

# Reference Data



## Tubular Elements and Assembly Selection Guide

The following two charts will help you select an appropriate heater based on your application and watt density restrictions. These charts are application driven. The total wattage required by your application should be known before selecting a specific heater type(s) from the stock tables. If your required wattage is not known, please contact your Watlow representative.

Once the heater type has been identified, turn to the appropriate product section for information on the element or assembly.

### Element and Assembly Selection Guide

To identify the tubular heater type best suited to your application, consult the *Element and Assembly Selection Guide*.

In most cases Watlow recommends using single tubular heating elements for low kilowatt applications.

Assemblies are better suited for large kilowatt applications to heat liquids, air or gases.

When selecting a heater according to watt density, be sure to consider the following:

- Liquid viscosity at start up and at process temperature
- Operating temperature
- Chemical composition

Under the “**Heating Method**” column in the *Element and Assembly Selection Guide* locate the method that applies to your application to find the recommended “Heater Type.”

After identifying the heater type(s) suitable for your application, refer to the *Supplemental Applications Chart* for further application data. This chart will assist you in selecting the appropriate watt density and sheath material for your specific application. It also presents the performance characteristics for both WATROD and FIREBAR elements.

### Element and Assembly Selection Guide

Application	Heating Method	Heater Type
<b>Liquids:</b>		
Acids	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, flange and pipe insert
Caustic soda 12% concentrate 10% concentrate 75% concentrate	Direct immersion (circulating/non-circulating)	WATROD, screw plug, square flange, flange, circulation and pipe insert
Degreasing solutions	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, square flange, flange and pipe insert
Electroplating	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, square flange, flange and pipe insert
Ethylene glycol 50% concentrate 100% concentrate	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, flange, circulation, booster and engine preheater
Oils Asphalt Fuel oils Light grades 1 and 2 Medium grades 4 and 5 Heavy grade 6 and Bunker C Heat transfer Lubricating SAE 10, 20, 30 SAE 40, 50 API STD 614 Vegetable (cooking)	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, square flange, flange, circulation, booster and pipe insert
Paraffin or wax	Direct immersion (circulating/non-circulating)	FIREBAR, WATROD, screw plug, square flange, flange, over-the-side, drum and pipe insert

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## Tubular Elements and Assembly Selection Guide

### Element and Assembly Selection Guide (Continued)

Application	Heating Method	Heater Type
Water Clean Deionized Demineralized Potable Process	Direct immersion (circulating/non-circulating)	FIREBAR (non-process water only) WATROD, screw plug, screw plug with control assembly, square flange, flange, circulation, booster, engine preheater and pipe insert
<b>Air:</b>	Direct (forced or natural convection)	FIREBAR, WATROD, FINBAR, WATROD enclosure heater, screw plug, flange, circulation and duct
<b>Gas:</b> Hydrocarbons, Nitrogen, Oxygen Ozone, Steam	Direct (forced convection)	FIREBAR, WATROD, screw plug, flange and circulation
<b>Molten Materials:</b> Aluminum Lead Salt Solder	Indirect (radiant) Direct (non-circulating) Direct (non-circulating) Direct (non-circulating)	WATROD FIREBAR and WATROD FIREBAR and WATROD FIREBAR and WATROD
<b>Surface Heating:</b> Dies, griddles, molds, platens	Direct	FIREBAR and WATROD

### Supplemental Applications Chart

This *Supplemental Applications Chart* is provided in addition to the *Element and Assembly Selection Guide*. This chart will help you select watt density and sheath materials for either WATROD or FIREBAR heating elements according to the specific media being heated.

For example, if you are heating vegetable oil, either WATROD or FIREBAR elements at 30 and 40 W/in<sup>2</sup> respectively (4.6 and 6.2 W/cm<sup>2</sup>) with 304 stainless steel, sheath can be used.

### Supplemental Applications Chart

Heated Material	Max. Operating Temperature °F (°C)		WATROD Element		FIREBAR Element			
			Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )	Sheath Material	Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )	Sheath Material		
<b>Acid Solutions (Mild)</b>								
Acetic	180	(82)	40	(6.2)	316 SS	40	(6.2)	Alloy 800
Boric (30% max.)	257	(125)	40	(6.2)	Titanium	40	(6.2)	304 SS
Carbonic	180	(82)	40	(6.2)	Alloy 600	40	(6.2)	304 SS
Chromic	180	(82)	40	(6.2)	Titanium	N/A	N/A	N/A
Citric	180	(82)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Fatty Acids	150	(65)	20	(3.1)	316 SS	30	(4.6)	Alloy 800
Lactic	122	(50)	10	(1.6)	316 SS	N/A	N/A	N/A
Levulinic	180	(82)	40	(6.2)	Alloy 600	40	(6.2)	304 SS
Malic	122	(50)	10	(1.6)	316 SS	16	(2.5)	Alloy 800
Nitric (30% max.)	167	(75)	20	(3.1)	316 SS	30	(4.6)	Alloy 800
Phenol—2-4								
Disulfonic	180	(82)	40	(6.2)	316 SS	40	(6.2)	Alloy 800
Phosphoric	180	(82)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Phosphoric (Aerated)	180	(82)	23	(3.6)	304 SS	30	(4.6)	304 SS

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# Reference Data



## Tubular Elements and Assembly Selection Guide

### Supplemental Applications Chart (Continued)

Heated Material	Max. Operating Temperature °F (°C)		WATROD Element		FIREBAR Element			
			Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )		Sheath Material	Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )		Sheath Material
Proponic (10% max.)	180	(82)	40	(6.2)	Alloy 800	40	(6.2)	304 SS
Tannic	167/180	(75/82)	23/40	(3.6/6.2)	Steel/304 SS	40	(6.2)	304 SS
Tartaric	180	(82)	40	(6.2)	316 SS	40	(6.2)	Alloy 800
Acetaldehyde	180	(82)	10	(1.6)	Alloy 800	16	(2.4)	Alloy 800
Acetone	130	(54)	10	(1.6)	304 SS	16	(2.4)	304 SS
Air			①	①	Alloy 800	①	①	Alloy 800
Alcyl alcohol	200	(93)	10	(1.6)	Alloy 800	16	(2.4)	Alloy 800
Alkaline solutions	212	(100)	40	(6.2)	Steel	48	(7.4)	304 SS
Aluminum acetate	122	(50)	10	(1.6)	316 SS	16	(2.5)	Alloy 800
Aluminum potassium sulfate	212	(100)	40	(6.2)	Alloy 800	N/A	N/A	N/A
Ammonia gas	①	①	①	①	Steel	①	①	304 SS
Ammonium acetate	167	(75)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Amyl acetate	240	(115)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Amyl alcohol	212	(100)	20	(3.1)	304 SS	30	(4.6)	304 SS
Aniline	350	(176)	23	(3.6)	304 SS	30	(4.6)	304 SS
Asphalt	200-500	(93-260)	4-10	(0.6 - 1.6)	Steel	6-12	(0.9 - 1.8)	304 SS
Barium hydroxide	212	(100)	40	(6.2)	316 SS	40	(6.2)	Alloy 800
Benzene, liquid	150	(65)	10	(1.6)	Alloy 800	16	(2.5)	304 SS
Butyl acetate	225	(107)	10	(1.6)	316 SS	16	(2.5)	Alloy 800
Calcium bisulfate	400	(204)	20	(3.1)	316 SS	N/A	N/A	N/A
Calcium chloride	200	(93)	5-8	(0.8 - 1.2)	Alloy 600	N/A	N/A	N/A
Carbon monoxide	—	—	①	①	Alloy 800	①	①	Alloy 800
Carbon tetrachloride	160	(71)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Caustic soda:								
2%	210	(98)	48	(7.4)	Alloy 800	—	—	Contact Watlow
10% concentrate	210	(98)	23	(3.6)	Alloy 800	—	—	Contact Watlow
75%	180	(82)	23	(3.6)	Alloy 800	—	—	Contact Watlow
Citric juices	185	(85)	23	(3.6)	Alloy 800	30	(4.6)	Alloy 800
Degreasing solution	275	(135)	23	(3.6)	Steel	30	(4.6)	304 SS
Dextrose	212	(100)	20	(3.1)	304 SS	30	(4.6)	304 SS
Dyes and pigments	212	(100)	23	(3.6)	304 SS	30	(4.6)	304 SS

#### Electroplating Baths:

Cadmium	180	(82)	40	(6.2)	304 SS	40	(6.2)	304 SS
Alloy 800	180	(82)	40	(6.2)	316 SS	N/A	N/A	N/A
Dilute cyanide	180	(82)	40	(6.2)	316 SS	N/A	N/A	N/A
Rochelle cyanide	180	(82)	40	(6.2)	316 SS	N/A	N/A	N/A
Sodium cyanide	180	(82)	40	(6.2)	316 SS	N/A	N/A	N/A
Potassium cyanide	180	(82)	40	(6.2)	316 SS	40	(6.2)	304 SS
Ethylene glycol	300	(148)	30	(4.6)	Steel	40	(6.2)	304 SS
Formaldehyde	180	(82)	10	(1.6)	304 SS	16	(2.5)	304 SS
Freon® gas	300	(148)	2-5	(0.3 - 0.8)	Steel			304 SS
Gasoline	300	(148)	23	(3.6)	Steel	30	(4.6)	304 SS

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① Contact your Watlow representative.



## Tubular Elements and Assembly Selection Guide

### Supplemental Applications Chart (Continued)

Heated Material	Max. Operating Temperature °F (°C)		WATROD Element			FIREBAR Element		
			Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )		Sheath Material	Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )		Sheath Material
Gelatin liquid	150	(65)	23	(3.6)		304 SS	30	
Gelatin solid	150	(65)	5	(0.8)	304 SS	7	(1.0)	304 SS
Glycerin	500	(260)	10	(1.6)	Alloy 800	12	(1.9)	304 SS
Glycerol	212	(100)	23	(3.6)	Alloy 800	30	(4.6)	304 SS
Grease:								
Liquid	—	—	23	(3.6)	Steel	30	(4.6)	304 SS
Solid	—	—	5	(0.8)	Steel	7	(1.0)	304 SS
Hydrazine	212	(100)	16	(2.5)	304 SS	20	(3.1)	304 SS
Hydrogen	①	①	—	—	Alloy 800	①	①	Alloy 800
Hydrogen chloride	①	①	—	—	Alloy 600	①	①	N/A
Hydrogen sulfide	①	①	—	—	316 SS (heavy wall)	①	①	N/A
Magnesium chloride	212	(100)	40	(6.2)	Alloy 600	40	(6.2)	Alloy 800
Magnesium sulfate	212	(100)	40	(6.2)	304 SS	40	(6.2)	304 SS
Magnesium sulfate	212	(100)	40	(6.2)	316 SS	40	(6.2)	304 SS
Methanol gas	①	①	—	—	304 SS	①	①	304 SS
Methylamine	180	(82)	20	(3.1)	Alloy 600	30	(4.6)	304 SS
Methylchloride	180	(82)	20	(3.1)	Alloy 800	N/A	N/A	N/A
Molasses	100	(37)	4-5	(0.6 - 0.8)	304 SS	5-8	(0.8 - 1.2)	304 SS
Molten salt bath	800-900	(426-482)	25-30	(3.8 - 4.6)	Alloy 400	N/A	N/A	N/A
Naphtha	212	(100)	10	(1.6)	Steel	16	(2.5)	304 SS

### Oils

Fuel oils:								
Grades 1 and 2 (distillate)	200	(93)	23	(3.6)	Steel	30	(4.6)	304 SS
Grades 4 and 5 (residual)	200	(93)	13	(2.0)	Steel	16	(2.5)	304 SS
Grades 6 and Bunker C (residual)	160	(71)	8	(1.2)	Steel	10	(1.6)	304 SS
Heat transfer oils: ②								
Static	500	(260)	16	(2.5)	Steel	23	(3.6)	304 SS
	600	(315)	10	(1.6)	Steel	16	(2.5)	304 SS
Circulating	500	(260)	23	(3.6)	Steel	30	(4.6)	304 SS
	600	(315)	15	(2.3)	Steel	20	(3.1)	304 SS
Lubrication oils:								
SAE 10, 90-100 SSU @ 130°F	250	(121)	23	(3.6)	Steel	30	(4.6)	304 SS
SAE 20, 120-185 SSU @ 130°F	250	(121)	23	(3.6)	Steel	30	(4.6)	304 SS
SAE 30, 185-255 SSU @ 130°F	250	(121)	23	(3.6)	Steel	30	(4.6)	304 SS
SAE 40, -80 SSU @ 210°F	250	(121)	13	(2.0)	Steel	18	(2.7)	304 SS
SAE 50, 80-105 SSU @ 210°F	250	(121)	13	(2.0)	Steel	18	(2.7)	304 SS

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① Contact your Watlow representative.

② Maximum operating temperatures and watt densities are detailed in *Heat Transfer Oil* charts on page 555.



## Tubular Elements and Assembly Selection Guide

### Supplemental Applications Chart (Continued)

Heated Material	Max. Operating Temperature °F (°C)		WATROD Element		FIREBAR Element			
			Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )	Sheath Material	Max. Watt Density W/in <sup>2</sup> (W/cm <sup>2</sup> )	Sheath Material		
Miscellaneous oils:								
Draw bath	600	(315)	23	(3.6)	Steel	30	(4.6)	304 SS
Hydraulic	—	—	15	③ (2.3)	Steel	15	③ (2.3)	304 SS
Linseed	150	(65)	50	(7.7)	Steel	60	(9.3)	304 SS
Mineral	200	(93)	23	(3.6)	Steel	30	(4.6)	304 SS
	400	(204)	16	(2.5)	Steel	23	(3.6)	304 SS
Vegetable/shortening	400	(204)	30	(4.6)	304 SS	40	(6.2)	304 SS
Paraffin or wax (liquid)	150	(65)	16	(2.4)	Steel	20	(3.1)	304 SS
Perchloroethylene	200	(93)	23	(3.6)	Steel	30	(4.6)	304 SS
Potassium chlorate	212	(100)	40	(6.2)	316 SS	N/A	N/A	N/A
Potassium chloride	212	(100)	40	(6.2)	316 SS	N/A	N/A	N/A
Potassium hydroxide	160	(71)	23	(3.6)	Alloy 400	N/A	N/A	N/A
Soap, liquid	212	(100)	20	(3.1)	304 SS	30	(4.6)	304 SS
Sodium acetate	212	(100)	40	(6.2)	Steel	50	(7.7)	304 SS
Sodium cyanide	140	(60)	40	(6.2)	Alloy 800	50	(7.7)	Alloy 800
Sodium hydride	720	(382)	28	(4.3)	Alloy 800	36	(5.5)	Alloy 800
Sodium hydroxide	—	—	—	—	See Caustic Soda	—	—	—
Sodium phosphate	212	(100)	40	(6.2)	Alloy 800	50	(7.7)	304 SS
Steam, flowing	300	(148)	10	(1.6)	Alloy 800	①	①	Alloy 800
	500	(260)	5-10	(0.8-1.6)	Alloy 800	①	①	Alloy 800
	700	(371)	5	(0.8)	Alloy 800	①	①	Alloy 800
Sulfur, molten	600	(315)	10	(1.6)	Alloy 800	12	(1.8)	Alloy 800
Toluene	212	(100)	23	(3.6)	Steel	30	(4.6)	304 SS
Trichlorethylene	150	(65)	23	(3.6)	Steel	30	(4.6)	304 SS
Turpentine	300	(148)	20	(3.1)	304 SS	25	(3.8)	304 SS

#### Water

Clean	212	(100)	60	(9.3)	Alloy 800	45	(7)	Alloy 800
Deionized	212	(100)	60	(9.3)	316 SS (passivated)	90	(14)	Alloy 800
Demineralized	212	(100)	60	(9.3)	316 SS (passivated)	90	(14)	Alloy 800
Potable	212	(100)	60	(9.3)	Alloy 800	45	(7)	Alloy 800
Process	212	(100)	48	(9.3)	Alloy 800			Contact Watlow

① Contact your Watlow representative.

③ Per API standards.