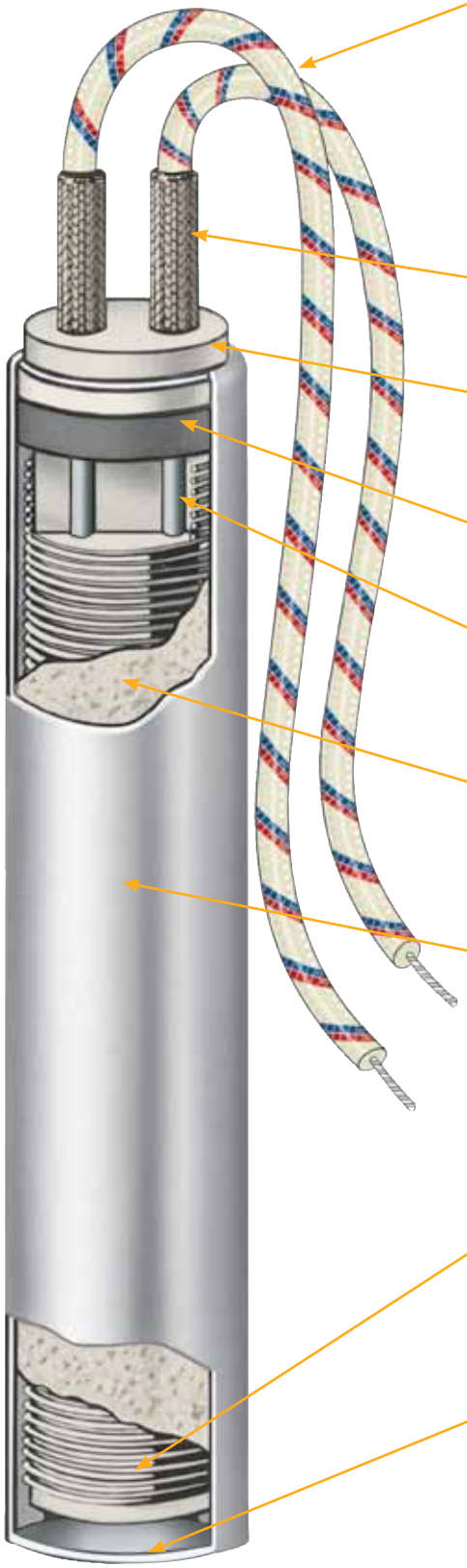
Hi-Density Cartridge Heaters



Features

The standard termination for Hi-Density Cartridge Heaters is Type N, 254 mm (10") long nickel conductor lead wires externally connected to 32 mm (1¼") solid conductor terminal pins. The lead wires have fiberglass insulation and are UL approved for temperatures up to 250°C (482°F).

Note: To meet the requirements of your application we offer over 40 standard termination styles to select from that will solve many of the most common application problems.

High temperature fiberglass sleeve provides maximum electrical insulation to the crimp connector used to splice the nickel conductors to the flexible leads.

Ceramic end cap prevents nickel conductors from shorting out against sheath when sharp bending of the leads is required. The ceramic cap may be eliminated in some cases to optimize the heater watt density.

Ceramic end cap and swaged-in lava plug protect the internal cartridge from outer contamination. Other types of seals can also be provided.

Solid conductor terminal pins are used to ensure a good electrical connection between the nickel conductor lead wires and the resistance wire. They are sized for the maximum current rating of the heater.

Specially selected grain size high purity Magnesium Oxide (MgO) is used to fill all remaining space inside the sheath. Heater is then swaged, which compacts the magnesium oxide grains into a solid mass, thereby increasing thermal conductivity and dielectric strength.

Standard sheath material is 321 Stainless Steel. It provides high temperature strength up to 650°C (1200°F), good thermal conductivity, and resistance to corrosion and scaling. Alloy 321 is a Nickel-Chromium Stainless Steel modified with the addition of Titanium. For higher operating temperatures up to 760°C (1400°F) or corrosive immersion heating applications, Incoloy® 800 is available. Consult OMEGA for other sheath materials.

Grade “A” Nickel-Chrome resistance wire precisely wound on a high purity magnesium oxide core places the resistance wire as close to the inside of the sheath as possible while maintaining dielectric strength. This provides excellent heat transfer and long heater life with the highest possible watt densities.

Welded end disc made from the same material as the sheath provides a positive seal against moisture and other contaminants.

OMEGA Offers the Most Comprehensive and Diverse Selection in Hi-Density Cartridge Heaters

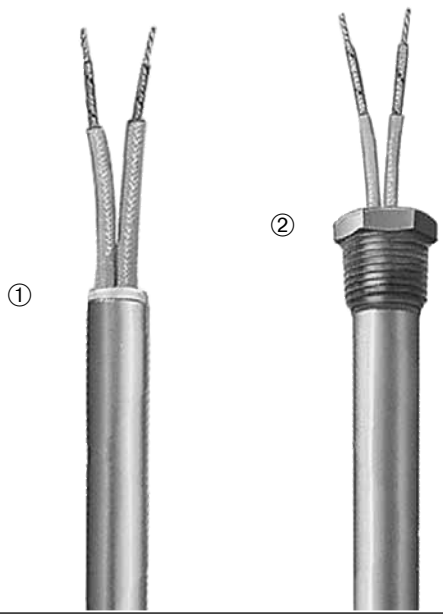
Typical Applications

- Plastic Extruders
- Hot Runner Molds
- Hot Stamping
- Medical Equipment
- Packaging Equipment
- Molds
- Aerospace
- Sealing Bags
- Semi-Conductor
- Plastic Molding
- Shoe Machinery
- Food Processing
- Heating Gases and Liquids
- Glue Guns
- Laminating Presses
- Platens
- Scientific Equipment
- Food Service Equipment

Hi-Density Cartridge Heaters Have Evolved and Today Offer a Multitude of Diverse Product Options:

1. (HDC) A hi-density cartridge heater in US sizes.

2. (HDL) A hi-density cartridge heater designed with NPT Fittings for Immersion heating.



Hi-Density Cartridge Heaters Provide Maximum Processing Temperature Capability

- Higher watt densities permit smaller heaters to be used without sacrificing life expectancy. This results in up-front as well as long-term cost savings.
- Swaged construction provides maximum support for the resistance wire and excellent heat transfer characteristics, improving the overall life expectancy of the cartridge heater.
- Termination styles and special features allow customization to any application.
- Applications up to 760°C (1400°F)

Hi-Density Cartridge Heaters are Classified in Two Distinct Categories

Multi-Purpose Use

The multi-purpose use cartridge heaters represent OMEGA's commitment to value-added customer service as we maintain in stock over 65,000 semi-finished hi-density cartridge heater substrates, offering a combination of over 1000 sizes in industry standard diameters and lengths ranging from 25.4 mm (1") to 914.4 mm (36") in a complete spectrum of wattages and operating voltages. Multi-purpose use cartridge heaters are the solution for a multitude of original equipment manufacturers (OEMs) or maintenance (MRO) applications.

Available through the terminator program. Complete details are found on page 8.

Highly Engineered Specific Purpose Use

OMEGA has been at the forefront of addressing the challenges of Original Equipment Manufacturers (OEMs) in a broad segment of diversified industries. As a company we are uniquely qualified and committed to providing value-added expertise in engineering and manufacturing capabilities assisting customers in developing highly engineered specific use cartridge heaters for dependable and reliable performance. Let us provide the optimal solution to your thermal loop system and cartridge heater design challenges.

Consult us with Your Requirements
We Welcome Your Inquiries

Hi-Density Cartridge Heater Specifications

Standard Specifications

Performance Ratings

Maximum Temperature: 760°C (1400°F)

Maximum Watt Density: 15.5 to 46.5 watt/cm^2 (100 to 300 Watt/in^2) depending on heater size and operating temperature

Note: *The maximum operating temperature and the life expectancy of a cartridge heater is dependent on two main factors:*

1. *The maximum recommended sheath temperature [648°C (1200°F) for a standard heater]*
2. *The maximum ambient temperature for the termination selected.*

Consult OMEGA if you require a recommendation for your application.

Length Tolerance for Lead Wires, Wire Braid Leads, and Armor Cable Leads:

Up to 914 mm (36"): -12.7, 25.4 mm (-½, 1")

914 to 1829 mm (36 to 72"): 25.4, 50.8 mm (-1, 2")

Above 72": 101.6 mm (±4")

Dimensional Specifications

Nominal Diameter	⅛" mm (inch)	¼" mm (inch)	5⁄16" mm (inch)	⅜" mm (inch)	½" mm (inch)	⅝" mm (inch)	¾" mm (inch)	1" mm (inch)
Actual Diameter	3.10 (0.122)	6.25 (0.246)	7.82 (0.308)	9.42 (0.371)	12.60 (0.496)	15.77 (0.621)	18.95 (0.746)	23.30 (0.996)
Diameter Tolerance	0.051 (±0.002)	0.051 (±0.002)	0.051 (±0.002)	0.051 (±0.002)	0.051 (±0.002)	0.051 (±0.002)	0.076 (±0.003)	0.076 (±0.003)
Minimum Length	31.8 (1.25)	25.40 (1)	25.40 (1)	25.40 (1)	25.40 (1)	25.40 (1)	31.75 (1¼)	44.45 (1¾)
Maximum Length	305 (12)	914 (36)	914 (36)	1219 (48)	1219 (48)	1829 (72)	1829 (72)	1829 (72)
Length Tolerance Heaters up to 127 mm (5") long	2.4 (±3/32)	2.4 (±3/32)	2.4 (±3/32)	2.4 (±3/32)	2.4 (±3/32)	2.4 (±3/32)	3.2 (±1/8)	3.2 (±1/8)
Length Tolerance Heaters over 127 mm (5") long	±2% of sheath length							
Camber Tolerance Heaters to 305 mm (12") long	0.254 mm (0.010") per foot of length							
Camber Tolerance Heaters over 305 mm (12") long	0.508 mm (0.020") per foot of length							

A certain amount of camber is unavoidable. With a slight force, hi-density cartridge heaters will flex enough to fit into a straight reamed hole.

Electrical Specifications

Nominal Diameter	⅛"	¼"	5⁄16"	⅜"	½"	⅝"	¾"	1"
Maximum Voltage	240	240	240	240	240	480*	480*	480*
Maximum Amperage (see next line for exceptions)	3.0	4.4	4.5	6.7	10.5	23	23	23
†Maximum Amperage for Types C1C, C1D, C2C, C2D, CS, F, M3, R1B, S1, S2, SA, W and W3 Terminations	—	3.0	3.0	5.5	7.6	9.7	9.7	9.7
Minimum Wattage at 120V on a 1" long Heater	—	50	45	45	50	50	—	—
Minimum Wattage at 120V on a 2" long Heater	5	20	20	20	20	20	20	20
Maximum Wattage at 120V	360	525	540	800	1260	2760	2760	2760
Maximum Wattage at 240V	720	1050	1080	1600	2520	5520	5520	5520
Maximum Wattage at 480V	—	—	—	—	—	11,000	11,000	11,000
Wattage Tolerance	+10, -15%	Plus 5%, minus 10%						
Resistance Tolerance	+15, -10%	Plus 10%, minus 5%						

†Current carrying capacities are for ambient temperatures up to 250°C (482°F) with mica insulated lead wires.

**480V when applicable. Consult OMEGA.*

Temperature Coefficient of Resistance

The electrical resistance (ohms) of the heater resistance wire increases with temperature rise.

OMEGA standard hi-density cartridge heaters are manufactured with ohms (cold ohms) 3.3% lower than the actual calculated ohms (hot ohms) to compensate for this increase.

Note: *Specifications detailed on this page are standard. consult OMEGA if your application requires tighter tolerances or has other special requirements*

Available Electrical Features

Diameter	Dual Volts	3-Phase	Dual Circuits	Multiple Heat Zones (maximum 3 zones)
⅛"	No	No	No	No
¼"	No	No	No	No
5⁄16"	No	No	No	No
⅜"	Yes*	No	No	Yes*
½"	Yes*	Yes	Yes	Yes*
⅝"	Yes	Yes	Yes	Yes
¾"	Yes	Yes	Yes	Yes
1"	Yes	Yes	Yes	Yes

Consult factory for maximum wattages and voltages

**Heaters may require a larger diameter transition area at lead end.*

Recommendations for Improving the Life of Hi-Density Cartridge Heaters

Hi-density cartridge heaters have been widely used in many demanding and diverse applications since 1972. The commonly used basic applications are platen, plastic mold and die heating, liquid immersion and air heating.

Note: *Selection of the wrong termination for a particular application is the primary reason for all heater failures. However, failure to consider other important criteria can also have a negative effect on the life of the heater. To get the best performance and assure long life, it is important to carefully evaluate the following factors.*

Operating Temperature

Operating temperature of a heater is a major factor in determining the life expectancy of a heating element. The heater life depends on the actual temperature of the resistance wire within the heater and not on the process operating temperature. The graph in Figure 1 demonstrates the proper relationship between operating temperature and watt density; the higher the operating temperature, the lower the maximum recommended watt density.

Heater Watt Density

Cartridge heater watt density is defined as the wattage dissipated per square inch of the heated sheath surface. For a particular application a heater's watt density governs internal resistance wire temperature, which determines the outer sheath temperature. These factors are critical to the proper heating of the application and to the life expectancy of the heater. Special construction features that promote excellent heat transfer permit Hi-Density Cartridge Heaters to operate at higher watt densities while maintaining the lowest possible resistance wire temperatures of any style cartridge heater.

Heater watt density (watts/in^2) is calculated using the following formula:

$$\text{Watt Density} = \frac{\text{Heater wattage}}{\text{Heated length} \times \text{Heater diameter} \times 3.1416}$$

Heated length is the overall length of the heater minus any unheated (cold) sections. Standard Type N, Hi-Density cartridge heaters have 10 mm (⅜") at the lead end and 6 mm (¼") at the disc end unheated. This would mean a 152 mm (6") long heater would have 265 mm (5⅜") effective heated length. Unheated sections vary with type of heater termination.

The graph in Figure 1 shows the maximum recommended watt density for hi-density cartridge heaters when used in a steel platen. Watt density limitations for various materials are given in the engineering section of this catalog. For liquid immersion heaters the maximum watt density depends on the type of liquid being heated. The more viscous, or thicker the liquid, the lower the maximum watt density. Higher watt density can cause the liquid to carbonize and accumulate on the heater sheath, which will cause premature heater failure. It is advisable to use heaters that have watt densities below the maximum recommended watt density to get the longest heater life. If the actual heater watt density is close to the maximum recommended watt density, you can correct the problem by:

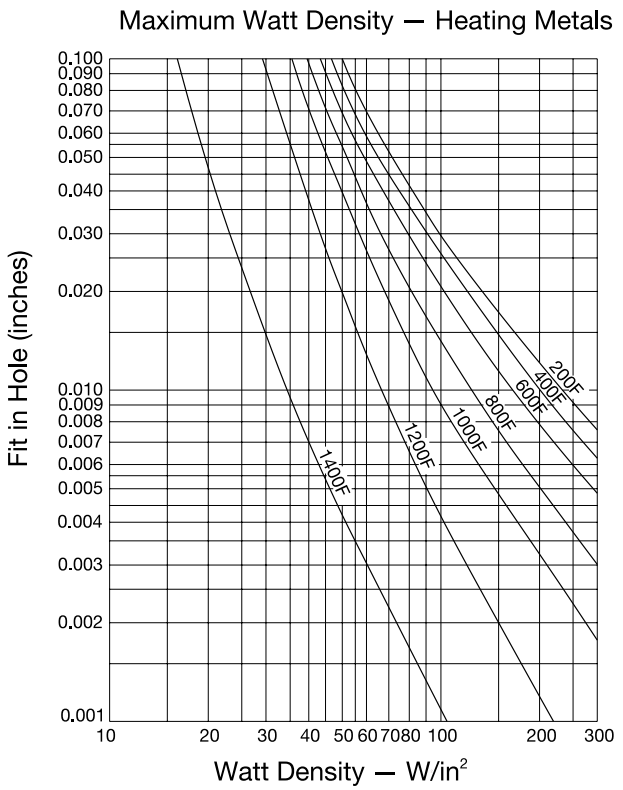
1. Increasing the number, diameter and length of heaters.

2. Lowering the total wattage; however, this may increase the heat-up time.

3. Obtaining tighter fit (see Figure 2 — Determining Fit).

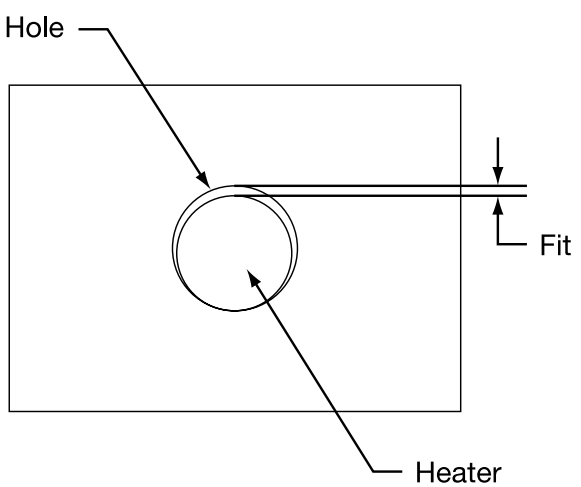
A hi-density cartridge heater designed at the maximum recommended watt density allows the smallest heater to be used to obtain the required wattage with good service life. All things being equal, using a lower watt density heater will typically provide optimized service life.

Figure 1
Recommended Watt Density for Heating Metal Parts



The graph shows the recommended maximum watt density for OMEGA Hi-Density cartridge heaters at different operating temperatures and fit, when the heater is installed in an oxidized mild steel block. The thermocouple is located 13 mm (½") from the heater. When heating other materials, the data needs to be extrapolated based on the thermal conductivity of the material. Consult OMEGA with your requirements.

Figure 2
Determining Fit



Recommendations for Improving the Life of Hi-Density Cartridge Heaters (Continued)

Determining Fit

When heating a platen, mold, die or hot runner probe with hi-density cartridge heaters inserted into drilled holes, fit is an important factor in determining the life expectancy of the heater. Fit is the difference between the minimum diameter of the cartridge heater and the maximum diameter of the hole. Unheated sections on a hi-density cartridge may be smaller in diameter due to swaging. To determine fit, use the smallest diameter on the heated length only.

Example: A 10 mm (⅜") nominal OD Hi-Density cartridge heater has an actual diameter of 9 mm (0.371") ±0.002, which translates to a minimum diameter of 9 mm (0.369"). If used in a 10 mm (0.376") ±0.002 hole, the fit would be 0.23 mm (0.009") 10 – 9 mm = 23 mm (0.378" – 0.369" = 0.009").

When medium watt density heaters (less than 60 watts per square inch) are used in low temperature applications [less than 315°C (600°F)] general purpose drills are commonly used to drill holes. The typical hole size may be 0.1 to 0.2 mm (0.003 to 0.008") over the drill size. For higher watt density and/or higher temperature applications, we recommend that the holes are drilled and reamed for the tightest possible fit. In applications where precise temperature control and heat transfer properties are required, hi-density cartridge heaters can be centerless ground to ±0.01 mm (±0.0005").

Although a tighter fit is desirable to efficiently transfer heat and to get long heater life, a looser fit will aid in installing and removing heaters, especially long heaters. We recommend that you apply BNS anti-seize cartridge heater coating as it will improve heat transfer and will make the removal of heaters easier.

The graph in Figure 1 (page 4) shows the effect of fit in determining the maximum recommended watt density on a steel platen. As it is indicated in the graph, the tighter the fit, the higher the maximum recommended watt density.

Temperature Control and Location of Temperature Sensing Device

In order to better control the heater temperature and hence the resistance wire temperature, use of an appropriate temperature control and the proximity of the heater to the sensor is very important. The graph in Figure 1 (page 4) shows the effect of operating temperature in determining the maximum recommended watt density on a steel platen where the sensor is located 13 mm (½") from the heater. Higher watt density heaters can generate heat faster than the surrounding area's ability to dissipate heat. This creates a thermal lag between the heater and the sensor. The closer the sensor to the heater, the better you can control the heater temperature. By keeping the sensor further from the heater, temperature gradients of several hundred degrees can be observed in many applications, especially during initial start-up and heavy thermal cycling. Although the set operating temperature may be low, the heater may be running at a very high temperature. This is a common cause of heater failure. This can be minimized using time proportional and PID functions of the temperature controllers.

Power Control

Power control methods affect the life expectancy of heating elements. In general, although economical, on-off controls increase thermal fatigue and oxidation rate on heating elements by causing wide temperature swings of the internal heating element. Silicon controlled rectifiers (scrs), mercury relays and solid state power controls can increase the life expectancy of heating elements by reducing the temperature swings of the internal heating element.

Common Causes of Cartridge Heater Failures

Contamination

Contamination is a major cause of heater failure. Moisture, hydraulic oils, and melted plastic are the most common contaminants that are seen on failed heaters. Since the magnesium oxide insulation in a hi-density heater is hygroscopic in nature, moisture is easily absorbed into the heater and typically results in premature heater failure. Moisture absorption during machine washdown or cleanup also is a frequent problem. These contaminants, which are electrically conductive, will short out the heater. Most probably, the failures will be at the lead end of the heater and in some cases can split or blow a hole on the heater sheath. The disc end of a Hi-Density cartridge heater is welded shut with a stainless steel disc.

Generally, contaminants enter the heater through the lead end of the heater. The high temperature lead wires used on Hi-Density heaters have fiberglass or mica insulation. Oil and moisture can wick through the insulation on the lead wire into the heater. OMEGA offers a wide variety of terminations to avoid this problem, including epoxy seals, PTFE seals, convoluted cables, welded end discs, PTFE insulated lead wires and SJO cable. However, there are temperature limitations on many of these terminations.

Excessive Flexing of Leads

Hi-Density heaters use flexible grade A nickel stranded lead wires with fiberglass or mica insulation. On certain terminations the lead wires are connected externally to solid nickel conductor pins. In applications where there is excessive movement or vibration, the solid pins could break due to fatigue. A simple solution is to give enough slack on the leads to minimize the stress on the solid pins or provide an internal lead wire connection within the heater. OMEGA also offers strain relief brackets and springs to prevent this problem.

Where heater leads can wear out by abrasion due to excessive flexing of the leads, OMEGA offers several abrasion resistant terminations.

Lack of Heat Sink

Hi-Density heaters are designed with minimum unheated (cold) sections. If the heated sections project from the platen or mold, these sections will get extremely hot due to lack of heat transfer. This will lead to premature heater failure. OMEGA can manufacture heaters with cold sections anywhere along the length of the heater to prevent overheating of the heater sheath.

When a hi-density heater is used as a liquid immersion heater, make sure the heater's sheath length is completely immersed in the liquid. The heater lead end should not be immersed in liquid, since most of the lead end seals are only moisture resistant, not moisture proof.

Note: *If you should encounter premature cartridge heater failure, consult OMEGA. Our team of professionals will have the solution to your problem.*

Recommendations for Improving the Life of Hi-Density Cartridge Heaters (Continued)

High Operating Temperature

OMEGA hi-density heaters are designed to operate at sheath temperatures up to 760°C (1400°F). When process temperatures approach the maximum heater sheath temperature, make sure the sheath temperature doesn't exceed its limitations. Location of the thermocouple and the type of temperature and power controls are factors that affect sheath temperature and potential overshoot conditions.

Although the heater is designed to run at temperatures up to 760°C (1400°F), heater lead wires and terminations are rated for much lower temperatures. Care should be taken to make sure that the heater lead end temperatures do not exceed their limitations. Heaters can be made longer with unheated sections at the lead end to bring the lead end out of the high temperature area. OMEGA can also provide you with a high temperature wiring harness, which can withstand temperatures up to 760°C (1400°F).

Wattage Rating

Heaters with very high wattage ratings can create temperature overshoots, uneven temperature distribution and high heater sheath temperatures, causing premature heater failure.

For liquid immersion heaters, maximum watt density depends on the type of liquid being heated. The heavier or thicker the liquid, the lower the maximum watt density. Higher watt density can cause the liquid to carbonize and accumulate on the heater sheath, which will cause premature heater failure.

Scale and Sludge Buildup

In liquid immersion applications, periodic cleaning of the heater sheath is necessary to remove any scale buildup on the sheath. Scale can accumulate on the sheath and cause the heater to overheat and fail. When used to heat liquid in a tank, be sure to clean any sludge from the bottom of the tank. A heater sheath covered with sludge will overheat and fail.

Note: *As explained in the above paragraphs, the single major cause for cartridge heater failure is the selection of the wrong type of heater lead end termination for the specific application. To assist you in selecting the right termination type, see section of detailed descriptions of over 40 terminations designed to solve many of the common application problems. If you need further assistance, consult OMEGA.*

Important Installation Considerations

1. For closest fit and best heat transfer, use reamed holes.
2. When possible, drill holes through the object being heated. This will make heater removal easier.
3. When using an anti-seize coating like BNS spray or paste, do not apply over lead wires or any other current carrying conductors.
4. When using insulated tape or sleeving, check to make sure it is rated for the temperature of the application. Lower temperature rated materials can contain an adhesive or binder that can carbonize and become electrically conductive.
5. When using heaters near their maximum recommended watt density, it is recommended that the temperature sensing probes be at maximum 13 mm (½") from the heater sheath.
6. Lead wires should not be located in the hole containing the cartridge heater during operation. This may cause the lead wires to be exposed to temperatures above their rated temperature.
7. When used in a vacuum application, make sure the lead end of the heater is outside the vacuum. If the lead has to be in the vacuum, consult OMEGA for specific recommendations.
8. Many applications will subject a heater's electrical terminations to one or more of the following potentially damaging conditions:

- Moisture
- Oil and other contaminants
- Flexing
- Abrasion
- High temperature

Note: *To protect the heater from damage in these harsh environments, OMEGA has a wide selection of terminations and options available.*

BNS Anti-Seize Cartridge Heater Coating

This high temperature, electrically insulating and thermally conductive coating will minimize oxidation and improve heat transfer from heater to the object being heated.

Brush a thin layer of paste or spray lightly over the cartridge heater prior to inserting the heater into a hole.

CAUTION! *Do not apply over lead wires or other bare current carrying conductors, since the water in the paste and spray can cause an electrical short circuit.*

13 oz.
Aerosol spray can
Part Number:
CML00010

- **Temperature Range 1562°F (850°C)**
- **High Heat Transfer**

4 oz. Paste with brush applicator top
Part Number: CML00020

- **Temperature Range 1562°F (850°C)**
- **High Heat Transfer**

Note: *Formulated to assist in the removal of cartridge heaters.*

Custom Terminated Multi-Purpose Use Cartridge Heaters from the Terminator Program

OMEGA stocks over 1000 different semi-finished hi-density cartridge heaters in diameters 6, 8, 10, 13, 16, and 19 mm (¼, 5⁄16, ⅜, ½, ⅝ and ¾").

These cartridge heaters are semi-finished (substrates), offering you the option to finish them by choosing from 19 program-qualified lead end terminations and options. Cartridge heaters will be ready for shipment within 1 to 3 days, depending on the termination/option selected.

Ordering Information — Follow These Simple Steps

1. Select an available 6 mm (¼") through 19 mm (¾") hi-density cartridge heater. The model numbers in the tables are for heaters with termination type N [254 mm (10") long externally connected lead wires].
2. Refer to the program-qualified lead terminations reference photos to select the cartridge heater termination type best suited for your application.

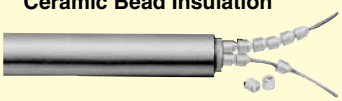
NOTE: Type "N" [254 mm (10") long externally connected plain lead wires] is the most common termination applied in the Terminator program. If a termination other than Type N is selected a new permanent part number will be assigned when your order is placed.

3. Specify your lead requirements in the event that the standard supplied lengths for Plain Leads 254 mm (10"), braid or armor cable [254 mm (10") over 305 mm (12") leads] are not suited for your application.
4. Specify the quantity.

Terminations

Type N
Standard Leads

Type B
Ceramic Bead Insulation

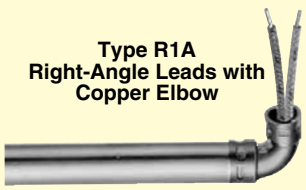


Type BL
Ceramic Bead and Leads

Type C1A & C1B only
Straight Armor Cable

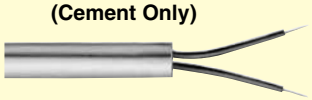
Type C2A & C2B
Right-Angle Armor
Cable with Copper Elbow

Type R1A
Right-Angle Leads with
Copper Elbow



Type W
Straight Wire Braided Leads

Type M2A & M2E
Potted Lead End Seal
(Cement Only)



Type CMB & CMP
Single Threaded Fitting

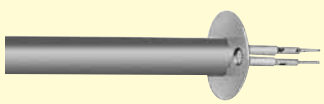
Type W1A & W1B
Right-Angle Wire
Braided Leads

Type C3A, C3B, C3C & C3D
Right-Angle Armor Cable

Type R2A & R2B
Right-Angle Leads

Options

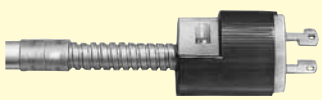
Type MFR
Mounting Flange Round



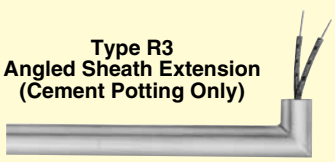
Type LR
Locating Ring

Type PS
Pull Strap

Type P
Quick Disconnect Plug



Type R3
Angled Sheath Extension
(Cement Potting Only)



Type E1
General Purpose Box

Type GL
Ground Lead Sheath

Complete specifications and details on these terminations can be found at omega.com.

Custom Engineered/Manufactured Hi-Density Cartridge Heaters

Because cartridge heaters can be very application specific, consult OMEGA with your special requirements. For sizes, electrical ratings and any other design features required but not listed in the catalog, OMEGA will custom engineer and manufacture to your specifications.

Consult OMEGA with Your Requirements. We Welcome Your Inquiries.