number for full roll.

Powdered Ceramic Fiber

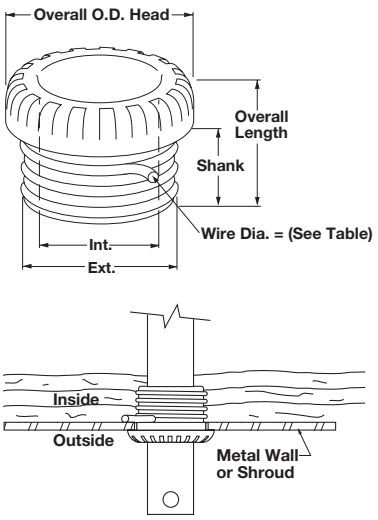
Powdered ceramic fiber is used primarily to improve surface finish in critical areas. It can also be used to fill voids, cracks and broken corners in damaged units. Use powdered ceramic fiber with rigidizer to make an easy to apply paste. A standard container size is one pint (0.47 L). Order part number **CFPDRFPT**.

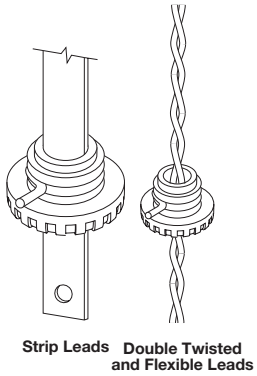
High Temperature Coating and Electrical Potting Cement

Two different high purity, high temperature cements can be used to mount thermocouple tubes, provide extra surface hardening, bond ceramic fiber gaskets and affix lightweight ceramic fiber insulation blanket to panels, as well as attach edge-spacer blocks and custom vestibules. Potting cement is packaged in a 1/4 pint (116 mL) jar, and may be ordered by specifying part number **CFPTGCMT**. The high temperature coating cement is available in pints or gallons, and can be ordered by using part numbers **CFCTGCMTPT** and **CFCTGCMTGAL**.

Strip Lead Porcelain Bushings

Strip lead porcelain bushings are primarily used to protect heater power leads when passing through metal walls and furnace structures. Bushings are available with inside diameters listed below for use with double twisted leads and the three standard strip lead widths. To select the appropriate inside diameter lead bushing, reference the heater selection tables on pages 435 through 440. The strip lead width for each heater is listed therein.





Porcelain Bushings Specifications

Conduit K.O. Size in. (mm)	Shank Dia. without Wire Nut Int. in. (mm)	Shank Dia. without Wire Nut Ext. in. (mm)	Wire Nut Dia. in. (mm)	Shank Length in. (mm)	Overall Length in. (mm)	Overall Head O.D. (Ref.) in. (mm)	Use With:	Part Number
3/8 (9.5)	3/8 (9.5)	21/32 (16.7)	0.080 (2.032)	9/16 (14.3)	7/8 (22.2)	7/8 (22.2)	All double twist	**CS45-11**
1/2 (13.0)	7/16 (11.1)	13/16 (20.6)	0.080 (2.032)	3/4 (19.0)	1 1/8 (28.6)	1 1/8 (28.6)	3/8 (9.5 mm) Strip	**CS45-20**
3/4 (19.0)	9/16 (14.3)	1 (25.0)	0.106 (2.692)	7/8 (22.2)	1 5/16 (33.3)	1 5/16 (33.3)	1/2 (13.0 mm) Strip	**CS45-30**

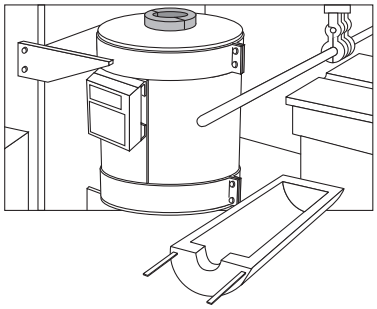
Ceramic Fiber Heaters

Mounting Methods

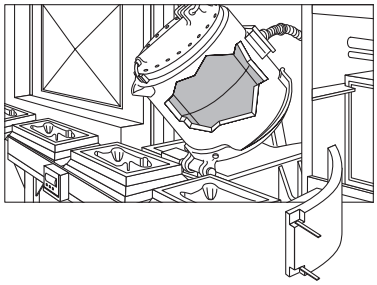
The Watlow ceramic fiber heater is available in a wide range of heater shapes and configurations to solve high temperature process applications. The modularity and range of sizes and wattages provide the greatest possible flexibility. Watlow has developed and can recommend many appropriate specific and generalized mounting systems for mounting heaters. Ceramic fiber heaters have been organized into seven major mounting categories or heater system configurations as shown in the following illustrations.

1. Full Cylinder Heaters

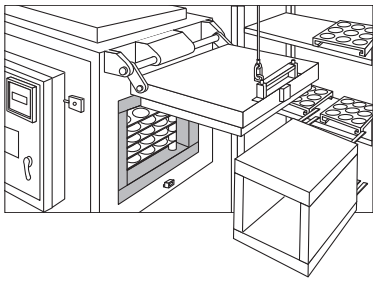
2. Semi-Cylindrical (180° section) Heaters



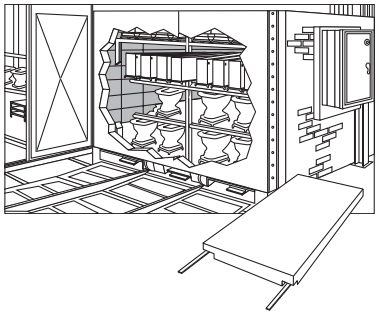
3. Arc-Section Arrays of Heaters (3 or more units of 120° or less each)



4. Flat Panels, with One Panel on Each Side



5. Flat Wall Array with Minimum Two-by-Two Units per Wall



6. Made-to-Order Molded Shapes with Up to Five Sides of a Box Molded as One Piece, Including Complex Curves