1.1 HISTORY OF ELECTRIC HEATING

Most people consider Thomas Edison as the inventor of electric heater but there is an ambiguity to it. Some people also believe that Alexander Graham Bell was the man behind the idea of electric heating. The basic electric heater has been altered very modestly as it is still used the same way. The electric heater converts electric energy into heat. Electric currents flow through the metal component which radiates heat in the surrounding area. In 1905, Albert Marsh discovered chromel. It was the first metallic amalgamation to serve as a heat element and was made of four parts nickel and one part chromium. This new alloy, called Nichrome was 300 times stronger than other heat elements founded so far. It created and dispersed heat more efficiently than the light bulbs in Bell's heater. After Marsh's invention, electric heating began to overtake the sales of fuel-based heating sources. For this reason, Marsh is called the “father of the electrical heating industry”. A patent on the development was acquired in 1906.

1.2 BENEFITS OF ELECTRIC HEATING

1.2.1 ECONOMIC ADVANTAGES

It is a frequent delusion that electric heating is pricey to run. Although other forms of fossil fuels are cheaper to buy than electricity, but, when on the whole running costs are analyzed, electric heating is a feasible substitute.

Lifecycle Costs

This is one of the foremost things to be considered, when comparing the fiscal impact of heating technologies. Among the many factors, the energy cost and the operating costs (including the depreciation costs) over the life span of the equipment are the most important. Electric heaters are 100% efficient at the point of use, i.e. all the electricity used is converted directly into heat, unlike fuel based systems where energy is wasted through flue. Also this kind of heating has virtually no moving parts; most systems can be expected to last for at least 15 years. But, it might be obligatory to compute the lifetime cost of the complete line including all its investment, production, and maintenance factors to make a reasonable assessment.

Low capital & installation costs

Electric heating is very easy to install, thereby installation costs are minimum. It simply requires a connection to the electrical circuit, so it can frequently be installed in a short span of time. As the heaters can work as stand-alone units or as a system, it is easy and cheap to add heaters to a system at anytime as budgets permit.

Initial Investment

In addition to lifecycle costs, another economic argument, the initial investment cost of the installation is to be kept in mind while making a decision. Except for dielectric heating, other electro-heat technologies usually have an upper hand on this point. In several cases, this will prove to be a major motive to prefer electro-heat technologies over heating techniques employing fossil fuel.
**Electricity pricing Tariffs**

In many applications heating is preferred principally during night. The availability of low-cost base-load electricity during low load periods of the day, such as night time is, by default, exceptionally favorable in such cases. Also, larger electricity consumers may gain from discounted special rates based on average annual load demand.

**Depleting resources**

An environmental cum economic argument in support of all electro-heat technologies is that electricity prices are less volatile than the prices of fossil fuels or natural gas. Natural gas is a diminishing energy source and its price will rise substantially greater before the last reserves are cracked. The Energy Return on Energy Investment (EROEI) is a fine gauge for evaluating the economic viability of an energy source. Trending nowadays, the EROEIs of both oil and natural gas are in sheer decline, showing that most accessible treasures have already been used. This implies that even without considering environmental issues into the big picture, we will be enforced to budge to a non-fossil-fuel economy at some point in the forthcoming decades.

**Safe & Reliable Systems**

Safety is always an important consideration in any process. Because no fuel is burnt internally to generate heat, they are protected from associated safety risks, such as carbon monoxide poisoning or explosions. Also, there is less risk of damage to system, as there are no leakages or radiators. With virtually no moving parts to break down or wear out, electric heating is exceptionally reliable and will usually run adequately for a much longer period.

**1.2.2 LOGISTIC ADVANTAGES**

**Accessible technologies**

Low initial investment cost owing to the high power density of electro heat technologies in addition to compact installations are a major leap in this area. Another fact is that there are no storage issues and fuel transport involved, as with some fossil fuels. These rewards coalesce to make electro-heat technologies much more accessible and hence popular among SMEs, especially in the food and metal processing industries.

**Suitable for control and automation**

The output of electro-heat equipment can be easily adapted to the ambient conditions and the target material by regulating parameters such as voltage and current. This makes them highly sensitive to errors and suitable for fully automated production. Thanks to PID controllers, SSR and SCR (thyristor) controllers, the installations can be turned on and off at high speed. Fossil fuel heaters are much trickier to control, often being limited to simple on-off control with a consequential loss of efficiency.
Conversion efficiency of electric heating

100% efficiency is a major milestone that promotes electric heating and is unaffected by running at less than full load. Although, fossil fuel heaters achieve maximum efficiencies in the range of 80% but when the heater is not running at full load or is subjected to cycling on-off, efficiencies can drop to as low as 5%. This should be kept in mind when comparing the running costs of electric heating with other fuel types.

1.2.3 ENVIRONMENTAL ADVANTAGES

Electro-heat techniques exhibit considerably better results than fossil fuel heating systems in terms of CO2 emissions, transmission and distribution losses taken into account. Water vapour is another by-product of combustion in fossil fuel heating, so this is a problem in cases where dehumidification is necessary. Electric heaters produce no fumes or water vapour, thereby eliminating the need for supplementary ventilation or dehumidification.

1.3 ELECTRO-HEAT TECHNOLOGIES

Mentioned below are the most practiced industrial electric process heating (electro-heating) technologies:

1. Direct Resistance Heating: The most commonly used heating technology; it operates by passing electric current directly through an electrically-conductive object to directly heat it by Joule heat utilizing the internal resistance of object. Direct Resistance Heating technology enables rapid heating of materials, thereby contributing to size reduction of heating equipment, improved heating efficiency, a clean work environment and simple operation. Due to these features, it is preferred over fuel based heating.

2. Indirect Resistance Heating: An electric current is driven through a resistor, which heats up, and through convection and radiation, heats up a surrounding fluid or gas. Its energy efficiency is rather poor, but can still be cost-effective by making use of special electricity tariffs and by optimizing the geometrical position. Advantages include a consistent product quality (essential in the food and drinks industry) and uniform energy supply over the volume (essential in metallurgy). It leads to an exact production capacity, consistent production quality, uniform energy supply over the volume and a high degree of modularity.

3. Infrared or Radiant Heating: This is a widely employed heating technique in which a heat source at high temperature emits infrared waves that are subsequently absorbed by a colder object. Commonly used for surface treatments (heating or drying) and pre-heating purposes, it is also frequently used in the food industry for baking and in the metallurgy and textile industries for fixing coatings and drying paint. Its major benefits include low investment cost of the installation and high power density, ensuing in very compact installations with a high heating rate.
4. **Arc Heating:** This method is ideal for creating very high temperatures. An electric arc drawn between two electrodes has a temperature between 3000 to 3500°C depending on the electrode material, so is employed in arc furnaces for melting of metals and also for arc welding. Electric arc furnaces are also used in stone wool manufacturing, production of inorganic chemicals, reduction and pre-reduction of non-ferrous metals, and production of high-carbon ferro-alloys.

5. **Direct Induction Heating:** Currents are induced by electromagnetic action in the body to be heated and produce a sufficiently high temperature to melt the metal. This is mainly used as a melting technique for non-ferrous alloys. Direct induction heating is inherently more efficient than fuel heating and infrared for heating metal strips.

6. **Indirect Induction Heating:** A solenoid generates an alternating magnetic field. If a conductor is placed inside this field, an alternating electric current, called eddy current, is induced in this conductor that opposes the alternating magnetic field. These eddy currents heat up the conductor. The heat so produced is transmitted to the body to be heated by radiation and convection, as in the indirect-resistance method.

7. **Dielectric Heating:** When a changing electrical field is applied to an electrical insulating material with an asymmetrical molecule structure, friction will occur between the vibrating molecules as they attempt to align with this field, leading to internal heat development. In spite of its low energy efficiency, it will often be the most energy efficient option for materials with low thermal conductivity, such as rubber and certain plastics. This technology is particularly common in food industry.

Among the different electro-heat technologies mentioned above, resistive heating is the simplest, efficient and useful technology as it based on an uncomplicated OHM’S LAW. Its applications include agro-food, petrochemicals, fine chemicals, pharmaceuticals, packaging industries, machine tool, and ovens, baking ovens (vault and / or sole), bath, fryers, stove and many more.

### 1.4 RESISTIVE HEATING

An electric current flowing through a material that has some resistance (except a superconductor) creates heat. This resistive heating corresponds to the work done by the charge carriers in order to travel to a lower potential.

Electric heaters consist of a conductor whose resistance is selected so as to generate the requisite amount of resistive heating.

There are two simple formulas for calculating the resistance of a conductor and amount of heat dissipated in a resistor. This heat is measured in terms of power i.e. energy per unit time. Thus we are calculating the rate at which energy is being converted into heat inside a conductor. The first formula for calculating the resistance is:

\[ V = I \times R \]

Where V is the voltage, I is the current through the resistor and R is the value of the resistor.
The second formula is:

\[ P = I^2 \times R \]

Where \( P \) is the power, \( I \) is the current and \( R \) is the resistance.

Power is measured in units of Watt (W). It can also be expressed as joules per second i.e. energy per unit time.

It is important to distinguish how power depends on current, voltage and resistor as these are all interdependent. The power dissipated is directly proportional to voltage and current. From the formula it can be established that power increases with increasing resistance, assuming that current remains constant. In many situations, the voltage also remains (approximately) constant. Given standard voltage, the resistance determines the amount of current “drawn” by the equipment according to Ohm’s Law; higher resistance means lower current, and vice versa.

---

<table>
<thead>
<tr>
<th>Ohms Law Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Known Values</strong></td>
</tr>
<tr>
<td>Current &amp; Resistance</td>
</tr>
<tr>
<td>Voltage &amp; Current</td>
</tr>
<tr>
<td>Power &amp; Resistance</td>
</tr>
<tr>
<td>Voltage &amp; Resistance</td>
</tr>
<tr>
<td>Power &amp; Resistance</td>
</tr>
</tbody>
</table>

**Advantages of Electric Resistance Heating**

- No exhaust gases or waste by-products are created.
- If the system malfunctions, dangerous carbon dioxide gas does not form.
- No explosion hazard exists because the system doesn’t involve flammable gases.
- Breakers or fuses can provide a cheap, automatic shut-down mechanism in the event of a short circuit, as long as the electrical system has a good earth ground.
1.5 GENERAL INFORMATION ABOUT ELECTRIC HEATERS

- Tube: it shields the resistance wire. Its nature depends on environment and temperature. It provides shock protection and resistance to corrosion.
- Sealing: it provides insulation against external moisture. Its nature depends on the industrial application, its external environment, and the temperature.
- Heating wire: Composition is Nickel Chromium Alloy 80/20, It is the active part of the heating element (Joule effect)
- Insulation: high quality compressed magnesium oxide; it ensures rapid heat transfer and good dielectric insulation.
- Sheath: part which makes contact with the material to be heated. Protects the heating wire from outside environment.
- Length: consists of cold length and heated length. Actual heat is produced in heated length and external connections from the heater are made in cold length.
- Ceramic insulate: Heating wire is wound on the ceramic tube to provide insulation and proper placement inside the device.

The simplest definition of any electric heater is a device that changes electrical energy into heat energy. But from this simple law, electric heaters expand into innumerable sizes, types, applications, and designs depending upon the customer requirement. The measure of electrical energy is called the Joule after its discoverer, James Prescott Joule and measured according to the formula already explained above. The time factor in heating becomes apparent in any device that gets hot when an electric current flows through it; its temperature rises as time passes.
1.6 METHODS FOR DETERMINING HEATER REQUIREMENTS

Following steps need to be taken for determining the requirements of heater for any application:

1. Define the Heating Problem
   - Gather application information
   - Sketch problem for visual reference
2. Calculate Power Requirements
   - System start-up power requirement
   - System maintenance power requirements
   - Operating heat losses
3. System Application Factors
   - Operating temperature
   - Operating efficiency
   - Safe/permissible watt densities
   - Mechanical considerations
   - Operating environment factors
   - Heater life requirements
   - Electrical lead considerations
   - Safety factor
4. Select Heater
   - Type
   - Size
   - Quantity
5. Select Control System
   - Type of temperature sensor and location
   - Type of temperature controller
   - Type of power controller

1.7 COMMON KNOW HOW FOR HEATERS

1.7.1 TRANSFER OF HEAT

When a body starts to generate heat, i.e. its temperature rises above that of other nearby objects; it is called a heat source. As its temperature increases, it starts to raise the temperature of the materials in its surrounding area using any combination of three different methods. These three methods are conduction, convection, and radiation.

Conduction transfers heat energy from one material to another via direct contact. It is a direct method of transferring heat energy, and is usually the most efficient: the highest percentage of heat energy created transfers to the colder object from the heat source.
Convection also uses physical contact to transfer heat energy, but the contact entails the use of an agent gas, typically air. In this kind of heating, the heat source warms the gas. The warmed gas now has less density, so it rises, creating convection currents that move the heated gas into contact with the colder objects, warming them. The left cooled gas flows back to the heat source where it is warmed again, and the process repeats.

Radiation does not rely on any physical contact between the heat source and the object to be heated. Instead, heat energy is transmitted through space from the heat source to the object in the form of electromagnetic radiation. One example is infrared wavelengths.

### 1.7.2 TEMPERATURE MEASURING SCALES

Three temperature measuring scales (Fahrenheit, Celsius, Kelvin) are widely used today.

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>The earliest established temperature scale using Mercury invented by Gabriel Fahrenheit in 1970 and named after him. The zero degrees were established by using a mixture of ice water and salt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celsius</td>
<td>Historically called centigrade, in the honor of the founder, Anders Celsius. An SI derived unit, accepted by most countries. The melting point of ice and boiling point of water are the two benchmarks of this unit.</td>
</tr>
<tr>
<td>Kelvin</td>
<td>Established as the standard for thermometry, Lord Kelvin developed a universal thermodynamic scale based on the temperature at which all thermal motion ceases in the classical description of thermodynamics.</td>
</tr>
</tbody>
</table>

For conversion from Fahrenheit to Celsius use the formula:

\[ C = (F - 32) \times \frac{5}{9} \]

For conversion from Kelvin to Celsius use the formula:

\[ C = K - 273.15 \]

### 1.7.3 ALLOYS FOR HEATING ELEMENT

Materials for electric heating depend upon an inherent resistance to the flow of electricity to generate heat. Copper wire does not get hot when carrying electricity because it has good electrical conductivity. Thus for an alloy to perform as an electric heating element, it must resist the flow of electricity. The property to resist the flow of electricity is called as resistivity. Along with resistivity, other properties are also essential for the alloy to work as heating element. One such property is that the alloy should have endurance capability to sustain the heat produced i.e. it should have good life.
To be useful as an electrical heating element, a material should have the following properties:

- High electrical resistivity
- Good strength and ductility
- Low temperature coefficient of resistance
- Good resistance to progressive oxidation in air
- Can be easily formed into desired shapes.

The resistance heating alloys can be divided into two main groups, the NiCr based alloys and FeCrAl based alloys. The NiCr alloys are called **austenitic** alloys and FeCrAl alloys are called **ferritic** alloys. Different composition of the constituents produces a range of variety useful for special purposes. Some of the compositions are given below:

**Austenitic Alloys**

**Nichrome 80**: This austenitic alloy has the highest nickel content. Due to its good workability and high temperature strength, it is widely used. Composition is 80% nickel and 20% chromium. Can be used up to 1200 °C or 2190 °F.

**Nichrome 70**: Normally used in furnace applications. Composition is 70% nickel and 30% chromium. Can be used up to 1250 °C or 2280 °F.

**Nichrome 60**: Has good corrosion resistance and oxidation properties. The corrosion stability is also good except in sulphur containing atmospheres. Typically used in tubular elements. Composition is 61% nickel and 15% chromium and 24% iron. Can be used up to 1150 °C or 2100 °F.

Some general physical and mechanical properties of Austenitic alloys are shown in the table:

<table>
<thead>
<tr>
<th>Property</th>
<th>Nichrome 80</th>
<th>Nichrome 70</th>
<th>Nichrome 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. operating temperature</td>
<td>1200 °C 2190 °F</td>
<td>1250 °C 2280 °F</td>
<td>1150 °C 2100 °F</td>
</tr>
<tr>
<td>Nominal Composition %</td>
<td>20 Cr 80 Ni  - Fe</td>
<td>30 Cr 70 Ni  - Fe</td>
<td>15 Cr 61 Ni 24 Fe</td>
</tr>
<tr>
<td>Density g/cm³</td>
<td>8.30</td>
<td>8.10</td>
<td>8.20</td>
</tr>
<tr>
<td>Resistivity at 20 °C or 68 °F Ωmm²/m</td>
<td>1.09</td>
<td>1.18</td>
<td>1.11</td>
</tr>
<tr>
<td>Temperature factor of resistivity Ct</td>
<td>250 °C 1.02</td>
<td>250 °C 1.02</td>
<td>250 °C 1.04</td>
</tr>
<tr>
<td></td>
<td>500 °C 1.05</td>
<td>500 °C 1.05</td>
<td>500 °C 1.08</td>
</tr>
<tr>
<td></td>
<td>1000 °C 1.05</td>
<td>1000 °C 1.05</td>
<td>1000 °C 1.11</td>
</tr>
<tr>
<td>Melting point °C</td>
<td>1400</td>
<td>1380</td>
<td>1390</td>
</tr>
</tbody>
</table>
KANTHAL APM: Used in furnace applications. Can be used up to 1425 °C or 2560 °F. Best among the Ferritic alloys. Composition is 22% Chromium, 5.8% Aluminium and balance Iron.

KANTHAL APMT: Advanced variety of KANTHAL APM. Better properties than it. Used in furnace applications. Composition is 22% Chromium, 5.8% Aluminium and balance Iron.

KANTHAL A-1: Used in furnace applications. Can be used up to 1400 °C or 2550 °F. Composition is 22% Chromium, 5.8% Aluminium and balance Iron.

KANTHAL A: Has high resistivity and good oxidation resistance so normally used in appliances. Can be used up to 1350 °C or 2460 °F. Composition is 22% Chromium, 5.3% Aluminium and balance Iron.

KANTHAL AF: Has good quality hot strength and oxidation properties. Used where good form stability is required. Can be used up to 1300 °C or 2370 °F. Composition is 22% Chromium, 5.3% Aluminium and balance Iron.

KANTHAL AE: Has exceptional form stability. Used to meet demands in fast response elements in quartz heaters and glass top hobs. Can be used up to 1300 °C or 2370 °F. Composition is 22% Chromium, 5.3% Aluminium and balance Iron.

KANTHAL D: Has high resistivity, low density and better resistance than austenitic alloys. Can be used up to 1300 °C or 2370 °F.

Some general physical and mechanical properties of Ferritic alloys are shown in the table.
<table>
<thead>
<tr>
<th></th>
<th>KANTHAL APM</th>
<th>KANTHAL A-1</th>
<th>KANTHAL A</th>
<th>KANTHAL AF</th>
<th>KANTHAL AE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. operating temperature °C</td>
<td>1425</td>
<td>1400</td>
<td>1350</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td>2600</td>
<td>2550</td>
<td>2460</td>
<td>2370</td>
<td>2370</td>
</tr>
<tr>
<td>Nominal Composition %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Al</td>
<td>5.8</td>
<td>5.8</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Fe</td>
<td>Balance</td>
<td>Balance</td>
<td>Balance</td>
<td>Balance</td>
<td>Balance</td>
</tr>
<tr>
<td>Density g/cm³</td>
<td>7.10</td>
<td>7.10</td>
<td>7.15</td>
<td>7.15</td>
<td>7.15</td>
</tr>
<tr>
<td>Resistivity at 20 °C or 68 °F Ωmm²/m</td>
<td>1.45</td>
<td>1.45</td>
<td>1.39</td>
<td>1.39</td>
<td>1.39</td>
</tr>
<tr>
<td>Temperature factor of resistivity Ct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 °C 480 °F</td>
<td>1.00</td>
<td>1.00</td>
<td>1.01</td>
<td>1.01</td>
<td>1.01</td>
</tr>
<tr>
<td>500 °C 930 °F</td>
<td>1.01</td>
<td>1.01</td>
<td>1.03</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>1000 °C 1830 °F</td>
<td>1.04</td>
<td>1.04</td>
<td>1.06</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>Melting point °C °F</td>
<td>1500</td>
<td>1500</td>
<td>1500</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td>2730</td>
<td>2730</td>
<td>2730</td>
<td>2730</td>
<td>2730</td>
</tr>
<tr>
<td>Tensile strength N/mm²</td>
<td>680</td>
<td>680</td>
<td>725</td>
<td>700</td>
<td>720</td>
</tr>
<tr>
<td>Hardness Hv</td>
<td>230</td>
<td>240</td>
<td>230</td>
<td>230</td>
<td>230</td>
</tr>
<tr>
<td>Elongation %</td>
<td>20</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>20</td>
</tr>
</tbody>
</table>

A quick comparison between these two alloys is represented by explaining their advantages

**Advantages of Austenitic alloys**

- Superior ductility after long use.
- Better emissivity than ferritic alloys, so lower element temperature
- Higher hot and creep strength than ferritic alloys.
- Good corrosion resistance at room temperature.

**Advantages of Ferritic Alloys**

- High maximum temperature in air
- Longer life as compared to austenitic alloys
- High watt density
- Good oxidation properties
- High resistivity and yield strength
• Lower density than austenitic alloys.

Alloys for heating element are chosen according to the properties it possesses so as to build a nearly ideal heater. Other alloys can also be used as heating elements but these two are the most popular and widely used. Austenitic alloys can be molded in the form of wire or strip for using it as a heating element. Ferritic alloys can be formed in wire, strip, tube or bar depending on the application.

The life of a resistance heating alloy depends on a number of factors such as temperature, temperature cycling, contamination, alloy composition, trace elements and impurities, wire diameter, surface condition, atmosphere, mechanical stress etc.

**Alloy Selection**

There are some important design factors which contribute to the choice of the alloy. Some of them are discussed below:

**a) Temperature**

• A graph showing the relation between resistivity and temperature of austenitic and ferritic alloys is shown below.

![Graph showing the relation between resistivity and temperature of austenitic and ferritic alloys.](image)

• The durability value of alloys relative to temperature in % is shown in the table below.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>1100 °C or 2010 °F</th>
<th>1200 °C or 2190 °F</th>
<th>1300 °C or 2370 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>KANTHAL A-1</td>
<td>340</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>KANTHAL AF</td>
<td>465</td>
<td>120</td>
<td>30</td>
</tr>
<tr>
<td>KANTHAL AE</td>
<td>550</td>
<td>120</td>
<td>30</td>
</tr>
<tr>
<td>Nichrome 80</td>
<td>120</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>Nichrome 60</td>
<td>95</td>
<td>25</td>
<td>-</td>
</tr>
</tbody>
</table>
The maximum temperature which any heating element (alloy) can attain also depends on wire dimensions. The table shows maximum wire temperature as a function of wire diameter when operating in air.

<table>
<thead>
<tr>
<th>Diameter mm (in):</th>
<th>0.41 - 0.95 °C (0.0061-0.0374)</th>
<th>1.0-3.0 °C (0.039-0.118)</th>
<th>&gt; 3.0 °C (&gt; 0.118)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
<td>°F</td>
<td>°F</td>
</tr>
<tr>
<td>KANTHAL AF</td>
<td>900-1100</td>
<td>1100-1225</td>
<td>1225-1275</td>
</tr>
<tr>
<td></td>
<td>1650-2010</td>
<td>2010-2240</td>
<td>2240-2330</td>
</tr>
<tr>
<td></td>
<td>1700-1920</td>
<td>1050-1175</td>
<td>1175-1250</td>
</tr>
<tr>
<td></td>
<td>1740-2100</td>
<td>1150-1225</td>
<td>1225-1250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2100-2240</td>
<td>2240-2300</td>
</tr>
<tr>
<td>KANTHAL A</td>
<td>925-1050</td>
<td>1050-1175</td>
<td>1175-1250</td>
</tr>
<tr>
<td></td>
<td>1700-1920</td>
<td>1920-2150</td>
<td>2150-2300</td>
</tr>
<tr>
<td></td>
<td>1740-2100</td>
<td>1150-1225</td>
<td>1225-1250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2100-2240</td>
<td>2240-2300</td>
</tr>
<tr>
<td>KANTHAL AE</td>
<td>950-1150</td>
<td>1025-1100</td>
<td>1100-1200</td>
</tr>
<tr>
<td></td>
<td>1700-1880</td>
<td>1880-2010</td>
<td>2010-2190</td>
</tr>
<tr>
<td>KANTHAL D</td>
<td>925-1025</td>
<td>1000-1075</td>
<td>1075-1150</td>
</tr>
<tr>
<td>Nichrome 80</td>
<td>925-1000</td>
<td>1830-1970</td>
<td>1970-2100</td>
</tr>
<tr>
<td>Nichrome 60</td>
<td>900-950</td>
<td>950-1000</td>
<td>1000-1050</td>
</tr>
<tr>
<td></td>
<td>1650-1740</td>
<td>1740-1830</td>
<td>1830-1920</td>
</tr>
</tbody>
</table>

**b) Oxidation Properties**

Resistance to oxidation can be accomplished by formation of a dense oxide layer on the surface of the alloy which resists the penetration of gases as well as metal ions. For this, the layer should be thin and adhere to the metal. Ferritic alloys are superior as the oxide formed displays higher electrical insulating and good chemical resistance properties by forming alumina layer (Al2O3). At temperatures above 1000 °C, the color is light grey while at temperatures below 1000 °C, the oxide layer becomes dark. The oxide formed on Nichrome alloy is Chromium oxide (Cr2O3) which is dark and properties are inferior to those of alumina layer as it spalls and evaporates easily.

**c) Corrosion Resistance**

Corrosion due to humidity or contamination can shorten wire life. The different corrosive constituents are:

- **Steam**: Its effect is more pronounced on Nichrome alloys than Ferritic alloys.
- **Sulphur**: Ferritic alloys are more stable in oxidizing gases containing sulphur while Nichrome alloys are sensitive to sulphur.
- **Salts and Oxides**: The salts of molten metals, boron compounds in high concentration are harmful to heating alloys.
Table given below shows the selection criteria for various alloys:

<table>
<thead>
<tr>
<th>Material</th>
<th>Temp.</th>
<th>Oxidizing</th>
<th>Reducing</th>
<th>Sulphurizing</th>
<th>Carburizing</th>
<th>Nitriding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nichrome 80</td>
<td>1200 °C</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nichrome 70</td>
<td>1250 °C</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nichrome 60</td>
<td>1150 °C</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KANTHAL APM</td>
<td>1425 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ *</td>
</tr>
<tr>
<td>KANTHAL A-1</td>
<td>1400 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ *</td>
</tr>
<tr>
<td>KANTHAL A</td>
<td>1350 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ *</td>
</tr>
<tr>
<td>KANTHAL AF</td>
<td>1300 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ *</td>
</tr>
<tr>
<td>KANTHAL AE</td>
<td>1300 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ *</td>
</tr>
</tbody>
</table>

Where + stands for superior to
- stands for inferior to
* stands for at low dew point (<20 °C) severe nitriding may occur

### 1.7.4 SHEATH MATERIAL AND WORKING TEMPERATURES

The metallic sheath on the outside of a heating element is used to protect the internal wires from chemically active and hot air gases. Selection of the best type of metal sheath is based on the working temperature, industry and surrounding conditions.

### 304 Stainless Steel:

Generally called 304L, it is a common alloy, readily available, low in the cost of both materials and manufacture and is easier to weld. It should not be used in corrosive environments where the sheath temperature is above 482 °C.

**Applications:**
- Food & beverage processing
- Chemical processing
- Dairy
- Hospital equipment
- Pharmaceutical equipment
- Nuclear reactor equipment
- Containers for mild corrosives

**Temperature limitations:** up to 649°C
**Inconel:** It is a nickel-chromium alloy and is more expensive than most stainless steels. It is suitable for prolonged use at high temperatures and resists corrosion by simple acids and very pure water. Inconel is also gaining popularity as a water heating element.

**Applications:**
- Furnace components
- Chemical & food processing
- Nuclear power generation
- Caustic chemicals
- Air and radiant heating

**Temperature limitations:** up to 1149°C

**310 Stainless Steel:** This is commonly used at higher temperatures because it is stronger and resists air attack better. Also better corrosion resistance in fossil fuel gases.

**Applications:**
- Air heaters
- Baking equipment
- Chemical processing equipment
- Furnace parts
- Heat exchangers and electric
- Petroleum refining

**Temperature limitations:** up to 1038 °C

**316 (& 316L) Stainless Steel:** Better corrosion resistance to most chemicals, salts, acids and good resistance to sulphur.

**Applications:**
- Marine trim exteriors
- Chemical and food processing
- Petroleum refining equipment
- Pharmaceutical equipment
- Paper & pulp
- Textile finishing

**Temperature limitations:** up to 871°C

**Hastelloy-X:** This alloy is expensive due to the addition of iron, chromium and molybdenum. It has excellent high temperature strength and good oxidation resistance.
Applications:
- Gas Turbines for power generation
- Aerospace applications
- Industrial furnaces
- Boiler & pressure vessels

Temperature limitations: up to 1177°C

1.7.5 HEAT REQUIREMENT CALCULATIONS

There are two basic heat energy requirements in the sizing of heaters for a particular application.

**Start up Heat** is the heat energy required to bring a process up to operating temperature. Start-up heat requirement calculations consist of three basic equations. These three different equations are referred to as Equations A, B, or C: the wattage needed to heat a material to a specific temperature in a given amount of time (Equation A); the wattage needed to overcome the losses at operating temperature (Equation B); and a special calculation needed to reach a melting or vaporizing point (Equation C).

Equation A calculates the amount of wattage (W) needed to raise the temperature of a material to a specific amount in °F (∆F) in a given number of hours (T), weight of the material being heated and its specific heat value (c) being known:

**Formula A: Wattage required for heat-up =**

\[
\frac{\text{Weight of material} \times \text{Specific Heat} \times \text{Temperature Rise °F}}{3.412 \times \text{Heat up Time}}
\]

Equation B calculates the amount of wattage (W) needed to maintain the temperature of a material based upon its known wattage loss per square foot (WL/SF) multiplied by the area (A) in square feet:

**Formula B: Wattage losses at operating temperature =** Wattage loss/sq.ft. x Area in sq.ft.

The final equation, Equation C, determines the additional wattage necessary for melting or vaporizing a material. Whenever a material changes state, from a solid to liquid, or liquid to gas, it requires an additional energy to initiate the change. The heat needed to melt a solid material is known as the latent heat of fusion (Hf) while the latent heat of vaporization (Hv) determines the energy needed to change a substance from a liquid to a vapor. The equation for both is identical, with the value of Hf or Hv substituted as necessary for the value H:

**Formula C: Wattage for melting or vaporizing =**

\[
\frac{\text{Weight of material} \times \text{Heat of fusion or vaporization}}{3.412 \times \text{Heat-up time}}
\]
Operating Heat is the heat energy required to maintain the desired operating temperature through normal work cycles. When calculating the required kW, the maximum flow of the medium to be heated, the minimum temperature at the heater inlet and the maximum desired outlet temperature are used.

Once the volume of airflow (CFM – in cubic feet per minute) and the required temperature rise ($\Delta T$ – in degrees F) through the heater are known, the required kilowatt rating (KW) of the heater can be determined from the formula:

$$KW = \frac{\text{Volume of air flow (CFM)} \times \text{temperature rise (F)}}{3193}$$

OR

$$KW = \frac{\text{Volume of air flow (Liters/Sec)} \times \text{temperature rise (C)}}{837}$$

The larger of the start-up heat and operating heat values, will be the wattage required for the application.

1.7.6 WATT DENSITY

Watt density is the rated wattage of the heater divided by the overall area being heated. Watt density (watts per square inch of heater surface area) determines heater operating temperature for a given set of conditions. The watt density depends on how efficiently the material being heated distributes its heat throughout its volume. For example, metals, light oils and water have high heat distribution rates that permit the use of high watt densities. While syrups, heavy oils and hydraulic fluids with low heat distribution need lower watt densities to prevent spot overheating. This can lead to damage of the heating element and even the heated material.

Safe values of watt density vary with operating temperature, flow velocity, and heat transfer rates. Higher the material temperature, lower the watt density should be, especially those materials which coke or carbonize, such as oils. Watt densities should be low if a material is being heated to a temperature near the change of state, such as water to steam at 212°F.

Watt Density Calculations

$$\text{Watt density} = \frac{\text{Rated wattage of the heater}}{\text{Total Area} \times \text{Heated Length}}$$

Safe values of watt densities vary with operating temperature, flow velocity, and heat transfer rates. If the watt density is too high, the elements may burn out or accelerated attack on sheath elements may take place. If the watt density is too low the heater price will be high. The greatest heater life will come from the lowest watt density practical for the application.

In general, watt density is determined by three factors:

a) Maximum outlet temperature
b) Type of fluid heated and
c) Fluid flow rate

Maximum watt densities are based on heated length, and may vary depending upon concentration of some solutions.

1.7.7 WIRING PRACTICES IN HEATERS

3-Phase Delta (Balanced Load)

\[ I_P = I_L / 1.73 \]
\[ V_P = V_L \]
\[ W_{\text{DELTA}} = 3(V_L^2)/R \]
\[ W_{\text{DELTA}} = 1.73 V_L I_L \]

3-Phase Wye (Balanced Load)

\[ I_P = I_L \]
\[ V_P = V_L / 1.73 \]
\[ W_{\text{WYE}} = V_L I_L^2 / R = 3(V_P^2)/R \]
\[ W_{\text{WYE}} = 1.73 V_L I_L \]

Where
\[ V_P: \text{Phase Voltage} \]
\[ V_L: \text{Line Voltage} \]
\[ I_P: \text{Phase Current} \]
\[ I_L: \text{Line Current} \]
\[ W: \text{Wattage} \]
1.7.8 CALCULATING CURRENT REQUIREMENT

On a single phase (two-wire) power supply, the amperage per line is calculated by:

1 Ph Current = Total Wattage / Line Voltage

On three phase power circuits with balanced Delta or Wye heating loads, line current is calculated by:

3 Ph Current = Total Wattage / Line Voltage x 1.73
1.7.9 QUICK METHODS OF CALCULATING POWER REQUIREMENTS

The following formula will give a quick estimate of the power required in each application.

For Heating Steels:

\[
\text{kW} = \frac{\text{Kilograms} \times \text{Temperature Rise (°C)}}{5040 \times \text{Heat-up Time (hrs.)}}
\]

For Heating Oils:

\[
\text{kW} = \frac{\text{Gallons} \times \text{Temperature Rise (°F)}}{800 \times \text{Heat-up time (hrs.)}}
\]

For Heating Water in Tanks:

\[
\text{kW} = \frac{\text{Gallons} \times \text{Temperature Rise (°F)}}{375 \times \text{Heat-up Time (hrs)}}
\]

For Heating Air:

\[
\text{kW} = \frac{\text{CFM}^* \times \text{Temperature Rise (°F)}}{3000}
\]

1.7.10 CALCULATIONS RELATED TO WIRE

Wires are the main heating elements of the heater, which can be made from either Austenitic alloys or Ferritic alloys. Different parameters related to wire are:

**Resistance**

The resistance of a conductor is directly proportional to its length, \( l \) and inversely proportional to its cross sectional area, \( A \). The formula for calculating resistance is

\[
R = \frac{\rho l}{A}
\]

The proportional constant is the resistivity of the material and is temperature dependent.

**Dimensions**

The following two formulae will help you calculate the diameter and length of wire under certain Capacity and Voltage.
\[ d' = \sqrt[3]{\frac{4 \times 10^7 p P^2}{\pi^2 U^2 W}} \]

\[ L = \frac{U^2 \pi d^2}{4 p P \times 10^3} \]

Where:
- \( d \) — Diameter of heating wire, mm
- \( p \) — Resistivity of heating wire, \( \Omega \cdot \text{mm}^2/\text{m} \)
- \( P \) — Power per phase, Kilowatts
- \( U \) — Voltage, Volts
- \( W \) — Watt Density, W/cm\(^2\)
- \( L \) — Length of heating wire, m

With the help of these formulas, the wire size can be known. However, for specific applications and temperatures, wire diameter and watt density differs according to the alloy used. Considerations must be made.

### 1.7.11 CLOSED LOOP SYSTEM OF HEATER CYCLE

In a closed loop control system there is a constant feedback from the heater through the temperature sensor which in turn adjusts the temperature through a controller to maintain set point. This is also called a feed back control. A closed loop temperature process control consists of four basic components:

- Heaters
- Temperature sensor
- Temperature controller
- Power controllers

The temperature sensor regulates the variable parameter through the temperature controller, which then completes the feedback by triggering the solid state devices to control the power delivered to the heater.

**Heaters:** There are several different types of heaters:

1. **Process Heaters** (Band Heaters, Cartridge Heaters, circulation Heaters, Immersion Heaters, flanged Heaters, Inline Heaters, Screw plug Heaters)
2. **Air Heaters** (Tubular Heater, Air Heater, Strip Heater, Duct Heater, Open-coil elements, Finned Tubular Heater, Finned Strip Heater, Infrared Radiant Heater)
3. **Flexible Heater** (Silicone Rubber Heater, Mica Band Heater, Heating Cable, Heating Bands)
**Temperature Sensor:** They can be classified as:

1. Contact Temperature Sensors such as Thermocouples, RTD’s and Thermistor
2. Non Contact Temperature Sensors such as Pyrometer.

**Temperature Controller:** Temperature controller also comes in a range of configurations.
The main groups are:

1. Thermostats
2. PID Controller (Microprocessor based)

**Power Controllers**

1. Solid State Relay System
2. SCR Controlling System
3. Integrated Control Panel System

**Temperature Sensors:** All temperature sensors work on the same principle; all of them run on the same basic principle that they give temperature in the output according to the changes produced in their physical characteristics in the input.

1. **Contact Temperature Sensors:** The sensors remain in contact with the body whose temperature is to be measured. In industrial and laboratory processes, the measurement point is usually far from the indicating instrument. So it senses the temperature in terms of electrical quantities like voltage, resistance etc. Majorly, they are of three types:
   
   a) **Thermocouples:** They are amongst the easiest temperature sensors used in science and industry and are very cost effective. Comprising of a thermo element (junction of two dissimilar metals), it operates on the basis of the junction located in the process producing a small voltage, which increases with temperature.

   b) **Resistance Temperature Detector (RTD):** It utilizes a precision resistor, the resistance (Ohms) value of which increases with temperature. RTD has a positive temperature coefficient. Such variations are very stable and precisely repeatable.

   c) **Thermistors:** Thermistor is a semiconductor used as a temperature sensor. It displays a very distinct non linear resistance versus temperature relationship. The resistance of thermistor decreases with increase in temperature; called as negative temperature coefficient. It exhibits a very large resistance change, for small temperature changes. High sensitivity and small size makes them ideal for use in medical equipment.

2. **Non Contact Temperature Sensors:** When the sensors used are inaccurate, too slow, or difficult to use, non contact temperature sensors are the perfect choice because they measure a target’s temperature without contact. Sensors are not allowed to remain in
contact with the body whose temperature is to be measured. Most common type is Pyrometer. Property of emission of heated objects is used as the principle in these sensors. Every object whose temperature is above absolute zero emits radiation. The wavelength/frequency of these heat radiations depends on temperature. The radiations are captured by detecting devices and transformed into electric signals.

**Temperature Controllers:** A temperature controller produces an output action based on the input signal received from a sensor. Controllers used in heating applications are called reverse acting. Depending on the controller, output actions can control a heating device.

Temperature controllers are either thermostats (on/off control) or PID controllers.

**Thermostat (On/Off Control):** Thermostat is a component which senses the temperature of the system and regulates it so that the system's temperature is maintained near a desired value. It does this by switching the heaters on or off. Sensors are used in thermostat to measure the temperature and output controls the heater. The output tends to high or low when the temperature crosses the predefined point. This constant on/off around the set point will lower life cycle of heater, increase thermal losses and oxidation rate of heating elements. To overcome this problem, a power controlling device can be used in conjunction with the thermostat or a PID controller can be used. This not only maximizes the heater performance but also adds a hysteresis to minimize stress on the heater and avoid contactor damage.

**PID (Proportional-Integral-Derivative) Temperature Control:** Such type of controllers is used for optimum thermal system performance. It senses the rate of temperature increase or decrease and adjusts the output action accordingly. As per its name, it provides a proportional control or a proportional combined integral and derivative temperature control. Proportioning means operating heat closer to the set point, hence less power requirement. This can be done by using derivative and integral operating modes. The controller comes in all sizes; inputs to it have to be decided prior, output action requires a power controller to withstand rapid switching cycles. Most PID controllers come with four different control functions for different applications.

- P control only
- PI control (no offset= higher overshoot)
- PD control (steady state in shortest time)
- PID control. It combines the advantages of PI and PD control. Also called fuzzy logic control.

**Power Controllers:** Power controllers receive input from the temperature controller and apply or interrupt the electric power to the heating element. Power controllers switch electric power through solid state devices.

Solid state devices use semiconductors, which can be electronically switched ON or OFF thereby giving precise power control. The advantages include almost infinite life and ability to deliver
the rapid switching cycles required by PID temperature controller. Common solid state power controllers are SSRs (solid state relays) and SCRs (silicon controlled rectifiers).

**Solid State Relay (SSR):** A solid state relay (SSR) is a transistor activated by a small AC or DC control signal produced by the temperature controller. This type of relay can switch from 10 to 75A up to 480V AC in less than a second. They are well suited to provide rapid switching cycles required by PID controllers and are mostly used in radiant heaters and air heaters which require very frequent power switching. Most SSR switch at the zero electrical potential to minimize electrical noise caused by mid cycle switching. Benefits include faster reaction time, increased life time of heater and no arcing during switching.

**Silicon Controlled Rectifier (SCR):** These are solid state contactors, offering power switching advantages not possible with SSR. This device can switch electrical loads from 10 to 1000A, up to 575V AC, in three phase and single phase. An SCR power controller consists of:

- Semiconductor power devices
- Control circuit called firing circuit
- Protective circuits (fuses and transient suppressors)

SCRs can control the amount of power applied through burst firing or phase angle firing:

- Burst-firing switches complete AC cycles ON and OFF at zero potential. Burst firing is best suited for applications requiring time proportional power control, high temperature and high watt density heaters but not for infrared heating applications.
- Phase angle firing switches power ON or OFF inside the AC sine wave. Phase angle firing is best suited for electrical loads that require "soft starting" because they change resistance values over time and temperature and radiant heaters.

**Benefits** of SCR power controllers:

- High reliability
- Infinite resolution
- Extremely fast response
- Selectable power control parameters
- Minimum maintenance

These power controllers can be integrated with temperature controllers and input power supply to form a complete control panel. This Integrated Control Panel System allows process temperatures to be controlled to precision values. Customized control panels are designed for unique applications.
1.7.12 MAINTENANCE OF HEATERS

Some general issues relating to the use, care and maintenance factors relative to obtaining the longevity of industrial heaters are

- Lead Consideration
- Lead Styles
- Bending Radius
- Brittleness
- Terminations
- Lead Protection

**Electrical Lead Considerations:** Apart from considering the type of electric heater and placement and wattage requirements, it is also essential to judge the types of electrical leads used and the methods by which they exit and terminate the heated area. Some general considerations in selecting various lead types are:

- Temperature of Lead Area
- Flexibility Required
- Relative Cost
- Contaminants in the Lead Area
- Abrasion Resistance Required
- Accessibility to Controls

**Lead Styles:** Element leads are available in a wide range of styles, but can generally be grouped into a few categories such as:

1. Single Conductor
2. Twisted Pair
3. Rod
4. Pad or Bar

**Bending Radius:** Lead wire extending from the heater elements can be bent to cater to specific needs. But caution should be ensured so that the integrity of the internal connection is maintained to extend the life of the heating element. The minimum bending radius of the wire should be 4 to 8 times the diameter of the wire. This works for both austenitic alloys and ferritic alloys.

**Brittleness:** Many high temperature metallic alloys suffer from poor ductility and brittleness, especially after they have been at operating temperature for any length of time. Once these alloys are cooled to room temperature, attempting to move them most likely will lead to breakage.
Terminations: Proper terminations are significant for a successful heating element application and if not done correctly, it will harmfully affect element life. One of the major objectives is to assure that the lead wire is in close contact with the actual termination.

Lead Protection: As a protective measure, it is desirable to provide a protective covering over the element leads. This may be requisite due to electrical or mechanical considerations. Great care should be taken when selecting a protective shield for the leads.

1.7.13 SAFETY FACTOR CALCULATION

A safety factor of varying size should be allowed while making calculations of heaters for unknown or unexpected conditions. The size of the safety factor is dependent on the accuracy of the wattage calculation. Heaters should always be sized for a higher value than the calculated figure. A factor of 10% is adequate for small systems that are closely calculated; 20% additional wattage is more common. Safety factors of 20% and 35% are not uncommon, and should be considered for large systems, such as those containing doors that open or are large radiant heat applications. The heater life and efficiency factors should be taken into account so that the heater cost is minimized.

Some general guidelines:

- 10% safety factor for small systems with closely calculated power requirements
- 20% safety factor is average
- 20% to 35% safety factor for large systems

Smaller the system with fewer variables and outside influences; smaller the safety factor. Conversely, larger the system and greater the variables and outside influences; greater the safety factor. The safety factor should be higher for systems that have production operations that contain equipment cycles subjecting them to excessive heat dissipations, e.g.: opening doors on furnaces, introducing new batches of material that can be of varying temperatures, large radiant applications and the like.

1.8 OPTIMIZING HEATER PERFORMANCE

* Watt density, sheath material and maximum sheath temperature are the most crucial factors affecting heating element. Compatibility must be ensured.
* Alloys for heating element must be carefully selected keeping in mind the temperature limits and ambient conditions.
* The hot length of the heater should not pop out of the material to be heated.
* The wiring connections to supply power should comply with the ratings of the heater and should include necessary protection equipments.
* The watt density and material of the heating element must fulfill the heating requirements.
* Proper selection of flange, if necessary, should be kept in mind.
* The heater should be selected according to the application, temperature of the ambient environment and the nature of the material.
* Leads should be protected from excessive movements and high temperature. If such a situation arises, select the appropriate heating equipment.
* Use power controller and temperature sensors to increase heater life.
* Contamination is the most frequent cause of heater failure. Try to avoid it.
* Prevent excessive temperature cycling to avoid detriment of heater.

We offer customized solution for every problem, be it large or small, simple or complex. Our team is dedicated to research and development, using the latest technologies while motivated to meet every customer’s needs by manufacturing high quality industrial heating products. Some of the standard industrial heaters offered by us are mentioned below.

**TUBULAR HEATERS**

Known for its versatility, ruggedness and dependability, tubular heaters can virtually be factory-configured to suit a variety of industrial heating applications. Tubular elements are frequently regarded as the foundation of all heating elements. The basic design consists of a resistance wire/coil precisely centered in a metal sheath. This wire/coil is surrounded by magnesium oxide to provide efficient heat transfer from coil to heating medium. Diameters are varied to give customized design and adjustable watt densities for best performance and long life. Bending radius is carefully chosen so as to give optimum performance. Tubular heating elements perform heat transfer by all three modes (conduction, convection and radiation). They are available in both single ended and double ended designs.

The single-ended tubular design has both terminals at one end. The opposite end is sealed. Flexible lead wires are 12 in. (305 mm) crimp connected to the terminal pin and have silicone-impregnated fiberglass over-sleeves. Maximum watt density is up to 45 W/square inch while the maximum operating temperature is 1200 degree F, so INCOLOY and stainless steel sheaths can be used.

The double-ended design has rounds cross sectional geometry, is highly adaptable for bending—especially when bending is performed in the field. Double-ended tubular elements offer several assemblages of resistor coils and thermocouples inside one sheath. They have the ability to sense the heater’s internal temperature accurately every time, or offer three-phase capability in one element. Maximum watt density is up to 120 W/square inch while the maximum operating temperature is 1800 degree F, so INCOLOY and stainless steel sheaths can be used.
**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>°F</th>
<th>°C</th>
<th>W/in²</th>
<th>W/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>982</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>1600</td>
<td>870</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>1200</td>
<td>650</td>
<td>60</td>
<td>9.3</td>
</tr>
<tr>
<td>750</td>
<td>400</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>350</td>
<td>175</td>
<td>60</td>
<td>9.3</td>
</tr>
</tbody>
</table>

**Options:**

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Copper, Steel, 304 Stainless steel, INCOLOY, Titanium</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 120 W/in²</td>
</tr>
<tr>
<td>Sheath Length</td>
<td>Up to 51 feet</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.260 inch, 0.315 inch, 0.375 inch, 0.430 inch, 0.475 inch, 0.625 inch</td>
</tr>
<tr>
<td>Terminal Enclosure</td>
<td>Customized terminal boxes</td>
</tr>
<tr>
<td>Element clamp</td>
<td>Customized</td>
</tr>
<tr>
<td>Mounting brackets</td>
<td>Customized</td>
</tr>
</tbody>
</table>
Electric tubular heaters fit almost every industrial heating applications ranging from immersion to air heating that requires temperatures of 1382 degree F. They are made using high quality alloys to minimize physical stress and offer high efficiency. Used to heat solids, liquids and gases.

<table>
<thead>
<tr>
<th>Material</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Water, Oil, Grease</td>
</tr>
<tr>
<td>Steel</td>
<td>Alkaline cleaning solutions, Tars, Asphalt or air heating</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>Corrosive liquids, food processing equipment, Radiant heating</td>
</tr>
<tr>
<td>Incoloy</td>
<td>Cleaning and degreasing solutions, Corrosive liquids</td>
</tr>
<tr>
<td>Inconel</td>
<td>Plating and pickling solutions, acid</td>
</tr>
<tr>
<td>Titanium</td>
<td>Corrosive liquids</td>
</tr>
</tbody>
</table>

**OPTIONS WITH TUBULAR HEATERS**

**Terminations**

Double ended tubular is available with a variety of terminations while single ended tubular has only flexible lead wires.

**Bend Formations**

Double-ended heating elements can be formed into spirals, compounds, multi-axis and multi-planes etc. Custom bending is also available. However bending is not recommended with single ended elements.

**Mounting methods**

Brackets, Mounting collars, Threaded Bulkheads are available.

**Moisture Resistant Seals**

It is important for the life and performance of the heater.

While selecting the ideal tubular elements for your application, please consider the following factors:

- Heating element watt density
- Sheath material (corrosive or non corrosive)
- Temperature of the product
- Air velocity within the application
- Ambient temperature
BOBBIN HEATERS

Bobbin heaters are mainly used for direct heating of air and indirect heating of liquids and gases where the element is fitted into a pocket in the process tank or system so that the element may be replaced without draining down the system or vessel. Highly energy efficient as 100% of the heat is generated within the solution. Extensively used for transmission of heat, these heaters are available in various specifications that meet the individual necessity in the best possible manner. Bobbin heaters are made with sheathed and without sheathed material. The sheath material ranges from nickel plated mild steel, copper, nickel plated copper to stainless steel. Resistance wire are supported on refractory insulators and connected to a terminal block at one end. Construction is done with ceramic link bobbins in either single or 3 phase connections. Thermowell can be provided for accurate temperature sensing or other controls can be provided as well. The element allows easy installation and handling. They are normally manufactured for horizontal mounting, but may be specially designed and constructed for vertical installation. Designed for any voltage or wattage within manufacturing limits, bobbin heaters are mainly used for low watt density heating and low temperature range. Known to be one of the most common and versatile heaters in the vast range, they are economical, simple and have low cost installation.

<table>
<thead>
<tr>
<th>Options:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Copper, Steel, 304 Stainless steel, INCOLOY</td>
</tr>
<tr>
<td>Wattage</td>
<td>Up to 6 kW</td>
</tr>
<tr>
<td>Diameter</td>
<td>Up to 50 mm</td>
</tr>
<tr>
<td>Terminal Enclosure</td>
<td>IP 23 Standard Terminal Box</td>
</tr>
<tr>
<td></td>
<td>IP 66 Water Proof Terminal Box</td>
</tr>
<tr>
<td>Control</td>
<td>Thermocouple, RTD, Thermostat, Digitally controlled</td>
</tr>
<tr>
<td>Immersion Length</td>
<td>Customized</td>
</tr>
<tr>
<td>Temperature</td>
<td>0 to 250 °C</td>
</tr>
<tr>
<td>Voltage</td>
<td>Customized</td>
</tr>
</tbody>
</table>
Applications

- Heating liquids
- Heating wax, fats and bitumens
- Heating water and oil

Benefits

- High quality
- Long life span
- Good conductor
- Highly efficient
- Versatile and non polluting
- Highly suitable for low watt densities

FLANGED IMMERSION HEATERS

Flanged industrial immersion heaters are amongst the most popular heaters owing to wide customization, easier installation and operations in stringent environment. Made by brazing or welding flange with several hairpin elements or bulge tubular elements, these are designed for heating chemical, petroleum and water based applications specially heat transfer fluids, medium and lightweight oils and water in tanks and pressure vessels. A thermocouple or RTD is often used within the bundle of elements to maintain the desired target temperature. Extra wiring boxes to make electrical connections are provided with it. Tubing known as a thermowell is used to protect thermocouples and heating elements. Temperature readings are then transmitted to a control unit that regulates power. Although, they occupy a small space, but have a large heating element which is perfect for applications which require high wattage heating. This is one of the most efficient forms of process heating with nearly 100 percent efficiency.

Different alloys and materials can be used to suit specific applications. For instance, steel flanges are used for deionized water, lubricant oils, heavy and light oils, waxes as well as mildly corrosive liquids and low flow gas and water tank heating. Stainless steel flanged heating elements are used with mild and severe corrosive solutions and military applications. The sheath materials used can be steel, stainless steel, copper as well as exotic alloys such as incoloy.
Options:

<table>
<thead>
<tr>
<th>Sheath Material</th>
<th>Maximum operating temperatures</th>
<th>Maximum Watt Densities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
<td>°C</td>
</tr>
<tr>
<td>INCOLOY</td>
<td>1600</td>
<td>870</td>
</tr>
<tr>
<td>304 stainless steel</td>
<td>1200</td>
<td>650</td>
</tr>
<tr>
<td>Steel</td>
<td>750</td>
<td>400</td>
</tr>
</tbody>
</table>

Different sheath materials used have different operating temperatures and watt densities. While selecting the material these values must match your criteria. Table shown below will help to make an ideal selection.
Some of the typical applications of flanged immersion heaters with their specific attributes are shown in the table below.

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>SHEATH MATERIAL</th>
<th>FLANGE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean water, hot water storage, portable water, freeze protection of liquid</td>
<td>Copper</td>
<td>Steel</td>
</tr>
<tr>
<td>Hot water, steam boilers, mildly corrosive solutions (in rinse tanks, spray washers), vapor degreasers</td>
<td>Incoloy</td>
<td>Steel</td>
</tr>
<tr>
<td>Oils (light or medium), Gases, hydraulic oil, stagnant or heavy oils, lubricating oil, crude asphalt</td>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Process water, soap and detergent solutions, Boiler and water heaters, deionized water, chemical baths</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Severe corrosive solutions, demineralized water</td>
<td>Incoloy</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>

OPTIONS WITH FLANGED HEATERS

![Diagram of terminal enclosure](image)

Terminal Enclosures

Apart from general purpose terminal enclosures without thermostats, other types are also readily available.

- Moisture resistant
- Corrosion resistant
- Explosion resistant
- Explosion/Moisture resistant combination
- Standoff terminal enclosures
Temperature Control

- **Thermostats:** It provides process temperature control and is generally mounted inside the terminal enclosure.

- **Thermocouple:** Type J or K thermocouple offers precise temperature control and sensing. It can be mounted inside the thermowell or attached to heater’s sheath. It essentially consists of a temperature and power controllers such as digital controllers or SCR as desired.

- **RTD’s:** If precision greater than thermowell is desired, an RTD is the right solution to the problem.

**Gaskets:** Rubber, asbestos-free and spiral wound gaskets are available for all flange sizes.

**Baffles:** Also called as Element spacers. Standard supports are provided for open tank or convection heating applications. In order to enhance or modify fluid or gas flow for better heat transfer, 316 stainless steel baffles can be provided.

![Diagram of a flanged immersion heater](image)

**BENEFITS OF ChoOSING FlANGED HEATER**

- 100% efficient and versatile
- Easy installation, control and maintenance
- Designed and built for safety
- Perfect for higher kW output applications

Before buying flanged immersion heaters, some things are to be kept in mind.

- Supply voltage: Single phase or three phase
- Heat capacity
CIRCULATION HEATERS

Circulation heater (a.k.a inline heaters) is basically an immersion heater covered by an anti-corrosion metallic vessel chamber. It is accompanied by National Pipe Thread (NPT) screw plug or ANSI flange heater assemblies mated with a pressure vessel. The vessel is mainly used to provide insulation to prevent heat loss in the circulation system. An inlet flange transports the fluid into the circulation system, which is then circulated and heated until the desired temperature is reached. The heating medium will then flow out of the output flange at a fixed flow rate decided by the temperature control mechanism. Since it is a compact heating system, the operation is fast and executed in a short time. The heat generated is evenly distributed and the efficiency of the heater is high. Drain valves are also provided to remove leftover fluids or residues. Temperature sensors can be used with any control to achieve the desired temperature range. To manage the liquid flow rate of the heater, the wattage can be manipulated. When the requirement is such that liquid is to be pumped around anyway, a circulation heater is a logical choice.

Circulation heaters provide a ready-made means to install electric heating with a minimal amount of time and labor. This is accomplished by combining heating elements, vessel, insulation, terminal enclosure, mounting brackets and inlet and outlet connections into a complete assembly. Such kinds of heaters are ideal for processing fluid, including hazardous liquids that require intermediate heating while maintaining viscosity and flow rate, waste oil, steam, gases, and liquids like DE-ionized water for use in semiconductor and electronics industries. These heaters are specially used to heat up vegetable oils efficiently, so proper viscosity is maintained during food manufacturing using indirect heating. For maintaining correct viscosity, lower watt densities are recommended. Also no additional terminal box is necessary for this application.
Options:
Sheath Material | Copper, Steel, 316 Stainless steel, INCOLOY
Kilowatt Ratings | 500 KW or lesser
Wearing Watt density | 6.5 W/in\(^2\), 15 W/in\(^2\), 23 W/in\(^2\), 45 W/in\(^2\), 65W/in\(^2\)
Flange & Vessel Material | Carbon steel, Stainless steel
Flange size | Up to 42 inches
Flange Rating | Up to 2500 lb pressure class ANSI
Terminal Enclosure | IP 23 Standard Terminal Box
                   | IP 66 Water Proof Terminal Box
Control | Thermocouple, RTD, Thermostat, Digitally controlled
Terminal Enclosure Standoff | 4 or 6 inches
Terminal Seals | silicon resin, silicone fluid, RTV, epoxy or hermetic
Standard Size | 1.25” NPT Screw Plug size to 14” diameter
Flange Gasket | Standard, Spiral wound or any other
Thermal Insulation | Standard, High temperature or weather proof jacket
Mounting position | Horizontal or Vertical

Different alloys and materials can be used to suit specific applications. The table below shows working temperatures and watt densities of variety of materials
<table>
<thead>
<tr>
<th>Sheath Material</th>
<th>Maximum operating temperatures</th>
<th>Maximum Watt Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
<td>°C</td>
</tr>
<tr>
<td>INCOLOY</td>
<td>1600</td>
<td>870</td>
</tr>
<tr>
<td>316 stainless steel</td>
<td>1200</td>
<td>650</td>
</tr>
<tr>
<td>Steel</td>
<td>750</td>
<td>400</td>
</tr>
</tbody>
</table>

Some of the typical applications of circulation heaters with their specific attributes are shown in the table below.

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>SHEATH MATERIAL</th>
<th>FLANGE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean water, hot water storage, portable water, freeze protection of liquid</td>
<td>Copper</td>
<td>Steel</td>
</tr>
<tr>
<td>Hot water, steam boilers, mildly corrosive solutions (in rinse tanks, spray washers), vapor degreasers</td>
<td>Incoloy</td>
<td>Steel</td>
</tr>
<tr>
<td>Oils (light or medium), Gases, hydraulic oil, stagnant or heavy oils, lubricating oil, crude asphalt</td>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Process water, soap and detergent solutions, Boiler and water heaters, deionized water, chemical baths, mildly corrosive solutions</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Severe corrosive solutions, demineralized water, food equipment</td>
<td>Incoloy</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>
FEATURES & BENEFITS

- Thermal insulation provided to prevent heat loss
- Mounting lugs provided for support
- Different terminal enclosures available for easy wiring
- Digitally controlled for precision
- Baffles and flange mounting holes provided.
- Easy to install, compact, clean and durable
- Works in conjunction with control panels
- Custom designed to meet specifications.
- Highly energy efficient and provide maximum dielectric strength.
- Compatible with standard industry piping and safety standards.
- Gaskets and mounting lugs provided as per specifications.

PIPE HEATERS

As the name suggests, Pipe Heaters are specifically manufactured to fit inside 2 or 3” pipes, which can then be utilized in tanks for heating. Pipe heaters do not actually touch the liquid being heated. Indirect heating from heating element to pipe is used to heat the liquid. The heating process can be compared to that of an oven in which the actual end of the device that radiates heat is installed inside of the tank whereas controller box is kept outside. An integrated digital controller can be used that acts as a closed loop system and regulates the heat intensity. Steel pipes can be used for good heat transfer properties and corrosion resistant to petrochemical solutions. Pipe heaters do not require much maintenance, as the tank does not need to be emptied out if the industrial heater needs to be replaced. Also, since the heater is not entirely exposed to the tank, there is no fear for sludge or carbon contamination to develop. They can use any configuration such as flange, screw plug or resistance coil.

These heaters are useful in tanks that require extremely low watt densities such as waxes, thick liquids such as tar, molasses and corrosive mediums. Designed to withstand high heat environments, pipe heaters are commendable to be used with heavy bunker fuel oils, corrosive liquids and liquids with high viscosity.

Installation: For this type of heaters, there are two methods to install. The nozzle can be attached directly to the tank or it can be welded. Welding is more preferred as it is easy to make modifications this way simply by cutting a hole in the tank to carry the process.
<table>
<thead>
<tr>
<th>System Type</th>
<th>Application</th>
<th>Operating Temperature</th>
<th>KW</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open coil elements</td>
<td>Pipe Insert</td>
<td>0-750°F</td>
<td>4-20</td>
<td>N/A</td>
</tr>
<tr>
<td>Large flexible tank</td>
<td>Below ground storage tank</td>
<td>250-225</td>
<td>6-80</td>
<td>NPT and welded</td>
</tr>
<tr>
<td>Large single immersion tank</td>
<td>Viscous fluid</td>
<td>50-400</td>
<td>15-72</td>
<td>Welded</td>
</tr>
</tbody>
</table>

Options:
- Pipe Size: 2 or 3 inches, 40 NPS
- Wattage: 4-20 kW
- Watt Density: 3 to 12 W/square inch
- Voltage: 240, 480 or 600 V, 3 phase
- Flange size: 4 to 14 inches
- Flange Rating: 150 lb pressure class ANSI
- Length: 60 to 320 inch (5-26 ft.)
- Outside Diameters: 1 7/8 or 2 ¼ inch

Features and Benefits
- Equipped with high density electrical ceramic insulating supports
- Can be bent in a vertical plane on at least 12” radius
- Heavy gauge bus bars and resistance wires
- Easy installation and very flexible
- Long service life and uniform heat distribution
- Equipped with a continuous support bar that ensures proper rigidity
When opting for a pipe heater, consider these things

- Tank size and liquid amount that is to be drained.
- Size, installation and maintenance cost, lifetime of the heater itself.
- Storing of liquid or any content that is to be heated when repairs are to be made.
- If the content is hazardous like chemicals, toxicants or other corrosive elements, must be isolated far from physical contact as well as kept away from other devices and machinery.
- Heating time, handling and servicing personnel availability and all matters must be accounted for.

**CONFIGURATIONS WITH PIPE HEATERS**

Pipe heater with coil Element

![Pipe heater with coil Element](image1)

Pipe heater with Flange

![Pipe heater with Flange](image2)
Pipe heater with Screw Plug

SCREW PLUG HEATERS

Screw Plug Immersion Heaters consist of hairpin tubular elements welded or brazed into a screw plug and provided with terminal enclosures for electrical connections. They can be screwed through a threaded opening into a tank wall or vessel. Welding or brazing depends upon the element sheath and plug material compatibility. Depending upon the customer requirement, thermo wells, thermostats or control panels can be used with these heaters to meet the objective of precise temperature control.

Used as a direct heating element, they are ideal for heating gases and liquids in tanks or vessels, process water heating, oils and heat transfer process, heating up flammable liquids or gases which require explosion proof housing. Screw plug heaters are widely used for various purposes in many industries including the food and beverage industry. In addition to the general use of boiling water and freeze protection, it is extremely useful for the purpose of steam generation. They are largely energy efficient and easy to regulate. The installation is a snap and the maintenance is very easy as well.

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Copper, Steel, 304 Stainless steel, INCOLOY</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 120 W/square inch</td>
</tr>
<tr>
<td>Screw Plug Material</td>
<td>Stainless steel, Brass, Steel, Titanium</td>
</tr>
<tr>
<td>Screw Plug NPT fittings</td>
<td>1 to 4 inches</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.260”, 0.315”, 0.375”, 0.430” and 0.475”</td>
</tr>
<tr>
<td>Voltage</td>
<td>120 to 480 V AC Single phase or three phase</td>
</tr>
<tr>
<td>Terminal Enclosure</td>
<td>IP 23 Standard Terminal Box</td>
</tr>
<tr>
<td></td>
<td>IP 66 Water Proof Terminal Box</td>
</tr>
<tr>
<td>Control</td>
<td>Thermocouple, RTD, Thermostat, Digitally controlled</td>
</tr>
</tbody>
</table>
The different sheath materials used in these heaters have different watt densities and operating temperatures. While choosing the sheath material following points should be looked at

- **Stainless Steel**: Maximum operating temperature is 1200 °F while the maximum watt density is 120 W/in\(^2\)
- **Steel**: Maximum operating temperature is 750 °F while the maximum watt density is 120 W/in\(^2\)
- **INCOLOY**: Maximum operating temperature is 1600 °F while the maximum watt density is 120 W/in\(^2\)

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>SHEATH MATERIAL</th>
<th>FLANGE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean water, hot water storage, portable water, freeze protection of liquid</td>
<td>Copper</td>
<td>Steel</td>
</tr>
<tr>
<td>Hot water, steam boilers, mildly corrosive solutions (in rinse tanks, spray washers), vapor degreasers</td>
<td>Incoloy</td>
<td>Steel</td>
</tr>
<tr>
<td>Oils (light or medium), Gases, hydraulic oil, stagnant or heavy oils, lubricating oil, crude asphalt</td>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Process water, soap and detergent solutions, Boiler and water heaters, deionized water, chemical baths, mildly corrosive solutions</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Severe corrosive solutions, demineralized water, food equipment</td>
<td>Incoloy</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>

There are three different types of screw plug heaters based on the type of applications: water application, heavy oil application, and light oil application. The applications are largely dependent upon the watt density (wpsi). The water application usually requires 55 to 80 wpsi whereas the light oil and heavy oil applications are respectively 20 to 30 wpsi and 5 to 15 wpsi. While the water application is defined for the purpose of heating water, the use of light oil application and heavy oil application are differentiated by the types of the medium used in conjunction with the heater.

The screw plug heater is particularly fit for heating flammable solutions with explosion proof housing. The electric nature of the heater makes it a perfect choice.
CHOICES FOR AN IDEAL HEATER

Terminal Enclosures
Apart from general purpose terminal enclosures without thermostats, other types are also readily available.

- Moisture resistant
- Corrosion resistant
- Explosion resistant
- Explosion/Moisture resistant combination
- Standoff terminal enclosures

Temperature Control

- **Thermostats:** It provides process temperature control and is generally mounted inside the terminal enclosure.

- **Thermocouple:** Type J or K thermocouple offers precise temperature control and sensing. It can be mounted inside the thermowell or attached to heater’s sheath. It essentially consists of a temperature and power controllers such as digital controllers or SCR as desired.

- **RTD’s:** If precision greater than thermowell is desired, an RTD is the right solution to the problem.

Some standards have been built to help you choose better. However Customized solutions are also available.
<table>
<thead>
<tr>
<th>Watts</th>
<th>Volts</th>
<th>Pipe thread (NPT) In</th>
<th>No. of Elements</th>
<th>Length In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4500</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>6000</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>9000</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>12000</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>15000</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>18000</td>
<td>240 or 480</td>
<td>2 ½</td>
<td>3</td>
<td>48</td>
</tr>
</tbody>
</table>

Maintenance of screw plug heaters is mandatory in every industry that deploys it for some specific application. While the maintenance suggestions are the same for every heater and are mentioned earlier, these heaters will give you a long lasting and safe service.

**Advantages of Maintenance**

- Efficient Heating and operation
- Less probability of breakdown
- No expensive repair cost
- Environmental performance
- Improves personal and industry safety

**OVER THE SIDE IMMERSION HEATERS**

When the customer demands are such that through-the-wall heaters cannot be installed, portability is required, heaters are to be removed without emptying the tanks, or when there is no access to the liquid medium except from the top, then over the side heaters is the right option. Various shapes and sizes are provided to fit customer dimensions such as, “installed-from-the-top” (L or O shaped) which can easily slide into tanks, vertical loop which are suited for open tank applications or drum heaters for direct immersion in drums. Brackets, risers, legs or junction boxes are used to support the heater if desired. Over the side immersion heaters can be installed in the upper portion of tanks, with the heated portion directly immersed along the side or at the bottom, hence the name. This not only provides ample operating space in the tank, but also allows easy removal and portability. Together with thermowells and control system, this
industrial heater, renders practicality and economic feasibility. Mobility is the unique feature of this heater, hence can be used in more than one container, making it a preferred choice for projects. Over the side immersion heaters are the most peculiar heater and stand out amongst the immersion heaters.

The large variation in shapes and heating elements, offer a wide selection in the application of these heaters. Commonly used in petroleum and chemical industries, it can be used for heating oils of varying viscosities, degreasing solutions, heat transfer oils and caustic solutions, plating baths, salts and acids. Over the side heaters are strong enough to withstand many harsh environments both indoors and outdoors and are an exceptional choice for projects with limited budgets. Application versatility is enhanced with optional sheath materials, kilowatt ratings, terminal enclosures and mounting methods. The drum immersion heaters are designed for direct immersion in a standard gallon steel drum. Vertical loop immersion heaters are well-suited for open tank applications.

<table>
<thead>
<tr>
<th>Options</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Steel, 304 Stainless steel, INCOLOY</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 60 W/in²</td>
</tr>
<tr>
<td>Wattage</td>
<td>Up to 50 kW</td>
</tr>
<tr>
<td>Voltage</td>
<td>Up to 600V AC</td>
</tr>
<tr>
<td>Sludge Legs</td>
<td>4 inches</td>
</tr>
<tr>
<td>Conduit opening size</td>
<td>1 inch</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.315”, 0.375”, 0.430”, 0.475”</td>
</tr>
<tr>
<td>Terminal Enclosure</td>
<td>IP 23 Standard Terminal Box</td>
</tr>
<tr>
<td></td>
<td>IP 66 Water Proof Terminal Box</td>
</tr>
<tr>
<td>Control</td>
<td>Thermocouple, RTD, Thermostat, Digitally controlled</td>
</tr>
</tbody>
</table>
Features and Benefits

- Rugged and lightweight construction
- Hairpins are re-compressed (re-compacted) which maintains Mgo density and dielectric strength, heat transfer and heater life
- Integral thermowells, thermostats and thermocouples as per specification
- Terminal enclosures (moisture resistant, corrosion resistant or explosion proof)
- Portable, durable, easy to install and maintain
- Sludge legs to keep element above sediments.

Applications

The application for over the side heaters varies greatly from simply water heating or freeze protection to some more complex setup such as viscosity control for oil or wax products that require a steady flow. There is plenty of space available in the container as the heating elements occupy the side of the container and can be moved around easily. The type of uncommon substances that these heaters are used for include paraffin, solvent, salt or other caustic solutions. The application for paraffin is of a particular interest in heating up the lamination wax. One of the difficulties in wax heating for lamination was the use of a conventional heater that couldn’t keep up with the wax requirement for consistent heating and the non-uniformity of wax in the process. Using the over the side heater, the laminating wax can maintain the maximum temperature with a constant viscosity and a uniform thickness of the lamination of wax.

Another fascinating application involving over the side heaters is solvent degreasing. Solvent is most widely used for degreasing various metals. The process of degreasing with solvent usually consists of either spraying or immersion of which the latter is the most common method. In the process of immersion, maintaining the specific viscosity is extremely important in order to maximize the degreasing effect to every part of the object for degreasing. The over the side heater is best suited for the process because the heat transfer is immediate and the temperature can be controlled to the point that no more heat is used than absolutely necessary.
These heaters are designed with heating elements to be directly immersed from the top of the container toward the bottom. Harnessed onto the bracket, the cold sections are carefully calculated and the heating elements are harnessed in the depth that will prevent the overheating in case the level of liquid in the container drops below a certain point due to evaporating.

**FINNED TUBULAR HEATER**

Finned tubular heaters are superior to tubular heaters since fins greatly increase surface area, permit faster heat transfer to air and permits putting more power in tighter spaces—like forced air ducts, dryers, ovens and load bank resistors resulting in lower element surface temperature. They are made of up of tubular heating elements and are equipped with electro galvanized steel fins. Mechanically bonded continuous fins assure excellent heat transfer and helps prevent fin vibration at high air velocities. As the surface area is increased and heat transfer is improved due to fins, it results in lower sheath temperature and maximizing of element life.

These industrial heating solutions are among the most common heaters and are best suited for a large number of applications such as conduction, convection, and radiation for stoves, industrial ovens, drying cabinets, air conditioners etc. They can be used in virtually every industrial environment up to about 750°C (1382°F) and be molded into many unique and complex shapes. Finned heaters are extremely rugged, have low capital cost and require negligible maintenance.
Options:

<table>
<thead>
<tr>
<th>Sheath Material</th>
<th>Copper, Steel, 304 Stainless steel, INCOLOY, Titanium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watt Density</td>
<td>Up to 120 W/in²</td>
</tr>
<tr>
<td>Fins Material</td>
<td>Aluminum, Stainless Steel</td>
</tr>
<tr>
<td>Voltage</td>
<td>Up to 480 V AC</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>Up to 1200 °F</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.375”, 0.430”, 0.475”</td>
</tr>
</tbody>
</table>

**FEATURES**

- Variety of custom bends available
- Silicone seals to ensure moisture resistance in humid environments.
- Numerous types of terminations available
- Customized cold sections
- Single ended termination
- Stainless steel mounting bracket, welded to the terminal end.
## Material Applications

<table>
<thead>
<tr>
<th>Material</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Water&lt;br&gt;Oil&lt;br&gt;Grease&lt;br&gt;Solutions non-corrosive to copper</td>
</tr>
<tr>
<td>Steel</td>
<td>Alkaline cleaning solutions&lt;br&gt;Tars&lt;br&gt;Asphalt&lt;br&gt;Air heating</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>Corrosive liquids&lt;br&gt;Food processing equipment&lt;br&gt;Radiant heating</td>
</tr>
<tr>
<td>Incoloy®</td>
<td>Cleaning and degreasing solutions&lt;br&gt;Corrosive liquids</td>
</tr>
<tr>
<td>Inconel®</td>
<td>Plating and pickling solutions&lt;br&gt;Acid</td>
</tr>
<tr>
<td>Titanium</td>
<td>Corrosive liquids</td>
</tr>
</tbody>
</table>

### BENEFITS

- Increase in surface area to approximately 16 square inches for every linear inch of element length.
- Precise and easy control of heat output
- Easy to install and replace
- Provides protection against humid storage conditions
- Configurable to virtually any shape
- Compact size and durable

### STRIP HEATERS

Strip heaters, commonly called component or clamp heaters, based on the principle of convection air heating, use surface area to transfer heat effectively. Using most advanced heat technologies, strip heaters are an outstanding industrial heating product. It comprises of a heating element, a protective sleeve or sheath, and mounting hardware and can be clamped or bolted onto objects or solid surfaces. A coiled nickel chromium element wire is placed in the center of the heater. The element wire is then embedded in magnesium oxide (MgO)-based insulation and compacted into a solid mass creating excellent heat conductivity and high dielectric strength. The heater is then enclosed in desired sheathing. Suitable to work in 500 degree F temperatures, magnesium oxide is used for increasing efficiency. Temperatures can be controlled by using a
temperature controller such as a thermostat. When using strip heaters, proper sheath material for resisting rusting or oxidation and suitable watt density of the element should be selected keeping in mind the application. These can be shaped and sized according to the use. A moderately inexpensive way of heating, strip heater is a tremendous solution to meet any budget.

<table>
<thead>
<tr>
<th>Options:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Iron, Steel, 304 Stainless steel, Aluminum, Zinc coated steel</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 100 W/in^2</td>
</tr>
<tr>
<td>Voltage</td>
<td>Up to 600 V AC</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Up to 1200 °F</td>
</tr>
<tr>
<td>Length</td>
<td>5 ½ to 48 inches</td>
</tr>
<tr>
<td>Width</td>
<td>1 ½ inch</td>
</tr>
</tbody>
</table>

**OPTIONS WITH STRIP HEATERS**

**Terminations**

Off set terminations, Parallel terminals, terminal at each end or lead wires available

**Mounting Tabs**

Available mounting tabs with holes, slots or without tabs

**Pressurized**

Compressed under high pressure for excellent heat transfer

**Thickness**

Customized to easily fit into applications.

**Heating Element**

Centered in the heater to assure uniform heat
APPLICATIONS

- Surface Heating
- Process Air Heating
- Winterizing
- Space Heating
- Food warming
- Packaging and sealing
- Laboratory equipment
- Autoclaves and ovens

BENEFITS

- Easy and economic to install
- Corrosion and vibration resistant
- Durable, versatile and easy to control
- Uniform Heat Distribution
- Suitable for higher temperatures

FINNED STRIP HEATERS

Finned Strip Heaters are used for both forced and natural convection air heating. It is designed using a helically wound resistance coil placed on a ceramic insulator. Remaining voids are filled with high purity magnesium oxide to increase thermal conductivity and dielectric strength. Continuous spiral fins are permanently furnace brazed to the sheath. Stainless steel rectangular tubing is used to house the heater assembly. It can be easily regulated by using a heating control panel or a thermostat as temperatures can reach as high as 500 degrees F. Lower sheath temperature and element life are all maximized by this finned construction as the fins improve heat transfer in free or forced air heating applications. They can be molded into rectangular, spiral, round or any shape as demanded.

Finned Strip Heater is a flexible and reasonable heating source used across a wide range of applications such as surface heating (platens, dies, molds, tanks, piping); process air heating (drying cabinets, ovens, baking ovens, vacuum dehydrating ovens, moisture protection for motors); dropping resistors for line applications in railroads and load banks; winterizing
(hoppers, conveyors, ducts, car heating, thawing); original equipment (air conditioning, laboratory equipment, food packaging, ovens, presses, drying equipment).

<table>
<thead>
<tr>
<th>Options:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Steel, 304 Stainless steel, Iron, Aluminum, Zinc coated Steel</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 38 W/square inch</td>
</tr>
<tr>
<td>Length</td>
<td>Up to 48 inches</td>
</tr>
<tr>
<td>Fins Material</td>
<td>Aluminum</td>
</tr>
</tbody>
</table>

**DUCT HEATERS**

Duct heaters are heat transferring devices which are an assembly of heating elements mounted in a frame or duct. Preferably used for non-pressurized air-heating systems, there are three types of duct heaters available: open coil, tubular or finned tubular heating elements that are either flanged or inserted in the duct. The individual elements are removable through the housing of the assembly, which eliminates the need to pull the complete heater from the ductwork. This reduces downtime costs because the heating elements can be replaced individually. Being the most easily adaptable heating solution, they are easily installed in applications requiring a wide range of temperature versus air flow combinations and offer greater reliability, energy efficiency, quicker response time and reduced infiltration from the air steam. Duct heaters can be equipped with a temperature control system and wired in various power configurations.
Options:

<table>
<thead>
<tr>
<th>Sheath Material</th>
<th>Steel, Copper, Stainless Steel, INCOLOY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watt Density</td>
<td>Up to 40 W/in²</td>
</tr>
<tr>
<td>Wattage</td>
<td>Up to 2 MW</td>
</tr>
<tr>
<td>Controls</td>
<td>SSR/ SCR/ Digitally Controlled</td>
</tr>
<tr>
<td>Diameter of Tube</td>
<td>0.260, 0.315, 0.375, 0.430, 0.475</td>
</tr>
<tr>
<td>Voltage</td>
<td>120, 240, 300, 480, 600</td>
</tr>
<tr>
<td>Sheath Length</td>
<td>11 – 240 inches</td>
</tr>
<tr>
<td>Process temperatures</td>
<td>-29 to 650 °C</td>
</tr>
</tbody>
</table>

**FEATURES & BENEFITS**

**Terminal Enclosures**

In addition to the standard, general purpose terminal enclosure, the following optional terminal enclosures are available to meet specific application requirements:

- Moisture resistant
- Explosion resistant
- High-temperature stand-off enclosures

**Control**

Type J or K thermocouples, inserted in the thermowell, accurately sense element sheath temperature for over-temperature conditions. Using a thermocouple requires an appropriate temperature and power controller.

**Field replaceable heating elements**

Permits easy service and reduces downtime. Element change out is made simple by a single screw clamp.
Mineral Insulation

Keeps wiring cooler and reduces heat losses.

Rigid stainless steel support

Prevents element sagging or deformation in various mounting positions

FAVORABLE FEATURES

- Provide great mechanical strength
- Not prone to moisture and dust
- Quite easy to mount
- Durable and easy maintenance
- Rugged construction eliminates hazard of electric shock
- Reinforced frame allows for minimum vibration and elevated temperatures
- Typically used for outdoor applications or in environments that are too harsh for open coil elements

APPLICATIONS

- Heating of platens and molds
- Air dryers
- Load Banks – Resistive
- Industrial Ovens
- Industrial Cabinets
- Preheating
- Reheating
- Laboratory Testing
OPTIONS
Tubular duct heaters offer a number of options

- Digital controls, Contactors, Relays, SCRs available for the most accurate temperature readings
- Disconnecting switches, airflow switches to help control unexpected pressure drops
- Fuse blocks and optional fuses available for low resistance and cool operations.
- Manual reset limit thermal cutout is used to prevent excessive temperatures with this the terminal housing

BUNDLE ROD HEATERS
As the name suggests, bundle rod heater consists of circular ceramic beads that hold the heating elements. They are designed for long life and maintenance free operation. The elements can be provided in almost any length but the standard dimensions available are 68 to 170 mm (2.6 to 6.6 inch). These heaters can be used as standalone elements or inside radiant tubes. Because of the ingenious design, Bundle rod heating elements deliver a much higher power (up to 100kW) than conventional cartridge heaters. In combination with the radiant tubes, a system is created which delivers high power, is rugged, versatile and needs low maintenance. Designed & manufactured in low voltages for faster heating in order to achieve temperatures quickly, these heaters can be mounted horizontally or vertically. Either NiCr alloy or FeCrAl alloy can be used as heating element. For temperatures up to 2100°F (1150°C), Austenitic (NiCr) alloy (80/20 or 70/30) and for temperatures up to 2597°F (1425°C), Ferritic (FeCrAl) alloy can be used. A comparison between bundle rod and cartridge heaters shows their effectiveness:

Superior Power Output
Bundle rod elements, with a higher power output, leads to major saving in cost and maintenance. Also when combined with Kanthal radiant tubes, they give highest power rating (up to 100 kW) as compared to any other heater.

Easy installation
Due to its ruggedness and versatility, bundle rod elements are easy to install and replace. Compatibility with radiant tubes allows installation to be either horizontal or vertical depending on the application. Easy repair and high temperature performance gives it an edge over others.

Custom designed for the voltage and wattage required, bundle rod heaters are used in heat treat furnaces and die casting machines to molten salt baths and incinerators. With radiant tubes they
can be used in high velocity convection furnaces and sealed quenched furnaces. They are also useful in converting gas-fired furnaces to electric heating.

**COMPONENTS OF BUNDLE ROD HEATERS**

- **Terminal Rod:** Carries the power supply wiring. Usually made of SS 310 or INCOLOY. Number of rods depends upon the supply connection.
- **Center Rod:** Used to provide central support to the heater. Usually made of SS 310 or INCOLOY. Is longer than the terminal rods.
- **Ceramic Disc:** Used to encompass all the heating elements to form a bundle. Made of Alumina. Usually flower shape.
- **Fiber Disc:** Used to hold the terminal rods and central rod together. Inserted in the cold zone of the heater. Made of ceramic fiber.

<table>
<thead>
<tr>
<th>Options</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Element Material</td>
<td>NiCr / FeCrAl alloy</td>
</tr>
<tr>
<td>Wattage</td>
<td>45 kW / 100 kW</td>
</tr>
<tr>
<td>Max. Temperature</td>
<td>1200 °C / 1425 °C</td>
</tr>
<tr>
<td>Diameter</td>
<td>68 to 170 mm</td>
</tr>
<tr>
<td>Length</td>
<td>Customized</td>
</tr>
<tr>
<td>Voltage</td>
<td>240 or 480 V AC, Single phase or three phase</td>
</tr>
</tbody>
</table>

The surface load has some limitations depending upon the temperature. A table shown below gives a brief idea:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Max. Surface Load (W/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 °C</td>
<td>3.0</td>
</tr>
<tr>
<td>1000 °C</td>
<td>2.0</td>
</tr>
<tr>
<td>1400 °C</td>
<td>&lt; 1.0</td>
</tr>
</tbody>
</table>
If controlling of temperature is required in these heaters either Individual heating elements can be series connected for operating at voltages higher than supply, eliminating the need for transformers or On/ off supply control using slow or fast fired thyristors, SCR/SSR can be used to offer better control of furnace temperature.

**Advantages:**

- Reduces CO2 emissions by eliminating flue gases.
- Minimized environmental impact
- Inside radiant tubes or as standalone elements
- Higher output with fewer assemblies
- Lower cost
- Reliable production
- Uninterrupted operation
**RADIANT TUBES**

Seamless high temperature tubes made from either iron-chromium-aluminum alloys (Kanthal APM, Kanthal APMT) or heat resistant casting alloys are called radiant tubes. The composition table for various alloys is given:

<table>
<thead>
<tr>
<th></th>
<th>KANTHAL APM</th>
<th>INCONEL 600</th>
<th>INCONEL 800</th>
<th>HK - 40</th>
<th>HU</th>
<th>HX</th>
<th>SS 310</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni</td>
<td>-</td>
<td>72.0 (min.) + Cobalt</td>
<td>30.0 – 35.0</td>
<td>19.0-22.0</td>
<td>37.0-41.0</td>
<td>64.0-68.0</td>
<td>19.0-22.0</td>
</tr>
<tr>
<td>Cr</td>
<td>20.5 – 23.5</td>
<td>14.0 – 17.0</td>
<td>19.0 – 23.0</td>
<td>23.0-27.0</td>
<td>17.0-21.0</td>
<td>15.0-19.0</td>
<td>24.0-26.0</td>
</tr>
<tr>
<td>Al</td>
<td>5.8</td>
<td>-</td>
<td>0.15 – 0.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe</td>
<td>Balance</td>
<td>6.0 – 10.0</td>
<td>39.5 (min.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Balance</td>
</tr>
<tr>
<td>Mn</td>
<td>0 – 0.4</td>
<td>1.0 (max.)</td>
<td>1.50 (max)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.00</td>
</tr>
<tr>
<td>Si</td>
<td>0 – 0.7</td>
<td>0.5 (max.)</td>
<td>1.0 (max.)</td>
<td>1.75</td>
<td>2.50</td>
<td>2.50</td>
<td>1.50</td>
</tr>
<tr>
<td>C</td>
<td>0 – 0.08</td>
<td>0.15 (max)</td>
<td>0.10 (max)</td>
<td>0.35-0.45</td>
<td>0.35-0.75</td>
<td>0.35-0.75</td>
<td>0.25</td>
</tr>
<tr>
<td>P</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.045</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>0.015(max)</td>
<td>0.015(max)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.030</td>
</tr>
<tr>
<td>Cu</td>
<td>-</td>
<td>0.5 (max.)</td>
<td>0.75 (max)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ti</td>
<td>-</td>
<td>-</td>
<td>0.15 – 0.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Temp</td>
<td>1250 ºC</td>
<td>1095 ºC</td>
<td>816 ºC</td>
<td>1093 ºC</td>
<td>1093 ºC</td>
<td>1150 ºC</td>
<td>1200 ºC</td>
</tr>
<tr>
<td>Melting Point</td>
<td>1500 ºC</td>
<td>1354-1413 ºC</td>
<td>1357-1385 ºC</td>
<td>1398 ºC</td>
<td>1343 ºC</td>
<td>1287 ºC</td>
<td>1400-1450 ºC</td>
</tr>
</tbody>
</table>
Highly customized to meet specifications, they are mostly used for gas heated or electrically heated furnaces. General designs include straight, U shaped and W shaped radiant tubes in any desired length. The lifetime of radiant tubes in Kanthal APMT and Kanthal APM is often many times longer. Kanthal material allows temperature in the range of 1250°C (2280°F). Used in extremely demanding environments, leakproofness and corrosion resistant are other unique features of radiant tubes. Heat resistant casting alloys allow operating temperatures up to 1100 °C. But are inferior to Kanthal material in terms of resistance to sulphurizing and nitriding atmospheres. Radiant tubes can be used as standalone elements or in collaboration with bundle rod heaters. But when used with bundle rod heaters, can be used for temperatures up to 1400 °C and have superior performance. Some of the advantages of radiant tubes include:

- Trouble free, longer service life and provides uninterrupted furnace operation.
- Cost effective solutions for maximized customer productivity and higher power output.
- Installation and replaced relatively easily.
- High loading potential and ready to install.
- Supplied flanged, with or without inner tubes or electric heating elements as desired.

The outer and inner diameters of tube have some standards with respect to the ceramic disc diameter. The heater dimensions fit inside these specifications. Huge deviation from the standard designs, however, will be customized. Standards are given in the form of table:

<table>
<thead>
<tr>
<th>Outer Diameter of Tube</th>
<th>Inner Diameter of Tube</th>
<th>Ceramic Disc Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>128</td>
<td>117</td>
<td>110</td>
</tr>
<tr>
<td>146</td>
<td>134</td>
<td>124</td>
</tr>
<tr>
<td>154</td>
<td>142</td>
<td>124</td>
</tr>
<tr>
<td>178</td>
<td>162</td>
<td>154</td>
</tr>
<tr>
<td>198</td>
<td>182</td>
<td>170</td>
</tr>
</tbody>
</table>
APPLICATIONS

- Heat treatment furnaces (carburizing furnaces and galvanizing furnaces)
- Melting, dosing and holding furnaces
- Dental furnaces
- Diffusion furnaces
- Laboratory furnaces

Supports for Radiant Tubes

Hangers are preferred with radiant tubes and bundle rod heaters to provide support in case of horizontal or vertical installation. It may be a furnace side wall support, constrained to a wall of the furnace or radiant tube support provided with a heating element. Anti sticking feature between the tubular element and the furnace side wall support is provided for supporting the radiant tube and allowing the lateral oscillation thereof, avoiding the sticking on the furnace side wall support.
The maximum unsupported length above which supports (hangers) for radiant tubes are considered essential is given below:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>800</td>
<td>2.2</td>
<td>2</td>
<td>2.2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>900</td>
<td>2.2</td>
<td>2</td>
<td>2.3</td>
<td>2.1</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>1000</td>
<td>2</td>
<td>1.9</td>
<td>2.2</td>
<td>2.0</td>
<td>2.5</td>
<td>2.2</td>
</tr>
<tr>
<td>1100</td>
<td>1.5</td>
<td>1.3</td>
<td>1.8</td>
<td>1.6</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>1200</td>
<td>1.2</td>
<td>-</td>
<td>1.4</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Where 0 stands for only tube (in meter)

1 stands for with bundle rods (in meter)

**OPEN COIL HEATERS**

Open coil heating elements have open circuits consisting of coiled resistance wire (usually Ni-Chrome or FeCrAl) fixed onto a supporting element that heat the medium directly. Termed as the most efficient and versatile while also the most economically feasible solution for heating, these elements have fast heat up times that improve efficiency and have been designed for low maintenance and inexpensive replacement parts. When an electrical current is applied to the wire, it gives off heat. The wire is connected to the control panel which regulates the amount of heat provided by the electric heater and fills the tunnel of the air handling unit. Because of the low mass and fast response time, SSR or SCR switching devices are advisable. They serve as an indirect solution to decrease watt density requirements and prevent heat sensitive materials from breaking down. The heater can be formed into a compact, coiled nozzle heater supplying a full 360 degrees of heat with optional distributed wattage.

The face velocity of the air passing over the open coil elements must not be less than a minimum specified value when the heater is energized. There are three factors that are considered when an appropriate face velocity is calculated, i.e. kW, frame size and heater element type. Sufficient airflow for the required kW in a given frame prevents an overheating condition. Heat must be dissipated away from the heating elements.
The following calculation is used for determining face velocity:

\[
\text{Face velocity} = \frac{\text{CFM}}{\text{Face Area}}
\]

Another consideration is the amount of current draw the electric heater will place on the incoming power source. Electric heaters should be divided into individual circuits drawing 48 amps or less. The amp draw can be calculated using the kW and voltage of the heater.

\[
\text{Amps} = \frac{(\text{kW} \times 1000)}{(\text{Vac} \times 1.732)}
\]

Attention must also be paid to the geographical area in which the open coil heater will be located.

DIFFERENT CONFIGURATIONS

- One, two or four resistance wires
- Parallel coil or straight wire
- Drawn or swaged sheaths
- With or without thermocouples
- Round, rectangular or square cable cross sectionals

<table>
<thead>
<tr>
<th>Options</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire</td>
<td>Nichrome or KANTHAL</td>
</tr>
<tr>
<td>Rating</td>
<td>4 - 20 kW</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 75 W/in²</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>Up to 650 °C</td>
</tr>
<tr>
<td>Length</td>
<td>60 to 320 inches</td>
</tr>
<tr>
<td>Outside diameters</td>
<td>1 7/8” and 2 3/4”</td>
</tr>
<tr>
<td>Voltage</td>
<td>240 or 480V AC</td>
</tr>
<tr>
<td>Controls</td>
<td>SSR/ SCR/ Relays/ RTD</td>
</tr>
<tr>
<td>Terminations</td>
<td>Customized</td>
</tr>
</tbody>
</table>

ADVANTAGES

- High ductility
- Low mass
- Constructed with no open seams
- Available with fittings for mounting
TYPICAL APPLICATIONS

- Plastic injection molding nozzles
- Semiconductor manufacturing and wafer processing
- Hot metal forming dies and punches
- Sealing and cutting bars
- Medical, analytical and scientific instruments
- Restaurant and food processing equipment
- Cast-in heaters
- Laminating and printing presses
- Air heating
- Textile manufacturing
- Heating in a vacuum environment

MINERAL INSULATED HEATER CABLES

Mineral insulated heating cables are series type heating cables and consist of one or two conductors embedded in a highly dielectric magnesium oxide insulation surrounded by a metal sheath. High nickel content Alloy 825 is renowned for its use as sheath material in high temperature applications, and corrosive environments. This alloy has superb resistance to pitting, chloride stress, and acid and alkali corrosion. Stainless steel can also be used as sheath. Highly compacted Magnesium Oxide provides insulation of the resistance wire for voltages up to 600V. Completely sealed sheath protects the MgO from moisture & contamination. MI heating cables are series-type heating cables and appropriate for temperatures up to 1022°F (550°C) and exposure temperatures up to 1200°F (650°C). At lower temperatures, watt densities of up to 50 W/Ft can be designed. It provides superior strength in dynamic cut-through, crush, and corrosion tests and provides rugged and reliable heat tracing for a variety of demanding applications. MI heating cable sets are supplied factory terminated and ready to install. They include a heating section and a non heating cold lead section. They are supplied in fixed lengths, so determining
and ordering the correct cable length is critical. The cold lead cable is connected to a junction box, which in turn is connected to the power supply. MI heating cable is the ideal choice when an application’s temperature and power output requirements exceed the capabilities of self-regulating and power-limiting heating cables.

Advantages of MI cables are:

- **High power output** due to perfect thermal conductivity of the metallic sheath.
- **Reduced size** due to the high dielectric strength of the magnesium oxide while maintaining good thermal conductivity.
- **Easy installation** due its reduced size and annealed state of outer sheath.
- **High flexibility during the design phase**, due to the wide range of available resistances.
- **Factory assembled** cable sets ready for installation
- **Fully annealed sheath** allows field bending
- **Corrosion resistant sheath**

<table>
<thead>
<tr>
<th>Options</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Alloy 825, Stainless Steel</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 50 W/in²</td>
</tr>
<tr>
<td>Process Temperature</td>
<td>1100 °F</td>
</tr>
<tr>
<td>Exposure Temperature</td>
<td>1400 °F</td>
</tr>
<tr>
<td>Maximum Voltage</td>
<td>600 V</td>
</tr>
</tbody>
</table>

**APPLICATIONS**

- **Refining crude distillation**: Hydro-cracking, Coking, Gas condensate prevention
- **Chemical and Petrochemical**: Synthetic fiber polymer, paints and resins, Nylon
- **Power Generation**: High pressure feed-water, blow-down lines, instrument lines
**CARTRIDGE HEATERS**

Cartridge heater often considered as component heater has a heating coil wound on a ceramic core and are cylindrical-shaped, heavy-duty Joule heating element. Electricity flows through coil when a two or three-phase voltage is applied. The electricity heats the coil and, subsequently, the cartridge sheath. The watt density (in Watt/inch²) depends on the number of spirals or turns per inch. The sheath comes in contact with the surface being heated. Insulation in the cartridge heater ensures that the heating wire never comes in contact with the sheath and protects the sheath from melting in case of any mishap. The leads that come out of the heater terminal have metal conduit, or silicon sleeves to protect from high temperature. Lead wires are often fiberglass or silicon rubber.

These heaters provide a suitable, reliable and competent method of applying concentrated heat to solid metal components to high temperatures, particularly where compact, insert type heating is desirable. Swaged construction provides minimal air gaps, which lead to high efficiency and improved heat transfer. Distinguished for long trouble free service, cartridge heaters have precise dimensions and tolerances. Heating elements are kept close to the material being heated for maximum heat transfer, minimum core temperature, and faster heating. Use of stainless steel sheaths provides non oxidizing surfaces. The surface watts density and operating temperature of a cartridge is dependent on hole clearance. The larger the hole clearance the lower the recommended watt density. For temperature sensing, a thermocouple should be positioned in the heater but its life is reduced by slow "on/off" cycling of power controllers. So PID auto tuning controllers with solid state relay or thyristor output are suggested.

<table>
<thead>
<tr>
<th>Options:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Stainless steel, INCOLOY</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 400 W/in²</td>
</tr>
<tr>
<td>Watt rating</td>
<td>Up to 11.5 kW</td>
</tr>
<tr>
<td>Voltage</td>
<td>Up to 480V AC</td>
</tr>
<tr>
<td>Length</td>
<td>Up to 72 inches</td>
</tr>
<tr>
<td>Leads</td>
<td>Stranded/ Swaged in/ Pin leads/ Customized</td>
</tr>
<tr>
<td>Diameter</td>
<td>Up to 1.297 inches</td>
</tr>
<tr>
<td>Controls</td>
<td>Thermocouple/ RTD</td>
</tr>
</tbody>
</table>
SPECIFICATIONS

Resistance wire: High grade nickel chromium resistance wire

Insulation: MgO

Leads: Stranded leads with silicone impregnated mica glass insulation or swaged in

Pin Leads: Available; Sealed using Epoxy or Teflon

Graphite Coating: For easy installation and removal

Thermocouples: Type J or K, grounded or ungrounded and attached either at the disc end or the middle of the cartridge.

Cold Section: Customized; controlled independently

APPLICATIONS

<table>
<thead>
<tr>
<th>Application</th>
<th>Sheath Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molds, Metal dies, Patens, hot plates, sealing tools, fluid heating, aerospace, semiconductor industry</td>
<td>Stainless Steel, INCOLOY</td>
</tr>
<tr>
<td>Food service and medical equipment, Deionized water</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>General applications</td>
<td>INCOLOY</td>
</tr>
<tr>
<td>Highly corrosion applications</td>
<td>Titanium</td>
</tr>
</tbody>
</table>
OPERATING TEMPERATURES and WATT DENSITY

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Operating Temperatures</th>
<th>Maximum Watt Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
<td>°C</td>
</tr>
<tr>
<td>INCOLOY</td>
<td>1400</td>
<td>760</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1000</td>
<td>538</td>
</tr>
</tbody>
</table>

SILICONE RUBBER HEATERS

Famously known as “flexible heaters”, silicone rubber heaters are composed of fiberglass reinforced silicone rubbers that are rugged, moisture and chemical resistant, flame retardant, have high dielectric strength and are non toxic. Wire or etched foil heating circuits are positioned between two “wafers” of silicone which provides flexibility and strength. Design versatility permits zones of higher or lower heat concentration as needed. They are capable of flexing and will conform to contoured surfaces. They can also be pre-formed to complex shapes and can withstand mechanical shock and vibration. Designed to meet the requirements of various low and medium temperature applications, they improve heat transfer; speed warm ups, and decrease wattage requirements. The silicone Fiberglass-reinforced silicone rubber gives the heater dimensional stability without sacrificing flexibility. Because very little material separates the element from the part, heat transfer is rapid and efficient. The heater construction creates a very thin heater allowing it to fit applications where space is limited.

With silicone rubber heaters, heat can be placed where it is needed. These heaters improve heat transfer, speed warm ups and decrease wattage requirements. Fiberglass-reinforced silicone rubber gives the heater dimensional stability without sacrificing flexibility. Because very little material separates the element from the part, heat transfer is rapid and efficient. The heater construction creates a very thin heater allowing it to fit applications where space is limited.
## Options:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1 to 120 inches</td>
</tr>
<tr>
<td>Width</td>
<td>1 to 36 inches</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.056&quot; standard, other thicknesses available</td>
</tr>
<tr>
<td>Watt Density</td>
<td>80 W/in²</td>
</tr>
<tr>
<td>Wattage Tolerance</td>
<td>+5, -10%</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-70 to 450 °F</td>
</tr>
<tr>
<td>Maximum Temperature</td>
<td>500 °F</td>
</tr>
<tr>
<td>Voltage</td>
<td>12V to 600V AC or DC</td>
</tr>
<tr>
<td>Lead wire</td>
<td>12 inch Teflon insulated, other types available</td>
</tr>
</tbody>
</table>

---

## FEATURES AND OPTIONS

### Dimensions : Maximum 38” x 98”

**Mounting Methods**
- Pressure Sensitive Adhesive Surface (PSAS)
- Silicone contact cement kit
- Field applied adhesive
- Mechanical fasteners
- Factory bonding

**Termination Styles**
- Teflon Leads
- Silicon Insulated Leads

**Construction**
- Wire wound
- Etched foil elements

**Holes, Cutouts and Notches :** Customized

**Thermal Insulation :** To increase heat efficiency

### APPLICATIONS
- Freeze protection and condensation prevention
- Drum Heaters
- Medical equipment
- Computer Peripherals
- Photo processing equipment
- Semiconductor processing equipment
- Shelving
MICA BAND HEATERS

Mica band heaters offer efficient and economical heating solutions to pipes and tubes that require external indirect heating. These heaters are used to heat-up the external surface of drums or pipes for a gradual heat transfer. A mica core surrounds the precisely wound heating element, producing a thin, efficient heater. The mica core is enclosed in a continuous corrosion resistant sheath and formed. All full mica band heaters are designed with closed ends to protect against contamination. The maximum sheath temperature is 800°F and is used mainly in plastic industry. Terminal boxes can be provided that protect terminations and also have the option of temperature controllers to help regulate applied heat. Mica is used as it provides exceptional insulation, dielectric strength and heat transfer capability for long heater life. Insulation is required to direct the heat to the application, avoid heat loss and slow heat-up time. In order to maintain a balance between the insulating characteristics of mica and the ease of heat transfer from the heating core, the thickness of each mica layer is cautiously selected. Various terminations are available with mica band heaters keeping in mind the diameter, width, voltage, operating temperature and cost. Several types of dimension, wattage, voltages and material are available to suit different applications.

Mica band heaters provide perfect solution for high watt densities and high operating temperature applications. Pipe heating, drum heating, barrel heating normally used for oils, lubricants or other circular applications prefer these heaters as it offers safety when heating volatile and explosive substances as well as pipes or containers that cannot otherwise be heated using direct heating. Majorly sought for in the plastic industry, other areas where it can be installed are injection molding machines, plastic extruders, food industry, blow molding machines, pharmaceutical industry and container tank and pipe heating as it provides fast heat up.
**Options:**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Sheath Temperature</td>
<td>800 degree F</td>
</tr>
<tr>
<td>Voltage</td>
<td>120 &amp; 240V</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 45 W/in²</td>
</tr>
<tr>
<td>Minimum Diameter</td>
<td>2”</td>
</tr>
<tr>
<td>Minimum width</td>
<td>1”</td>
</tr>
<tr>
<td>Regular gap</td>
<td>3/8”</td>
</tr>
<tr>
<td>Terminal Enclosure</td>
<td>Regular or moisture resistant terminal box</td>
</tr>
<tr>
<td>Control</td>
<td>Thermostat or thermocouple</td>
</tr>
</tbody>
</table>

**FEATURES**

- **Independent Straps**: Tightly clamped around the surface
- **Flange Lock-up**: Most economical clamping mechanism
- **Spring loaded**: Useful in thermal expansion
- **Built in ceramic fiber insulating mat**
- **Clamping Pads**: Designed for two-section partial heaters
- **Latch and Hinges**

**CERAMIC BAND HEATERS**

Ceramic band heaters are medium-to-high temperature heaters that can deliver up to 1600°F (870°C). The heating element (Nichrome wire) is embedded in a flexible outer wall made of interlocking ceramic tiles, assembled like a brick wall. A ceramic fiber insulating mat and a stainless steel/Aluminized Steel jacket cover this assembly. This makes them flexible, highly efficient, prevents heat loss and reduces electrical consumption by 20%. An energized ceramic heater that operates at 1200°F internally will have around 400°F on its outside shell. These durable heaters have versatile configurations which allow selection of clamping mechanism, terminal styles, holes and cut outs and perforations. Uniform heat distribution is an added advantage of ceramic band heaters. Limitations on the width of these heaters within a certain incremental range of sizes, is due to ceramic tiles that are available in specific lengths. Ceramic Band Heaters afford customers a means to heat large cylinders from intermediate to high temperatures without concern of failures due to "Hot-Spotting". A layer of thermal insulation reduces ambient heat loss and power consumption.
Some of the advantages of Ceramic band heaters include:

- **Lower Operating Cost** – Less heat escapes to the air and less wattage is required to maintain barrel temperature, due to superior insulation.
- **Heat transfer** – Conduction and radiation are used as the means to transfer heat, thus they are less prone to thermal expansion problems and a near perfect fit is not required as with other heaters.
- **Longer Heater Life** – because all materials used are rated to operate at very high temperatures.
- **Higher Operating Temperatures**
- **Flexible** – easy to install and remove

Band heaters can be combined with high velocity fans to form fast responding heat/cool units in accurate heating applications. These heaters are made with a perforated outside stainless steel sheath, and with no insulating jacket.

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath Material</td>
<td>Steel or Stainless Steel</td>
</tr>
<tr>
<td>Insulation Material</td>
<td>Ceramic Fiber Blanket</td>
</tr>
<tr>
<td>Watt Density</td>
<td>Up to 45 W/in²</td>
</tr>
<tr>
<td>Watt Ratings</td>
<td>500 - 5000 W</td>
</tr>
<tr>
<td>Voltage</td>
<td>120-600 V</td>
</tr>
<tr>
<td>Width</td>
<td>1 ½ - 6&quot;</td>
</tr>
<tr>
<td>Diameter</td>
<td>Customized</td>
</tr>
</tbody>
</table>
INDUSTRIAL INFRARED HEATERS

Infrared heaters are electric heaters specifically designed to emit infrared heat, where heating by other means is not ideal. As they rely on infrared energy, they are able to transmit heat without losing it to the outside. Infrared heaters use either quartz element or tubular element that radiate ample heat because it attains high temperatures. Terminals are protected by waterproof housing and are used in conjunction with control panels. If the tubular elements need to be replaced, they are available at an economic cost. Different lengths and sizes are available to meet specifications. Industrial infrared heaters are high intensity heaters and used where high temperatures are necessary. These heaters are simple, economic, easy to clean, cost effective and efficient.

Categorized as the most useful heaters, they are designed to work in large and exposed areas (indoor and outdoor) and heavy duty projects. Some areas include arenas, ice rinks, gymnasium, aircraft hangars etc. Some industries that have realized the effectiveness of infrared heating and incorporated their benefits to provide quality services include:

- Medical
- Mining/Oil/Gas
- Construction/Manufacturing
- Thermoforming

Medical
Hospitals, clinics and medical institutions implement infrared radiant heating in separating platelets from the blood, neutralizing viruses and bugs and cleaning incubators hygienically.

Mining/Oil/Gas
The mining, oil and gas industries combine infrared and microwave heat to clean the oil laced sand from the crude oil tanks, hence enhancing their productivity and quality.

Construction/Manufacturing
Infrared radiant heaters are helpful in binding different materials together in extreme temperatures, which can satisfy both domestic and industrial needs.

Thermoforming
The plastic thermoforming industry has gained wide profit margins, by reducing average expenses on thermoforming, through the use of infrared heating.
<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>CONSTRUCTION TYPE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyerised or batch type ovens</td>
<td>Single tubular element (Type 1)</td>
<td>The mineral insulated alloy sheath heating element prevents splashing and vibration and provides a longer service life than other source types.</td>
</tr>
<tr>
<td>Drying</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-greasing, Weld preheating,</td>
<td>Double tubular element (Type 2)</td>
<td>Two series wired heating elements in Reflectors</td>
</tr>
<tr>
<td>Roll heating, Drying, Sterilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor installations Wash-down exposed areas</td>
<td>Hairpin tubular element with</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>moisture resistant terminal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>housing (Type 3)</td>
<td></td>
</tr>
<tr>
<td>Industrial applications with medium intensity</td>
<td>Quartz tube (Type 4)</td>
<td>Horizontal mounting for tube fixtures</td>
</tr>
<tr>
<td>infrared heat: Paint spray, Booths, Curing,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drying Softening resins, Vinyl and Plastics</td>
<td>Double quartz tube elements (Type 5)</td>
<td>Horizontal mounting for tube fixtures</td>
</tr>
<tr>
<td>High intensity heat applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High intensity radiation, on/off heating:</td>
<td>Quartz lamp element (Type 6)</td>
<td>Horizontal mounting for tube fixtures</td>
</tr>
<tr>
<td>Baking, Drying, Curing (paint, varnishes, lacquers, adhesives, softening plastics, food processing)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EDGE WOUND HEATERS**

Edge wound elements are used in applications where utmost power is required in limited space. These elements replace rod elements in furnaces requiring more power and are used to convert gas-fired furnaces to electric heating. Different furnaces such as roller hearth, pit, batch, low temperature aluminum tempering furnaces and high temperature exothermic gas generators use these heating elements to meet their heating requirement. A nickel-chromium alloy (80/20 or 70/20) forms the basis of these heaters. Dimensions are custom made to suit high temperature and high power ratings. Benefits include:
• Higher power density
• Easy to install, replace and install
• Long service life at all temperatures
• Horizontal or vertical mounting
• Repairable to extend service life

<table>
<thead>
<tr>
<th>Options</th>
<th>NiCr alloy (80/20 or 70/30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Element Material</td>
<td>NiCr alloy (80/20 or 70/30)</td>
</tr>
<tr>
<td>Wattage</td>
<td>65 kW</td>
</tr>
<tr>
<td>Max. Temperature</td>
<td>1950 degree F (1050 degree C)</td>
</tr>
<tr>
<td>Length</td>
<td>Customized</td>
</tr>
</tbody>
</table>

**BLOWER ASSEMBLY**

A blower assembly is used to distribute air in various kinds of equipment. It is commonly seen in cars, furnaces, and home appliances. During forging or furnace operation, air is the utility that should be available at all time in order to ensure a smooth and standardized operation. Supplying air manually will reduce productivity and more man hour to accomplish a given task. Thus, an electric blower was designed in this regard with an efficient electric motor as the driver. The suction conditions and other application data are appropriately used to calculate the design parameters such as: suction specific speed, the power input to the blower, the inlet and outlet velocity, the twisting moment of the impeller shaft etc. Beyond the basic parts of a blower assembly, there are several ways the equipment can be varied. Depending on its use, the wheel can be extremely long or wide. There can also be a wide
variance in the way the assembly is secured. This includes different sizes of casings, which can range from small, circular models which are not much bigger than the blower wheel to larger rectangular structures. Depending on the use, the blower assembly can also be made to be affixed to equipment in several different ways. Primary considerations include the amount of space available to secure the assembly and how much support the equipment needs, which typically depends on the size and power of a particular component. The configuration of a blower assembly depends upon the size and needs of the item being cooled. For small to mid-sized equipment a single assembly will typically suffice. Larger machines may have dual blower assemblies. Housing for the blower assembly will also vary, depending on the amount of space available. While housings can be made snug and still function adequately, these sizes are not ideal. For optimum performance, it will be made with extra space so the parts have room to function efficiently.

They are exclusively engineered to endure the most rugged handling and withstand the increased workload expected of quality replacement products through years of service. Furnace blowers account for about 80% of the total furnace electricity consumption and are primarily used to distribute warm air throughout the home during furnace operation as well as distribute cold air during air conditioning operation.