Watlow®
FIREROD® Cartridge Heaters

heaters | sensors | controllers

WATLOW®

FIREROD®

Quality Engineered, Built-To-Last Heating Solutions.

All Cartridge Heaters Are Not The Same

When optimum heater performance is critical to your productivity and profitability, it is important that you choose a cartridge heater that meets all of the requirements for dependable performance in your most demanding applications. With Watlow's FIREROD® cartridge heater, you are guaranteed:

- Optimized design for your specific application
- Intelligent product engineering
- Tight manufacturing controls and testing to ensure product quality, reliability and consistency
- High-quality materials, manufacturing processes and construction

When you choose Watlow® as your thermal solution partner, you can count on expert application assistance and technical support throughout your project development.

Custom Engineered and Tested for Continuous Reliability

The Watlow FIREROD cartridge heater incorporates engineering excellence and is supported by over 60 years of solid industry performance across a broad range of simple and complex applications. As the premier choice in swaged cartridge heating, thousands of industrial manufacturers continue to choose Watlow as their trusted thermal partner and certified cartridge heater supplier.

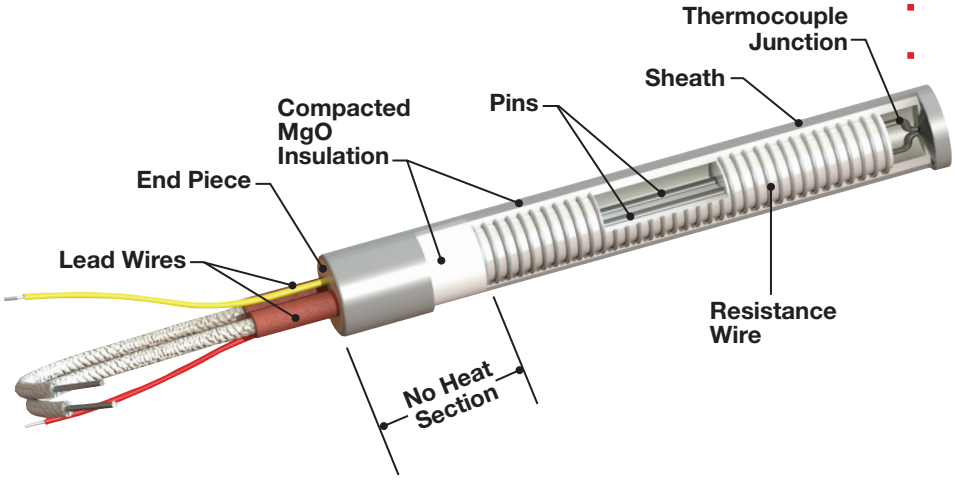
Built using premium materials and tight manufacturing process controls, the FIREROD cartridge heater provides superior heat transfer, uniform temperatures and resistance to oxidation and corrosion throughout demanding high-temperature applications.

As the world's largest single source supplier of heaters, sensors and controllers, you can expect Watlow's manufacturing facilities to perform product and system testing above and beyond the competition—we do not cut corners. Every heater meets our stringent quality assurance specifications, in addition to those set forth by leading standards and regulating agencies, including the International Organization for Standardization (ISO) 9001.

Our pledge is to continuously improve design, manufacturing and delivery of the highest quality products as efficiently as possible. Our employees are committed to applying lean manufacturing processes to eliminate waste, ensure product consistency, improve productivity, reduce lead time and control cost.

You can count on over 60 years of Watlow engineering excellence, quality assurance, product testing and reliability inside of each FIREROD cartridge heater that leaves our manufacturing facilities.

Peter Desloge
President, CEO and Chairman of the Board



FIREROD cartridge heater assembly.

Engineering Excellence You Can Count On Every Day

For more than 90 years, unmatched engineering and quality control have established Watlow as a preferred supplier for many high-performance heating requirements. Unsurpassed application expertise and assistance have made the FIREROD cartridge heater the first choice for the most demanding applications. More than 250,000 variations of FIREROD heaters have been designed and manufactured for industries including semiconductor, medical equipment, foodservice, nuclear, aerospace, oil refining and petrochemicals.

High-Quality, Durable Materials Yield The Best Performance

If the raw material quality does not measure up, neither will your cartridge heater. Low-quality materials can result in oxidation, corrosion and deterioration to the heater's outer sheath due to chemical exposure, heat and atmospheric conditions.

Many years of testing materials and manufacturing processes across challenging applications have proven which materials and manufacturing methods yield the best performance and longest product life.

The FIREROD cartridge heater is manufactured using the highest quality materials and construction methods. Extensive quality testing throughout the design and production process ensures continuous and superior performance to meet our exacting requirements and yours.

FIREROD Cartridge Heater Construction – Built To Last

- **Resistance Wire:** The standard nickel chromium wire is computer calculated for gauge, length and spacing, wound on a supporting core and precisely centered to guarantee uniform temperatures and long life.
- **Sheath:** Our standard Alloy 800 sheath provides high-temperature resistance to oxidation and corrosion, proving far superior to 304 stainless steel alloys used by other manufacturers.
- **Insulation:** We use only high purity magnesium oxide (MgO), compacted to a carefully predetermined and closely monitored density. This assures high dielectric strength and optimal heat transfer.
- **Lead Wire:** Watlow purchases high temperature, flexible and fray-resistant wire available from certified suppliers.

Temperature Performance Efficiency

Watlow heaters are swaged to increase thermal conductivity and provide faster and more even heating. First introduced by Watlow, swaging heaters with the nickel-chromium resistance wire ensures even, efficient distribution of heat to the sheath contributing to prolonged heater life and lower energy consumption.

It is critical that your cartridge heater is able to tolerate temperature extremes and fluctuations. The high temperature (HT) FIREROD cartridge heater is designed for high temperature platen applications up to 1600°F (871°C).

Watlow's 1/8-inch FIREROD cartridge heater provides maximum performance in limited spaces.

With Watlow's patented lead adapter (LA) manufacturing process, more than 150,000 FIREROD cartridge heater configurations and lead combinations can be ordered and shipped the same day.

Tight Manufacturing Controls Ensure High-Quality Products

Instead of adapting manufacturing processes to comply with existing equipment, we design and build equipment that meets our very high quality standards. This ensures that each FIREROD heater measures up to consistent quality metrics to perform at its maximum intended capacity. Certified supplier partnerships enable us to take advantage of advances in materials science to ensure that our strict standards are met every time.

Specially designed swaging equipment produces consistent quality and tight tolerances.

The design of Watlow's fill machines, combined with the exacting specifications of the heater raw materials, ensure uniform fill thickness for better dielectric strength.

Our electronic winding machines enable extremely consistent windings for uniform temperature response and tight resistance tolerances.

The Right Size Makes A Difference

Using the correct size cartridge heater, configured for your application ensures optimum performance. This is why FIREROD cartridge heaters are available from ⅛- to 1-inch diameters and in lengths ranging from less than 1 to 100 in. (25 to 2540 mm)—the widest selection offered by almost any heater manufacturer.

Ship It Fast and Ship It Right

Largest Selection Of Cartridge Heaters

Watlow's full-line of heater products offer the industry's most complete selection of FIREROD cartridge heaters to accommodate an extensive range of lengths and diameters, watt densities, non-destructive testing and subassembly requirements. Watlow offers stock FIREROD cartridge heater configurations, as well as FIREROD cartridge heaters with extended capabilities for complex applications.

Same Day Shipment Options

Watlow's extensive FIREROD RAPID SHIP program and unique lead adaptor (LA) modification method allow same day shipment of more than 150,000 configurations of stock FIREROD heaters and lead combinations. The LA modification method employs Watlow's patented lead attachment technique. A specially designed cap is swaged onto the FIREROD heater to permanently secure the leads. Most orders can be shipped the very same day they are received.

Made-To-Order Options Match Your Needs

Watlow's FAST TRACK™ program for made-to-order FIREROD cartridge heaters allows a range of FIRERODs to be shipped in two or five days.

With the FAST TRACK program, you can choose the size, voltage, wattage and termination from a predetermined set of options and choose when you want it—either a two- or five-day lead time.

Prevent Heater Damage and Premature Heater Failure

The four most common factors that contribute to premature heater failure are:

1. **Contamination**
2. **Corrosion**
3. **Over temperature**
4. **Lead wire failure**

Protect Your Heater From Contaminants

Contamination occurs when foreign materials enter a heater's internal area resulting in a breakdown of the element or insulation materials. Contaminants are usually organic and cause either a gross electrical short to ground or an accelerated deterioration of the heater's internal elements and/or power leads.

Heaters that are prone to large temperature swings or cycling are most susceptible to ingesting harmful contaminants. When a heater temperature rises and falls, it "breathes" air in and out from its surroundings due to thermal expansion and contraction of the air inside. As application temperatures increase, substances normally considered inert can damage the heater when subjected to high temperatures.

These substances include lubrication oils, cleaning solvents, antiseize lubricants, plastics, fumes, electrical tape adhesives, gases emitted from over temperatured lead wire, potting compounds and moisture.

It is important that the seal end of the heater does not exceed the maximum operating temperature of the seal material. Permitting enough natural or forced air convection to cool the area, or specifying a length of no-heat zone between the heated and the sealed areas of the heater, will prevent temperatures from exceeding maximum operating levels. Smaller diameter heaters drop in temperature along a no-heat zone at a faster rate than larger diameter heaters. A reliable estimate for no-heat zone length can be interpolated for most temperature, seal and heater diameter combinations **(see Graph A)**.

FIREROD heaters can be designed with special seals to resist contaminants and accommodate a range of application temperatures **(see Table 1)**.

Combat Sheath Corrosion

Corrosion occurs when the heater's outer sheath deteriorates and allows contaminants to enter the heater. Watlow offers several sheath materials to protect a FIREROD cartridge heater from corroding when exposed to various environmental elements **(see Table 2)**. For certain applications, such as medical equipment and aerospace, passivated or electropolished heater sheaths can be provided to prevent corrosion.

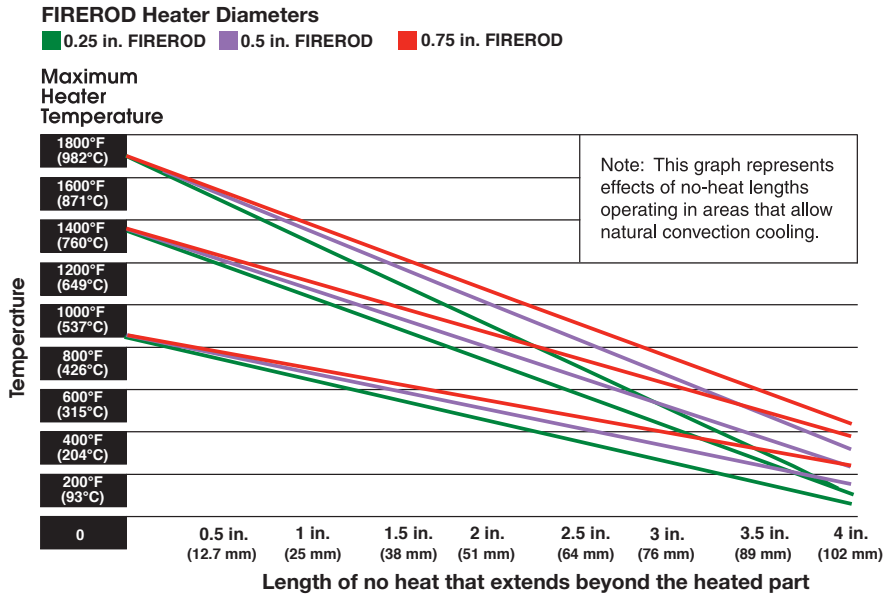
Prevent Heater Over Temperature

Watlow designers optimize the internal construction of your FIREROD heater based on the wattage and operating temperature that you specify. However, various conditions can cause the heater to reach over temperature.

The incidence of heater over temperature is minimized by reducing mineral deposit buildup, correctly sizing a hole to fit the heater and choosing the optimum heater insertion length and sensor location.

A heater that is forced to operate beyond its maximum operating temperature is destined for premature failure. Extreme over-temperature conditions will cause the heater's internal conductors to melt, dielectric breakdown and leakage/short circuit. Less severe over temperature conditions will accelerate a heater's normal aging process. Operating a heater 100°F (37°C) beyond its maximum recommended temperature can reduce heater life by as much as two-thirds.

Graph A: Seal Operating Temperature Versus No-Heat Zone Length



Prevent Buildup In Immersion Applications

The watt density and control of the heater are critical to ensure that the heater functions correctly. With immersion applications, buildup of mineral deposits on the heater sheath can inhibit heat transfer between the heater and surrounding liquid.

When this occurs, heat is unable to escape, causing the heater's internal temperature to rise dramatically. For example, if local boiling occurs on the surface of the heater, the heater temperature reacts almost as if it is being operated in free, open air. **(see Graph B)**.

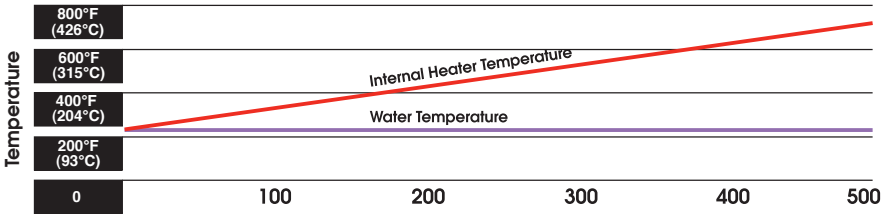
Table 1

Seal Type	Maximum Continuous Operating Temperature
Silicone Rubber	350°F (176°C)
PTFE	392°F (200°C)
FIREROD HT (high temp.)	1000°F (538°C)
Mineral Insulated Leads	1500°F (815°C)

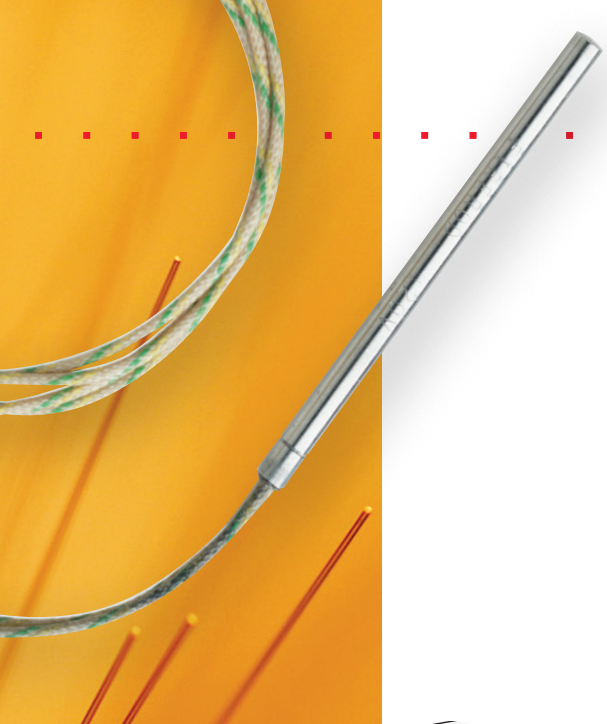
Table 2

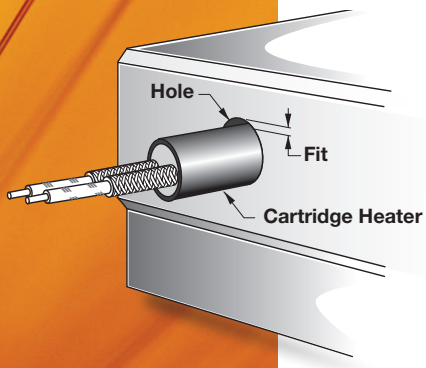
Sheath Material	Typical Applications
Alloy 800 (FIREROD standard)	Excellent for most general applications
304 SS	Foodservice and medical; deionized water
316L SS	Semiconductor and medical

Graph B: Internal Heater Temperature Versus Watt Density

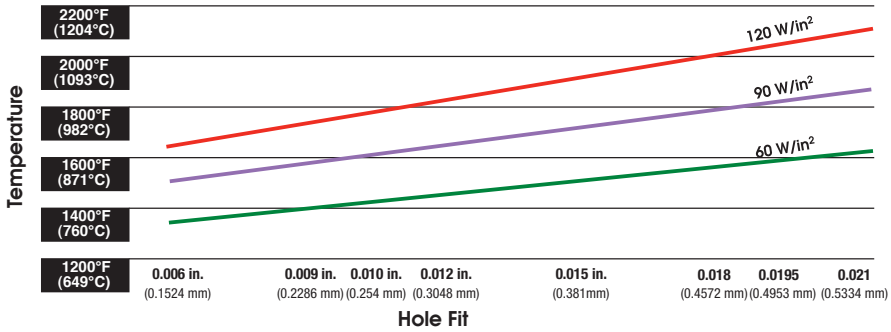


Water's ability to accept heat from a FIREROD heater changes with watt density. To ensure efficient heater performance in immersion applications, add 1°F for every W/in² of heater surface to the boiling point of water. Example: on a 200 W/in² heater, internal operating temperature = 200 W/in² + 212° = 412°F.





Graph C: How Hole Fit and Watt Density Can Affect Internal Heater Temperature



A loose fit causes cartridge heaters to operate at temperatures that are much higher than the part being heated. This is even more dramatic at higher watt densities. Using a tighter hole fit and lowering the watt density will keep the heater's internal temperature low, prolonging its life significantly.

Size The Hole Correctly To Fit Your Heater

Over temperature failure frequently occurs when a heater is placed in a hole that is too large, impeding heat transfer from the heater to the part. Watlow's hole graphs illustrate how dramatically hole fit affects the temperature of the heater's internal components **(see graphs C and D)**.

Fit equals the maximum inside diameter of the hole minus the minimum outside diameter of the FIREROD. **Graph D** helps to determine the maximum allowable hole fit for an application. Note that both the heated part maximum temperature and the heater's surface watt density affect the recommended hole fit.

Ensure Proper Insertion Length

Allowing part of the heater section to operate in open air can cause the temperature of the exposed section to rise significantly, while the part immersed or inserted into the application is kept at the desired temperature. Fully inserting the heated section into your heated part or liquid will resolve this problem.

Choose The Correct Sensor Location

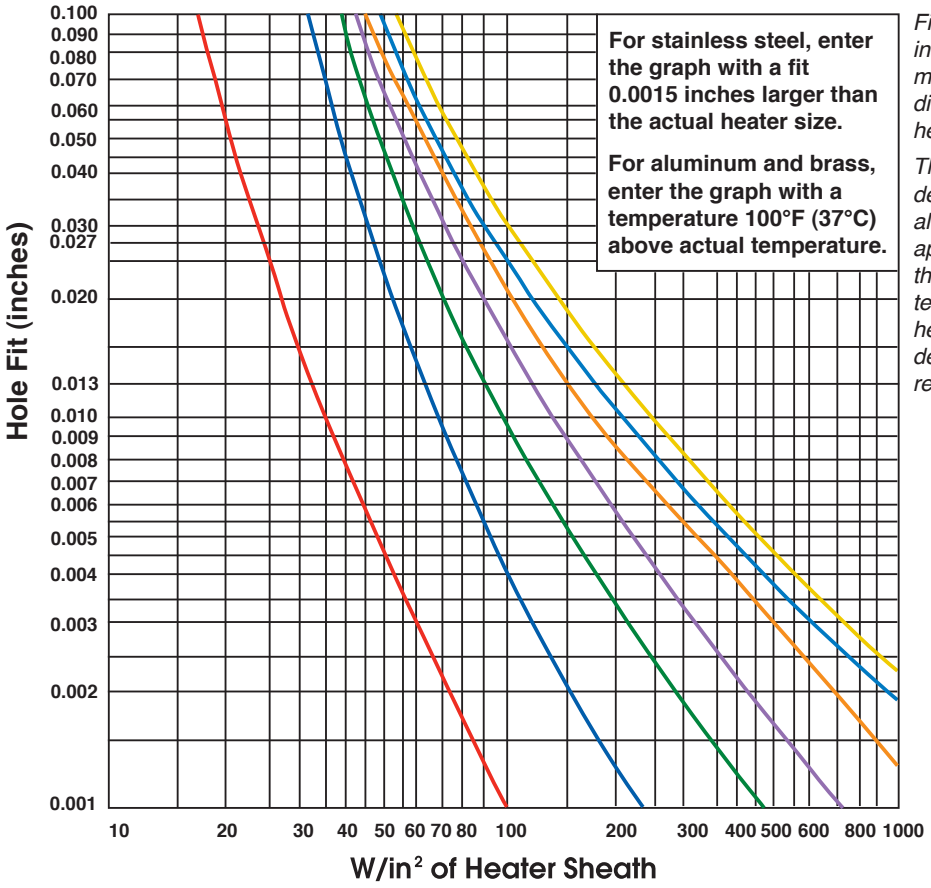
Choosing an undesirable location to place the sensor is another common cause of heater over temperature and, ultimately, its failure. If the thermocouple is placed on the edge of a heated part that operates cooler due to "end effects" of heat losses to atmosphere, the center portions of the heated part can reach a significantly higher temperature. This forces the heater to operate well above its maximum recommended temperature. Placing the temperature sensor in the hottest part of the application allows the heater to operate at maximum capacity.

When heating fluids or gases in chambers, the process heats up as substances flow through the chamber. Thermocouples at the cooler chamber end are unable to properly control heaters at the hot end, causing early heater failure. Repositioning thermocouples to the hot end or using a lower watt density heater can resolve this problem.

Watlow can design your FIREROD heater with an internal thermocouple located at the disc end of the heater or anywhere along the heater length to provide accurate temperature readings. This is especially beneficial for extremely sensitive, zoned or uniform temperature applications.

Watlow's FIREROD immersion heaters are designed primarily for direct immersion in liquids.

Graph D: Recommended Maximum Hole Fit For Heating Metals



Fit equals the maximum inside diameter of the hole minus the minimum outside diameter of the FIREROD heater.

The graph helps to determine the maximum allowable hole fit for an application. Note that both the heated part maximum temperature and the heater's surface watt density affect the recommended hole fit.

Protect Your Lead Wires

Match Lead Wire With Application Temperature

Placing power leads in a high temperature environment can lead to premature heater failure if the leads are not properly rated for the application. The binders in the lead wire insulation can bake out and the insulation becomes brittle. Any amount of flexing after this occurs usually results in electrical shorting between the lead wire conductors or a grounded surface. Watlow offers six types of lead wire insulation to combat this problem **(see Table 3)**.

Provide Relief To Over-Flexed Lead Wire

Heater failure can occur when lead wire is flexed beyond capacity. This can be prevented by adding strain reliefs to carry mechanical stress to the stronger parts of the heater. Adjusting the lead length to add extra slack can also minimize the incidence of leads being stretched too far.

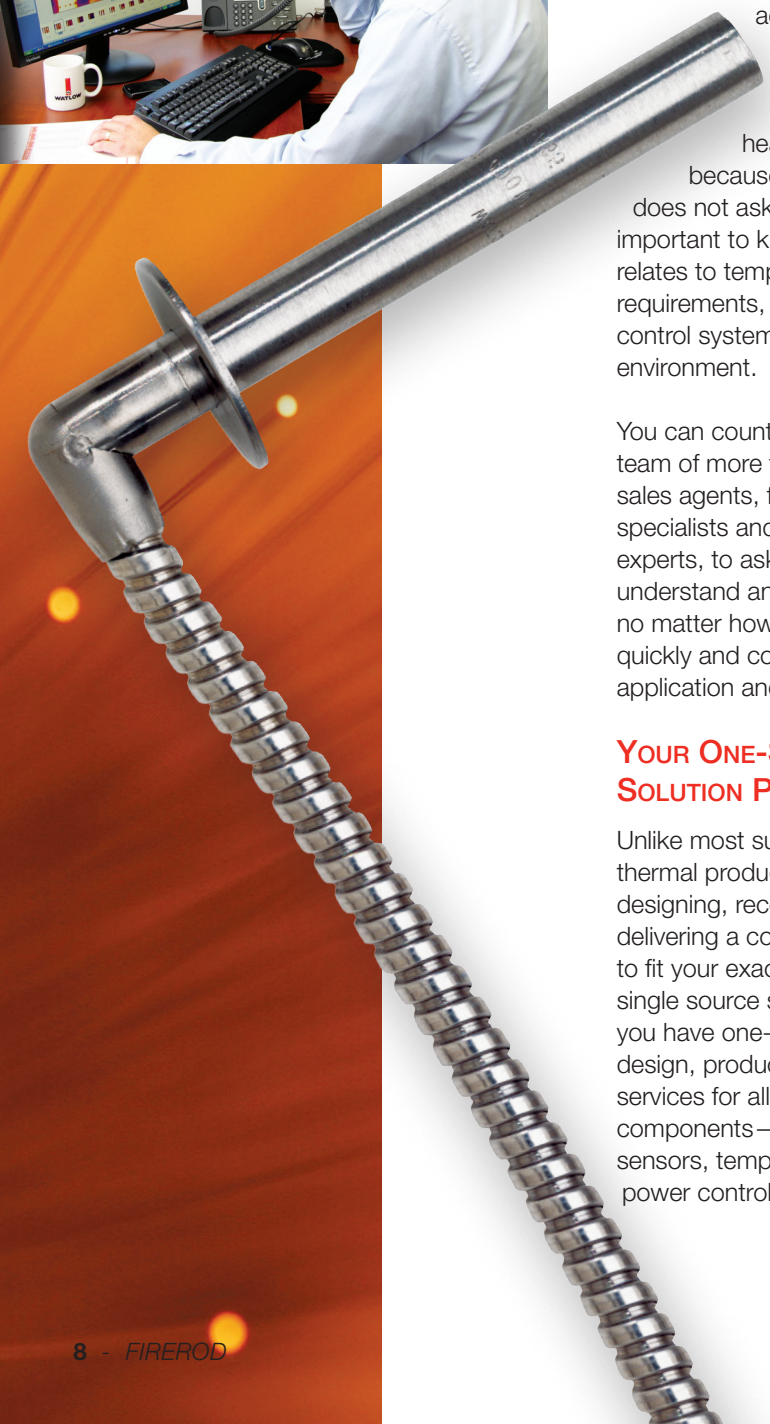
Put A Barrier Between Lead Wires And Heated Parts

It is important to protect lead wire from direct contact with a heated part. Stainless steel over braid and flexible metal conduit placed between the leads and heated components prevent lead wire abrasion from causing a heater to fail.

Table 3

Insulation Material	Maximum Continuous Operating Temperature
Silicone Rubber	302°F (150°C)
PTFE	392°F (200°C)
Fiberglass/Silicone (GGS)	482°F (250°C)
Mica/Fiberglass/MGT	842°F (450°C)
Ceramic Beads	1200°F (649°C)
Mineral Insulated Leads	1500°F (815°C)

Expert Technical and Global Application Support



We Ask The Right Questions To Solve Your Problem

We provide dedicated cartridge heater technical support throughout your project to optimize performance of the heater in your application. In addition to low-quality materials and poorly controlled processes and standards, premature heater failure often occurs because a thermal supplier does not ask the right questions. It is important to know how your application relates to temperature, watt density requirements, temperature sensing, control systems and the process environment.

You can count on Watlow's global team of more than 400 consultative sales agents, field engineers, product specialists and systems engineering experts, to ask the right questions to understand and solve your problem—no matter how complex—correctly, quickly and cost effectively, to meet your application and product lifecycle needs.

Your One-Stop Thermal Solution Provider

Unlike most suppliers that sell a single thermal product, Watlow's expertise is designing, recommending, building and delivering a complete thermal solution to fit your exact needs. Choosing a single source supplier means that you have one-stop access to expert design, products and engineering services for all of your thermal system components—heaters, temperature sensors, temperature controllers and power controllers.

Delivering The Complete Solution with Subassemblies

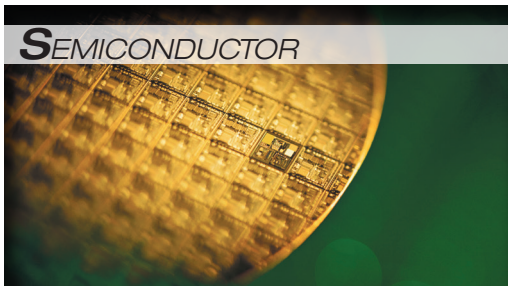
A subassembly can be as simple as attaching a special connector with a lead wire to developing a complex integration of sensors, controllers and other components. Watlow will partner with you throughout the process to develop a fully functional, complete thermal subassembly of various components into a modular unit that can be easily integrated with your application or process.

Engineering Expertise With Scalable Models And Prototypes

Our engineers can translate a concept into a model of a custom-designed cartridge heater using state-of-the-art, 3-D modeling tools. This can eliminate the need to test multiple prototypes that may not fit specific application requirements. Watlow utilizes the latest computational and finite element analysis (FEA) modeling techniques to measure system performance prior to production start up. Design revisions can be easily incorporated into a model, resulting in significant reduction in the lead time and cost to develop new products.

FIREROD Cartridge Heater Industry Solutions

Semiconductor



A large semiconductor equipment manufacturer of back-end inspection and packaging processes uses FIREROD cartridge heaters. Heaters need to be designed with multiple heated zones in a short heater length to ensure consistent sealing of finished chip packages. The FIREROD heater's increased uniform thermal profile along its length substantially improves the yield of the process, extends the life of the heater and reduces downtime and maintenance issues.

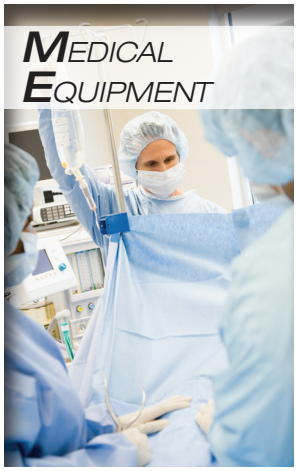
Foodservice

Watlow designed an integrated FIREROD heater, sensor, and controller assembly for a foodservice operator's fryer application to ensure maintenance of proper oil levels, which is critical to preventing fires and containing operation costs. Integrating the sensor with the FIREROD heater also lowered the cost and the size of the assembly.

Aerospace

A government contractor that manufactures halon flame suppression systems required a solution to prevent an explosion from occurring in the event that projectiles puncture an aircraft wing's fuel tanks during combat. FIREROD cartridge heaters are submerged in the liquid halon, keeping it warm enough to increase gas pressure, evacuate the liquid halon and replace it with vapor.

Medical Equipment



A heater used on equipment that interfaces with a patient during surgery in an operating room must meet strict packaging, electrical leakage, reliability and wattage tolerance requirements. Engineers from Watlow and the medical device manufacturer collaborated to develop an innovative product design solution that minimized electrical leakage and satisfied government agency requirements for heater manufacturing processes and documentations.

Nuclear

A pressurized water nuclear reactor requires an external pressurizer to control pressure and prevent water from boiling within the reactor's primary loop— a safety critical factor. Watlow's specialized pressurizer cartridge heaters generate steam for the primary loop to regulate overall system pressure. These heaters are designed and manufactured to meet nuclear industry specifications, ensuring safe and continuous operation.

Oil Refining and Petrochemicals

FIREROD cartridge heaters are used in a portable crude oil analyzer to boil a crude oil and water mixture in a sample chamber. Due to the risk of boil off, Watlow specially designed the heaters to eliminate occurrence of heaters exposure to open air and overheating. The FIREROD heater's swaged construction and close proximity of its resistance element winding to the sheath proved to significantly outlast competitive products considered for this application.

WATLOW®
www.watlow.com

Find out more about Watlow and how we can provide thermal solutions for your company:

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About Watlow

Watlow designs and manufactures industrial heaters, temperature sensors, controllers and supporting software as well as assemblies – all of the components of a thermal system. The company partners with its customers to optimize thermal performance, decrease design time and improve efficiency of their products and applications.

Watlow brings its experience to numerous industries, including semiconductor processing, environmental chambers, energy processes, diesel emissions, medical and foodservice equipment.

Since 1922, Watlow has grown in product capability, market experience and global reach. The company holds more than 450 patents and employs 2,000 employees working in nine manufacturing facilities and three technology centers in the United States, Mexico, Europe and Asia. Watlow also has sales offices in 16 countries around the world. The company continues to grow, while the commitment remains the same – to provide its customers with superior products and services for their individual needs.

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