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10 section

Tubular Heaters

Tubular Heater Introduction

Typical Applications

- *Forced air heating*
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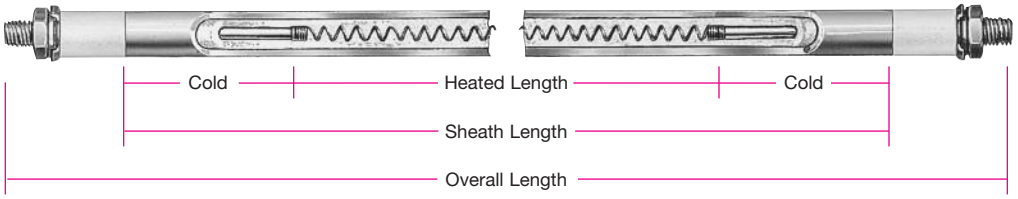
- *Direct immersion in liquids*
- *Comfort radiant heaters*
- *Welded, brazed or clamped to tanks and pipes*
- *Hot runner molds*
- *Combination radiant and convection heater for ovens and dryers*



Construction Characteristics

Tempco Tubular Heaters are the most versatile and widely used source of electric heat for industrial, commercial and scientific applications. They can be designed in a wide range of electrical ratings, diameters, lengths, terminations, and sheath materials. Important and useful characteristics of tubular heaters are that they can be formed into virtually any shape, brazed or welded to any metal surface, and cast into metals. Carefully researched manufacturing methods and quality materials have made Tempco tubular heaters stand apart from other heating elements claiming similar performance.

The cutaway view shows the tubular heater's basic construction. A computer-designed helical coil of 80% Nickel 20% Chromium alloy resistance wire is fusion welded to the nickel-coated steel terminal cold pin. This coil assembly is precisely stretched and centered in the element metal sheath, which is then filled with Grade "A" Magnesium Oxide powder (MgO). The filled tube is then compacted by a roll reduction mill into a solid mass, permanently stabilizing the coil in the center of the tube while providing excellent heat transfer and dielectric strength between the coil and the sheath.

Design Guidelines

Resistance Tolerance

Tubular heating elements have an Industry Standard Resistance Tolerance of +10%, –5% which translates to a Wattage Tolerance of +5%, –10%. Consult Tempco if tighter tolerances are required for your application.

Watt Density

Element Watt Density is the wattage dissipated per square inch of the element sheath surface and is critical to the proper heating of the application and to the life expectancy of the heater. The Watt Density is calculated with the following formula:

$$\text{Watt Density (w/in}^2\text{)} = \frac{\text{Element Wattage}}{\pi \times \text{Element Dia.} \times \text{Element Heated Length}}$$

For a particular application element watt density will govern element sheath and internal resistance wire temperature. Factors to consider when choosing a suitable watt density are:

1. Many materials are heat sensitive and can decompose or be damaged if the element is running too hot.
2. Air and other gases that are poor conductors of heat require watt densities matched to the velocity of the gas flow to prevent element overheating.
3. When heating hard water or cleaning solutions, mineral deposits can build up on the element sheath, acting as a heat insulator and raising the internal element temperature. If these deposits cannot be periodically removed, use a lower watt density element to increase heater life expectancy.
4. Page 16-12 in the Engineering Data Section of this catalog lists the maximum recommended heater watt density for many materials. For additional information and help please contact Tempco.

CAUTION

Important Note — When heating any substance it is critical to match the heater watt density, operating temperature and sheath material to the specific medium being heated. Failure to do so will result in premature heater failure and/or unsafe conditions.

Tubular Heating Elements being filled with MgO insulating powder.

Agency Approvals

Tempco Tubular Heating Elements are certified as Recognized Components by Underwriters Laboratories (File Number E90771) under CCN UBJY2/8 to meet UL Standard UL1030. Tempco's equivalent CSA File Number is 043099. Tubular elements with bulkhead fittings have also been certified for oil heating and heat transfer fluid applications (File Number MP4154) under CCN MDST2/8 to meet UL Standard 574.

If you require UL, CSA, or other NRTL agency approvals, please specify when ordering.

Tubular Heater Standard Specifications

Element Diameter in	Element Diameter mm	Maximum Voltage	Maximum Amperage	Resistance in Ohms per Heated Inch min	Resistance in Ohms per Heated Inch max	Sheath Length min. in	Sheath Length min. mm	Sheath Length max. in	Sheath Length max. mm
.260	6.6	250	15	.100	17	11	279	200	5080
.315	8.0	480	30	.060	21	11	279	200	5080
.375	9.5	600	30	.040	21	11	279	200	5080
.430	10.9	600	40	.040	21	11	279	268	6807
.475	12.1	600	40	.040	21	11	279	268	6807
.625	15.9	600	40	.040	17	11	279	255	6477

Table 1 Electrical Limitations and Minimum/Maximum Sheath Lengths

Length in	Length mm	Sheath Length Tolerance (±) in	Sheath Length Tolerance (±) mm	Heated Length Tolerance (±) in	Heated Length Tolerance (±) mm	Minimum Unheated Length Each End in	Minimum Unheated Length Each End mm
11-20	279-508	3/32	2.4	1/4	6	1	25
20-50	508-1270	1/8	3.2	1/2	13	1-1/4	32
50-80	1270-2032	5/32	4.0	7/8	22	1-1/2	38
80-110	2032-2794	3/16	4.8	1-1/8	29	1-5/8	42
110-140	2794-3556	7/32	5.6	1-3/8	35	1-3/4	44
140-170	3556-4318	1/4	6.4	1-5/8	41	2	51
170-200	4318-5080	3/8	9.5	1-7/8	48	2-1/4	57
200-up	5080-up	1/2	12.7	2-3/8	60	2-1/2	64

Table 2 Sheath and Heated Length Tolerance
(applicable for all diameters)

Tubular Heater Standard Sheath Materials

The selection of a sheath material should be made based on the chemical composition of the gas or liquid being heated, the characteristics of the materials entering the solution, and the processes controls. A material selection guide can be found on page 16-12.

NOTE: The best source for chemical/sheath compatibility is the supplier of the gas or liquid to be heated.

The following are the most common tubular element sheath materials. For other materials consult Tempco.

Incoloy® 840: Nickel 18-20%, Chromium 18-22%, Iron balance. Has about 10% less nickel than Incoloy 800. Used in many air heating applications, where it has exhibited superior oxidation resistance at less cost than Incoloy 800.
Maximum Sheath Temperature: 1600°F / 871°C

Incoloy® 800: Nickel 30-35%, Chromium 19-23%, Iron balance. The high nickel content of this alloy contributes to its resistance to scaling and corrosion. Used in air heating and immersion heating of potable water and other liquids.
Maximum Sheath Temperature: 1600°F / 871°C

316 Stainless Steel: Chromium 16-18%, Nickel 11-14%, Iron balance. Modified with the addition of Molybdenum (2-3%) to improve corrosion resistance in certain environments, especially those which would tend to cause pitting due to the presence of chlorides. Applications include deionized water.
Maximum Sheath Temperature: 1200°F / 649°C

304 Stainless Steel: Chromium 18-20%, Nickel 8-11%, Iron balance. Used in the food industry, medical, and chemical heating.
Maximum Sheath Temperature: 1200°F / 649°C

321 Stainless Steel: Chromium 17-20%, Nickel 9-13%, Iron balance. Modified with the addition of Titanium to prevent carbide precipitation and resulting intergranular corrosion that can take place in certain mediums when operating in the 800-1200°F (427-649°C) temperature range.
Maximum Sheath Temperature: 1200°F / 649°C

Copper: Standard Copper Alloy
A low temperature, inexpensive material used mainly for clean water heating.
Maximum Sheath Temperature: 350°F / 177°C

Steel: Low Carbon
Used for high to low viscosity oils, asphalt, tar, wax, molten salt, heat transfer liquid media and other compatible solutions.
Maximum Sheath Temperature: 750°F / 399°C

Other Sheath Materials: Available for a limited number of diameters. Consult Tempco for more information.

Inconel® 600: Iron 6-10%, Chromium 14-17%, Nickel balance
Maximum Sheath Temperature: 1800°F / 982°C

Incoloy® 825: Nickel 38-46%, Chromium 19.5-23.5%, Molybdenum 2.5-3.5%, Iron balance
Maximum Sheath Temperature: 1100°F / 593°C

CAUTION

Maximum Sheath Temperature refers to the maximum temperature of the element sheath material.
Consideration must be given to the maximum temperature that can be safely applied to the heated material.
See **Watt Density** on the previous page for additional information.

Incoloy® and Stainless Steel Element Sheath Surface Treatments

Standard Surface Finish

The standard tubular heater element surface finish is a black chrome oxide, produced when the element is annealed prior to forming in an exothermic atmosphere furnace.

Optional Surface Finishes

Bright Annealing is an option where the tubular heater is annealed in a dissociated ammonia atmosphere furnace. This produces a clean metallic appearance without surface-etching the sheath.

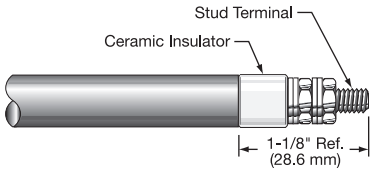
Electro-Polishing is an electrochemical process that removes surface imperfections and contaminants, enhancing the corrosion resisting ability of the sheath. The resulting surface is clean, smooth and has a bright finish; it is highly recommended for medical, food and other harsh applications.

Passivation removes surface contamination, usually iron, so that the optimum corrosion resistance of the stainless steel is maintained. Surface contamination could come from the small amount of steel that may be worn off a tool during the manufacturing process.

Standard Tubular Heater Terminations

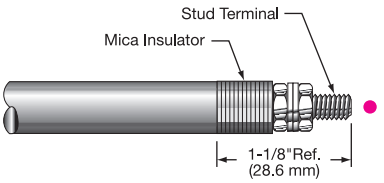
Select the termination style that meets your requirements for space, accessibility and reliability.

Note: If the listed terminations do not seem to fit your requirements, call us and let us design one that will.



TYPE T—STANDARD

Threaded stud terminal with ceramic insulator.



TYPE TM—Stud with Mica Insulator

Stud terminal with mica insulator.

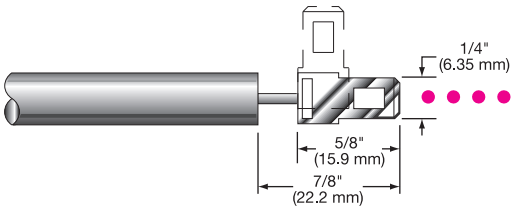
Element Diameter in	Element Diameter mm	Standard Thread Size
.260	6.6	6-32
.315	8.0	8-32
.375	9.5	8-32
.430	10.9	10-32
.475	12.0	10-32
.625	15.9	10-32

Other thread sizes and lengths are available.

TYPE P—Plain Pin

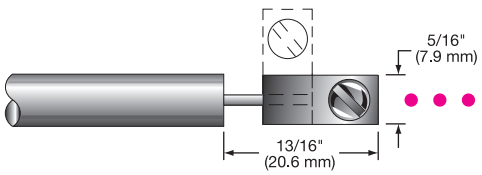
Plain terminal pin. Specify Length "L."
Standard 1/2" (12.7 mm) pin length.

Element Diameter in	Element Diameter mm	Nominal Pin Diameter in	Nominal Pin Diameter mm
.260	6.6	.091	2.3
.315	8.0	.105	2.7
.375	9.5	.105	2.7
.430	10.9	.125	3.2
.475	12.0	.125	3.2
.625	15.9	.160	4.1



TYPE SF & SF9 (90°)—Quick Connect

1/4" male (3/16" optional) quick connect (slip-on) terminals are welded to the element terminal pin. They provide quick and easy installation of lead wire with excellent holding force. Specify if an optional mica or ceramic insulator is required. Material: Nickel-Plated Steel.



TYPE L__ & L9__ (90°)—Terminal Lug

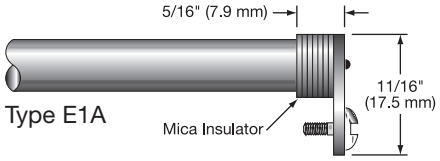
A nickel-plated steel lug is projection welded to the terminal pin straight (Type "L_") or at 90° to the sheath (Type "L9_"). Specify if an optional mica or ceramic insulator is required.

Standard LA, L9A 10-32 screw **Optional LB, L9B** 8-32 screw

Tubular Heater Standard Terminations

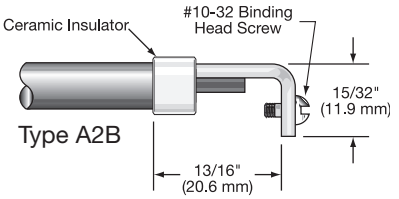
TYPE E__ __—Right-Angle Lug Terminal

Type E1A 8-32 screw with mica insulator (Standard)
Type E1B 8-32 screw with ceramic insulator
Type E2A 10-32 screw with mica insulator
Type E2B 10-32 screw with ceramic insulator



TYPE A__ __—Right-Angle Terminal (for use when space is tight)

Type A1A 8-32 screw with mica insulator
Type A1B 8-32 screw with ceramic insulator
Type A2A 10-32 screw with mica insulator
Type A2B 10-32 screw with ceramic insulator (Standard)



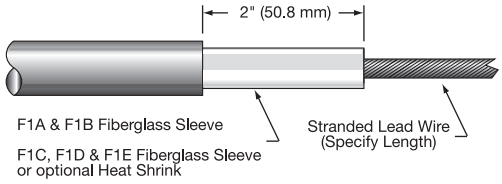
TYPE F1__—Lead Wire

When selecting a lead wire type, consideration should be given to the maximum ambient temperature the lead wire is exposed to and the environment it is in. Lead wire options Type R1 and W1 below will provide additional environmental protection to the Type F1 lead wire selected.

Type F1A 250°C (482°F) TGGT insulation
Type F1B 450°C (842°F) MGT insulation
Type F1C 200°C (392°F) Teflon® insulation
Type F1D 150°C (302°F) Silicone Rubber insulation
Type F1E 105°C (221°F) Thermoplastic (PVC) insulation

Standard 10" (254 mm) leads with fiberglass sleeve. Specify if other lead length is required.

F1C F1D & F1E available with optional heat shrink sleeving. Specify when ordering if required.



CAUTION

Lead wire gauge is determined by the ampacity of the heater with the lead wires in an ambient temperature of 40ºC (104ºF). Higher ambients may require heavier gauge lead wires.

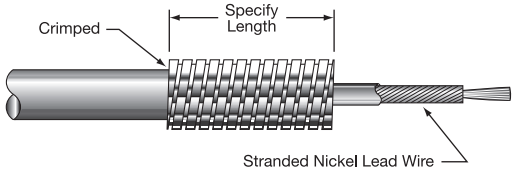
Lead Wire Termination Options

TYPE R1__—Flexible Armor Cable

Type R1A Galvanized cable
Type R1B Stainless steel cable

Provides excellent protection to lead wires in abrasive environments.

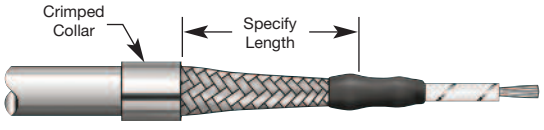
Standard 10" (254 mm) armor cable over 12" (305 mm) leads. Specify if other lead and/or cable lengths are required.



TYPE W1—Stainless Steel Wire Braid

Provides good protection to lead wires where flexibility is needed.

Standard 10" (254 mm) braid over 12" (305 mm) leads. Specify if other lead and/or cable lengths are required.



Tubular Heater Standard Mounting Methods

TYPE B — Bulkhead Fittings

Bulkhead fittings provide a leakproof method for mounting tubular heating elements through tank walls. Standard are round brass fittings crimped onto the element that are suitable for low pressure water (up to 80 psig) and non-pressure air. A brass hex nut, plated steel washer and gasket are supplied as standard.

Fittings for vacuum or high pressure gas and liquid use are silver brazed or TIG welded. Method will vary by material and application. Fittings in table are most commonly used. Special fittings can be made to meet your application requirements.

Standard fitting location is with threads flush at the end of the element sheath as shown below. For other locations specify distance from end of sheath.

CAUTION *Do not locate the fitting over the heated section of the element.*

Specify: Material; Round (Standard) or Hex Flange; Thread Type and Length; Location on Sheath; Crimped, Brazed, or Welded Construction.

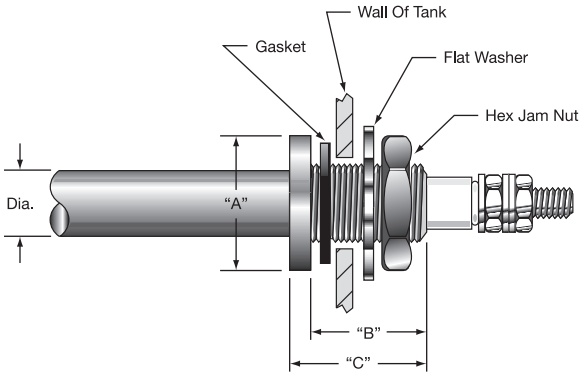
Fitting Attachment Method — General Guidelines

These are guidelines only. Consult Tempco if you require assistance in determining the method best suited to your application.

Fittings Crimped: Low pressure water (up to 80 psig) and non-pressure air applications

Fittings Brazed: Non-ferrous alloys (copper) and dissimilar non-weldable metals

Fittings Welded: High pressure liquids and gases, and high temperature applications



Standard Bulkhead Fittings For Tubular Heaters — Round Flanged Standard

Tubular Diameter in	Tubular Diameter mm	Fitting Material	Flange Type	"A" in	"A" mm	"B" in	"B" mm	"C" in	"C" mm	Thread Size (UNF)
.260	6.6	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.260	6.6	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.315	8.0	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.315	8.0	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.430	10.9	Brass	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Stn. Stl.	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Stn. Stl.	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	1	25	3/4	19.0	7/8	22	3/4-16
.475	12.1	Stn. Stl.	Round	1	25	3/4	19.0	7/8	22	3/4-16
.625	15.9	Stn. Stl.	Round	1-1/8	29	3/4	19.0	1	25	7/8-14

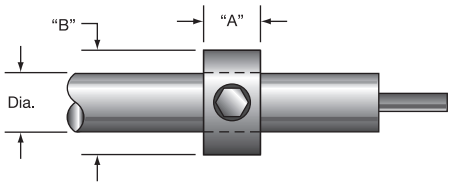
Note: Optional Larger Thread Sizes and Hex Flanged Bulkhead Fittings are available. Consult Tempco with your requirements.

Tubular Heater Standard Mounting Methods

Part Number	For Element Diameter		"A" Thick		"B" OD	
	in	mm	in	mm	in	mm
FAS-108-102	.260	6.6	5/16	7.9	5/8	15.9
FAS-108-102	.315	8.0	5/16	7.9	5/8	15.9
FAS-108-103	.375	9.5	3/8	9.5	3/4	19.1
FAS-108-104	.430	10.9	7/16	11.1	7/8	22.2
FAS-108-106	.475	12.0	7/16	11.1	1	25.4

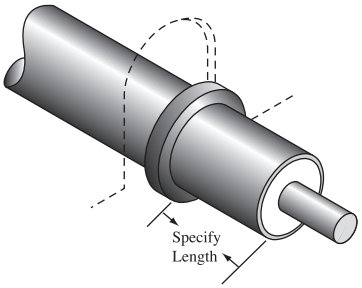
TYPE MC — Mounting Collar

Plated steel mounting collars are locked in place with a set-screw and serve as an adjustable stop for through-the-wall mounting. Collars are shipped in bulk unless otherwise specified. Mounting collars can be ordered with the heater or purchased separately.



TYPE LR — Locator Washer

Locator washers are permanently attached to the heater sheath by staking/crimping and are used to limit the movement of the heater while allowing for expansion and contraction of the heater sheath. When ordering, specify location from end of sheath.



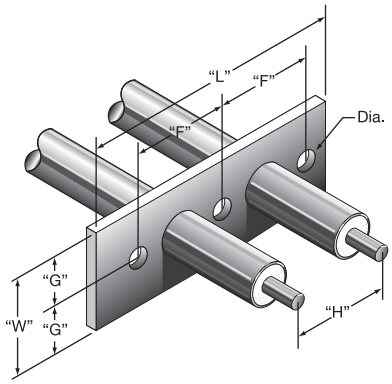
Multiple element heater assembly with a custom mounting bracket.

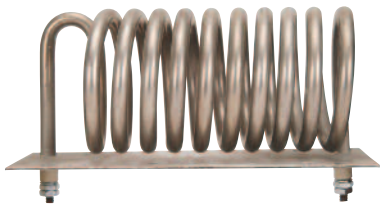
TYPE MF — Mounting Bracket

Tempco's made-to-order mounting brackets are made from 18 gauge stainless steel for strength and stiffness. It is an economical way to mount the heater in non-pressurizing, non-liquid applications. Unless otherwise specified, the bracket will be located 1/2" from the edge of the heater sheath. OEM quantity brackets are manufactured by Tempco on our own high speed precision N/C Turret Press. The standard method of attaching the tubular element to the bracket is staking or crimping.

The rectangular mounting bracket shown at right is a popular made-to-order design. Specify all dimensions shown when requesting a quote.

Custom brackets of any size, thickness or material can be supplied to meet your requirements.





Tubular Heater Standard Moisture Seals

Magnesium Oxide (MgO) is used as the insulating material in Tempco tubular heaters because of its excellent thermal conductivity and dielectric strength. However, MgO is hygroscopic and can absorb moisture from the atmosphere. This absorption of moisture may be detected when an Insulation Resistance (IR) test is done with a megohmmeter prior to energizing the heater circuit. In very humid environments, circuits utilizing a GFI (ground fault interrupter) for safety may experience nuisance tripping when energizing the heater.

The Tempco manufacturing process produces a dry element with an IR of several thousand megohms minimum. However, after shipment and depending on humidity levels and storage time, a heater can absorb moisture and show a decrease in IR. In many cases, depending on the supply voltage and the application, the heater can be safely energized and will dry itself out.

If a heater has absorbed moisture, a safe and effective method of drying it out prior to installation is to bake it in an oven at 300°F (149°C) until an acceptable IR reading is obtained. When possible, removing the terminal hardware will expedite this process. If this method is not practical consult factory for other recommendations.

For applications where moisture absorption would be unacceptable Tempco has several optional element end seals to retard absorption of moisture in the MgO. If a true hermetic seal is required, ceramic to metal end seals (Type H) are available. With any of these seals, the maximum recommended termination temperature in the seal area must not be exceeded.

Style SS—Silicone Resin Seal

A brushed-on coating that penetrates the MgO, offering economical moisture protection under humid storage conditions.

Maximum Usable Termination Temperature: 390°F (200°C)

UL Rated Maximum Termination Temperature: 221°F (105°C)

Type V2A: conformal coating
Type V2B: silicone oil

Style SER—RTV Seal

RTV (room temperature vulcanizing) silicone rubber adhesive sealant provides a good moisture seal.

UL Rated – Maximum Termination Temperature:

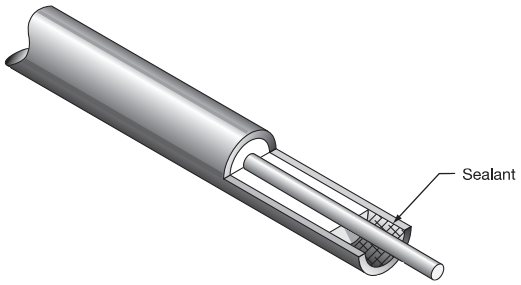
Type R: 302°F (150°C)
Type R1: 392°F (200°C)

Style SEH—Epoxy Resin Seal

Epoxy resin provides a moisture resisting barrier.

UL Rated – Maximum Termination Temperature:

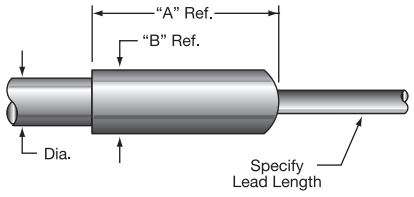
Type V: 194°F (90°C)
Type V1: 266°F (130°C)
Type V4: 392°F (200°C)



TYPE M—Self Sealing Heat Shrinkable Boot with Lead Wire

This type seal is used primarily for defrost heaters. Temperature range -67 to 300°F (-55 to 149°C). Standard 10" (254 mm) leads; specify longer leads if required.

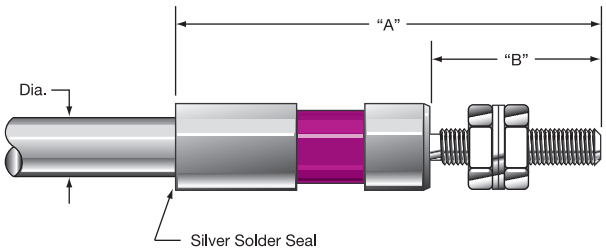
Heater Diameter		"A"		"B"	
in	mm	in	mm	in	mm
.260	6.6	2-1/8	54	7/16	11
.315	8.0	2-1/8	54	7/16	11
.430	10.9	2-1/8	54	9/16	14



TYPE H—Hermetic Seal

Ceramic to metal seals provide an airtight seal for temperatures to 500°F (260°C) in the seal area.

Heater Diameter		"A"		"B"		Thread Size
in	mm	in	mm	in	mm	
.260	6.6	1-11/16	43	13/32	10	8-32
.315	8.0	1-11/16	43	13/32	10	10-32
.430	10.9	2-1/8	54	21/32	17	1/4-28
.475	12.1	2-1/8	54	21/32	17	1/4-28



Tubular Heater Standard Bend Formations

Forming Tubular Elements

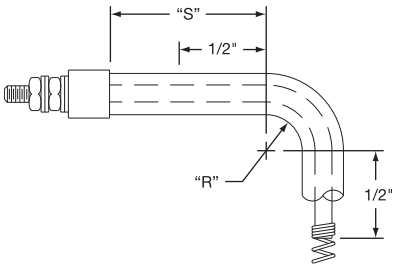
The MgO insulation used in tubular heating elements is compacted by reducing the element diameter in a roll reducing mill. The elements are then annealed in a controlled atmosphere furnace to relieve the metal stressing (work hardening) that takes place during the rolling to size reduction of the sheath. Annealing brings the metal back to a soft state, allowing the element to be bent into virtually any configuration. However, since forming also work hardens the metal, some precautions must be observed in order to prevent the sheath from breaking during bending or developing stress cracking marks.

Note: Elements with tight bends and some applications require the bends to be recompacted in special dies to restore the integrity of the insulation density and maintain dielectric strength. Large bends do not need to be recompacted.

Tubular Element Minimum Bending Radius

Element Diameter		Factory Bend Minimum R		Field Bend Minimum R		Minimum S	
in	mm	in	mm	in	mm	in	mm
.260	6.6	3/8	9.5	3/4	19.1	1/2	12.7
.315	8.0	1/2	12.7	1	25.4	1/2	12.7
.375	9.5	9/16	14.3	2	50.8	5/8	15.9
.430	10.9	3/4	19.1	2-1/2	63.5	3/4	19.1
.475	12.0	7/8	22.2	2-1/2	63.5	1	25.4

Note: Smaller inside bending radius than listed in the table can be factory accomplished. It requires special forming techniques to prevent damage to the tubular heater. Consult Tempco with your requirements.

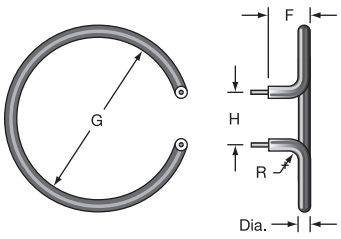


Avoid bends within a minimum of 1/2" of the terminal pin and resistance wire junctions unless the bending radius is a minimum 3"(75 mm).

Elements are being fed into a roll reducing mill to compact the MgO insulating powder. After rolling, the elements are annealed in the conveyor belt furnace seen in the background.

TYPICAL Bend Formations

We do custom formations. Contact Tempco with your requirements.



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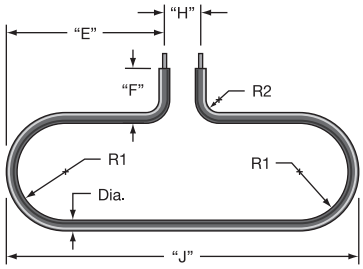

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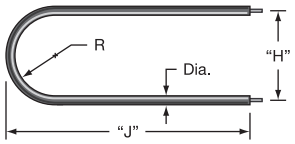

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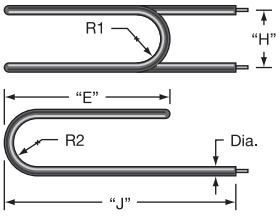

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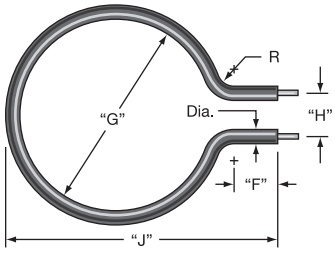

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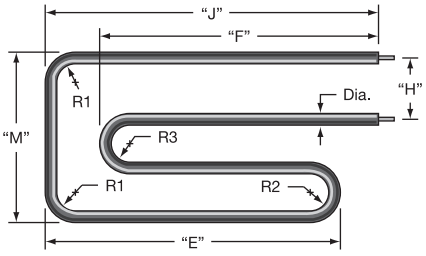
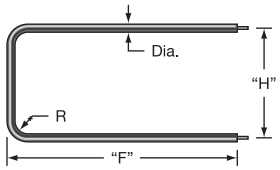


FT6

Tubular Heater Standard Bend Formations



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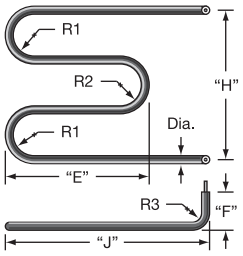

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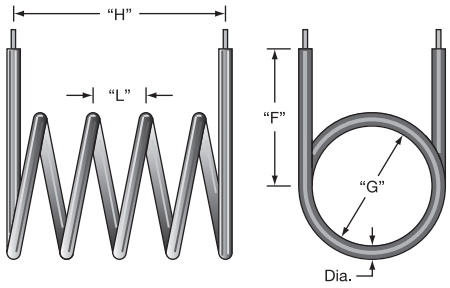

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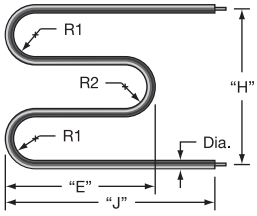

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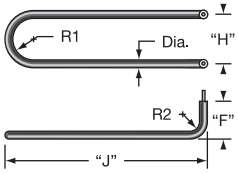

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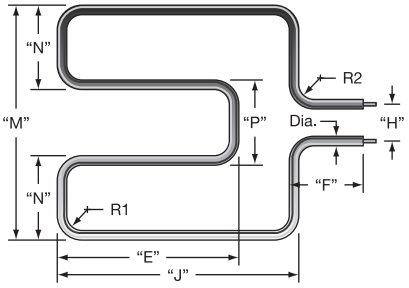

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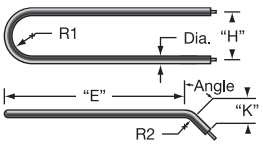

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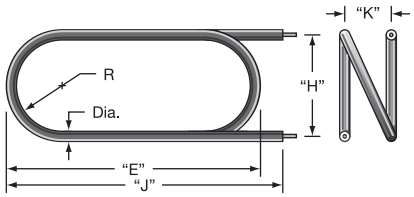

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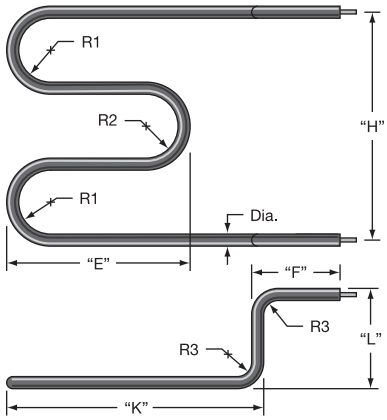

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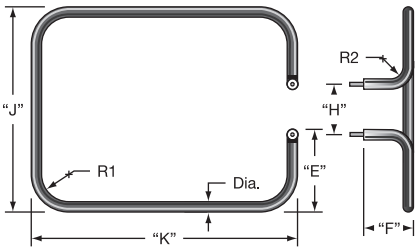

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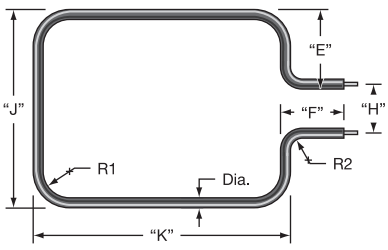

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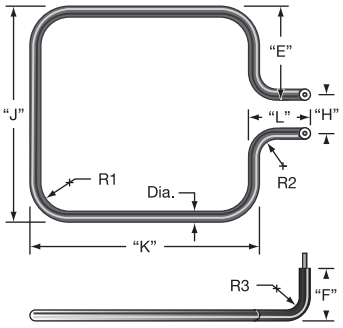
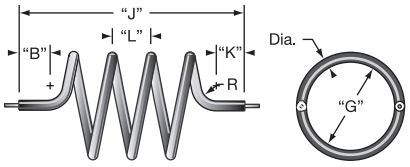


FT18

Tubular Heater Standard Bend Formations



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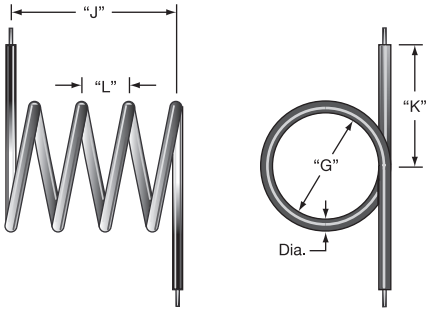

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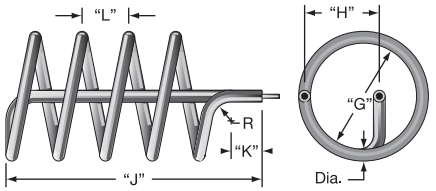
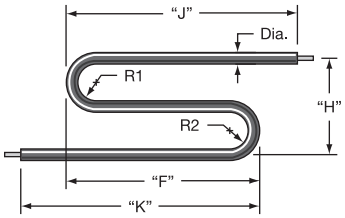


FT21

TYPICAL Bend Formations

We do custom formations. Contact Tempco with your requirements.



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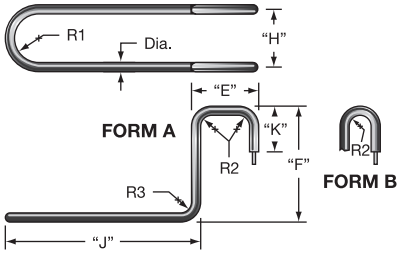

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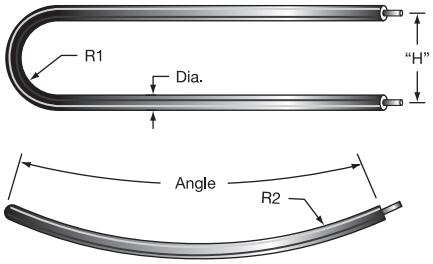

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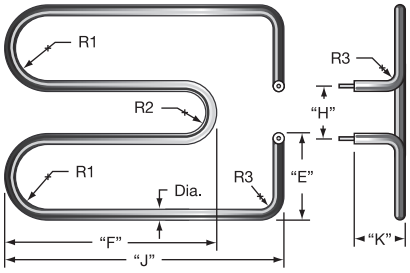

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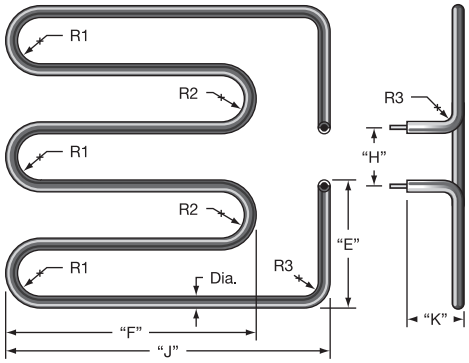

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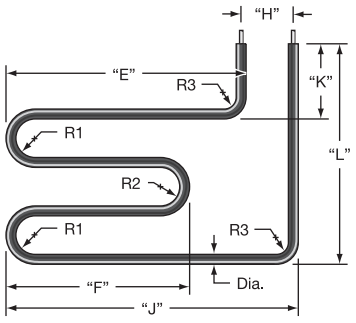
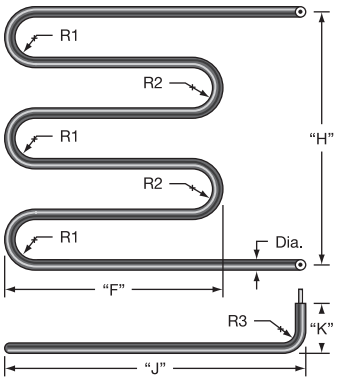


FT27

Tubular Heater Standard Bend Formations



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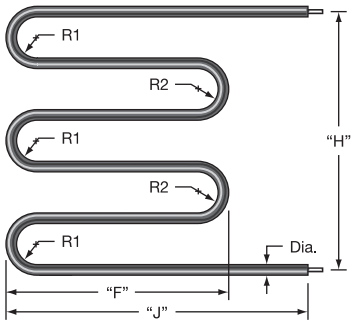

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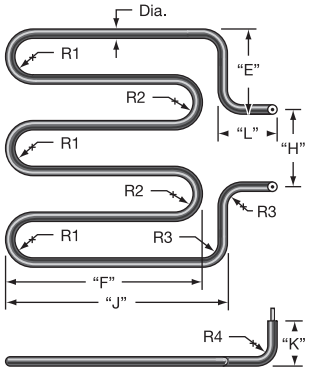

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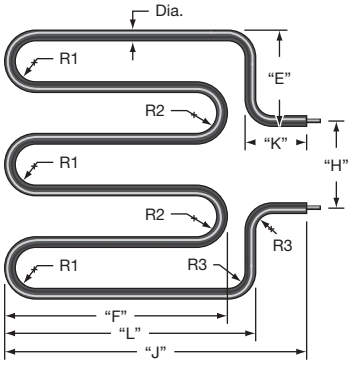

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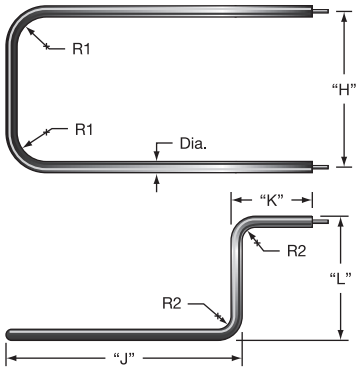

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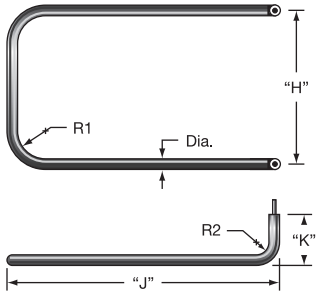

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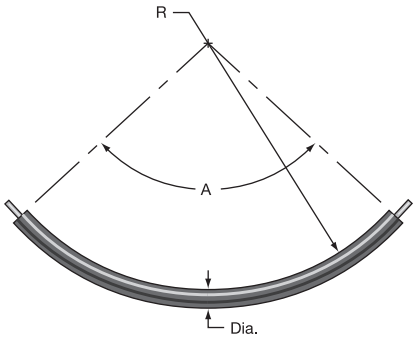

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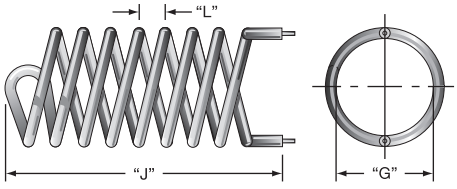

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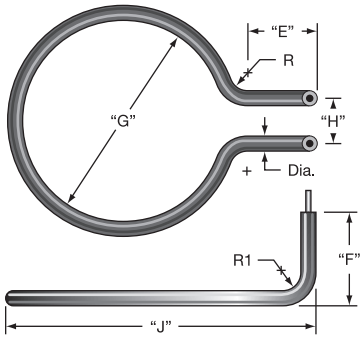

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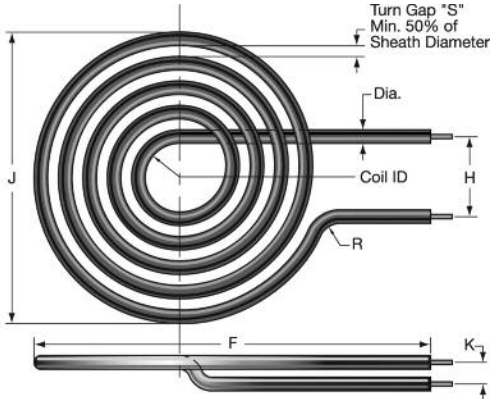
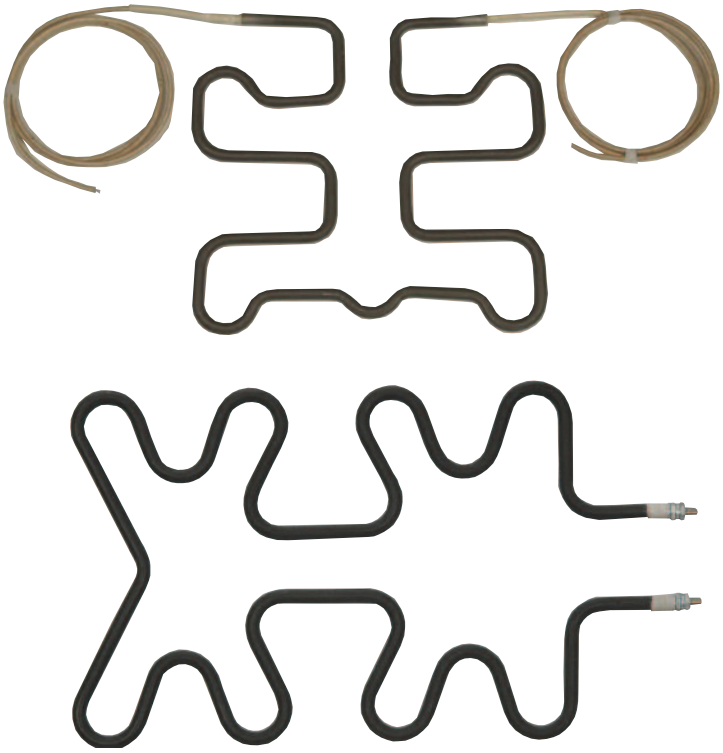


FT37

Tubular Heaters for Hot Runner Manifolds



Construction

Hot Runner Manifold Heaters are made to order using .260", .315" or .375" diameter Incoloy® tubular heating elements. Commonly specified terminations include threaded stud or wire leads.

Important Information on Forming

Precise forming of the tubular heater is required for it to seat properly into the milled slot in the manifold. To ensure this fit, we use a physical template as an inspection tool in the forming process to verify bending accuracy.

The template is a reproduction of the milled slot in the form of a plastic or aluminum plate. It can be customer supplied or manufactured by Tempco. Only through the use of a forming template is bending accuracy guaranteed.

When ordering for new applications:

Supply a drawing or forming template if available.

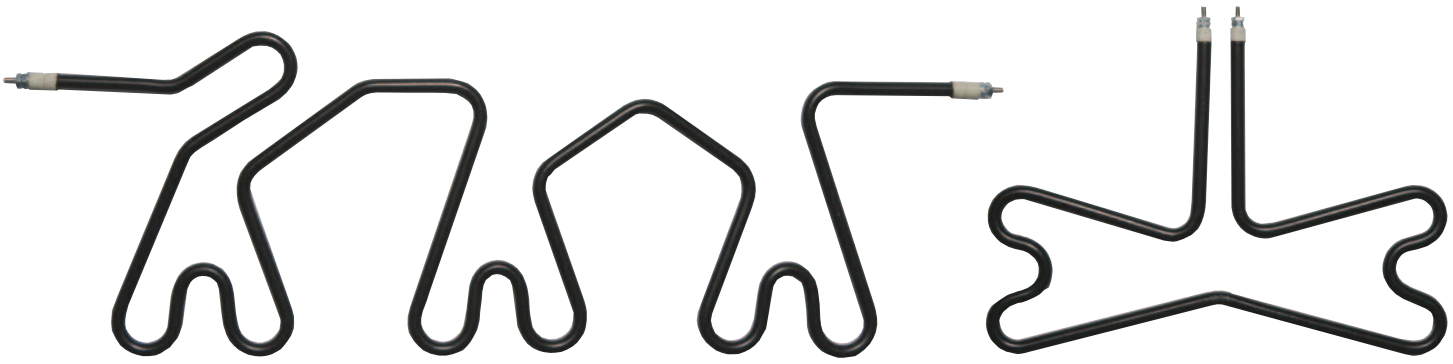
When ordering for replacement:

Supply a sample heater and/or a drawing of the manifold indicating the milled heater slot.

Note: For heaters originally manufactured by Tempco only the Tempco Part Number is required.

Examples of Mold Heater Formations

Consult Tempco With Your Requirements.
We Welcome Your Inquiries.



Heat Transfer Cement

When tubular heating elements are used in a milled slot any air gaps between the element and the plate can cause hot spots on the element. Heat transfer cement is used to fill these air gaps, permitting the heater to run cooler, thus maximizing its life expectancy. Cement is water soluble and can be applied with a putty knife or trowel and can be used in temperatures up to 1250°F (675°C).

Part Number **SEA-108-101 (1 Gallon)**
SEA-108-102 (1 Quart)

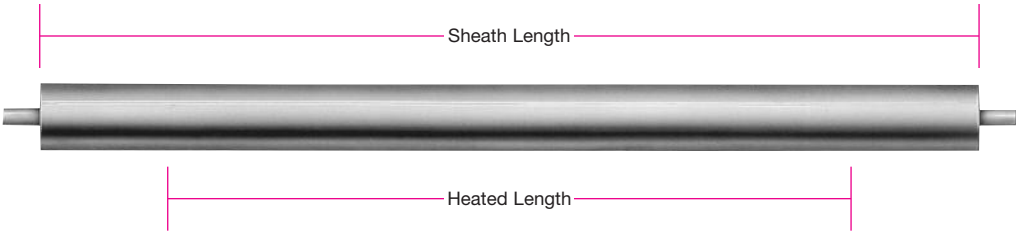
Ordering Information

TEMPCO will design and manufacture a Tubular Hot Runner Manifold Heater to meet your requirements.

Please Specify the following:

- ❑ Wattage and Voltage
- ❑ Diameter
- ❑ Heated Length
- ❑ Unheated Length at each end
- ❑ Termination Type (see pages 10-4 and 10-5)
- ❑ Supply a Drawing or Template

Tubular Heater Standard (Non-Stock) and Stock Sizes and Ratings



Standard tubular heaters are fully annealed for field or factory bending. They are inventoried with plain pin extensions that allow quick installation of Termination Types T, TM, F1, A, E, SF, SF9, L and L9.

Part Numbers listed are for heaters with Type "T" termination. For other terminations a Part Number will be issued at time of order.

Standard (Non-Stock) and Stock Sizes and Ratings with Type T Termination

Stock Items Are Shown In RED

Element Description	Sheath Length in	Sheath Length mm	Heated Length in	Heated Length mm	Watts	Part Number 240V	Approximate Net Weight lbs	Approximate Net Weight kgs
23 W/in² .475 Dia. Incoloy® 840 12 mm (3.6 W/cm²)	39	991	27	686	1000	**THE04000**	1.0	.5
	54	1372	42	1067	1500	**THE04001**	1.1	.5
	69	1753	57	1448	2000	THE04002	1.3	.6
	84	2134	72	1829	2500	**THE04003**	1.4	.6
	99	2515	87	2210	3000	THE04004	1.6	.7
	132	3353	120	3048	4175	THE04005	1.7	.8
	157	3988	145	3683	5000	THE04006	1.8	.8
30 W/in² .260 Dia. Incoloy® 840 6.6 mm (4.7 W/cm²)	20	508	15	381	400	THE04007	.2	.1
	25	635	20	508	500	THE04008	.2	.1
	30	762	25	635	600	THE04009	.2	.1
	35	889	30	762	800	**THE03384**	.3	.1
	40	1016	35	889	900	**THE04010**	.3	.1
	45	1143	40	1016	1000	**THE04011**	.4	.2
	50	1270	45	1143	1200	THE04012	.4	.2
	55	1397	50	1270	1200	THE03383	.4	.2
	60	1524	55	1397	1400	**THE03373**	.5	.2
	65	1651	60	1524	1600	THE02648	.5	.2
	70	1778	65	1651	1800	THE04013	.6	.3
	75	1905	70	1778	1800	THE04014	.6	.3
	80	2032	75	1905	2000	THE04015	.6	.3
30 W/in² .315 Dia. Incoloy® 840 8.0 mm (4.7 W/cm²)	15	381	10	254	300	THE04016	.2	.1
	20	508	15	381	400	THE04017	.3	.1
	25	635	20	508	600	THE04018	.3	.1
	30	762	25	635	800	THE04019	.4	.2
	35	889	30	762	900	THE03328	.5	.2
	40	1016	35	889	1000	**THE04020**	.5	.2
	45	1143	40	1016	1200	THE04021	.6	.3
	50	1270	45	1143	1400	THE04022	.7	.3
	55	1397	50	1270	1600	**THE04023**	.7	.3
	60	1524	55	1397	1800	**THE03134**	.8	.4
	65	1651	60	1524	1800	THE04024	.9	.4
	70	1778	65	1651	2000	**THE03380**	1.0	.5
	75	1905	70	1778	2200	THE04025	1.0	.5
	80	2032	75	1905	2400	THE04026	1.1	.5
	90	2286	85	2159	2600	THE04027	1.2	.5
	100	2504	95	2413	3000	THE04028	1.3	.6

Tubular Heater Standard (Non-Stock) and Stock Sizes and Ratings

Standard (Non-Stock) and Stock Sizes and Ratings with Type T Termination

Stock Items Are Shown In RED

Element Description	Sheath Length in	Sheath Length mm	Heated Length in	Heated Length mm	Watts	Part Number 240V	Approximate Net Weight lbs	Approximate Net Weight kgs
30 W/in² .430 Dia. Incoloy® 840 10.9 mm (4.7 W/cm²)	15	381	10	254	400	THE04029	.3	.1
	20	508	15	381	600	THE04030	.5	.2
	25	635	20	508	800	THE04031	.6	.3
	30	762	25	635	1000	THE04032	.7	.3
	35	889	30	762	1200	THE04033	.8	.4
	40	1016	35	889	1400	THE04034	.9	.4
	45	1143	40	1016	1600	THE04035	1.0	.5
	50	1270	45	1143	1800	THE04036	1.1	.5
	55	1397	50	1270	2000	THE03415	1.3	.6
	60	1524	55	1397	2200	THE03376	1.4	.6
	65	1651	60	1524	2400	THE04037	1.5	.7
	70	1778	65	1651	2600	**THE04038**	1.6	.7
	75	1905	70	1778	2800	**THE04039**	1.7	.8
	80	2032	75	1905	3000	**THE04040**	1.8	.8
	90	2286	85	2159	3500	THE04041	2.0	.9
	100	2540	95	2413	4000	**THE03593**	2.3	1.0
	110	2794	105	2667	4500	**THE03067**	2.5	1.1
	120	3048	115	2921	5000	THE04042	2.7	1.2
40 W/in² .375 Dia. Incoloy® 840 9.5 mm (6.2 W/cm²)	21 1/16	535	16 13/16	427	800	THE04043	.4	.2
	27 1/8	689	22 7/8	581	1100	THE04044	.5	.2
	32 1/8	816	27 7/8	708	1300	THE04045	.6	.3
	42 7/8	1089	38 5/8	981	1800	**THE04046**	.8	.4
	57 1/2	1461	53 1/4	1353	2500	THE04047	1.1	.5
	69 1/4	1759	65	1651	3000	THE04048	1.3	.6
	81 1/4	2064	77	1956	3600	THE04049	1.5	.7
	109 1/4	2775	105	2667	4000	THE04050	2.1	1.0
	134 1/2	3416	127 3/4	3245	5000	THE04051	2.5	1.1
	153 3/8	3896	145 7/8	3705	5500	THE04052	2.9	1.3
	179 1/4	4553	171 1/4	4350	6500	THE04053	3.4	1.5
48 W/in² .475 Dia. Incoloy® 840 12 mm (7.4 W/cm²)	23	584	14	356	1000	THE04054	.6	.3
	30	762	21	533	1500	THE04055	.9	.4
	39	991	27	686	2000	THE04056	1.1	.5
	44	1118	35	889	2500	THE04057	1.3	.6
	54	1372	42	1067	3000	THE04058	1.6	.7
	69	1753	57	1448	4000	THE04059	2.0	.9
	84	2134	72	1829	5000	THE04060	2.2	1.0
	99	2515	87	2210	6000	THE04061	2.8	1.3
	149	3785	133	3378	9720	THE04062	4.0	1.8

Ordering Information

Catalog Heaters

Part Numbers in **RED** are in stock for immediate delivery with Type T termination.

Termination Types TM, F1, A, E, SF, SF9, L, and L9 can be applied to stock heaters. For these terminations the Heater Part Number will be issued at time of order.

Non-Stock Part Numbers are standard designs that are available straight in 2 weeks and formed in 4 weeks.

Custom Engineered/Manufactured Heaters

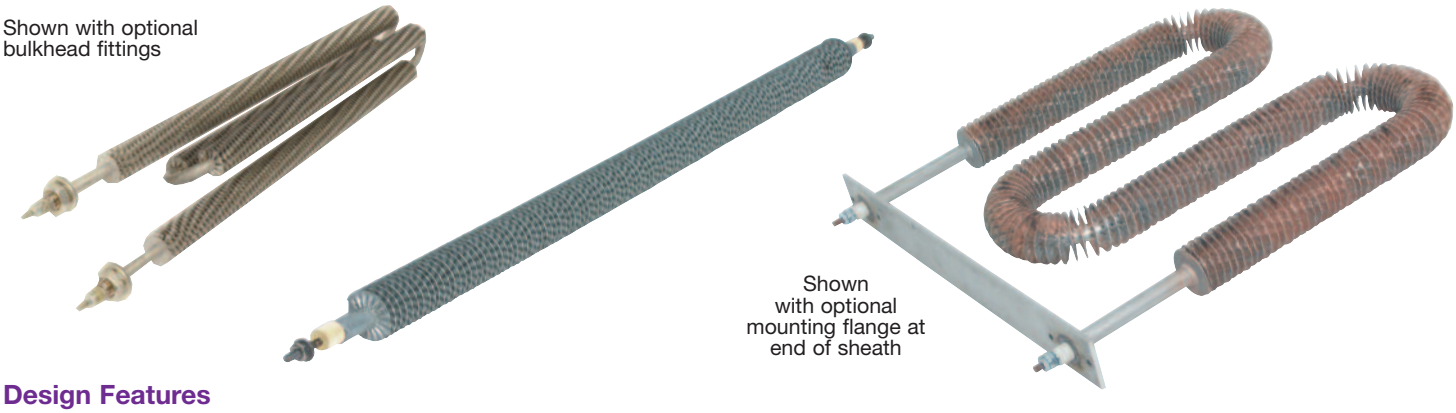
An electric heater can be very application specific; for sizes and ratings not listed, **TEMPCO** will design and manufacture a tubular heater to meet your requirements. ***Standard lead time is 4 weeks.***

Please Specify the following:

- ❑ Type of Application
- ❑ Wattage and Voltage
- ❑ Diameter
- ❑ Heated Length
- ❑ Unheated Length at Each End
- ❑ Sheath Material
- ❑ Termination Type
- ❑ Type of Mounting, if Required
- ❑ Type of Moisture Seal, if Required
- ❑ Bending Configuration (supply Drawing and/or Sample)

Finned Tubular Heaters

Shown with optional bulkhead fittings



Shown with optional mounting flange at end of sheath

Design Features

- ***Copper brazed steel fins on steel sheath standard. Aluminum based protective coating available.***
- ***Stainless steel fins on stainless alloy sheath standard.***
- ***.315, .430, & .475 Sheath diameters standard. .260 & .375 diameters optional. .625 diameter is special order in limited lengths.***
- ***5/16" fins standard on .315 diameter units, 3/8" fins on .430 & .475 diameter heaters. See physical specifications for optional sizes.***
- ***Monel fins on Monel sheath available on special order only. Consult Tempco for details.***
- ***4.5-5 fins/in standard. 3.5-6 fins/in optional***
- ***Steel finned catalog heaters have brazed brass bulkheads. Welded steel or staked bulkheads available. Stainless steel welded bulkheads are standard on cataloged stainless steel finned heaters. Fittings will have UNF threads unless custom threads are specified. See page 10-16B.***
- ***Custom Mounting Brackets can be provided. See page 10-16C.***
- ***Type T Post terminals standard. .315 dia. heaters have 8-32 threads and 10-32 threads are used on .430 & .475 dia. heaters. Full selection of tubular terminations available See page 10-4.***
- ***Catalog units have V2A silicon resin seals as standard. Most all other tubular seal options available. See page 10-16C.***
- ***Numerous factory bending formations available. Supply Tempco with dimensional sketch, drawing, or photo. See page 10-9.***
- ***Bright annealed, Nickel plating, Hi-heat aluminum, or Hi-heat flat black finishes available Furnace brazed Stainless Steel fins available as an option.***
- ***U2 & M2 formations are ideal for duct heating applications***
- ***Unfinned sections in bends or straight lengths of heated area can be provided on heaters up to 32wsi sheath watt density.***
- ***Catalog listed Steel heaters are UL recognized for use up to 750°F sheath temperature & Stainless construction up to 1000°F at a maximum of 85 wsi on sheath.***

Construction Characteristics

THF finned heaters are constructed using Tempco's robust tubular element as the basis of construction. Fin material is continuously spiral wound tightly onto the element surface to increase the convective surface area for air and non-corrosive gas heating. Fin spacing and size have been tested and selected to optimize performance. Steel finned units are then furnace brazed, bonding the fins to the sheath to increase conductive efficiency. This allows higher wattage levels to be achieved in the same flow area and produces lower sheath temperatures prolonging heater life. For higher temperature or more corrosive applications, stainless steel fins securely wound on alloy sheath are available. Application conditions such as vibration and toxic/flammable media should be taken into consideration when installing heaters. Protective coatings are available for use on steel finned heaters for mildly corrosive or high humidity applications.

Finned tubular elements are safer to operate than open coil heaters as the risk of fire from combustible particles in the flow stream and electrical shock is minimized. Increased service life and less maintenance required due to the rugged finned element construction. Power loading (w/in) of finned tubulars can be matched to any open coil installation. Pressure drop when using finned elements will be slightly more than with open coil but normally not enough to matter. It varies with flow velocity ranging from .04"H_2O at 500 fpm to about .30"H_2O at 1500 fpm when elements are banked together in several rows for duct heaters.

The finned tubular elements are normally used in forced or free convective air applications at low to medium temperatures. Typical applications are for heating indoor clean air from ambient conditions up to 250/275°F for steel finned units & to 550°F for stainless fins. Steel finned heaters can be operated up to 750°F on sheath and stainless steel finned heaters used up to 1200°F (1000°F UL limit) sheath temperatures. Nominal sheath watt density and recommended operating conditions for the cataloged heaters are included in the table headings & footnotes. Lower airflows will require lower watt density ratings. Consideration should be given to using un-finned alloy sheath tubular elements for heating to higher outlet air temperatures or if operating in higher ambient air. Application conditions of flow velocity and inlet/outlet temperatures will govern sheath watt density to be used. The airflow graphs and examples presented will help with determining proper heater watt density. The cataloged designs are suitable for most low temperature applications that will be encountered.

Agency Approvals

Finned Tubular Heaters are UL recognized and CSA certified up to 85W/in² and 750°F for Steel sheath/steel finned and . 85W/in² and 1000°F for Alloy or SS sheath/SS finned. The UL File Number is E65652 (CCN KSOT2/KSOT8).

If you require UL, CSA, or other NRTL agency approvals, please specify when ordering.

Typical Applications

- *Convective air & gas heating in ducts*
- *Load resistor banks*
- *Moisture removal (dehumidification)*
- *Curing ovens & plastics dryers*
- *Low/medium temperature heat treating*
- *Convection ovens for food preparation*
- *Exhaust gas heating*
- *Forced air electric heaters*
- *Heat pump auxiliary systems*
- *Return air heating*
- *Inert Industrial process gas heating*
- *Organic Resins & Paint curing, baking, & drying*
- *Autoclaves*
- *Film & ink drying*
- *Hopper heating*
- *Chemical processing & core drying*
- *Food Roasting & baking*
- *Textile & Varnish drying*
- *Heating for rail & marine applications*

TUBULAR ELEMENT SIZES & MATERIALS

Sheath Diameter: .315", .375", .430" and .475"

Sheath Material: Steel, 304L SS, 316L SS, Incoloy 840 and Incoloy 800

Sheath Lengths: 12" to 196" depending on sheath diameter

Sheath Material Selection

Standard steel finned heaters are ideal for use in low temperature clean air applications not containing toxic contaminants or high humidity. When coated with one of the optional coatings available they are suitable for high humidity, organic vapors, or mildly corrosive applications. Stainless steel finned heaters should be employed for higher temperature uses or if the air/gas contains vapors known to be corrosive to steel. Optional nickel plated heaters can also be provided.

PERFORMANCE RATINGS

Maximum Temperature:

Steel fins on steel sheath—750°F (400°C)

Steel fins on Incoloy or SS sheath—750°F (400°C)

Stainless Steel fins on stainless, Incoloy 840 or Incoloy 800 sheath—1200°F (650°C)

Maximum Element Power Density Limits:

.315 dia.—84 watts/linear inch
.375 dia.—100 watts/linear inch
.430 dia.—115 watts/linear inch
.475 dia.—127 watts/linear inch

These values are for heaters with 3/8" fins at 4.5-5 fins/inch. De-rate to 83% for heaters with 5/16" fins or that have less than 4.5 fins/inch.

ELECTRICAL RATINGS

Maximum Voltage: Up to 600VAC (480V for UL)

Resistance Tolerance: +10%, –5%

Wattage Tolerance: +5%, –10%

Sheath watt density range: 20-85 wsi (2-13 w/cm2), @ 4.5-5 fins/in

OPTIONAL FEATURES

Bulkhead Fittings: Brazed brass are standard. Welded or brazed Steel & SS optional. UNF threads standard, metric or special threads available.

Custom mounting brackets: (type MF or special). Dimensional sketch or drawing needed with material specs.

Locator washer: (type LC) specify location

Adjustable mounting collar**:** (type MC) w/set screw

Full selection of tubular termination options: Bulkhead fittings & type T post terminals standard.

Moisture Seals: V2A Silicon resin seal standard

SPECIFICATIONS AND PHYSICAL SIZE OF FINS

Fin Materials and Attachment Method:

Steel & 304 SS

Steel wound with copper wire between fins for oven brazing to sheath. Stainless steel is mechanically wound but can be oven brazed as an option if a bright annealing atmosphere is used.

Fin Strip Width:

5/16" on .315, .375 and .430 diameters
3/8" on .315, .375 .430 and .475 diameters

Fin Thickness:

26 Ga. (.018) for Steel and 304 SS. Optional 24 Ga. (.024) for steel only

Finned OD's:

.315" dia. with 5/16" fins—.92" OD
.315" dia. with 3/8" fins—1.05" OD
.375" dia. with 5/16" fins—.98" OD
.375" dia. with 3/8" fins—1.11" OD
.430" dia. with 5/16" fins—1.04" OD
.430" dia. with 3/8" steel fins—1.15" OD, SS fins 1.16" OD
.475" dia. with 3/8" fins—1.21" OD

Fin Pitch Standards:

5±.5 for 5/16 material, 4.5-5 for 3/8 material (up to 6 per inch maximum

SURFACE FINISHES

Oven brazed steel finned units - standard

Copper brazed stainless steel fins using inert atmosphere - special

Bright annealed steel or stainless steel finned heaters

High heat aluminum painted steel — 700°F Maximum

High heat flat black painted surface — 1000°F Maximum

Nickel plated finish — 500°F Maximum

FORMING LIMITATIONS

Minimum Element Centerline Bend Radius:

.315" dia. with 5/16" fins . . . . . 3/4"
.315" dia. with 3/8" fins . . . . . 7/8"
.375" dia. with 5/16" fins . . . . . 7/8"
.375" dia. with 3/8" fins . . . . . 1.00"
.430" dia. with 5/16" fins . . . . . 1.00"
.430" dia. with 3/8" fins . . . . . 1.00"
.475" dia. with 3/8" fins . . . . . 1.00"

The above values are for factory formed heaters. Consult Tempco for field bending limits.

Fitting Attachment Method — General Guidelines

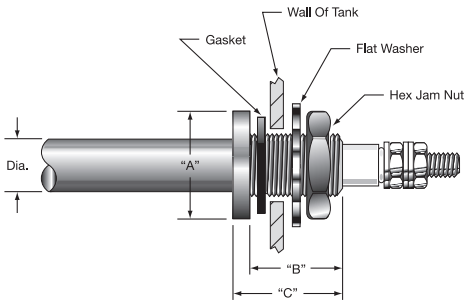
These are guidelines only. Consult Tempco if you require assistance in determining the method best suited to your application.

Fittings Crimped: Low pressure water (up to 80 psig) and non-pressure air applications

Fittings Brazed: Non-ferrous alloys (copper) and dissimilar non-weldable metals

Fittings Welded: High pressure liquids and gases, and high temperature applications

Standard Bulkhead Fittings For Tubular Heaters — Round Flanged Standard



Tubular Diameter in	Tubular Diameter mm	Fitting Material	Flange Type	"A" in	"A" mm	"B" in	"B" mm	"C" in	"C" mm	Thread Size (UNF)
.315	8.0	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.315	8.0	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.430	10.9	Brass	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Stn. Stl.	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Stn. Stl.	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	1	25	3/4	19.0	7/8	22	3/4-16
.475	12.1	Stn. Stl.	Round	1	25	3/4	19.0	7/8	22	3/4-16
.625	15.9	Stn. Stl.	Round	1-1/8	29	3/4	19.0	1	25	7/8-14

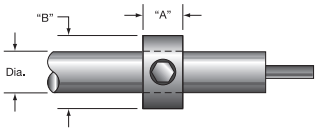
Note: Optional Larger Thread Sizes and Hex Flanged Bulkhead Fittings are available. Consult Tempco with your requirements.

Tubular Heater Standard Mounting Methods

Part Number	For Element Diameter in	For Element Diameter mm	"A" Thick in	"A" Thick mm	"B" OD in	"B" OD mm
FAS-108-102	.315	8.0	5/16	7.9	5/8	15.9
FAS-108-103	.375	9.5	3/8	9.5	3/4	19.1
FAS-108-104	.430	10.9	7/16	11.1	7/8	22.2
FAS-108-106	.475	12.0	7/16	11.1	1	25.4

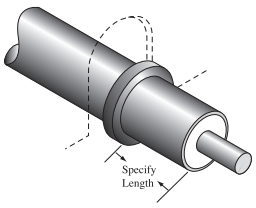
TYPE MC — Mounting Collar

Plated steel mounting collars are locked in place with a set-screw and serve as an adjustable stop for through-the-wall mounting. Collars are shipped in bulk unless otherwise specified. Mounting collars can be ordered with the heater or purchased separately.



TYPE LR — Locator Washer

Locator washers are permanently attached to the heater sheath by staking/crimping and are used to limit the movement of the heater while allowing for expansion and contraction of the heater sheath. When ordering, specify location from end of sheath.

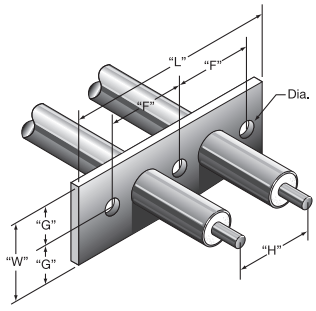


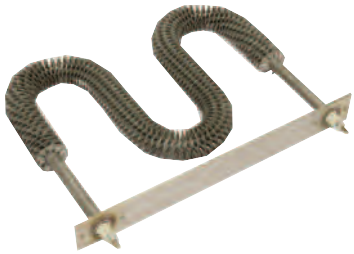
TYPE MF — Mounting Bracket

Tempco's made-to-order mounting brackets are made from 18 gauge stainless steel for strength and stiffness. It is an economical way to mount the heater in non-pressurizing, non-liquid applications. Unless otherwise specified, the bracket will be located 1/2" from the edge of the heater sheath. OEM quantity brackets are manufactured by Tempco on our own high speed precision N/C Turret Press. The standard method of attaching the tubular element to the bracket is staking or crimping.

The rectangular mounting bracket shown at right is a popular made-to-order design. Specify all dimensions shown when requesting a quote.

Custom brackets of any size, thickness or material can be supplied to meet your requirements.





Tubular Heater Standard Moisture Seals

Magnesium Oxide (MgO) is used as the insulating material in Tempco tubular heaters because of its excellent thermal conductivity and dielectric strength. However, MgO is hygroscopic and can absorb moisture from the atmosphere. This absorption of moisture may be detected when an Insulation Resistance (IR) test is done with a megohmmeter prior to energizing the heater circuit. In very humid environments, circuits utilizing a GFI (ground fault interrupter) for safety may experience nuisance tripping when energizing the heater.

The Tempco manufacturing process produces a dry element with an IR of several thousand megohms minimum. However, after shipment and depending on humidity levels and storage time, a heater can absorb moisture and show a decrease in IR. In many cases, depending on the supply voltage and the application, the heater can be safely energized and will dry itself out.

If a heater has absorbed moisture, a safe and effective method of drying it out prior to installation is to bake it in an oven at 300°F (149°C) until an acceptable IR reading is obtained. When possible, removing the terminal hardware will expedite this process. If this method is not practical consult factory for other recommendations.

For applications where moisture absorption would be unacceptable Tempco has several optional element end seals to retard absorption of moisture in the MgO. If a true hermetic seal is required, ceramic to metal end seals (Type H) are available. With any of these seals, the maximum recommended termination temperature in the seal area must not be exceeded.

Style SS—Silicone Resin Seal

A brushed-on coating that penetrates the MgO, offering economical moisture protection under humid storage conditions.

Maximum Usable Termination Temperature: 390°F (200°C)

UL Rated Maximum Termination Temperature: 221°F (105°C)

Type V2A: conformal coating
Type V2B: silicone oil

Style SER—RTV Seal

RTV (room temperature vulcanizing) silicone rubber adhesive sealant provides a good moisture seal.

UL Rated – Maximum Termination Temperature:

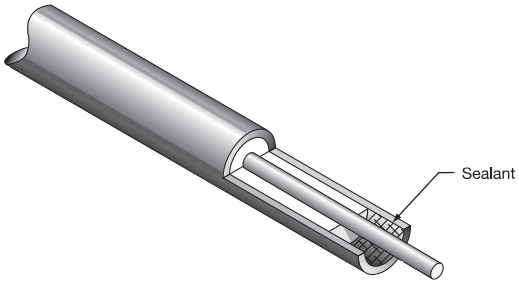
Type R: 302°F (150°C)
Type R1: 392°F (200°C)

Style SEH—Epoxy Resin Seal

Epoxy resin provides a moisture resisting barrier.

UL Rated – Maximum Termination Temperature:

Type V: 194°F (90°C)
Type V1: 266°F (130°C)
Type V4: 392°F (200°C)



Finned Tubular Heaters

Design Guidelines

The major factors that need to be considered when specifying THF finned tubular heaters are as follows:

- Minimum FPM airflow velocity at heater inlet. Is it continuous or fluctuating
- Inlet air temperature
- Outlet air temperature and temperature rise through heating elements
- Selection of element watt density to keep sheath material within its temperature limits
- Sheath material selection
- Condition of air or gas to be heated
- Mounting & airflow restrictions around elements
- KW sizing and # of circuits required (48 amp max/circuit)
- Temperature sensors & flow controls

Heater KW Sizing

Once the inlet temperature, outlet temperature, process CFM, and operating pressure are known, the KW required for the application can be determined using the following equations. If the process is heating air & operating from ambient temperature and atmospheric pressure (70°+/- 10°F & 14.7 psi), the following formula can be used;

KW = {[SCFM x (T2-T1)] ÷ 3190} + S.F.

Where:
T2 = °F outlet temperature
T1 = °F inlet temperature
SCFM = standard air flow in cu.ft./min. at atmospheric pressure and ambient temperature
S.F. = safety factor % to account for process losses

Converting CFM to SCFM

If the air heating process is pressurized or operating at an inlet temperature other than at or near ambient, the CFM at a point in the process with a known pressure & temperature must be used & converted to standard SCFM by the following formula;

SCFM = 35.4 x CFM2 x {(P2+14.7) ÷ (T2 + 460°)}

Where CFM_2 is cu.ft./min. air flow at process pressure P2.
P_2 = process pressure (psig)
T_2 = inlet °F or temperature at point of measured CFM2

Using the SCFM and the heater face flow area we can now calculate the air velocity in SFPM into the heater core as follows;
SFPM = SCFM ÷ A1
SFPM = inlet air velocity at standard conditions.
A1 = Sq.Ft. of inlet flow area at heater

An alternate method for calculating KW needed to heat air or other gas, from any inlet to outlet temperature can be done using the following general energy equation;

KW = {[60 min/hr x SCFM x Density x Sp Ht x ΔT] ÷3412} + S.F.

Where:
SCFM = standard air flow in cubic feet/min (@ 70°F & 14.7 psia)
Density = Gas density in lbs/cuft at standard conditions or if pressurized process at process pressure and inlet temperature. (see table)
Sp Ht = Specific heat of gas in Btu/lb-°F at standard conditions or if pressurized process at process pressure and inlet temperature. (values for air are shown in the gas density table)
ΔT = Process gas temperature rise -°F
3412 = conversion factor for Btu/hr to KW (1 KW = 3412 Btu/hr)
S.F. = safety factor % to account for process losses.

Using the inlet air velocity at the heater and the maximum outlet temperature desired the maximum sheath watt density can now be determined from the following charts for the type of heater being specified if a cataloged design is not suitable. The physical size and constraints of the application will dictate the final configuration and number of heaters required. For large installations, 3 phase circuits need to be balanced and all circuits limited no more than 48 amps per circuit. If voltages are higher than 250V, .375, .430, or .475 diameter elements are recommended.

Sheath Watt Density

The maximum sheath watt density to be specified is directly determined by the operating variables of FPM airflow velocity and inlet/outlet air/gas temperatures required. It must be selected such that sheath operating temperatures are not exceeded; 750°F for steel sheath-steel finned, or 1200°F for stainless steel/alloy sheath with stainless fins. Cataloged heaters are designed to operate within these parameters. The following charts will help guide the user in selecting proper watt density.

Allowable Sheath Watts/Square Inch at Various Air Velocities for Steel or Stainless Steel Finned THF heaters

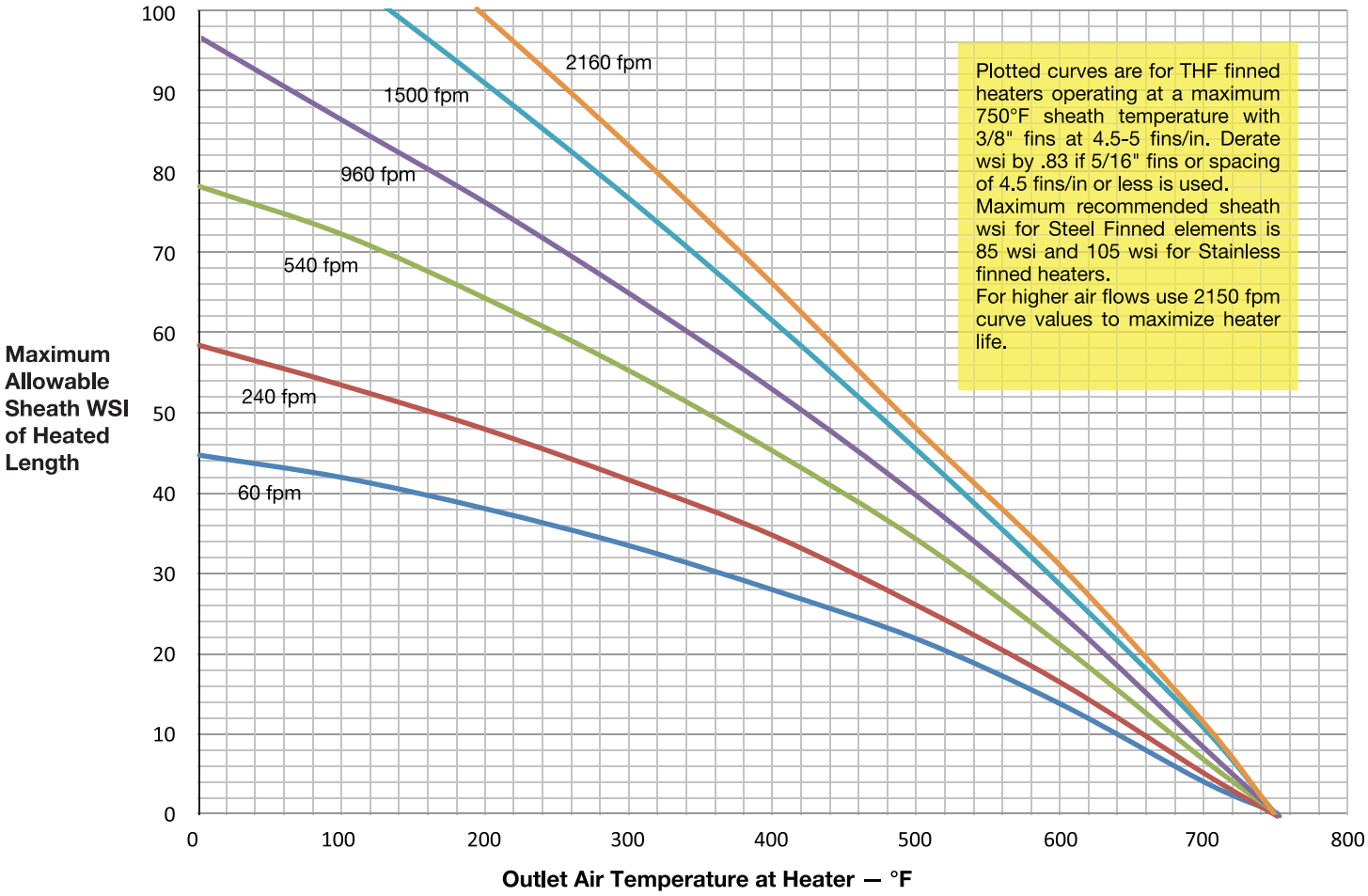


Chart 1 for steel (or SS) finned elements relates the maximum allowable sheath wsi to outlet air temperature that will be obtained at various air velocity levels.

These curves are for 750°F (or lower) sheath operating temperature.

The following Examples Illustrate the Graph's Use

Example 1

An application requires a heater to output 275°F air at an air velocity of 750 FPM. Entering the curves with 275°F, then up to 750 FPM level we find that a maximum of 62-64 wsi can be applied. Depending on voltage and space constraints either a .315 or .430 diameter catalog heater could be used.

Example 2

A curing oven needed 325°F outlet air at a minimum velocity of 1500 FPM. Entering chart at 325°F up to the 1500 FPM curve, we see that the heater could have a maximum of 70-72 sheath wsi. If a higher outlet air temperature is required, or if the airflow velocity is lower, then a reduced a sheath wsi would have to be specified.

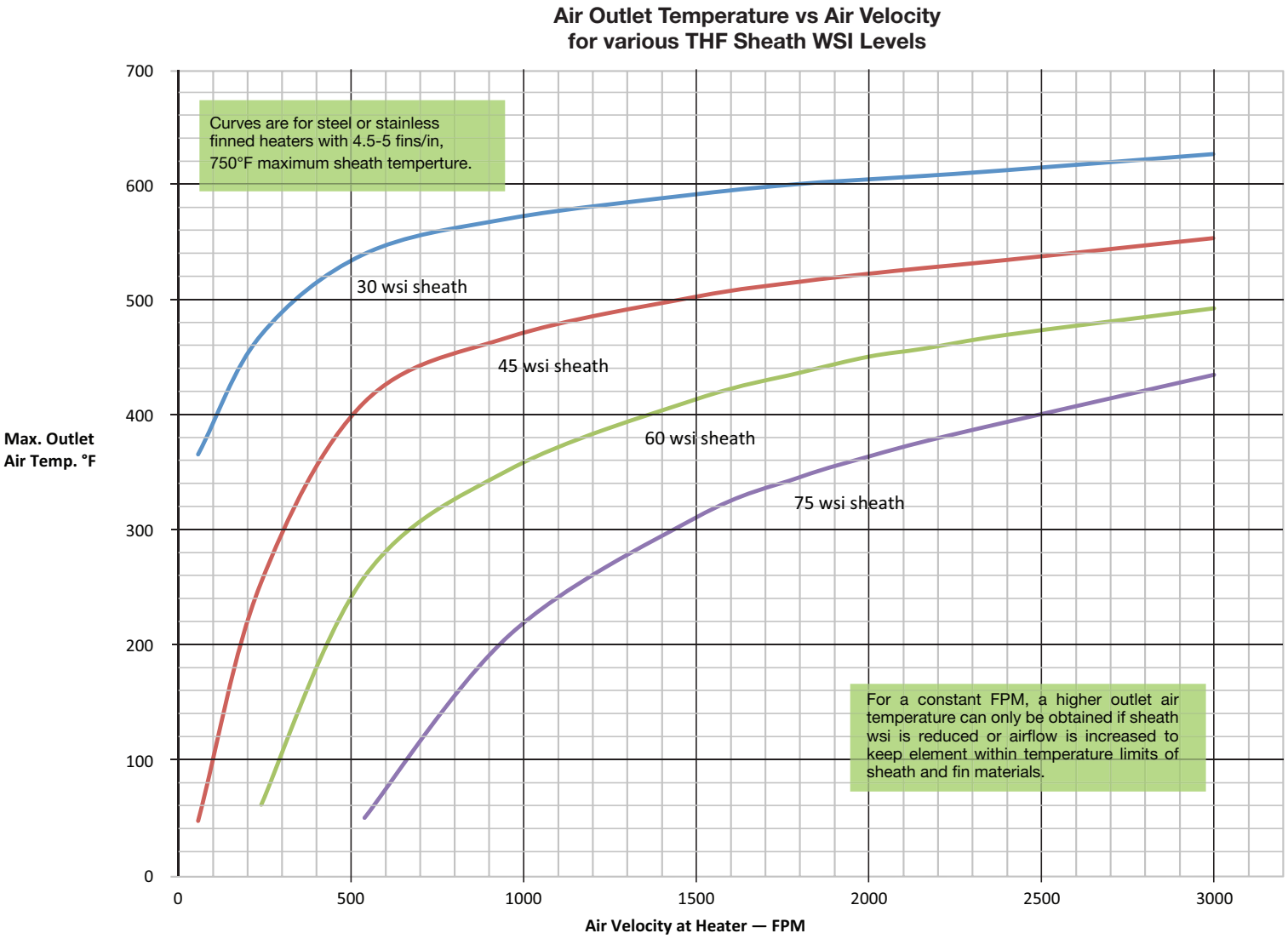


Chart 2 shows the relationship of maximum outlet air temperature obtained vs inlet air velocity at several sheath wsi levels.

This chart can be used for either steel or stainless steel finned elements operating at a maximum of 750°F and provides a way of establishing either airflow required or outlet temperature that will be obtained when sheath wsi is known for an application.

These curves show that to obtain a higher air outlet temperature at a constant FPM, the sheath wsi must be reduced to keep the element within the 750°F temperature limit of sheath & fin materials. These curves are for air entering a heater at or near ambient (60°-105°F).

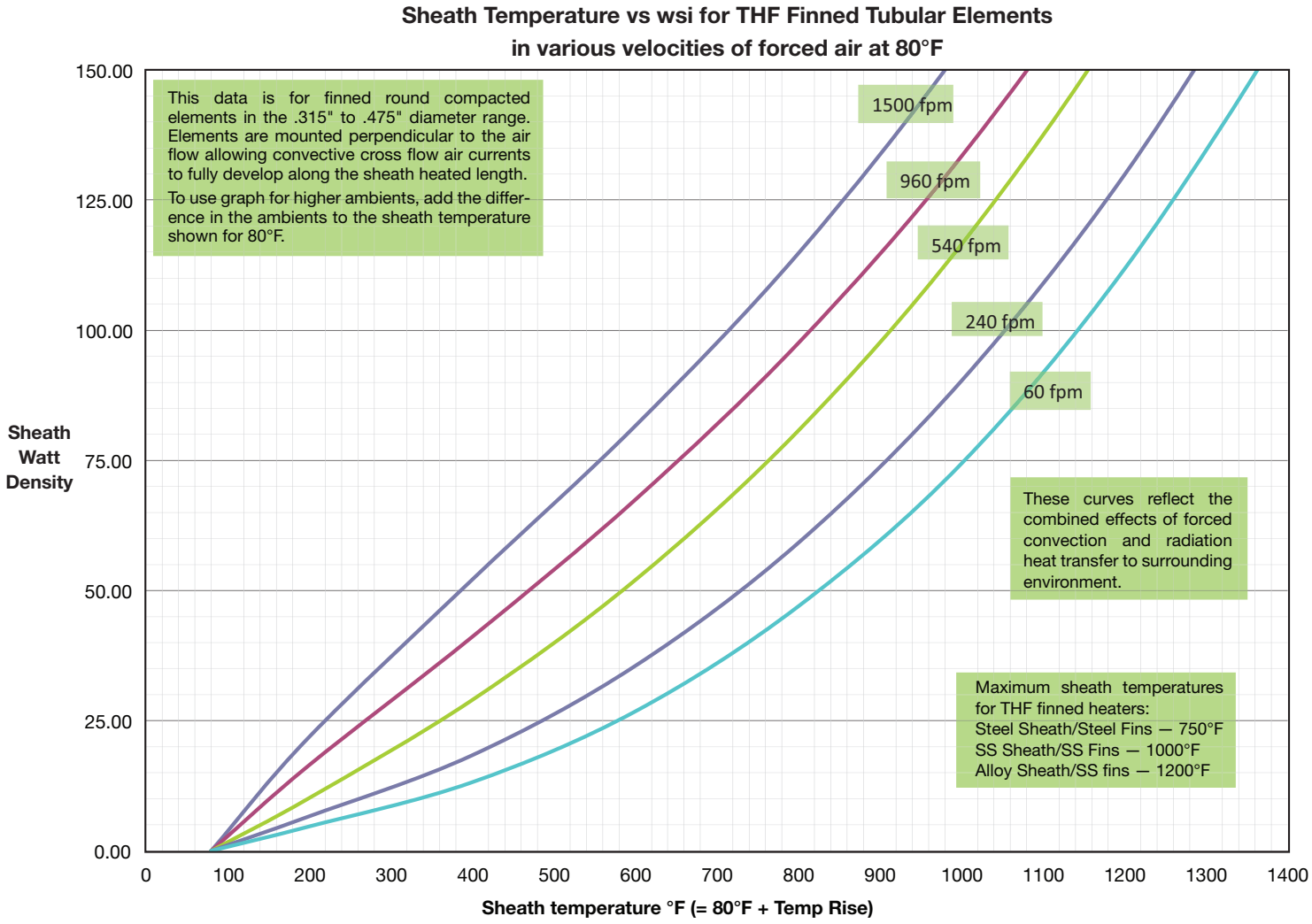


Chart 3 is a plot of sheath temperature and sheath watt density at various levels of inlet forced air at 80°F

It can be used to determine a maximum allowable sheath wsi for heating applications not restricted to the steel sheath limit of 750°. It can be used directly for most ambient air heating processes using Incoloy or Stainless Steel sheathed elements with stainless steel fins.

The following Example Illustrates the Graph's use when Operating in a Higher Ambient

Application

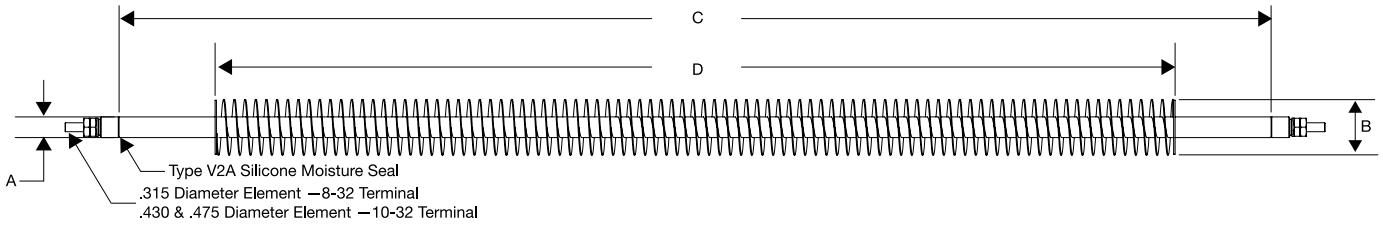
A recirculating process oven with organic vapors, moisture & other air contamination present, requires 500°F air at a minimum flow velocity of 900 FPM. Can a Stainless steel finned alloy sheathed heater at 80 wsi be used?

Using the Graph

Entering this chart at 900 FPM and 80 wsi, we find the sheath temperature when operating at 80°F ambient will be 700°F. The ambient temperature difference from the graph value of 80°F to the new higher 500°F ambient is 420°F (500-80). The new sheath temperature when operating in the 500°F ambient will be approximately 1120°F. (700 + 420). This is just 80° lower than the 1200°F limit for a stainless steel finned heater.

To conserve heater life it would be best to use a lower watt density & operate the heater at the lowest point possible given voltage, size, and construction constraints of the application. Consideration should be given to increasing the air velocity or using un-finned alloy sheath tubular heaters for this application. (See page 11-104)

Tech note: The reverse is true if element is operating in an ambient lower than 80°F. The sheath temperature would be reduced by the difference in the temperatures. The WSI range shown on the chart is approximately 4.25 times an unfinned tubular. The data has been confirmed by Tempco lab testing on .430 & .475 diameter finned heaters with 4.5-5 fins/in.



Standard (Non-Stock) Sizes and Ratings with Type T Termination

62-64 Sheath Watt Density (wsi)

Element Description	Dim. "A" inches	Dim. "B" inches	Dim. "C" inches	Dim. "D" inches	Watts	Part Number 120V	208V	240V	277V	480V
.315 Dia. Steel Element 5/16 Brazed Steel Fins 60 W/in	.315	.92	12½	8½	500	THF00321	—	—	—	—
	.315	.92	17½	13½	750	THF00322	THF00323	THF00324	—	—
	.315	.92	20½	16½	1000	THE00325	THF00326	THF00327	—	—
	.315	.92	29	25	1500	THF00328	THF00329	THF00330	—	—
	.315	.92	37	33	2000	THF00331	THF00332	THF00333	—	—
	.315	.92	54	50	3000	—	THF00334	THF00335	—	—
	.315	.92	70	66	4000	—	THF00336	THF00337	—	—
.430 Dia. Steel Element 3/8 Brazed Steel Fins 80 W/in	.430	1.15	17	13	1000	—	THF00338	THF00339	THF00340	THF00341
	.430	1.15	22¾	18¾	1500	—	THF00342	THF00343	THF00344	THF00345
	.430	1.15	29	25	2000	—	THF00346	THF00347	THF00348	THF00349
	.430	1.15	41	37	3000	—	THF00350	THF00351	THF00352	THF00353
	.430	1.15	53	49	4000	—	THF00354	THF00355	THF00356	THF00357
	.430	1.15	65	61	5000	—	THF00358	THF00359	THF00360	THF00361
	.430	1.15	77½	73½	6000	—	THF00362	THF00363	THF00364	THF00365
.475 Dia. SS Element 3/8 SS Fins 90 W/in	.475	1.21	21½	17½	1500	—	THF00366	THF00367	THF00368	THF00369
	.475	1.21	26½	22½	2000	—	THF00370	THF00371	THF00372	THF00373
	.475	1.21	37	33	3000	—	THF00374	THF00375	THF00376	THF00377
	.475	1.21	48	44	4000	—	THF00378	THF00379	THF00380	THF00381
	.475	1.21	59	55	5000	—	THF00382	THF00383	THF00384	THF00385
	.475	1.21	70	66	6000	—	THF00386	THF00387	THF00388	THF00389
	.475	1.21	81	77	7000	—	THF00390	THF00391	THF00392	THF00393
	.475	1.21	92	88	8000	—	THF00394	THF00395	THF00396	THF00397

.315 diameter elements are typically used for air heating from ambient to 250/275°F at a minimum airflow of 700 FPM.

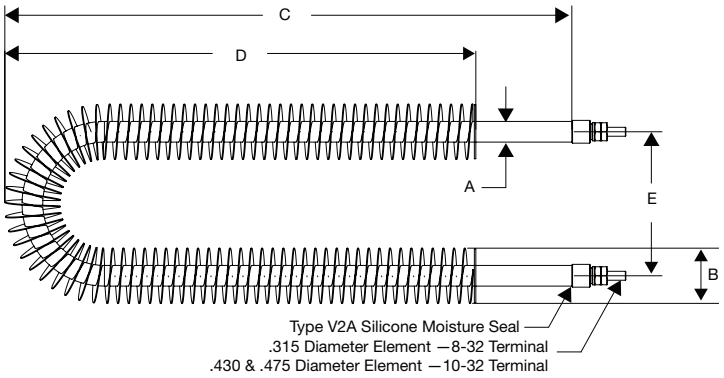
Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows

.430 diameter elements are typically used for air heating from ambient to 275/300°F at a minimum airflow of 750 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows.

.475 diameter elements are typically used for air heating from ambient to 450/500°F at a minimum airflow of 1400 FPM.

Maximum sheath temperature is 1200°F. Reduced sheath watt density (wsi) required for lower airflows.



Standard (Non-Stock) Sizes and Ratings with Type T Termination

62-64 Sheath Watt Density (wsi)

Element Description	Dim. "A" inches	Dim. "B" inches	Dim. "C" inches	Dim. "D" inches	Dim. "E" inches	Watts	Part Number 120V	208V	240V	277V	480V
.315 Dia. Steel Element 5/16 Brazed Steel Fins 60 W/in	.315	.92	8¾	6¾	2	750	THF00398	THF00399	THF00400	—	—
	.315	.92	10¾	8¾	2	1000	THF00401	THF00402	THF00403	—	—
	.315	.92	14¾	12¾	2	1500	THE00404	THF00405	THF00406	—	—
	.315	.92	18½	16½	2	2000	THF00407	THF00408	THF00409	—	—
	.315	.92	26½	24½	2	3000	THF00410	THF00411	THF00412	—	—
	.315	.92	34½	32½	2	4000	—	THF00414	THF00415	—	—
	.315	.92	43	41	2	5000	—	THF00417	THF00418	—	—
.430 Dia. Steel Element 3/8 Brazed Steel Fins 80 W/in	.430	1.15	8½	6½	2	1000	—	THF00419	THF00420	THF00421	THF00422
	.430	1.15	11½	9½	2	1500	—	THF00423	THF00424	THF00425	THF00426
	.430	1.15	14½	12½	2	2000	—	THF00427	THF00428	THF00429	THF00430
	.430	1.15	21	19	2	3000	—	THF00431	THF00432	THF00433	THF00434
	.430	1.15	27	25	2	4000	—	THF00435	THF00436	THF00437	THF00438
	.430	1.15	32½	31	2	5000	—	THF00439	THF00440	THF00441	THF00442
	.430	1.15	39½	37½	2	6000	—	THF00443	THF00444	THF00445	THF00446
.475 Dia. SS Element 3/8 SS Fins 90 W/in	.475	1.21	10½	8½	2½	1500	—	THF00447	THF00448	THF00449	THF00450
	.475	1.21	13¼	11¼	2½	2000	—	THF00451	THF00452	THF00453	THF00454
	.475	1.21	18½	16½	2½	3000	—	THF00455	THF00456	THF00457	THF00458
	.475	1.21	24	22	2½	4000	—	THF00459	THF00460	THF00461	THF00462
	.475	1.21	29½	27½	2½	5000	—	THF00463	THF00464	THF00465	THF00466
	.475	1.21	35	33	2½	6000	—	THF00467	THF00468	THF00469	THF00470
	.475	1.21	40½	38½	2½	7000	—	THF00471	THF00472	THF00473	THF00474
	.475	1.21	46	44	2½	8000	—	—	THF00475	THF00476	THF00477

.315 diameter elements are typically used for air heating from ambient to 250/275°F at a minimum airflow of 700 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows

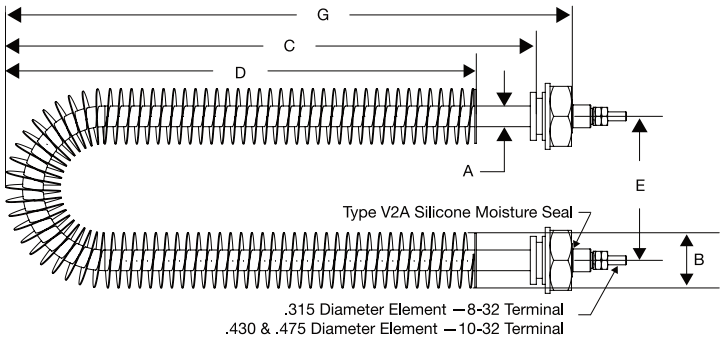
.430 diameter elements are typically used for air heating from ambient to 275/300°F at a minimum airflow of 750 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows.

.475 diameter elements are typically used for air heating from ambient to 450/500°F at a minimum airflow of 1400 FPM.

Maximum sheath temperature is 1200°F. Reduced sheath watt density (wsi) required for lower airflows.

Finned Tubular Heaters



Standard (Non-Stock) Sizes and Ratings with Type T Termination

62-64 Sheath Watt Density (wsi)

Element Description	Dim. "A" inches	Dim. "B" inches	Dim. "C" inches	Dim. "D" inches	Dim. "E" inches	Dim. "G" inches	Watts	Part Number 120V	208V	240V	277V	480V
	.315	.92	8¼	6¾	2	8¾	750	THF00478	THF00479	THF00480	—	—
.315 Dia.	.315	.92	10¼	8¾	2	10¾	1000	THF00481	THF00482	THF00483	—	—
Steel Element	.315	.92	14¼	12¾	2	14¾	1500	THE00484	THF00485	THF00486	—	—
5/16 Brazed	.315	.92	18	16½	2	18½	2000	THF00487	THF00488	THF00489	—	—
Steel Fins	.315	.92	26	24½	2	26½	3000	THF00490	THF00491	THF00492	—	—
60 W/in	.315	.92	34	32½	2	34½	4000	—	THF00493	THF00494	—	—
	.315	.92	42½	41	2	43	5000	—	THF00495	THF00496	—	—
	.430	1.15	7¾	6½	2	8½	1000	—	THF00497	THF00498	THF00499	THF00500
.430 Dia.	.430	1.15	10¾	9½	2	11½	1500	—	THF00501	THF00502	THF00503	THF00504
Steel Element	.430	1.15	13¾	12½	2	14½	2000	—	THF00505	THF00506	THF00507	THF00508
3/8 Brazed	.430	1.15	20¼	19	2	21	3000	—	THF00509	THF00510	THF00511	THF00512
Steel Fins	.430	1.15	26¼	25	2	27	4000	—	THF00513	THF00514	THF00515	THF00516
80 W/in	.430	1.15	32¼	31	2	33	5000	—	THF00517	THF00518	THF00519	THF00520
	.430	1.15	38¾	37½	2	39½	6000	—	THF00521	THF00522	THF00523	THF00524
	.475	1.21	9¾	8½	2½	10½	1500	—	THF00525	THF00526	THF00527	THF00528
	.475	1.21	12½	11¼	2½	13¼	2000	—	THF00529	THF00530	THF00531	THF00532
.475 Dia.	.475	1.21	17¾	16½	2½	18½	3000	—	THF00533	THF00534	THF00535	THF00536
SS Element	.475	1.21	23¼	22	2½	24	4000	—	THF00537	THF00538	THF00539	THF00540
3/8 SS Fins	.475	1.21	28¾	27½	2½	29½	5000	—	THF00541	THF00542	THF00543	THF00544
90 W/in	.475	1.21	34¼	33	2½	35	6000	—	THF00545	THF00546	THF00547	THF00548
	.475	1.21	39¾	38½	2½	40½	7000	—	THF00549	THF00550	THF00551	THF00552
	.475	1.21	45¼	44	2½	46	8000	—	—	THF00553	THF00554	THF00555

.315 diameter elements are typically used for air heating from ambient to 250/275°F at a minimum airflow of 700 FPM.

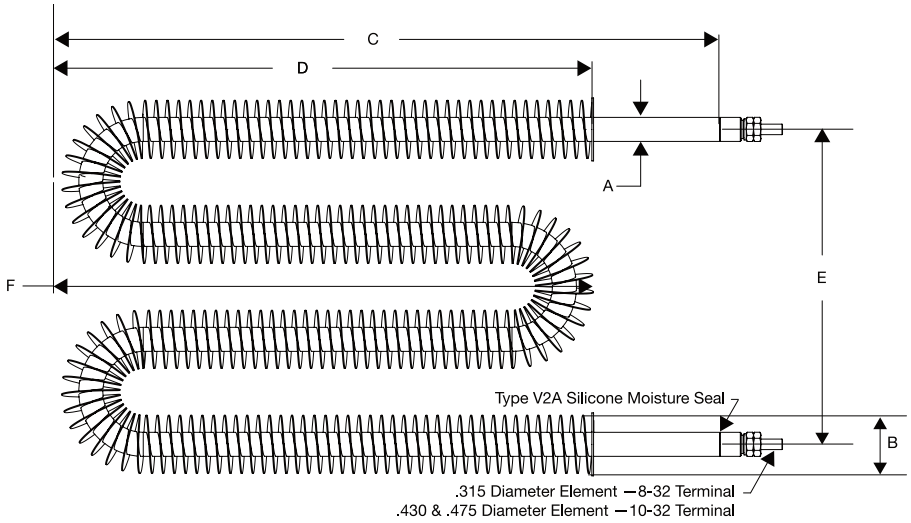
Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows

.430 diameter elements are typically used for air heating from ambient to 275/300°F at a minimum airflow of 750 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows.

.475 diameter elements are typically used for air heating from ambient to 450/500°F at a minimum airflow of 1400 FPM.

Maximum sheath temperature is 1200°F. Reduced sheath watt density (wsi) required for lower airflows.



Standard (Non-Stock) Sizes and Ratings with Type T Termination

62-64 Sheath Watt Density (wsi)

Element Description	Dim. "A" inches	Dim. "B" inches	Dim. "C" inches	Dim. "D" inches	Dim. "E" inches	Dim. "F" inches	Watts	Part Number 120V	208V	240V	277V	480V
.315 Dia. Steel Element 5/16 Brazed Steel Fins 60 W/in	.315	.92	6¼	4¼	6	4¼	1000	THF00556	THF00557	THF00558	—	—
	.315	.92	8¼	6¼	6	6¼	1500	THF00559	THF00560	THF00561	—	—
	.315	.92	10¼	8¼	6	8¼	2000	THE00562	THF00563	THF00564	—	—
	.315	.92	14¼	12¼	6	12¼	3000	THF00565	THF00466	THF00567	—	—
	.315	.92	18¼	16¼	6	16¼	4000	THF00568	THF00569	THF00570	—	—
	.315	.92	22¼	20¼	6	20¼	5000	—	THF00571	THF00572	—	—
	.315	.92	24¼	24¼	6	24¼	6000	—	THF00573	THF00574	—	—
.430 Dia. Steel Element 3/8 Brazed Steel Fins 80 W/in	.430	1.15	8	6	7.5	6	2000	—	THF00575	THF00576	THF00577	THF00578
	.430	1.15	11	9	7.5	9	3000	—	THF00579	THF00580	THF00581	THF00582
	.430	1.15	14	12	7.5	12	4000	—	THF00583	THF00584	THF00585	THF00586
	.430	1.15	17	15	7.5	15	5000	—	THF00587	THF00588	THF00589	THF00590
	.430	1.15	20	18	7.5	18	6000	—	THF00591	THF00592	THF00593	THF00594
	.430	1.15	23	21	7.5	21	7000	—	THF00595	THF00596	THF00597	THF00598
	.430	1.15	26	24	7.5	24	8000	—	—	THF00599	THF00600	THF00601
.475 Dia. SS Element 3/8 SS Fins 90 W/in	.475	1.21	7½	5½	9	5½	2000	—	THF00602	THF00603	THF00604	THF00605
	.475	1.21	10	8	9	8	3000	—	THF00606	THF00607	THF00608	THF00609
	.475	1.21	12½	10½	9	10½	4000	—	THF00610	THF00611	THF00612	THF00613
	.475	1.21	15½	13½	9	13½	5000	—	THF00614	THF00615	THF00616	THF00617
	.475	1.21	18	16	9	16	6000	—	THF00618	THF00619	THF00620	THF00621
	.475	1.21	21	19	9	19	7000	—	THF00622	THF00623	THF00624	THF00625
	.475	1.21	24	22	9	22	8000	—	—	THF00626	THF00627	THF00628

.315 diameter elements are typically used for air heating from ambient to 250/275°F at a minimum airflow of 700 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows

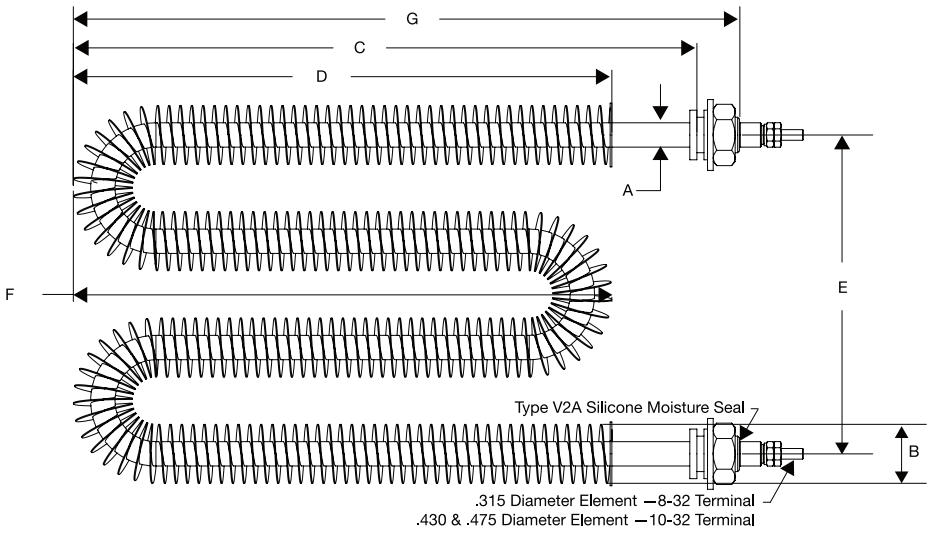
.430 diameter elements are typically used for air heating from ambient to 275/300°F at a minimum airflow of 750 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows.

.475 diameter elements are typically used for air heating from ambient to 450/500°F at a minimum airflow of 1400 FPM.

Maximum sheath temperature is 1200°F. Reduced sheath watt density (wsi) required for lower airflows.

Finned Tubular Heaters



Standard (Non-Stock) Sizes and Ratings with Type T Termination

62-64 Sheath Watt Density (wsi)

Element Description	Dim. "A" inches	Dim. "B" inches	Dim. "C" inches	Dim. "D" inches	Dim. "E" inches	Dim. "F" inches	Dim. "G"	Watts	Part Number 120V	208V	240V	277V	480V
.315 Dia. Steel Element 5/16 Brazed Steel Fins 60 W/in	.315	.92	5¾	4¼	6	4¼	6¼	1000	THF00629	THF00630	THF00631	—	—
	.315	.92	7¾	6¼	6	6¼	8¼	1500	THF00632	THF00633	THF00634	—	—
	.315	.92	9¾	8¼	6	8¼	10¼	2000	THE00635	THF00636	THF00637	—	—
	.315	.92	13¾	12¼	6	12¼	14¼	3000	THF00638	THF00639	THF00640	—	—
	.315	.92	17¾	16¼	6	16¼	18¼	4000	THF00641	THF00642	THF00643	—	—
	.315	.92	21¾	20¼	6	20¼	22¼	5000	—	THF00644	THF00645	—	—
	.315	.92	25¾	24¼	6	24¼	26¼	6000	—	THF00646	THF00647	—	—
.430 Dia. Steel Element 3/8 Brazed Steel Fins 80 W/in	.430	1.15	7¼	6	7.5	6	8	2000	—	THF00648	THF00649	THF00650	THF00651
	.430	1.15	10¼	9	7.5	9	11	3000	—	THF00652	THF00653	THF00654	THF00655
	.430	1.15	13¼	12	7.5	12	14	4000	—	THF00656	THF00657	THF00658	THF00659
	.430	1.15	16¼	15	7.5	15	17	5000	—	THF00660	THF00661	THF00662	THF00663
	.430	1.15	19¼	18	7.5	18	20	6000	—	THF00664	THF00665	THF00666	THF00667
	.430	1.15	22¼	21	7.5	21	23	7000	—	THF00668	THF00669	THF00670	THF00671
	.430	1.15	25¼	24	7.5	24	26	8000	—	—	THF00672	THF00673	THF00674
.475 Dia. SS Element 3/8 SS Fins 90 W/in	.475	1.21	6¾	5½	9	5½	7½	2000	—	THF00675	THF00676	THF00677	THF00678
	.475	1.21	9¼	8	9	8	10	3000	—	THF00679	THF00680	THF00681	THF00682
	.475	1.21	11¾	10½	9	10½	12½	4000	—	THF00683	THF00684	THF00685	THF00686
	.475	1.21	14¾	13½	9	13½	15½	5000	—	THF00687	THF00688	THF00689	THF00690
	.475	1.21	17¼	16	9	16	18	6000	—	THF00691	THF00692	THF00693	THF00694
	.475	1.21	20¼	19	9	19	21	7000	—	THF00695	THF00696	THF00697	THF00698
	.475	1.21	23¼	22	9	22	24	8000	—	—	THF00699	THF00700	THF00701

.315 diameter elements are typically used for air heating from ambient to 250/275°F at a minimum airflow of 700 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows

.430 diameter elements are typically used for air heating from ambient to 275/300°F at a minimum airflow of 750 FPM.

Maximum sheath temperature is 750°F. Reduced sheath watt density (wsi) required for lower airflows.

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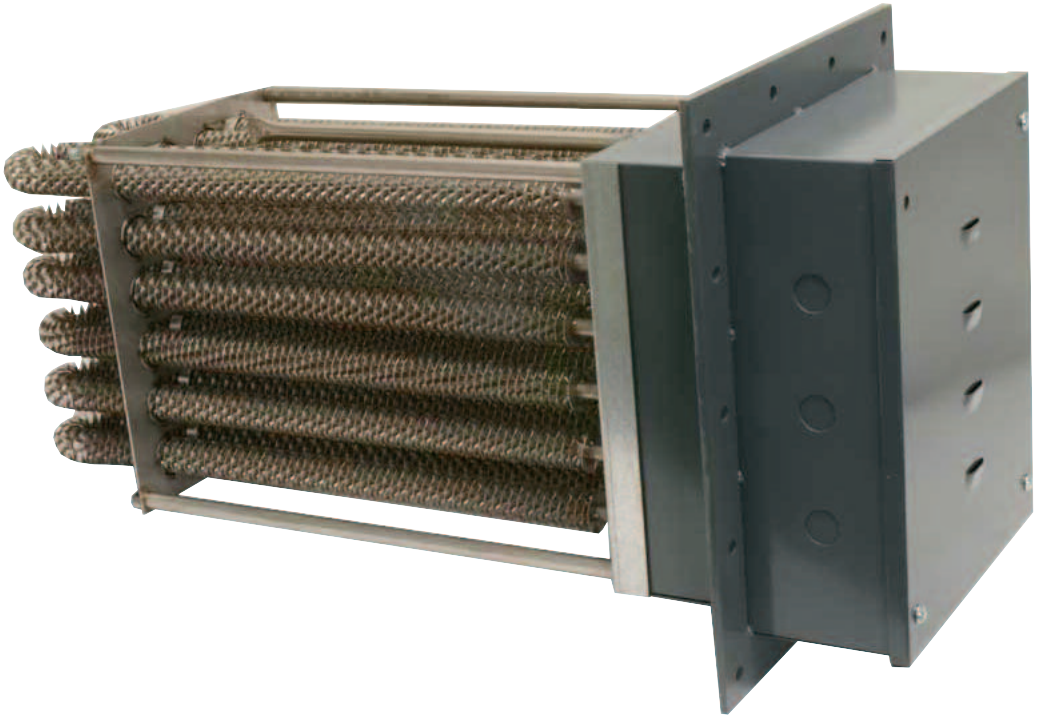
Maximum sheath temperature is 1200°F. Reduced sheath watt density (wsi) required for lower airflows.

Finned Duct Heaters can be found on Page 11-113A and 11-113B



Single-Ended Tubular Heaters

The Single-Ended Tubular Heater manufacturing and design process is similar to that of the double ended tubular heater. Single ended tubular heaters are made strictly per customer request, providing an economical alternative to cartridge heater applications, simplifying wiring and installation for applications requiring localized heat. Flanges, bulkhead and NPT fittings can be attached to the sheath for mounting or immersion heating applications.

Specifications

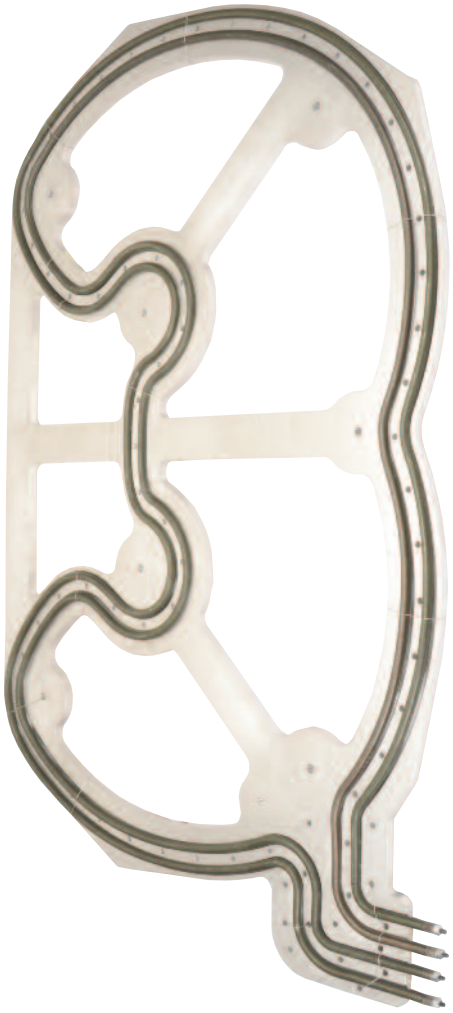
Diameters: .315" .430" .475".490", .625"
Material: 304SS, 316SS, Monel, Steel
Min. Sheath Length: 11" **Max. Sheath Length:** 96"
Termination: Lead Wires
Max. Volts: 277 Vac **Max. Amperage:** 30 Amp

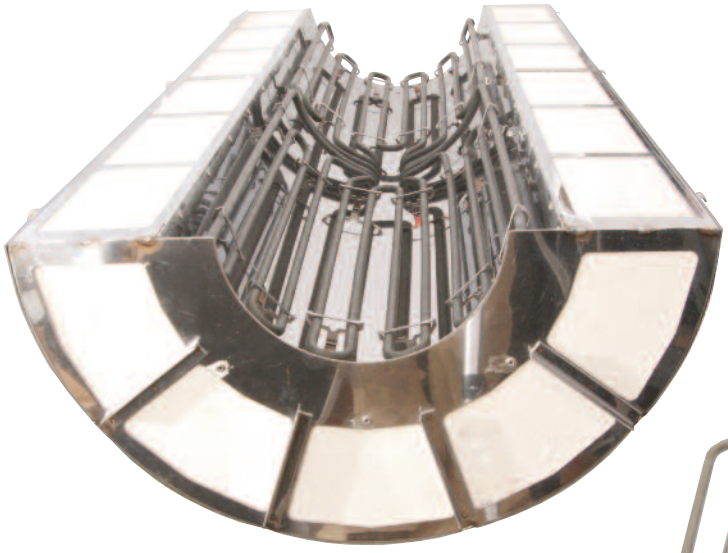
Ordering Information Single-Ended Tubular Heaters

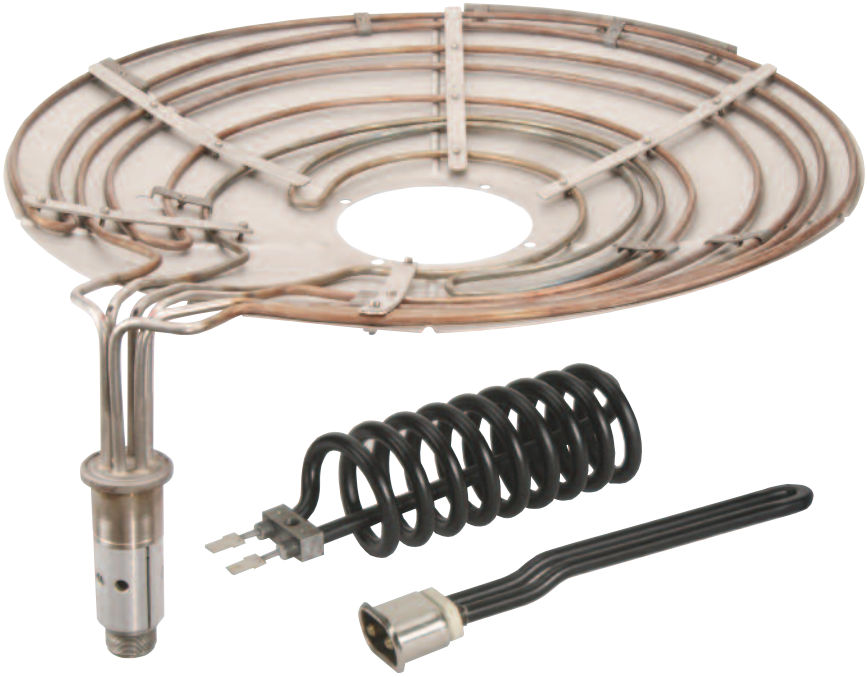
Please Specify the following:

- ❑ Sheath Material and Diameter
- ❑ Heater Length and Cold Ends
- ❑ Bulkhead Fittings
- ❑ Wattage and Voltage
- ❑ Terminations and Seals
- ❑ Mounting Flange

The Tubular Heater — The Most Customizable Electric Heating Element







Type ART Tubular Radiant Heater Arrays

Tempco can design and manufacture a custom tubular heater array for applications requiring infrared heat. Call for details.

Other type infrared heaters can be found in Section 7.

Quote Request

Tubular Heater, Finned Tubular Heater and Single Ended Tubular Heater Quote Request

Made-To-Order Quote Request Form — Copy and Fax (630-350-0232) us your requirements.

Customer Drawing

Name _____
Company _____
Address _____
_____
_____
Phone _____ **Fax** _____
Email _____

Application Information

Describe in Detail _____
_____
_____
Air or Immersion _____
Maximum Load Temperature _____
Quantity _____

Specifications

Type: Standard _____ Finned _____ Single Ended _____
Sheath Material _____
Diameter _____ **Fin Dia.** ***if applies*** _____
Overall Sheath Length _____
Cold Section: 1st end _____ 2nd end _____
Watts _____ **Volts** _____
UL _____ **cUL** _____ **CSA** _____ **CE** _____
Termination Type _____ ***(Type T – standard screw)***
Standard Options _____

Mounting: MC ___ LR ___ Location: _____ MF ___
Bulkhead Fittings ___ Material ___ Flange Type ___
Describe if Custom _____
_____

Moisture Seals

Moisture Seals: None ____
Optional: Style SS: Type V2A____ Type V2B____
Style SER: Type R ____ Type R1 ____
Style SEH: Type V ____ Type V1 ____
Type M ____ Type H ____
Describe if Custom _____
_____
_____

Optional Sheath Surface Treatments

(For Incoloy® and Stainless Steel Sheath Elements only)
Passivation _____ **Bright Annealing** _____
Electro-Polishing _____
Other _____
_____
_____

Bends and Shapes

Standard Formation Code _____
Specify Letters and Corresponding Dimensions Below:
__ _____ __ _____ __ _____ __ _____ __ _____ __ _____
__ _____ __ _____ __ _____ __ _____ __ _____ __ _____
__ _____ __ _____ __ _____ __ _____ __ _____ __ _____
Number of Bends ***if known***
Single/Multiple _____ Plane _____
Coils/Turns _____ Dia. _____
Circle: Full ___ Dia. ___ Partial ___ Degree ___
Describe if Custom: _____
_____
_____
_____

View Product Inventory @ www.tempco.com