A detailed description of the heaters being manufactured at RAVIRAJ Process Controls with application notes on the use of different types of heaters with illustrations

# Heater Catalouge

## Constructional details with speciifcation for Flexible & Tubular heaters

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HEATERS ARE DEVELOPED AS PER CUSTOMER INPUTS AND REQUIREMENTS AND SPECIFICATIONS HAVING THE REQUIRED CERTIFICATION FOR ITS USE IN SPECIAL APPLICATIONS THAT INCLUDE FLAMMABLE ENVIRONMENTS WITH APPROVALS FROM THE FOLLOWING CERTIFYING AUTHORITIES

# ATEX, IECEX AND PESO

पेट्रोलियम तथा विस्फ़ोटक सुरक्षा संगठन
Petroleum and Explosives Safety Organisation
Department for Promotion of Industry and Internal Trade
Ministry of Commerce & Industries
Government of India

# WHAT IS AN ELECTRIC HEATER?

An Electric heater can be defined as a device which converts electrical energy to heat energy, which is employed for heating applications. It may be understood that from this simple definition that, electrical heaters explode into myriad of different types, sizes, designs and capacity based on the applications, what is being heated, the degree of heating needed and the method by which the heat is applied.

An electrical heater consists of a coil which transforms electrical energy to heat energy.

A coil is a heating element attached to the heating unit itself. The heater generates the electric current which flows into the coil. The heating coil transfers the electric energy into heat energy. It may be directly immersed in the medium to heat it up or radiate heat through an open space.
The coil may be exposed or covered, depending on its application.

## ELECTRIC HEATER BENEFITS

General benefits of electric heaters include,

- Flexibility and Versatility.

This is because using electric heating system eliminates the need of flues and pipes. This also means that electric heaters can be used in almost any industry regardless of the construction.
Electric heaters also offer

- Low cost installation

Setting up these machines is not so complicated. As mentioned above, no piping is required, so you just need to have a connection to an electric circuit. This particularly helps during re-wiring and refurbishing.
Most importantly,

- Electric heaters are safe and reliable.

As stated before, no internal burning is required in this heating system, which eliminates the risks such as explosions and carbon monoxide poisoning. Moreover, since there are no radiators, problems of leakage or bursting will not only be avoided, but there will also be less risk of damage to properties.
All these factors also make electric heaters

- Environmentally friendly as well,
- Protecting the health of the workforce as well as
- Protecting the surrounding areas of the factory/plant.

Costs are obviously a consideration. The costs of electricity heating are higher than the direct use of fuel. In addition, the capital and infrastructure costs are also high. However, consider the fact that electric heaters do not require refueling and the absence of internal burning also removes a large part of maintenance problems of using these machines.

It has been seen in the past couple of years that as the oil and gas reserves depletes, whereas the demand for natural gas experiences an upward trend. In this setting, electric heaters can be used in oil fields to preheat produced fluids. Other benefits include

- Moisture resistance,
- No sound pollution,
- Portability,
- Precision,
- Durability,

- **Control of temperature and**
- **Distribution of heat energy.**

## Choosing Electric Heater Coil Materials

**The best materials choice for electric heater coils is dictated by the purpose of the heater and the medium being heated. Two of the most popular choices are Nickel-based materials and Iron-based materials.**

**The most common Nickel-based coil material is Nichrome. Nichrome is an alloy containing 80% Nickel and 20% Chrome. Nichrome is predominantly used in high-temperature applications up to 1250°C. This mixture has a number of advantages including:**

- Oxidation Resistant
- Reliable Resistance
- High Melting Point
- Minimal Expansion When Heated

**Iron-based may also be used for this purpose. Most commonly used is an Iron-Chromium-Aluminum alloy. This alloy costs less than nickel but is more prone to corrosion.**

**Silicon Carbide (SiC) and Molybdenum Disilicide ($MoSi_2$) heating coils are more expensive but offer higher temperatures and longer lifespans. SiC is capable of heating up to 1600°C and $MoSi_2$ can reach as high as 1800°C.**

## Types of Electric Heating Coil Elements

**There are two main types of electric heating coil elements, open and covered. In short, open coils are for indirect heating, and covered are for direct heating. Although open coils are inexpensive and highly-efficient they aren't suitable for all applications.**

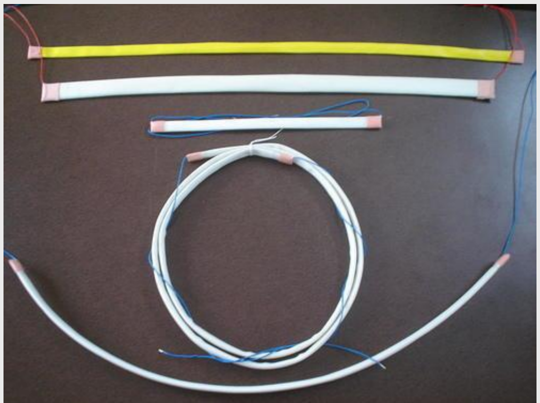
### Open Electric Heating Coils

**Open coils leave the elements exposed. There is no need for them to heat up a protective covering, so they have rapid heat up times. They are low maintenance and have inexpensive, easy to replace parts. The downside is that the exposed elements are more vulnerable to damage.**

Open coil elements are mainly used in:

- Space Heating
- Duct Heating
- Pipe Heating
- Metal Tubing
- Tank Heating
- Forced Air
- Ovens

**AN ILLUSTRATION OF DIFFERENT TYPES OF HEATERS MANUFACTURED**



**Flexible type Heaters**

**Immersion Heaters**

**O type SS sheath Heater**

**O type SS sheath finned Heater**

**U type SS sheath finned Heater**

**W type SS sheath finned Heater**

U type SS sheath Heater

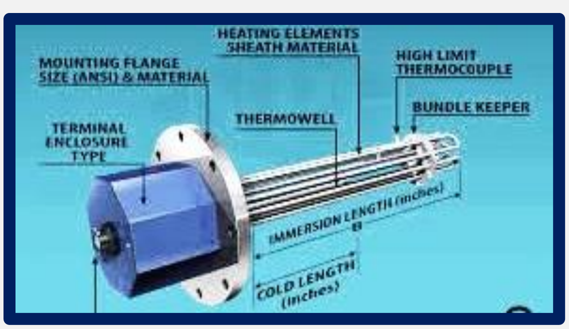
Strip sheath Heater

Immersion Heater

## Covered Electric heating Coils

- **Exposed elements are not appropriate for all heating applications. In direct heating, for instance, open coils are susceptible to damage and corrosion. To prevent this, heater coils use a protective sheath. This sheath protects the elements while also reducing risks of electrocution or fires.**
- **The sheath material is an important consideration when choosing an immersion heater. Material selection should be based both on the application and the properties of the medium being heated. Severely corrosive solutions, for example, would likely use an Incoloy sheath due to its corrosion-resistant properties.**

### Typical Heater design



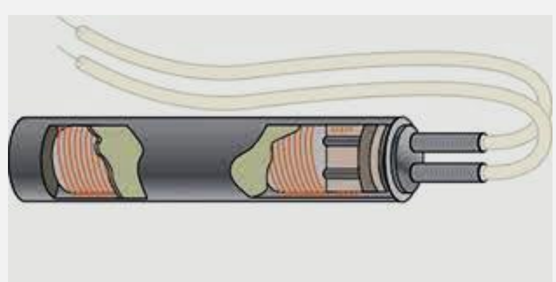



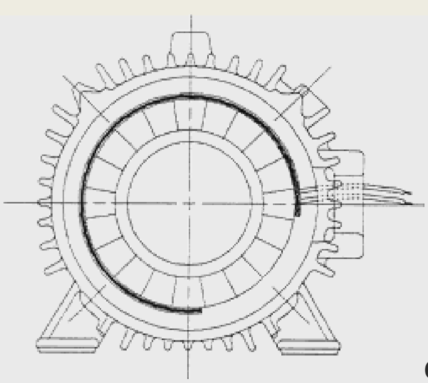
Figure: Typical heater constructional details

# WHY USE SPACE HEATERS IN MOTORS?

**When a motor is built as a "totally enclosed" (TE) unit, no free interchange of air can take place between interior and exterior. That's good protection against entry of solid or liquid contaminants.**

**But no enclosure can be airtight. As the TE motor heats and cools between "on" and "off," or from day to night, outside air will "breathe", in and out, and the water vapor in that air will condense on interior surfaces of windings and bearings. The result will eventually be insulation failure and bearing corrosion.**
**To prevent that, the motor's interior needs to be kept warm — above the condensation temperature — whenever it's not running. This is particularly true for motors that run only a few hours a day, are seasonally idle, or are installed in unusually damp locations. It's not a function of motor size or type. The same conditions exist, and will be equally damaging, whether the motor is 1 horsepower or 1000.**
**Two methods of internal heating are possible. For the larger machines, separate electric resistance heating elements can be built into the motor frame. These "space heaters," energized from (typically) a 120 volt auxiliary circuit, are switched on automatically by the motor starter whenever the motor itself is switched off.**

**For smaller three-phase machines, particularly at 230 or 460 volts, the control circuit can be arranged to supply a low voltage to one phase of the winding whenever the motor is de-energized. At least one electronic "black box" to do this, mounted in the motor control center, taking its power supply directly from the motor branch circuit and using solid-state devices to convert that voltage to the low value needed for heating the idle winding. That's less effective for a large motor because the space to be warmed is much larger. Although the winding itself may be adequately heated, the bearings and other metal surfaces throughout the motor interior may not be protected.**
**To suit whichever of these two methods of heating may be appropriate, a more suitable term for the technology would be "space heating" rather than "space heaters." The voltage available for separate heaters must be specified by the motor purchaser, and for motors in the 1000-5000 hp size range may be 480 volts three phase. But a single-phase 120 volt circuit is most common.**
**Little heating power is needed, depending upon the method. Since the alternative can be unexpected winding breakdown, with possibly high downtime and repair costs, "efficiency" of the heaters (used only when the motor is idle) should not be an issue.**
**Whatever is used, the heating system should not be neglected. Although heating circuits are generally reliable, any maintenance program should include some check of heater operation, because long-term damage resulting from heater failure may not be apparent until too late.**

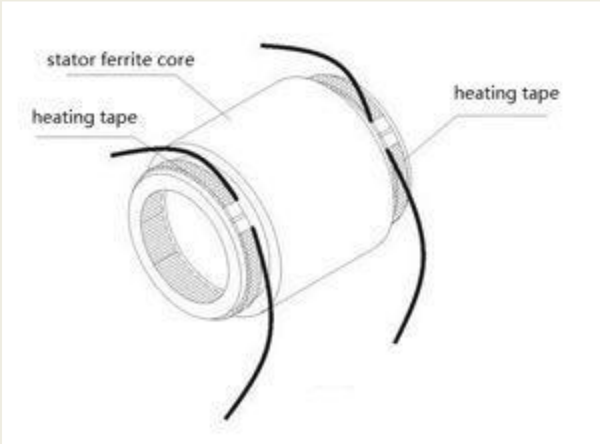


**Condensation problem in motors can be solved by maintaining motor winding temperature 5-10°C above the surrounding air temperature. You can calculate the approximate wattage required by using the equation** W=2DL**, where "W" is the heat in watts, "D" is the outside diameter of the stator lamination in inches, and "L" is the length of the stator core in inches.**

Large motors (≥H315) often require one heating tape in each end (watts calculated above should be divided on each heater). DC Motors may take 50 to 100% more heat to keep them dry.

Ideally the heating tape length should be close to the perimeter of the motor end. However overlap is absolutely forbidden.

Flexible heating tapes can be laced to the outside diameter of the end turns of varnished windings. Heater leads are brought out through the motor terminal box and connected to the available single phase power supply. A heater is typically activated by means of a motor control circuit relay contact, which energizes the heater when the motor power is disconnected. Timers sometimes are used.




# WATT DENSITY

The watt density rating of the heat source is so important when designing or troubleshooting a thermal system.

In the design of a thermal system -- and in the design of an electric heating element -- watt density is one of the most important considerations. The ability of the heater to dissipate heat from the resistance element to the heater sheath and then from the sheath to the process is determined by watt density. Too high a watt density can result in:

- Failure of the heater.
- Damage to the material being heated.
- Damage to the equipment or other components.

Watt density is the rated wattage per unit of the heated surface area, most commonly expressed in W/in2 or W/cm2. Each electric heater product has unique watt density characteristics and can range from less than 5 to more than 300 W/in2 (less than 1 to more than 46 W/cm2).

Heaters manufactured using a sheath-reduction process have higher watt density capabilities than other heaters. Swaging or roll reducing process will compact the heater components to a rock-hard mass. Electrical insulation and heat transfer are at practical maximum capabilities. Tubular heaters and most insertion heaters are manufactured using this compaction process. Some band and strip heaters use a combination process that embeds the resistance element in the refractory material. High temperature processing then blends and solidifies the element and the refractory material. Known generically as mineral-insulated, band and strip heaters of this design have higher watt density and temperature capabilities than others. Both manufacturing processes will transfer heat from the resistance element to

**the sheath efficiently, allowing lower resistance-element temperatures and long heater life. Mica heaters and silicone rubber flexible heaters, among others, have much less watt density capability.**

**When determining manufacturing specifications of electric heaters, considerations include the watt density of the internal resistance element. Consistently extreme internal temperatures and wire oxidation result from high watt densities. Attention is given to the watt density from inside the heater to outside the heater. After that, those responsible for applying the heater to the process must be certain that heat is dissipated from the heater throughout the thermal system. A combination of an inappropriately high watt density and a heated medium with a low conductivity rate will cause the heat being generated to not be transferred or dissipated from the heater sheath. The heater will overheat and fail.**

**How can this be prevented? Measures that can be adopted are described**

## Avoid Excessive Watt Densities

**Watt density is a process-specific variable. Certain materials have watt density limitations. Figure 1 shows recommended allowable ratings for various materials, temperature conditions and application considerations. Some materials such as water, vegetable oils and metals have high conductivity rates. The heat generated travels quickly from the element and through the medium. These materials can be heated at relatively high watt densities. Other materials such as sugar syrups, most gases, fuel oils, lubricating oils and hydraulic fluid, which have low conductivity rates, must be heated at low watt densities.**

**A major concern for any heat processing operation using heaters is to dissipate the heat generated by the element. This is particularly true for specific applications, including liquid immersion heating. Excessive watt densities cause several problems in liquid immersion heating:**

**At higher than recommended watt densities and sheath temperatures, thermal degradation causes heat transfer fluids and hydrocarbon oils to break down. Deposits form on the element, increasing to where a barrier to the flow of heat results in overheating.**

**Mineral deposits contained in water supplies build up on the heater sheath at high watt densities, insulating the heater sheath. As a result, heat transfer is prevented.**

**In addition, in some applications, lower watt density is required to minimize unavoidable process-related effects. For example, when heating corrosive materials, heat is a catalyst in a chemical reaction. Lowering watt densities and sheath temperatures will lessen the severe effects of heating corrosive materials.**

**Matching watt densities to material limitations and other application dynamics such as temperature and flow rates will ensure satisfactory heater performance. Generally the lower the heater watt density it is a better choice.**

### 23T: Watt Density and Operating Temperature Guidelines for Various Materials

The information presented is only intended as a guideline. Adjustments may be necessary should variations occur in heat transfer, flow rates and temperatures. The sheath material and watt density selected must be based upon the specific dynamics of the application. See complete **Corrosion Resistance of Sheath Materials (24T).**

| Material To Be Heated | Max. Maximum Operating Temp (°F) | Watt Density (W/sq. in.) | Sheath Material |
|---|---|---|---|
| Acid Solutions (Mild) | | | |
| Acetic | 180 | 40 | C-20, Quartz |
| Boric | 257 | 40 | Quartz |
| Carbonic | 180 | 40 | |
| Chromic | 180 | 40 | C-20, Quartz |
| Citric | 180 | 23 | 316 S.S. |
| Fatty Acids | 150 | 20 | 316 S.S. |
| Lactic | 122 | 10 | 316 S.S. |
| Malic | 122 | 10 | 316 S.S. |
| Nitric | 167 | 20 | Quartz |
| Phenol—2.4 Disulfonic | 180 | 40 | 316 S.S. |
| Phosphoric | 180 | 23 | Quartz |
| Phosphoric (Aerated) | 180 | 23 | Stainless Steel |
| Proponic | 180 | 40 | Copper |
| Tannic | 167/180 | 23/40 | Quartz |
| Tartaric | 180 | 40 | 316 S.S. |
| Acetaldehyde | 180 | 10 | Copper |
| Acetone | 130 | 10 | INCOLOY |
| Air C/F | | INCOLOY | |
| Alcyl Alcohol | 200 | 10 | Copper |
| Alkaline Solutions | 212 | 40 | Steel |
| Aluminum Acetate | 122 | 10 | 316 S.S. |
| Aluminum Potassium Sulfate | 212 | 40 | Copper |
| Ammonia Gas | C/F | | Steel |
| Ammonium Acetate | 167 | 23 | INCOLOY |
| Amyl Acetate | 240 | 23 | INCOLOY |
| Amyl Alcohol | 212 | 20 | Stainless Steel |
| Aniline | 350 | 23 | Stainless Steel |
| Asphalt | 200-500 | 4-10 | Steel |
| Barium Hydroxide | 212 | 40 | 316 S.S. |
| Benzene, liquid | 150 | 10 | Copper |
| Butyl Acetate | 225 | 10 | 316 S.S. |
| Calcium Bisulfate | 400 | 20 | 316 S.S. |
| Calcium Chloride | 200 | 5-8 | Quartz |
| Carbon Monoxide | — | 23 | INCOLOY |
| Carbon Tetrachloride | 160 | 23 | INCOLOY |
| Caustic Soda 2% | 210 | 48 | INCOLOY |
| 10% | 210 | 25 | INCOLOY |
| 75% | 180 | 25 | INCOLOY |
| Citrus Juices | 185 | 23 | 316 S.S. |
| Degreasing Solution | 275 | 23 | Steel |
| Dextrose | 212 | 20 | Stainless Steel |
| Dyes & Pigments | 212 | 23 | Stainless Steel |
| Electroplating Baths | | | |
| Cadmium | 180 | 40 | Stainless Steel |
| Copper | 180 | 40 | Quartz |
| Dilute Cynaide | 180 | 40 | 316 S.S. |
| Potassium Cyanide | 180 | 40 | Quartz |
| Rochelle Cyanide | 180 | 40 | Stainless Steel |
| Sodium Cyanide | 180 | 40 | Stainless Steel |
| Ethylene Glycol | 300 | 30 | Steel |
| Formaldehyde | 180 | 10 | Stainless Steel |
| Freon gas | 300 | 2-5 | Steel |

| Material To Be Heated | Max. Maximum Operating Temp (°F) | Watt Density (W/sq. in.) | Sheath Material |
|---|---|---|---|
| Acid Solutions (Mild) | | | |
| Fuel Oils | | | |
| Grades 1 & 2 (distilate) | 200 | 23 | Steel |
| Grades 4 & 5 (residual) | 200 | 13 | Steel |
| Grades 6 & bunker C (residual) | 160 | 8 | Steel |
| Gasoline | 300 | 23 | Steel |
| Gelatin; Liquid | 150 | 23 | Stainless Steel |
| Solid | 150 | 5 | Stainless Steel |
| Glycerine | 500 | 10 | INCOLOY |
| Glycerol | 212 | 23 | INCOLOY |
| Grease; Liquid | — | 23 | Steel |
| Solid | — | 5 | Steel |
| Hydrazine | 212 | 16 | Stainless Steel |
| Hydrogen | C/F | — | INCOLOY |
| Hydrogen Sulfide | C/F | — | 316 S.S. |
| Linseed Oil | 150 | 50 | Steel |
| Lubrication Oil | | | |
| SAE 10 | 250 | 23 | Steel |
| SAE 20 | 250 | 23 | Steel |
| SAE 30 | 250 | 23 | Steel |
| SAE 40 | 250 | 13 | Steel |
| SAE 50 | 250 | 13 | Steel |
| Magnesium Chloride | 212 | 40 | C-20, Quartz |
| Manganese Sulfate | 212 | 40 | Quartz |
| Methanol gas | C/F | — | Stainless Steel |
| Methylchloride | 180 | 20 | Copper |
| Mineral Oil | 200 | 23 | Steel |
| | 400 | 16 | Steel |
| Molasses | 100 | 4-5 | Stainless Steel |
| Naptha | 212 | 10 | Steel |
| Oil Draw Bath | 600 | 23 | Steel |
| Oils (see specific type) | 400 | 24 | Steel |
| Paraffin or Wax (liquid state) | 150 | 16 | Steel |
| Perchloroethylene | 200 | 23 | Steel |
| Potassium Chlorate | 212 | 40 | 316 S.S. |
| Potassium Chloride | 212 | 40 | 316 S.S. |
| Potassium Hydroxide | 160 | 23 | Monel |
| Soap, liquid | 212 | 20 | Stainless Steel |
| Sodium Acetate | 212 | 40 | Steel |
| Socium Cyanide | 140 | 40 | Stainless Steel |
| Sodium Hydride | 720 | 28 | INCOLOY |
| Sodium Hydroxide | — | See Caustic Soda | — |
| Sodium Phosphate | 212 | 40 | Quartz |
| Steam, Flowing | 300 | 10 | INCOLOY |
| | 500 | 5-10 | INCOLOY |
| | 700 | 5 | INCOLOY |
| Sulfur, Molten | 600 | 10 | INCOLOY |
| Toluene | 212 | 23 | Steel |
| Trichlorethylene | 150 | 23 | Steel |
| Turpentine | 300 | 20 | Stainless Steel |
| Vegetable Oil & Shortening | 400 | 30 | Stainless Steel |
| Water (Process) | 212 | 60 | S.S., INCOLOY |

**Figure 1**

## Add Wattage to Handle Large Temperature Gradients

**Temperature gradients exist in every thermal system. Some gradient is necessary for heat flow, but large differences will cause problems with control and higher-than-necessary heater temperatures. As the distance from the heat source to the ambient areas increases, temperatures decrease. To compensate for losses, additional wattage often is added to the system.**

**An initial step when designing a thermal system is to spread the wattage requirement over several heaters (figure 2). If 15 kW are needed, one heater might be 48 W/in2. By using two heaters at 7.5 kW each, the watt density would be reduced to 24. By using three heaters at 5 kW each, watt density is reduced to 16. Several smaller heaters also will distribute the heat better than one large heater. Agitating the liquid also will dissipate and distribute the heat better. In fact, in many applications, increasing the turbulence or flow will allow the process to be heated at higher watt densities. Sheath temperatures will be reduced. Insulation will lower the wattage requirement and is recommended wherever possible.**

**Increasing heater dimensions also will reduce watt densities. Consider an application using 0.375 x 12" cartridge heaters at 1,000 W each, with a watt density of 74 W/in2. If space is available, increasing the**

**diameter to 0.5" lowers the watt density to 55 W/in2. Obviously, lengthening the heated area, if possible, also will reduce the watt density.**

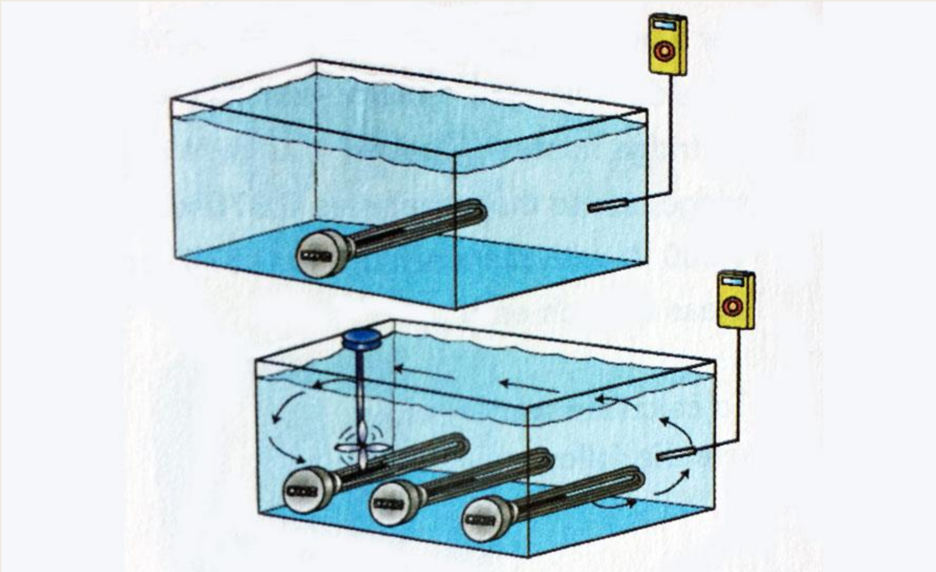


**Figure 2**

**Extremely high sheath temperatures can be produced easily in forced convection air heating applications. Empirical charts and graphs in many electric heating element catalogs show the correlation between sheath temperature, air velocity, process temperature and watt density. Lower watt densities will result in lower element temperatures and longer life. By substituting finned tubular or finned strip heaters in the same space, wattages can be increased substantially. In some applications, it makes sense to call in a professional for assistance: Air and gas heating in pressurized ducts or circulation heaters require the density of the compressed gas and the mass velocity of the flow to be included along with watt density and other considerations.**

## Heater Fit Matters

**In conductive heating, where the heat source is placed in a drilled or reamed hole, watt density also is important. The hole into which a cartridge-type heater is inserted typically is reamed to the nominal diameter of the heater. Insertion heaters are normally 0.002 to 0.006" undersize to ease installation and removal. Fit tolerances, or the difference between the maximum inner diameter of the hole and the minimum outer diameter of the heater, can range from 0.040 to 0.001". The exact dimension to use is derived from allowable maximum watt density graphs (figure 3). The higher the temperature and watt density, the greater the requirement for metal-to-metal contact between the outer diameter of the heater and the inner diameter of the hole. This is to be certain that the heat generated is dissipated throughout the process and heater temperatures are as low as possible.**

**The discussion has been purposely limited to conduction and convection heat transfer. Watt density is equally significant in radiant heat transfer applications. When designing a new thermal system, or troubleshooting problems in an existing system, watt density of the heat source is of critical importance and should never be overlooked or treated as an afterthought.**

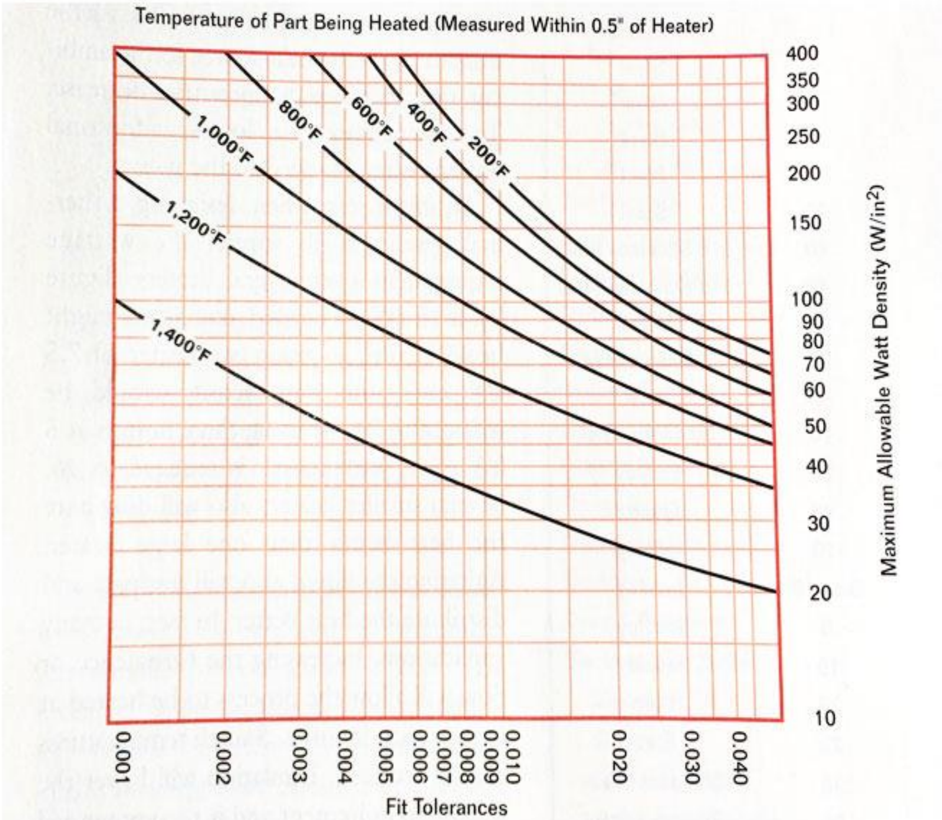



**Figure 3**

## ***Heat Calculations & Watt Density for Cartridge Heaters & Other Heater Applications:***

### Manual Calculation of total heat requirements for insertion heaters applications:

**KW = W x C x ΔT W = Weight of material in lbs.**

**3412 x hrs C = Specific Heat of material (platen, block etc.)**

**ΔT= Delta T = Change in temperature, °F**

**KW = Kilowatts**

**3412 = Conversion factor, Btu to kWh**

**Hours = Heat-up time in hours to reach set point**

### How to Determine Watt Density

**The term "Watt density" refers to the heat flow rate or surface loading. It is the number of Watts per square inch of heated surface area. For calculation purposes, stock cartridge heaters have a 1/4" unheated length at each end. Thus, for a 3/4" x 10" heater rated 1200 Watts, the Watt density calculation would be as follows:**

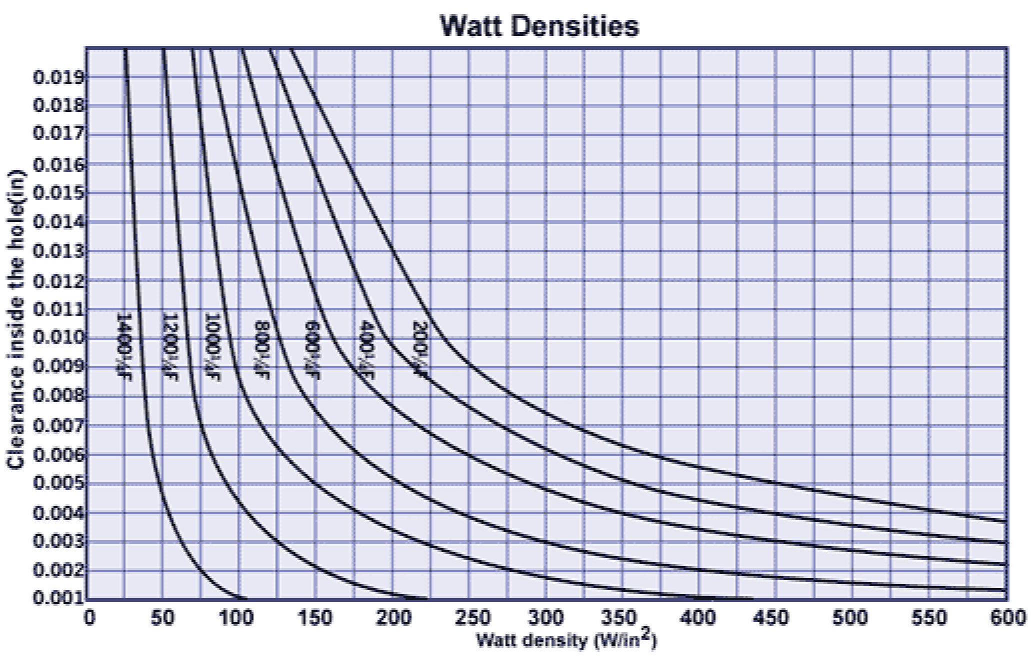
**Watt Density = W / (¶ x D x HL)**
**Where:**
**W=wattage = 1200 W**
**¶ = pi (3.14)**
**D= diameter = 0.75 inch**
**HL = Heated Length = 9.5 inch**

Watt Density = 1200/(3.14 x .75 x 9.5) = 53.64 W/in

**Calculate Watt Density and Fit** - After the wattage for each heater has been established, the watt density and fit must be calculated. Then, use graph below to be sure that the watt density is within allowable limits. For example a 3/4" x 10" heater rated 1200 watts has a watt density of 53.64 W/in 2 . 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 90 W/in 2 . Thus, the actual watt density of 53.64 W/in 2 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 allowed by the graph, consider the following changes.

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.

**Using the Maximum Allowable Watt Density Graph** - This graph is useful for choosing type NPH cartridge heaters. The curves should be considered as guides and not precise limits. The graph is based on a 1400°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 other materials are used which have a lower thermal conductivity or lower emissivity than oxidized mild steel.




***Standard Construction Features - Pipe Insert Heaters:***

**Elements Materials** — Copper, Steel, 304/316 Stainless Steel, Inconel
**Number of Elements in Flanges** — 1,2,3,6, plus
**Element Diameter** — 0.315" – 0.430"
**Watt Density** — 6.5, 15, 23, 45, 75W/in2
**Flange - Materials** - Carbon Steel, Stainless Steel, Brass
**Flange Rating** - 150 lb. Pressure Class per ANSI B16.5
**Flange Sizes** – 2”, 3", 5", 6", 8", 150 lb.

***High Conductivity Elements -***

**Filled with highest purity blends of magnesium oxide refractory (MgO) compacted to rock hard density to insure maximum thermal conductivity and maximum electrical resistance, and assure long element life.**

***Heavy Coil Construction –***

**Watt density on the heating coil is designed for low watt density operation by increasing the coil diameter and length to give maximum coil surface area and limit coil surface temperature, providing longer coil life.**

***Common Industrial Heater Terminal Enclosure -Types:***

**Safe operation of heaters equipped with these enclosures depends on employment of electrical wiring meeting National Electric Code and limiting maximum operating temperatures (including temperatures on outside of vessel, piping, flanges, screw-plugs, enclosures and other heat conducting parts) as dictated by flammable liquids, vapors, or gases present. Approved pressure and/or temperature limiting controls must be used to assure safe operation in the event of system malfunction.**

***Common Nema Enclosure Types –:***

***Terminal Enclosure Types -*** *General purpose, sheet metal, (NEMA-1) painted with enamel. Moisture Resistant-Nema 4, Nema 4X, Explosion Proof Nema 7.*

***Grounding Connector Standard -*** *A solid terminal connector is standard on all NPH immersion heaters insuring positive ground and personal safety.*

***Special Features Available:***

**Kilowatt Ratings - 500 KW and above available**

Flanges:

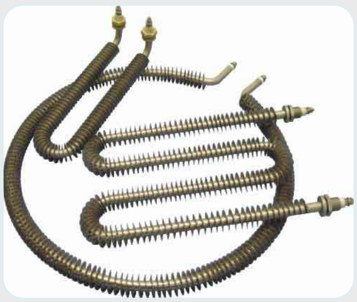
**Materials** - 316, 321, 347 stainless steel. Inconel,
**Ratings** - 300 lb. up to 2500 lb., pressure classes available
**Sizes** - 10" , 12", 14", 16", and 18" available. Please contact NPH for other materials or ratings.
**Elements Materials** - 316, 321, 347 stainless steel. Inconel. Other materials available, please contact NPH
**Other Features** - ASME Sections I, IV, and VIII designed and certified. Baffles on elements to distribute flow. Passivation on stainless steel. Immersion lengths up to 240". Underwriters Laboratories U.L./CSA listing available.

Heater Corrosion Policy:

**We cannot warrant any electric immersion heater against failure by sheath corrosion if such failure is the result of operating conditions beyond the control of the heater manufacturer. It is the responsibility of the purchaser to make the ultimate choice of sheath material based on his knowledge of chemical composition of corrosive solution, character of materials entering the**

solution, and controls which he maintains on the process. * Not intended for use in hazardous locations.

# 1. TUBULAR HEATER

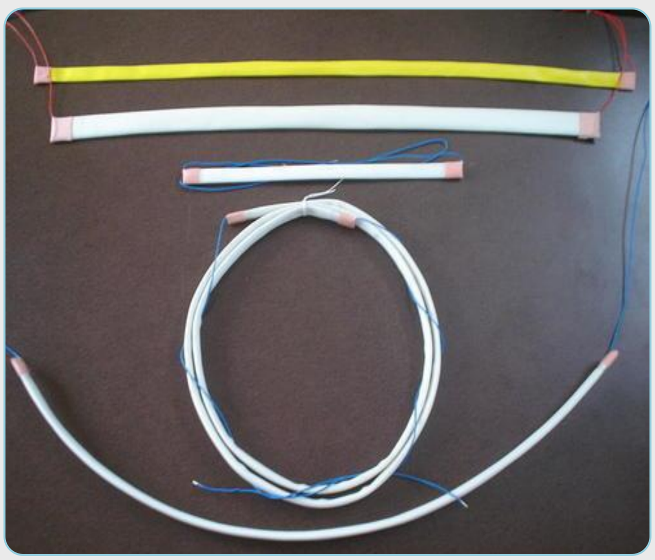


## TUBULAR HEATER

### SPECIFICATION

| | |
|---|---|
| **SHAPE** | ❖ U – TYPE<br>❖ 3 U - TYPE<br>❖ W – TYPE<br>❖ I – TYPE<br>❖ SEMI CIRCLE – TYPE<br>❖ MULTI BEND<br>❖ *CUSTOM SHAPE* |
| **WATTAGE** | 75 – 4000 WATT |
| **VOLTAGE** | 110-415 VOLT |
| **HEATER SHEATH** | SS304 ; SS321 ; INCONEL800 |
| **SHEATH LENGTH** | 350 – 3000 MM |
| **SHEATH DIAMETER** | 6.5 – 16.0 MM |
| **FIN** | SS 304 ( SPIRAL FIN)<br>SS 304 (SQUARE FIN) |
| **HEATING ELEMENT** | NICHROME WIRE( CR20NI80) |
| **INSULATION** | MgO |
| **INSULATION RESISTANCE(IR)** | >550 MΩ @ 500 VDC |
| **HV TEST** | 2.0 kV 50HZ FOR 1 MINUTE |
| **HUMIDITY TEST** | 95 % RH @ 30°C FOR 24 HRS. |

# 4. FLEXIBLE HEATER



## FLEXIBLE HEATER

### SPECIFICATION

| | |
|---|---|
| **WATTAGE** | 10 – 400 WATT |
| **VOLTAGE** | 110 – 460 VOLT |
| **HEATER SHEATH** | 1. SILICON COATED FG SLEEVE<br>2. FG SLEEVE<br>3. PERIFLEX SLEEVE<br>4. PTFE |
| **SHEATH LENGTH** | 235 - 300 MM |
| **WIDTH** | 11.0 - 25.0 MM |
| **THICKNESS** | 3.0 - 6.0 MM |
| **HEATING ELEMENT** | NICHROME WIRE (CR20NI80) |
| **INSULATION** | 1. VARNISH<br>2. FIBREGLASS TAPE<br>3. PTFE TAPE |
| **INSULATION RESISTANCE(IR)** | >550 MΩ @ 500 VDC |
| **HV TEST** | 2.0 kV 50HZ FOR 1 MINUTE |

# 5. CORD TYPE HEATER

## CORD HEATER

### SPECIFICATION

| | |
|---|---|
| **WATTAGE** | 15 – 200 WATT |
| **VOLTAGE** | 110 – 440 VOLT |
| **HEATER SHEATH** | 1. SILICON COATED FG SLEEVE<br>2. PTFE |
| **SHEATH LENGTH** | 400 - 4000 MM |
| **SHEATH DIAMETER** | 2.0 - 3.0 MM |
| **HEATING ELEMENT** | NICHROME WIRE (CR20NI80) |
| **INSULATION** | 1. FIBREGLASS CHORD<br>2. PTFE<br>3. SILICON COATED FIBREGLASS SLEEVE |
| **INSULATION RESISTANCE(IR)** | >550 MΩ @ 500 VDC |
| **HV TEST** | 2.0 kV 50HZ FOR 1 MINUTE |

## ATEX / PESO CLASSIFICATION OF HEATERS WITH SPECIFICATIONS

## CHORD HEATERS

### *Heaters for 120Volts operating input*

| TABLE 1 : GAS GROUP Vs HEATER LENGTH ( CORD HEATER) | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| 120 | 20 | 400 - 500 | 600 - 1100 | 1200 - 1800 |
| | 30 | 500 - 800 | 900 - 1600 | 1700 - 2400 |
| | 40 | 700 - 1100 | 1200 - 2200 | 2300 - 4000 |
| | 50 | 850 - 1400 | 1500 - 2700 | 2800 - 4000 |
| | 60 | 1100 - 1700 | 1800 - 3300 | 3400 - 4000 |
| | 70 | 1250 - 1900 | 2000 - 3800 | 3900 - 4000 |
| | 80 | 1450 - 2200 | 2300 - 4000 | |
| | 90 | 1600 - 2500 | 2600 - 4000 | |
| | 100 | 1800 - 2800 | 2900 - 4000 | |
| | 110 | 2000 - 3100 | 3200 - 4000 | |
| | 120 | 2200 - 3300 | 3400 - 4000 | |
| | 130 | 2300 - 3600 | 3700 - 4000 | |
| | 140 | 2500 - 3900 | 4000 | |
| | 150 | 2700 - 4000 | | |
| | 160 | 2900 - 4000 | | |

*Heaters for 240Volts operating input*

| TABLE 2 : GAS GROUP Vs HEATER LENGTH ( CORD HEATER) | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| 240 | 20 | | | 1500 - 1800 |
| | 30 | | 1200 - 1600 | 1700 - 2400 |
| | 40 | 700 - 1100 | 1200 - 2200 | 2300 - 4000 |
| | 50 | 850 - 1400 | 1500 - 2700 | 2800 - 4000 |
| | 60 | 1100 - 1700 | 1800 - 3300 | 3400 - 4000 |
| | 70 | 1250 - 1900 | 2000 - 3800 | 3900 - 4000 |
| | 80 | 1450 - 2200 | 2300 - 4000 | |
| | 90 | 1600 - 2500 | 2600 - 4000 | |
| | 100 | 1800 - 2800 | 2900 - 4000 | |
| | 110 | 2000 - 3100 | 3200 - 4000 | |
| | 120 | 2200 - 3300 | 3400 - 4000 | |
| | 130 | 2300 - 3600 | 3700 - 4000 | |
| | 140 | 2500 - 3900 | 4000 - | |
| | 150 | 2700 - 4000 | | |
| | 160 | 2900 - 4000 | | |
| | 170 | 3000 - 4000 | | |
| | 180 | 3200 - 4000 | | |
| | 190 | 3400 - 4000 | | |
| | 200 | 3600 - 4000 | | |

## *Heaters for 440Volts operating input*

| TABLE 3 : GAS GROUP Vs HEATER LENGTH ( CORD HEATER) | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **T2** | **T3** | **T4** |
| 440 | 40 | | | 3000 - 4000 |
| | 50 | | 2500 - 2700 | 2800 - 4000 |
| | 60 | | 2000 - 3300 | 3400 - 4000 |
| | 70 | 1800 - 1900 | 2000 - 3800 | 3900 - 4000 |
| | 80 | 1450 - 2200 | 2300 - 4000 | |
| | 90 | 1700 - 2500 | 2600 - 4000 | |
| | 100 | 1800 - 2800 | 2900 - 4000 | |
| | 110 | 2000 - 3100 | 3200 - 4000 | |
| | 120 | 2200 - 3300 | 3400 - 4000 | |
| | 130 | 2300 - 3600 | 3700 - 4000 | |
| | 140 | 2500 - 3900 | 4000 | |
| | 150 | 2700 - 4000 | | |
| | 160 | 2900 - 4000 | | |
| | 170 | 3000 - 4000 | | |
| | 180 | 3200 - 4000 | | |
| | 190 | 3400 - 4000 | | |
| | 200 | 3600 - 4000 | | |

# STRIP HEATERS

***Heaters for 120Volts operating input (16mm width)***

| TABLE 1 ( STRIP HEATER 16.0MM) : GAS GROUP Vs HEATER LENGTH | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| **120 V** | 20 | | 400 - 600 | 650 - 950 |
| | 30 | 400 - 450 | 500 - 850 | 900 - 1250 |
| | 40 | 450 - 600 | 650 - 1150 | 1200 - 2050 |
| | 50 | 500 - 750 | 800 - 1400 | 1450 - 2050 |
| | 60 | 600 - 900 | 950 - 1700 | 1750 - 2050 |
| | 70 | 700 - 1000 | 1050 - 1950 | 2000 - 2050 |
| | 80 | 800 - 1150 | 1200 - 2050 | |
| | 90 | 850 - 1300 | 1350 - 2050 | |
| | 100 | 950 - 1450 | 1500 - 2050 | |
| | 110 | 1050 - 1600 | 1650 - 2050 | |
| | 120 | 1150 - 1700 | 1750 - 2050 | |
| | 130 | 1200 - 1850 | 1900 - 2050 | |
| | 140 | 1300 - 2000 | 2050 | |
| | 150 | 1400 - 2050 | | |
| | 160 | 1500 - 2050 | | |

## *Heaters for 240Volts operating input (16mm width)*

| TABLE 2 ( STRIP HEATER 16.0MM) : GAS GROUP Vs HEATER LENGTH | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| **240 V** | 20 | | | 800 - 950 |
| | 30 | | 650 - 850 | 900 - 1250 |
| | 40 | 450 - 600 | 650 - 1150 | 1200 - 2050 |
| | 50 | 500 - 750 | 800 - 1400 | 1450 - 2050 |
| | 60 | 600 - 900 | 950 - 1700 | 1750 - 2050 |
| | 70 | 700 - 1000 | 1050 - 1950 | 2000 - 2050 |
| | 80 | 800 - 1150 | 1200 - 2050 | |
| | 90 | 850 - 1300 | 1350 - 2050 | |
| | 100 | 950 - 1450 | 1500 - 2050 | |
| | 110 | 1050 - 1600 | 1650 - 2050 | |
| | 120 | 1150 - 1700 | 1750 - 2050 | |
| | 130 | 1200 - 1850 | 1900 - 2050 | |
| | 140 | 1300 - 2000 | 2050 | |
| | 150 | 1400 - 2050 | | |
| | 160 | 1500 - 2050 | | |
| | 170 | 1550 - 2050 | | |
| | 180 | 1650 - 2050 | | |
| | 190 | 1750 - 2050 | | |
| | 200 | 1850 - 2050 | | |

## *Heters for 440Volts operating input (16mm width)*

| TABLE 3 ( STRIP HEATER 16.0MM) : GAS GROUP Vs HEATER LENGTH | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| **440 V** | 40 | | | 1550 - 2050 |
| | 50 | | 1300 - 1400 | 1450 - 2050 |
| | 60 | | 1050 - 1700 | 1750 - 2050 |
| | 70 | 950 - 1000 | 1050 - 1950 | 2000 - 2050 |
| | 80 | 800 - 1150 | 1200 - 2050 | |
| | 90 | 900 - 1300 | 1350 - 2050 | |
| | 100 | 950 - 1450 | 1500 - 2050 | |
| | 110 | 1050 - 1600 | 1650 - 2050 | |
| | 120 | 1150 - 1700 | 1750 - 2050 | |
| | 130 | 1200 - 1850 | 1900 - 2050 | |
| | 140 | 1300 - 2000 | 2050 | |
| | 150 | 1400 - 2050 | | |
| | 160 | 1500 - 2050 | | |
| | 170 | 1550 - 2050 | | |
| | 180 | 1650 - 2050 | | |
| | 190 | 1750 - 2050 | | |
| | 200 | 1850 - 2050 | | |

## *Heaters for 120/240/440Volts operating input (20mm width)*

| TABLE 4 ( STRIP HEATER 20.0MM) : GAS GROUP Vs HEATER LENGTH | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| **120 V 240 V** | 20 | | 550 - 650 | |
| | 30 | | 450 - 850 | |
| | 40 | | 615 - 1385 | |
| | 50 | | 750 - 1385 | |
| | 60 | | 915 - 1385 | |
| | 70 | | 1015 - 1385 | |
| | 80 | 650 - 785 | | |
| | 90 | 715 - 850 | | |
| | 100 | 785 - 950 | | |
| | 110 | 850 - 1050 | | |
| | 120 | 915 - 1150 | | |
| | 130 | 985 - 1185 | | |
| | 140 | 1050 - 1285 | | |
| | | | | |
| | 150 | 1115 - 1385 | | |

| TABLE 5 ( STRIP HEATER 20.0MM) : GAS GROUP Vs HEATER LENGTH | | | | |
|---|---|---|---|---|
| **Voltage (Volt)** | **Power (Watt)** | **Heater Length ( mm)** | | |
| | | **Gas Gr. T2** | **Gas Gr. T3** | **Gas Gr. T4** |
| **440 V** | 40 | | 1050 - 1385 | |
| | 50 | | 885 - 1385 | |
| | 60 | | 915 - 1385 | |
| | 70 | | 1015 - 1385 | |
| | 80 | 650 - 785 | | |
| | 90 | 715 - 850 | | |
| | 100 | 785 - 950 | | |

| | | | | |
|---|---|---|---|---|
| | 110 | 850 - 1050 | | |
| | 120 | 915 - 1150 | | |
| | 130 | 985 - 1185 | | |
| | 140 | 1050 - 1285 | | |
| | 150 | 1115 - 1385 | | |

## ***PROCESS HEATING***

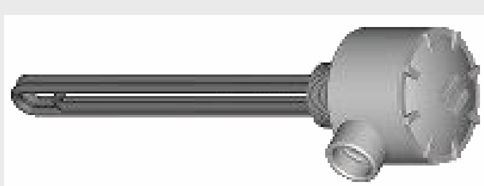
**For process heating elements suitable for many industrial and commercial applications, the Heater range includes cartridge elements, band heaters, coil heaters, strip heaters, flexible tubular heaters and box heaters.**

### Air heater

**Selecting the right process heater for your application is critical to ensure you get the consistent heating your application requires. An air heater is a great solution for plastic welding, laminating, drying, heat staking, heat sealing and other applications where air must be heated up to 500°C. They are constructed from an open coil of high temperature resistance wire which is electronically isolated in a stainless steel sheath. Air passes over the resistance wire which allows maximum heat transfer.**

## ***Coil heaters***

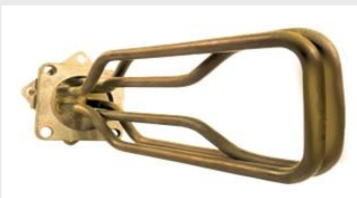
**Coil heaters are also referred to as high performance tubular heaters, or cable heaters. The construction method consists of compacted MgO, high temperature resistance wire and chrome nickel steel tube. Coil heaters can be constructed with or without built in thermocouples. The applications for coil heaters include:**



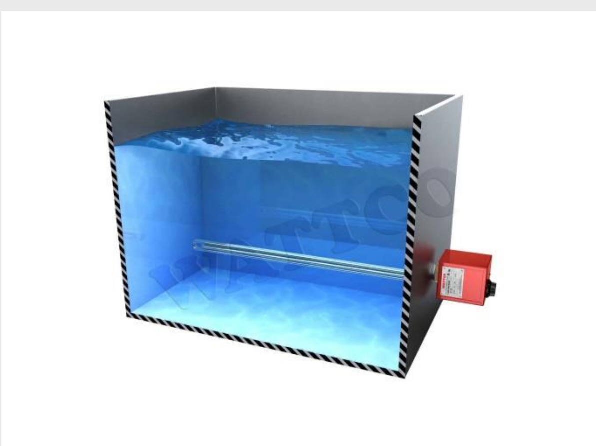
### Tube extrusion

- **Hot runner distribution plates**
- **Sealing and cutting bars and jaws for packing machines**
- **Pipe forming**
- **Small manifold heating**
- **Hot metal forming dies and punches**
- **Semiconductor manufacturing**
- **Hot runner nozzles and brushings**
- **Wafer processing**

## ***Tubular heaters***



Tubular heaters **are the most versatile type of heater when it comes to metal sheathed heaters. They are available in many diameters, sheath materials, lengths and electrical ratings. The mechanical flexibility allows the heater to be fabricated into many shapes and sizes which provides great adaptability for the engineer or designer to integrate into a process. Sheath materials are selected from a range of materials depending on the application, from liquid immersion to high temperature radiant heating (871°C). The type of application will determine the most suitable tubular heater assembly. Choose from Dutch heaters, circular heaters, flanged immersion heaters, finned tubular or finned duct heaters, ESP hopper heaters or if your requirement is for a high pressure process heater a large tank heater may be the best option.**

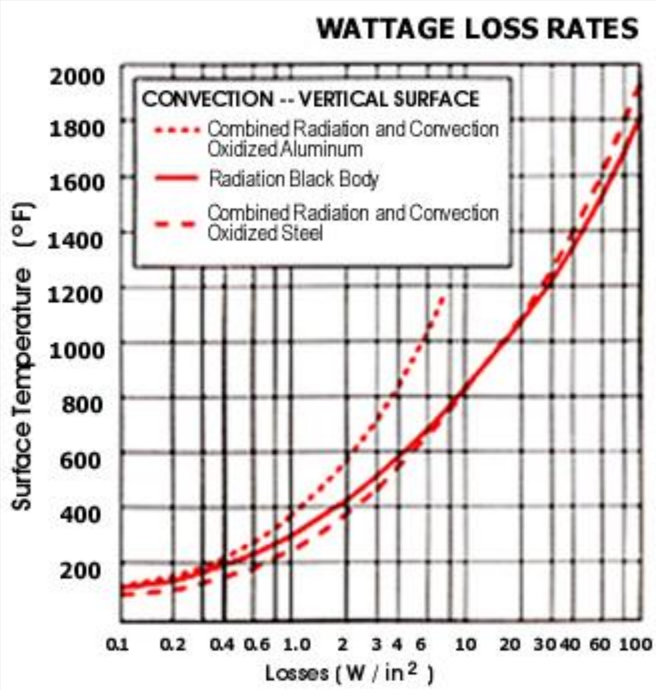


**IMMERSION HEATER FOR LIQUID HEATING**

## Process Heating Engineering Data and Application Design Considerations

The following reference information can assist you in the selection of Watt-Flex heaters for new process heating designs.

### Heating Metal Parts




The required wattage for a metal-heating application is equal to the sum of watts required for material heat up plus watt loss during heat-up, plus a 20% safety margin added for contingencies.

To calculate the heater capacity needed to produce a required level of heat, find the thermal values in the Physical Properties of Materials Table below and plug them into the following equations:

### Calculation of Required Wattage

To calculate the heater capacity needed to produce a required level of heat, find the thermal values in the Physical Properties of Materials Table below and plug them into the following equation:

- WATTS FOR MATERIAL HEAT-UP =
  WeightofMaterial(lbs.)∗SpecificHeat∗TemperatureRise(F)3.412∗HeatupTime(hours)Weig
  htofMaterial(lbs.)∗SpecificHeat∗TemperatureRise(F)3.412∗HeatupTime(hours)
- WATTS HEAT LASS DURING HEAT-UP =
  WattLosspersq.in.∗[Area(sq.in)WattLosspersq.in.∗[Area(sq.in)
- Total Watts Required = (A + B)*1.2
  (20% safety factor for contingencies)
- **Consult graph for applicable wattage loss rates

## Physical Properties of Materials Table

| Substance | Specific Heat | Heat of Fusion | Lowest melting point | Density | | Thermal conductivity | Thermal Expansion |
|---|---|---|---|---|---|---|---|
| | Btu/lboF | Btu/lboF | oF | lb/ft3 | lb/in3 | Btu/hr/ ft2/oF/ft | inches per inch per oF x 10-6 |
| Aluminum 1100 | .24 | 169 | 1190 | 169 | .098 | 128 | 13.1 |
| Aluminum 2024 | .24 | 167 | 935 | 173 | .100 | 112 | 12.9 |
| Aluminum 3003 | .24 | 167 | 1190 | 170 | .099 | 112 | 12.9 |
| Antimony | .052 | 69 | 1166 | 423 | .245 | 10.9 | 4.7 - 6.0 |
| Brass | .10 | - | 1700± | 525 | .304 | 56 | 11.1 |
| Carbon | .204 | - | 6700 | - | .080 | 13.8 | .3 -> 2.4 |
| Copper | .10 | 91 | 1981 | 550 | .318 | 224 | 9.2 |
| Glass | .20 | - | 2200± | 165 | .096 | .45 | 5 |
| Graphite | .20 | - | | 130 | .075 | .104 | - |
| Incoloy800 | .12 | - | 2475 | 501 | .290 | 8.1 | 7.9 |
| Inconel 600 | .11 | - | 2470 | 525 | .304 | 9.1 | 7.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Invar | .13 | - | 2600 | 508 | .294 | 6.1 | 0.6 |
| Iron, Cast | .13 | - | 2300± | 450 | .260 | 33 | 6.5 |
| Iron, wrought | .12 | - | 2800± | 480 | .278 | 36 | 6.5 |
| Lead, solid | .031 | 10 | 621 | 710 | .411 | 20 | 16.3 |
| Lead, melted | .04 | - | - | 665 | .385 | - | - |
| **Substance** | **Specific Heat** | **Heat of Fusion** | **Lowest melting point** | **Density** | | **Thermal conductivity** | **Thermal Expansion** |
| | **Btu/lboF** | **Btu/lboF** | **oF** | **lb/ft3** | **lb/in3** | **Btu/hr/ ft2/oF/ft** | **inches per inch per oF x 10-6** |
| Magnesium | .232 | 160 | 1202 | 109 | .063 | 91 | 14 |
| Monel 400 | .11 | - | 2370 | 551 | .319 | 14 | 7.7 |
| Nickel 200 | .11 | 133 | 2615 | 554 | .321 | 39 | 7.4 |
| Nichrome (80% Ni, 20% Cr) | .11 | - | 2550 | 524 | .303 | 8.7 | 7.3 |
| Solder (50%Pb, 50%Sn) | .04 | 17 | 415 | 580 | .336 | 26 | 13.1 |
| Steel, mild carbon | .12 | - | 2550± | 490 | .284 | 38 | 6.7 |
| Steel,stainless 304 | .11 | - | 2550 | 488 | .282 | 8.8 | 9.6 |
| Steel,stainless 430 | .11 | - | 2650 | 475 | .275 | 12.5 | 6.0 |
| Tin, solid | .056 | 25 | 450 | 455 | .263 | 36 | 13 |
| Tin, melted | .064 | - | - | 437 | .253 | 18 | - |
| Type Metal (85% Pb, 15% Sb) | .040 | 15 | 500 | 670 | .388 | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zinc | .095 | 51 | 787 | 445 | .258 | 65 | 9.4 - 22 |

## Heating Liquids

Consideration should be given to the following factors when heating liquids with Cartridge Heaters:

- Locate heater wells in an unrestricted space in the main body of the liquid.
- The heated section of the well should be covered by liquids at all times.
- In metal-melting applications, explosions can result unless pressure is vented during melting phase of heat-up.
- Certain watt-density limits exist in immersion applications. Factory should specify and consider this aspect.