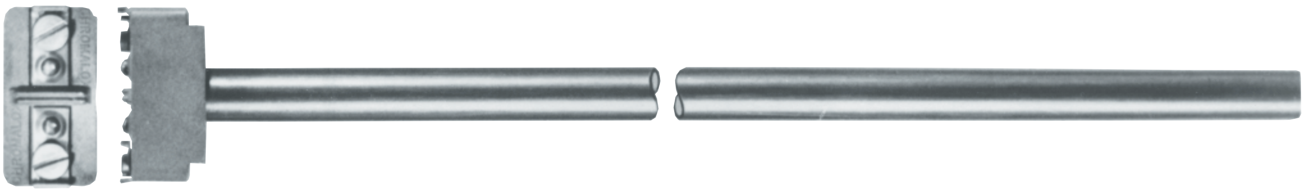
# OMEGALUX® HIGH/MEDIUM WATT DENSITY CARTRIDGE HEATERS

## With 300 Stainless Steel Sheathing

### OMEGALUX Cartridge Heater Selection Guide



MADE IN USA

Cartridge heaters are most frequently used for heating metal parts by insertion into drilled holes. For easy installation, the heaters are made slightly undersize relative to their nominal diameter.

The CIR high Watt density cartridge heater is supplied with an Incoloy sheath, type “F” long life stranded flexible leads and high watt densities. The Incoloy sheath allows operation at sheath temperatures to 1500°F.

The CIR series cartridge heaters feature a high temperature Incoloy sheath and swaged construction, which allows for higher Watt densities and maximum life at higher operating temperatures. The maximum sheath temperature for the CIR series is 1500°F.

The CSH series cartridge heaters also feature a swaged construction for higher Watt densities and efficient heat transfer from the nichrome resistance wire to the surface of the heater. The maximum operating temperature for the 300 series stainless steel sheath is 1250°F.

The CSS series cartridge heaters are constructed of coiled resistance wire which is wound through ceramic cores, and a 300 series stainless steel sheath. They are available in lower Watt densities and in diameters as small as ⅛". The maximum temperature for the 300 series stainless steel sheath is 1250°F.

All cartridge heaters are rated by wattage and Watt density (Watts per square inch) for either 120 or 240 Volt operation. In some applications it may be useful to derate the wattage by operating the cartridge heater at a lower voltage. When operating at lower voltages, the wattage is derated using the following formula:

(Operating Voltage/Rated Voltage)$^2$ x Wattage at Rated Voltage = Derated Wattage

Example: The CIR-1027/240 cartridge heater is rated at 200 Watts and 128 Watts per square inch at 240 Volts. To determine the derated wattage when operating on 120 Volts:

(120 Volts/ 240 Volts) 2 X 200 Watts = 50 Watts

When operating on 120 Volts, the Watt density of this heater would also be reduced by a factor of 4 from 128 Watts per square inch to 32 Watts per square inch.

The tightly compacted refractory insulation provides excellent heat transfer to the heavy wall stainless steel sheath. This means the resistance wire runs at a lower temperature than competitive units with loose-fill insulation. The result is much longer life. This heavy-duty construction also provides high dielectric strength as well as shock and vibration resistance required for many industrial applications.

### CSH SERIES

**Sheath Material:** Series 300 stainless steel
**Maximum Sheath Temperature:** 1250°F (676˚C)
**Leads:** Fiberglass insulated, maximum temperature 482°F (250˚C)
**Lead Length:** 6"
**Diameters:** ¼" to ¾"
**Lengths:** 1" to 12"

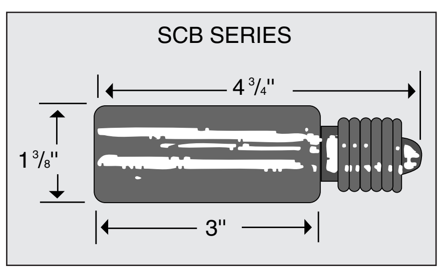
### CSS SERIES

**Sheath Material:** Series 300 stainless steel
**Maximum Sheath Temperature:** 1250°F (676˚C)
**Leads:**
- **⅛" to ¼" diameter:** Teflon insulated leads, maximum temperature 392°F (200˚C)
- **⅜" to ¾" diameter:** Fiberglass leads, maximum temperature 482°F (250˚C)

**Lead Length:** 6"
**Diameters:** ⅛" to ¾"
**Lengths:** 1" to 12"

### SCB SERIES

**Used as a space heater for closets and control cabinets**
**Max. Work Temperature:** 600°F (315°C)
**Wattage:** 50-200 Watts
**Length:** 4¾"
**DIameter:** 1⅜"
**Sheath Material:** Brass
**Max. Sheath Temperature:** 1000°F (538˚C)
**Type of Terminals:** Edison screw base (light bulb socket)



# APPLICATION OF OMEGALUX® CARTRIDGE HEATERS–CIR SERIES*

OMEGALUX cartridge heaters are most frequently used for heating metal parts by insertion into drilled holes. For easy installation, the heaters are made slightly undersize relative to their nominal diameter.

**Application at medium Watt densities**. Figure D-1 (page D-6) shows maximum allowable Watt density for various fits and operating temperatures . The vast majority of applications do not require maximum watt/in², however. Use a Watt density only as high as you need. Take advantage of the safety margin provided by using ratings less than the maximum allowed. Select space heaters for most even heat pattern rather than for the highest possible wattage per heater.

At medium Watt densities, general purpose drills are usually adequate for drilling holes. Typically, these result in holes .003" to .008" over the nominal size of the drill, resulting in fits of .010" .015". Of course, the tightest fit is desirable from a heat transfer standpoint, but somewhat looser fits aid in installing and removing cartridge heaters, especially long ones. Holes drilled completely through the part are recommended to facilitate removal of the heater. After drilling, clean or degrease the part to remove cutting lubricants.

**Application at high Watt density.** OMEGALUX cartridge heaters are designed and manufactured to provide Watt density capabilities second to none. To obtain best life at the highest Watt densities close attention to application details is suggested.

**a.** For closest fit and best heat transfer, holes should be drilled and reamed, rather than just drilled to final diameter with a general purpose drill.

**Determining fit**. At high watt densities, a close fit is important. The fit is the difference between the minimum diameter of the heater and maximum diameter of the hole. For example, at ½" diameter an OMEGALUX cartridge heater is actually .498" plus 000" minus .005". If this heater is placed in a hole which has been drilled and reamed to a diameter of .503" - .493" = .010").

**b.** The sensor for the temperature control should be placed between the working surface of the part and the heaters. The temperature of the part approximately ½" away from the heaters is used in selecting maximum allowable Watt density from the graph.

**c.** Control of power is an important consideration in high Watt density applications. On-off control is frequently utilized, but it can cause wide excursions in the temperature of the heater and working parts. Thyristor power controls are valuable in extending the life of high Watt density heaters, since they effectively eliminate on-off cycling.

**Determining Watt density.** The term "Watt density" refers to the heat flow rate of surface loading. It is the number of Watts per square inch of heated surface area. For calculation purposes, stock cartridge heaters have ¼" unheated length at each end. Thus, for a ½" x 12" heater rated 1000 Watts, the Watt density calculation would be as follows:

$$\text{Watt density} = \frac{W}{\pi \text{ n x D x HL}}$$

W = wattage = 1000W
D = diameter = .5 in.
HL= heater = 11.5 in.

$$\text{Watt density} = \frac{1000}{3.14 \text{ x } 5 \text{ x } 11.5}$$

$$= 55 \text{ W/in.}$$

**Selecting sizes and ratings.** The calculation of total heat requirements for an application is outlined in the technical section Z. For assistance, contact OMEGALUX.

Once total heat requirements are established, the quantity, size and rating of cartridge heaters can be decided. Plan for enough heaters to permit even temperatures through the part during heat-up and operation. The sensor for the temperature control should be placed close to working surface for accurate control.

After the wattage for each heater has been established, the Watt density and fit must be calculated. Then, use Fig. D-1 on page D-6 to be sure that the Watt density is within allowable limits. For example, a ½" x 12" OMEGALUX CIR series rated 1000 Watts has a Watt density of 55/in². If it were used in a part with an operating temperature of 1000°F with a fit of 0.01", the allowable Watt density from the graph would be 90W/in², thus, the actual Watt density of 55w/in² is well below the maximum allowed. A substantial safety margin would exist and high reliability can be expected.

If the heater selected had a Watt density higher than that allowable by graph, then those changes could be considered.

1. Using more heaters of lower watt density.
2. Using longer or larger diameter heaters.
3. Improving the fit.
4. Reducing heat requirements by reducing heat losses or by allowing for longer heat-up time.

*For information on the CIR Series, visit our website at ***omegacartridgeheater.info***

# HEATING PLATENS, DIES, MOLDS USING CARTRIDGE HEATERS–CIR SERIES*

This heating application may usually be easily accomplished by using cartridge heaters, although in some applications strip or tubular heaters can be inserted in grooved slots in the metal. When cartridge heaters are used, it is essential that the following factors are checked to insure that the heater will experience the longest possible life and provide sufficient heat for the job:

1. Sheath watt density.
2. Proper fit of cartridge heater in machined hole.
3. Provisions made to protect heater from contamination from oil, oil vapors, etc.
4. Sufficient kW is installed to accomplish work and make up for heat losses from the flat surface.

The maximum permissible sheath watt densities for alloy sheath cartridge heaters at a given desired temperature on the metal are given by Figure D-1. This curve gives watt densities for various fits using CIR cartridge elements. Figure D-2 is useful for using C series elements.

When cartridge heaters are installed in a drilled hole, the hole should be drilled to the nominal diameter of the heater. Cartridge heater diameters are actually .003" to .005" smaller than the nominal diameter. This allows for easy installation when cold, but upon heating the cartridge heater expands for a snug fit and excellent heat transfer.

When cartridge heaters are used in plastic forming dies, extruders, etc., care must be taken to protect the heater from possible contamination entering through the terminal end. Standard end opposite terminal construction for standard cartridge heaters is a positive weld.

Special moisture and abrasive resistant terminal construction is available and where moisture or contamination problems are present, hermetic seals can be supplied (see pages D-15 and D-16).

## CARTRIDGE HEATERS

A plastic forming operation requires 2 lb. of plastic to be processed per hour; the plastic has a specific heat of 0.45 BTU/lb/°F and reaches a pliable state at 300°F. Two platens, each weighing 245 lbs. and measuring 24 in. long x 12 in. wide x 3 in. thick, must be preheated to 300°F in ½ hour. The platens are not insulated. The steel platens have a specific heat of 0.12 BTU/lb°F.

Heat-up is accomplished with the platens closed. In addition, losses encountered during operation (from opening and closing the platens) are negligible. Room ambient is 70°F. The total exposed surface area is considered to be 7ft².

$$kW = \frac{W_T \times C_p \times {}_\Delta T}{3412 \times H}$$

where

$W_T$ = weight of material to be heated

$C_p$ = specific heat (BTU/lb/°F)

${}_\Delta T$ = temperature (°F)

H = heat-up time in hours

3412 is conversion factor of BTU to kWh

## kW REQUIREMENTS FOR INITIAL HEAT-UP

$$kW = \frac{245 \times 2 \times 0.12 \times (300-70)}{3412 \times \frac{1}{2}(hr)}$$

$$= \frac{13524}{1706} = 7.93$$

Losses during heat-up are 150 w/ft² at the operating temperature of 300°F.

$$kW = \frac{7.0(ft^2) \times 150\ (W/ft^2)}{1000(W/kW)}$$

Average loss (Note 1) $= \frac{1.05}{2} = .53kW$

Total reqd. = 7.93 + .53 = 8.46
8.46 x 1.2(safety factor) = 10.15kW

## OPERATING REQUIREMENTS

$$kW = \frac{2(lbs) \times 0.45 \times (300-70)°F}{3412 \times 1(hr)}$$

$$= \frac{207}{3412} = 0.061$$

$$kW = \frac{7.0(ft^2) \times 150\ (W/ft^2)}{1000(W/kW)}$$

= 1.05

Total reqd. = 0.061 + 1.05=1.111kW
1.11 x 1.2 = 1.33 kW

*NOTE 1:*
*Average heat loss is the heat loss at the final operating temperature divided by an averaging factor*
*2. The averaging factor is used since during initial heat-up, the platen is not at the final operating temperature all of the time.*

*For information on the CIR Series, visit our website at ***www.omega.com***

# Maximum Watt Density vs. Platen Temperature for Various Fits Using Type CIR Cartridge Heaters



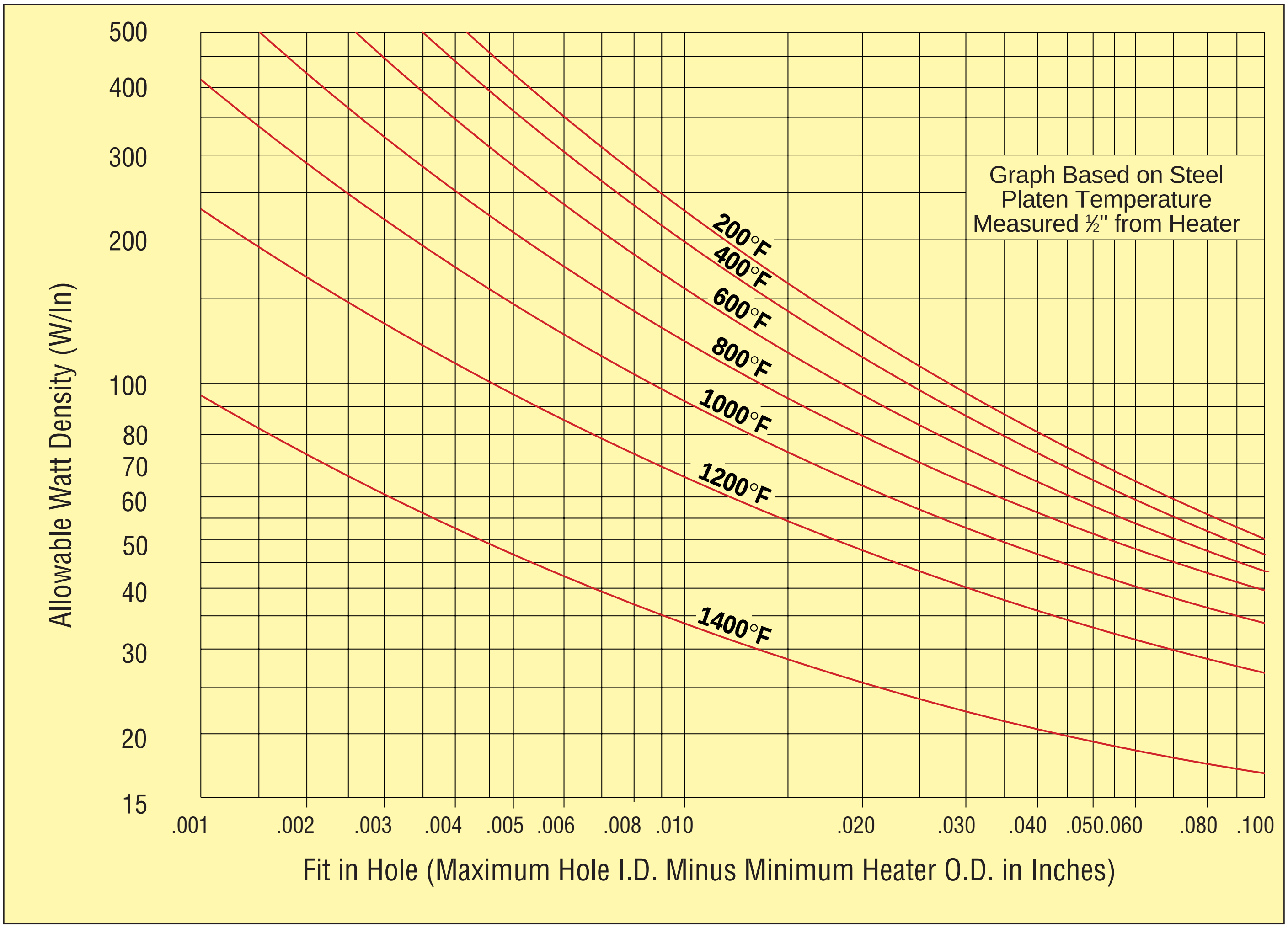



**FIGURE D-1** Allowable Watt density vs platen temperature for various fits using OMEGALUX® Type CIR cartridge elements.

Since the heat-up requirement is greater than that for operation, we should install 10 kW.

## INSTALLATION AND SELECTION OF CARTRIDGE HEATERS

Heater selection is often governed by available space. In this instance, however, space is not a problem since we can easily install 5 cartridge heaters CIR 3122 ½ in. diameter x 12 in. sheath length in each platen. Each unit can be rated 1000 Watts for a total installed capacity of 10 kW. Holes for cartridge heaters should be drilled and reamed to 0.500 in. max., since close fits are important for best heat transfer. Holes in the platens should be drilled completely through the 12" wide platen to facilitate removal of heaters when necessary.

**Using the maximum allowable Watt density graphs: FIGURE D-1**

This graph is useful for choosing OMEGALUX® Type CIR cartridge heaters. The curves should be considered as guides and not precise limits.

The graph is based on a 1600°F resistance wire temperature inside the cartridge heater, when the heater is installed in an oxidized mild steel block. Watt density values from the graph should be lowered by about 10% or more when block materials are used which have a lower thermal conductivity or lower emissivity than oxidized mild steel.

# HOW TO GET THE BEST PERFORMANCE FROM OMEGALUX CARTRIDGE HEATERS

**1. Installation recommendations.**
**a.** On moving machinery, anchor the leads securely. As little movement as possible should be allowed close to where the leads emerge from the heater. A loop in the lead wire will frequently extend lead life. If application conditions result in continual lead flexing, terminate the cartridge heater leads at a terminal block which moves from the heated assembly. Flexing is transferred to the extension leads which can be economically replaced.

**b.** For rapidly vibrating equipment, employ the terminal block described above. Keep leads from heater to block short and well supported to prevent lead movement due to vibration.

**c.** Protect leads from spray, oil, and abrasive. Contaminating liquids and vapors can enter unsealed cartridge heaters and cause insulation breakdown.

**d.** Avoid tape on leads where they emerge from the cartridge heater. The adhesive on some tapes can enter the heater and turn to carbon which is electrically conductive. Where glass tape cannot be avoided, a tape with a silicone based adhesive is suggested.

**e.** Design the installation so that the leads are in an ambient temperature which doesn't exceed the rating on the lead insulation (392°F for standard leads).Where temperatures require it, use nickel or nickel plated copper wire with Teflon, silicone impregnated fiberglass or rockbestos insulation to extend leaders. (See Section H.)

**f.** Graphite and other lubricants to help insert the cartridge heater into the hole are generally not recommended. These are electrically conductive and can get on the lead end of the heater unless extra care is taken.

**g.** As operating temperatures go up, thermal insulation on the heated part becomes more desirable to conserve heat. Thermal insulation results in lower wattage requirements and therefore lower Watt density on the heaters. Other benefits are more even work temperatures and greater operator safety and comfort.

**h.** Leads must not extend into the hole containing the cartridge heater. Generally, the lead end of the heater should be flush with surface.

**2. Vacuum Operation.** When heaters are operated in a block which is in a vacuum, the inside of the holes should be preoxidized to improve emissivity. Substantial reductions in maximum allowable Watt density are usually necessary for vacuum operation. Where possible, the installation should be designed so that the lead end of the heater is outside the vacuum. When the lead end of the heater is inside the vacuum, a voltage of 120 Volts or less is recommended. On an unsealed heater, outgassing may be expected.

**3. Operation in square grooves.** Round series CIR cartridge heaters may be installed in square or V-shaped grooves if this proves convenient. The inside of the groove should be treated to improve its emissivity (by oxidizing or anodizing). Allowable W/in$^2$ can be estimated by using the .050 fit line in Figure D-1 on page D-6, providing that the square is approximately the same width as the nominal diameter of the heater.

**4. Operation on 480 Volts.** (CIR Series only) OMEGALUX CIR Series cartridge heaters ⅝" diameter and larger can be operated on 480 Volts. One approach is to take two stock 240-Volt heaters and connect them in series on 480-Volts. Another is to order specially rated 480-Volt cartridge heaters. Contact OMEGALUX.

Because of higher voltage stresses inside the heater, lower maximum Watt densities are allowable in 480-Volt applications, either with two 240-Volt heaters in series or with specially rated 480-Volt units. To determine maximum allowable Watt density at 480-Volts, enter the graph on page D-6 with an operating temperature value which is 200°F higher than the actual operating temperature. A maximum operating temperature of 1000°F is suggested.

An extra layer of high temperature fiberglass sleeving is recommended for the leads to increase electrical insulation.

**5. Testing recommendations.** Testing under simulated operating conditions is suggested when equipment manufacturers design new products. Cartridge heaters of the appropriate physical size are operated on a variable transformer until the heat output is at the proper level. Then, voltage and current measurements are taken and required wattage rating is calculated. Heaters of the correct wattage rating are then ordered for product design.

# CIR SERIES HIGH WATT DENSITY CARTRIDGE HEATERS - WITH INCOLOY SHEATHING

- **Type F Flexible Leads**
- **¼", ⅜"(1cm), ½", ⅝" & ¾" Inches in Diameter**
- **120 & 240 V**
- **UL Component Recognized & C.S.A. Certified**
- **Patented Design**

## FEATURES

**Type F leads**, standard on CIR series, consist of standard, flexible manganese nickel wire insulated with impregnated fiberglass to approximately 392°F. the leads can be bent at a sharp angle where they emerge through the flush terminal block, without exposing bare conductors.

When leads longer than 10" (25 cm) are needed, additional lengths of high-temperature wire can be spliced on stock heaters, either at the factory or by the user. Specially fabricated CIR series heaters can be supplied with unspliced leads up to 32" (81 cm) in length.

**Sheath material.** OMEGALUX® CIR series cartridge heaters are made with a high-temperature Incoloy sheath material.

Higher temperatures, faster production rates. The CIR series patented construction and high-Watt-density capability let you put more heat in less space.

**Welded end disc** seals end opposite leads from contamination.

**Black oxide sheath.** Black transfers heat better than shiny surfaces. OMEGALUX heaters go to work immediately when energized and operate at cooler sheath temperatures. Shiny heaters begin operating at higher temperatures, shortening life expectancy while they slowly oxidized and turn black.

**Shock and vibration resistant.** Tightly compacted refractory insulation for severe application.

**Lead length.** CIR series heaters are stocked with Type F leads 10" (24 cm) long, ±⅜"(1cm). Longer lead lengths can be readily spliced on.

**Eliminating operational problems,** the manganese nickel electrical leads are stranded, not solid. They remain continuously covered with fiberglass insulation even when bent sharply where they emerge from the heater. The construction is covered by issued and pending patents.

**Cartridge heater performance** depends upon adherence to basic heat transfer principles. In the resistance winding inside the cartridge, electrical energy is converted to heat energy with100% efficiency. CIR units are designed and constructed to maximize heat energy flow and thus keep resistance wire temperature relatively low.

**Even temperature** throughout the heater's length is produced by the uniform winding of the wire on the smooth supporting core. Close and even spacing between wire and inside of sheath is maintained for good heat transfer. Tight spacing between turns permits use of largest gauge resistance wire.

D

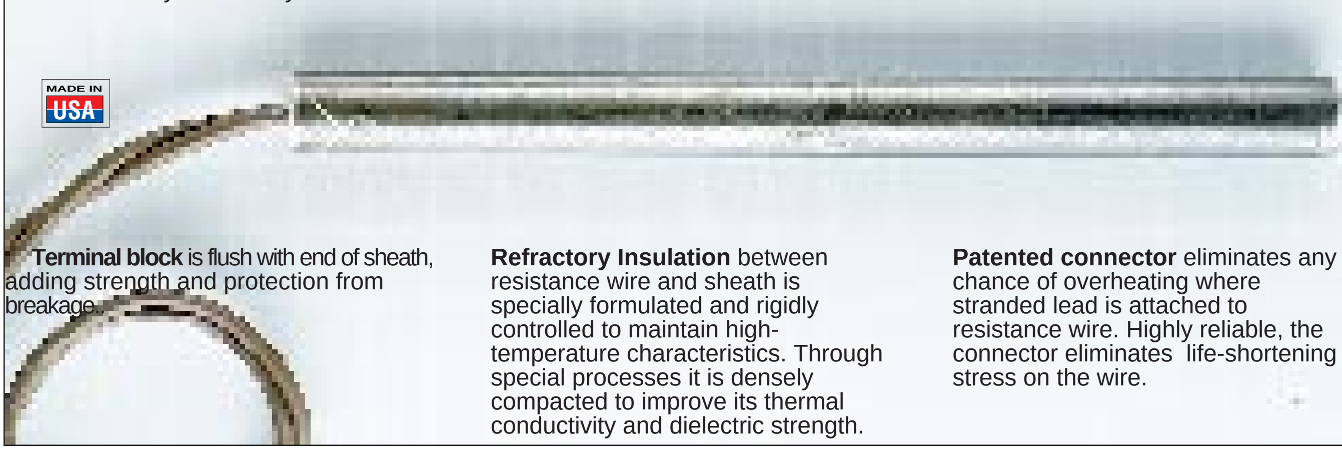
### CAUTION AND WARNING!

Fire and electrical shock may result if products are used improperly or installed or used by non-qualified personnel. See inside back cover for additional warnings.

**Excellent oxidation and corrosion resistance** is provided by special OMEGALUX alloy sheath. Thermal expansion characteristics of sheath and refractory are closely matched.

**Highest quality nickel-chromium resistance wire** is used for the resistance winding. Long life and consistent performance from one unit to the next are assured.

**Heavy-gauge end disc,** securely welded, seals out contaminants. This rugged construction and oxidation resistance of sheath facilitate heater removal.




**Terminal block** is flush with end of sheath, adding strength and protection from breakage.

**Refractory Insulation** between resistance wire and sheath is specially formulated and rigidly controlled to maintain high-temperature characteristics. Through special processes it is densely compacted to improve its thermal conductivity and dielectric strength.

**Patented connector** eliminates any chance of overheating where stranded lead is attached to resistance wire. Highly reliable, the connector eliminates life-shortening stress on the wire.