

Watt Density & Sheath Selection

Watt Density – Watt density is one of the most critical factors affecting element life. Watt density, expressed in watts per square inch of heater surface area, determines the heater operating temperature for a given set of conditions. The sheath temperature of an electric heating element should be limited to provide a reasonable heater life and to avoid possible damage of the medium being heated. We can estimate the sheath temperature or select the appropriate watt density based on the charts and tables provided.

Watt density is calculated as follows:

Watt Density = element wattage/3.14 x element diameter (inches) x heated length (inches)

An example is:

An 8 kW flange heater has three 0.475" diameter elements with a "B" dimension of 47 inches and a 2 inch cold end. The watt density is:

$$\begin{aligned} 0.475 \times 3.14 \times (47 \text{ in.} - 2 \text{ in.}) \times 3 \text{ (\# of elements)} \times 2 \text{ (u-bend)} &= \\ 403 \text{ in}^2 & \\ 8,000 \text{ Watts} \div 403 \text{ in}^2 &= 20 \text{ W/in}^2 \end{aligned}$$

Sheath Material – Also critically important, the sheath material must be suitable for the corrosive conditions and the extreme temperatures of the application. Copper sheathed elements are typically used for low temperature applications such as heating water and some aqueous solutions. Steel is generally used with oil heating applications. Stainless steel and INCOLOY® are used when heating corrosive solutions or high-temperature gas/air. Table I and II list the maximum recommended operating temperatures for common sheath materials.

Watt Density and Sheath Material Selection – Selecting the proper watt density and the proper sheath material is critical to heater life and, if applicable, fluid integrity. If the watt density is too high, the fluid may carbonize, break down chemically, or the elements may burn out. If the watt density is too low the heater price will be high. The greatest heater life will come from the lowest watt density practical for the application.

In general, watt density is determined by three factors:

- 1) maximum outlet temperature
- 2) type of fluid heated and
- 3) fluid flow rate

Sheath material depends on the type of fluid and maximum temperature. If the sheath material selection is incorrect, it will corrode, destroying the element

Heating Air and Other Gases – Charts A through C give maximum sheath temperatures for a range of watt densities and velocities. This data is based upon air at atmospheric pressure and a 75°F inlet air temperature. For higher inlet temperatures, the sheath temperature will increase accordingly. Contaminants in the air, while normally not affecting the sheath temperature, may require a more highly corrosion-resistant sheath and/or fin material. For heating compressed air and other gases, consult the factory or your local Heatrex representative for watt density and sheath recommendations.

Watt Density & Sheath Selection

Chart A

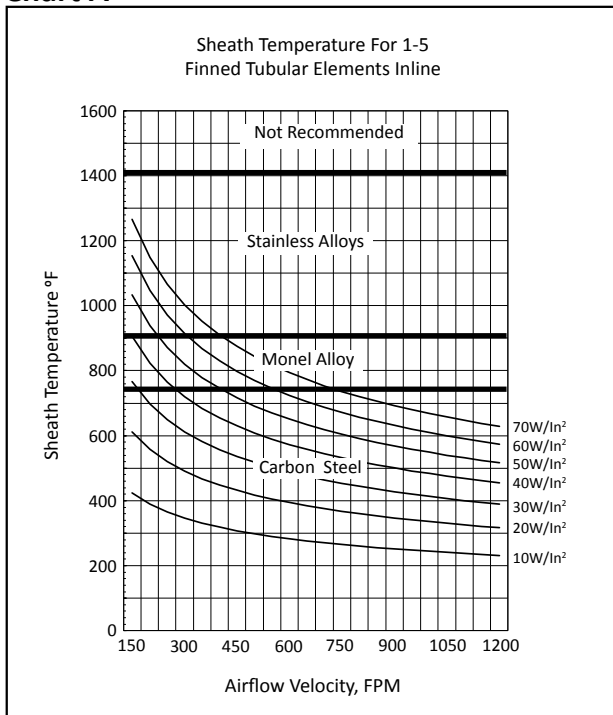


Chart B

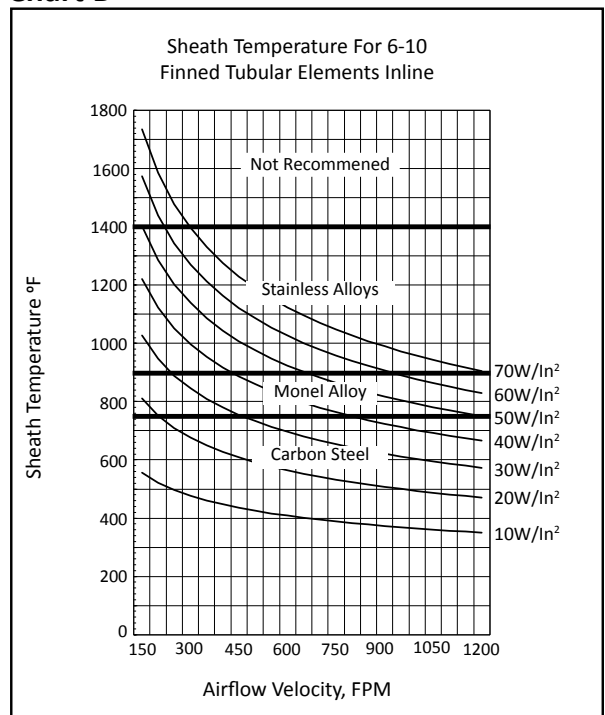
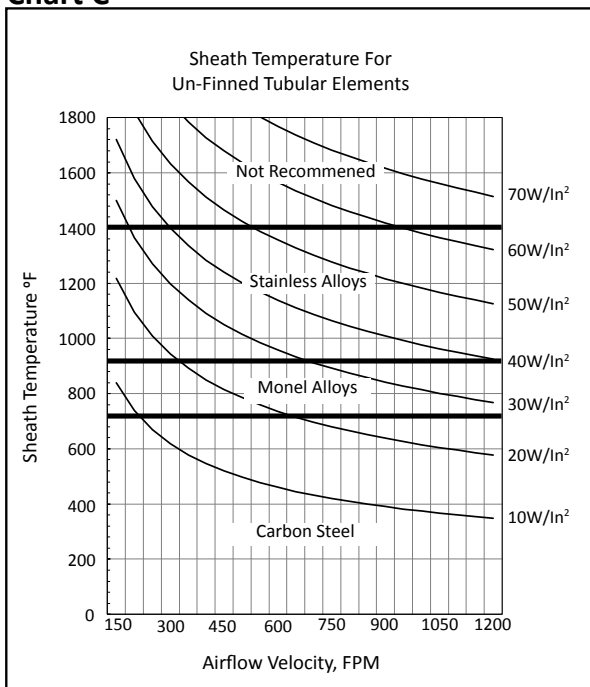


Chart C



Watt Density & Sheath Selection

Watt Density and Sheath Materials – Table III has sheath materials recommended for each fluid and temperature. Where a range of watt densities are shown, the lower end of the range represents a more conservative design.

While Table III represents our most current knowledge, many application factors are beyond our control. Thus, this table should be used only as a guide. Heatrex cannot be responsible for heater failures due to corrosion.

Table III

Legend	Sheath Material													Notes
	Max. Operating Temperature °F °C		Max. Watt Density W/In ² W/cm ²		Carbon Steel	Copper	INCONEL® 600	INCOLOY® 800	MONEL® 400	304 and 321 SS	316 SS	C276 Hastelloy®	Titanium	
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available														
Heated Material	Corrosion Rating													
Acetic Acid (100%)	100 200	38 93	30-40 10-15	4.7-6.2 1.5-2.3	X	X	C	B	BC	BC	A	A	A	
Acetic Acid (50%)	100 200	38 93	50-65 20-25	7.8-10.1 3.1-3.9	X	X	X	B	B	C	A	BC	A	
Acetaldehyde	180	82	10	1.6		X	B		B	A	A	C	A	
Allyl Alcohol					B	A	A	A	A	A	A	B	B	2
Alcohol					B	A	A	A	A	B	A	B	A	2
Alcohol (Butyl)	110	43	5-7	0.8-1.1	BC	A	A	A	A	A	A	B	B	2
Alcohol (Ethyl)	100 150	38 66	5-7 3	0.8-1.1 0.5		A		A	A	B				
Alcohol (Methyl)	100 150	38 66	10-12 5	1.6-1.9 0.8		A		A	A	B				
Alkaline Cleaners			30-40	4.7-6.2						B				1
Alkaline Solutions	212	100	23	3.6	B									
Aluminum Acetate	120	49	10	1.6	X	B	B		B	AB	A	A	A	
Aluminum Chloride (Aqueous)					X	X	X	X	X	X	X	A	X	1
Aluminum Cleaners					C	X	A	A	A	A	A		B	1, 9
Aluminum Sulphate (Sat.)					X	X	X	BC	X	BC	BC	BC	A	1
Alum					X	X	BC	BC	X	X	BC	BC	A	1
Ammonia (Anhydrous)					A	X	A	C	A	B	A	A	A	
Ammonia (Sat. Liquid)	120	49	10-12	1.6-1.9	B					B	A		A	
Ammonia Chloride (50%)							A				A			
Ammonia (Gas)					C	X	B	C	X	A	A	A	A	
Ammonium Bifluoride					X	X	X	X	B	X	B	B	X	
Ammonium Chloride (50%)					X	X	A	C	A	C	C	A	A	
Ammonium Hydroxide (25%)					BC	X	A	A	X	A	A	B	A	
Ammonium Nitrate					A	X	X	BC	X	A	A		C	
Ammonium Persulphate					X	X	C	C	X	C	B			

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Table III (continued)

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Heated Material	Corrosion Rating													
Ammonium Sulphate (<40%)					X	X	B	A	B	C	B	B	A	
Amyl Alcohol			20	3.1	A	A	B	B	BC	B	B	B	A	2
Aniline (Commercial)	100 200 300	38 93 149	40-55 30-55 10-15	6.2-8.5 4.7-8.5 1.6-2.3		B		A		A				
Anodizing					X	X	X	X	X	X	X	A	X	
Arsenic Acid					X	C	X	B	X	B	B	C	X	
Asphalt (Tar)	200-500	93-260	5-9	0.8-1.4	A	X	A	A	X	A	B	B	A	2
Barium Hydroxide (Sat.)					B	X	B	B	C	B	B	B	AC	
Barium Sulphate			55	9	C	B	B	AC	B	B	B	B	A	
Beer			30-40	4.7-6.2	X	B	A	B	A	AC	A	A	B	
Benzene	100 150	38 66	20-25 10-15	3.1-3.9 1.6-2.3	A			A		A				
Black Liquor			15	2.3	X	X			BC	BC	BC	C		
Bleach 5.5% Cl, Clorox™			15-20	2.3-3.1	X					BC	BC	AC		
Boric Acid	250	121	40	6.2	X	C	C	A	BC	BC	BC	A	A	
Brass Cyanide										A				1
Bright Nickel			23	3.6									A	1, 5
Brine (Salt Water)			55	8.5	X	BC	AC	AC	B	C	B	A		10, 11
Bronze Plating					A					A				1
Cadmium Plating										A				
Calcium Chlorate	200	93	40	6.2	B	X	B	B	B	BC	BC	B	B	
Calcium Chloride (30% Solution)	100 190	38 88	20-25 5-8	3.1-3.9 0.8-1.2		B							A	
Calcium Chloride (Sat.)			23	3.6	B	B	B	B	B	BC	B	A	A	
Carbon Dioxide - Dry Gas			10-23	1.6-3.6	B	BC	A	A	A	A	A	A	AC	
Carbon Dioxide - Wet Gas			10-23	1.6-3.6	X	X	A	A	A	B	B	B	BC	2
Carbon Tetrachloride			23-26	3.6-4.0	C	AC	A	A	A	A	A	AC	A	1
Carbolic Acid (Phenol)					B	X	A	AC	AC	A	A	A	A	1
Castor Oil			23-26	3.6-4.0	A	AC	A	A	A	BC	B	A	A	1
Caustic Etch			15-26	2.3-4.0	A	C	A	A	A	A	A	BC	A	6
Caustic Soda	180	82	25-40	3.9-6.2				B						2
Chlorine Gas - Dry					C	C	B	A	AC	C	BC	B	X	
Chlorine Gas - Wet					X	X	X	X	C	X	X	BC	X	
Chloroacetic Acid					X	X	C	C	C	X	X	AC	A	

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Table III (continued)

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Heated Material	Corrosion Rating													
Chloroform	100 140	38 60	10-15 5-8	1.6-2.3 0.8-1.2				A			A			
Chromic Acid (40%)	180	82	40	6.2	X	X	X	X	X	BC	B	B	A	
Citric Acid (Conc.)	180	82	23	3.6	X	X	B	AC	B	BC	A	A	A	1
Clear Chromate											A		A	1
Cod Liver Oil			23-26	3.6-4.0			A	A		A	A			1
Copper Bright										A				1
Copper Chloride					X	X	X	B	X	X	X	B	A	
Copper Cyanide						X	BC	B	X	B	B	A	AC	
Copper Fluoborate							B	B	B	B	B			
Copper Nitrate					X	X	X	BC	X	A	A	C	B	
Copper Pyrophosphate										A				1
Copper Strike					A					A				1
Copper Sulphate					X	X	BC	B	X	B	B	B	A	
Creosote			6-15	0.9-2.3	A	BC	B	B	B	B	B	B	A	2
Cresylic Acid (50%)					BC		C	C	X	B	A	B	B	2
Deoxidizer (3AL-13 Non-Chrome)										A	A			1
Detergents			40-50	6.2-7.8		A		B		A	B	AC	A	
Dichromic Seal					X					A	A			1
Diethylene Glycol					AC	B	B	B	B	A	A	B	A	1
Diphenyl C ₁₂ H ₁₀	600	316	10-15	1.6-2.3	A			A		A				
Dowtherm - A	100 200 300 400	38 93 149 204	55-60 40-50 20-35 3-5	8.5-9.3 6.2-7.8 3.1-5.4 0.5-0.8	A			A		A				
Dowtherm - G	675	357			A			A		A				
Dur-Nu™													A	1, 5
Electro Cleaner					A			A						1
Electroless Nickel													A	1
Electroless Tin (Alkaline)											A		A	1
Ethers, General					B	B	B	A	B	A	A	B	B	2
Ethyl Chloride					B	B	A	A	B	A	A	B	A	2
Ethylene Glycol (100% Solution)	200 300 390	93 149 199	30-40 20-30 5-10	4.7-6.2 3.1-4.7 0.8-1.6	A	B	B	A	B	B	A	A	A	

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Table III (continued)

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A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available														
Heated Material	Corrosion Rating													
Fatty Acids			23-26	3.6-4.0	X	C	B	AC	B	BC	A	A	A	
Ferric Chloride					X	X	C	X	X	X	X	BC	A	
Ferric Nitrate (<50%)					X	X	X	BC	X	BC	B	BC	AC	
Ferric Sulphate					X	C	C	C	C	BC	AC	A	A	
Fluoboric Acid					AC	X			B	BC	AC	A	X	
Flourine Gas (Dry)					X	X	A	C	A	AC	A	BC	X	
Formaldehyde (<50%)					X	B	B	B	B	AC	AC	B	A	
Formic Acid (10-85%)					X	C	B	B	B	AC	B	A	C	
Freon (F-11, F-12, F-22)			3-9	0.5-1.4	C	B	A	A	A	A	A	B		
Fruit Juices (Pulp)			30-40	4.7-6.2	X		B	A	A	BC	B	A	A	
Fuel Oil 1&2 5&6 Bunker B&C	200 200 160	93 93 71	15-20 5-12 5-12	2.3-3.1 0.8-1.9 0.8-1.9	A B B	B A A	B A A	A B A	B A A	A A A	A A A	B A A	A	2, 3, 7
Fuel Oil (Acid)			6-10	0.9-1.6	X	X	C	C	C	C	B		A	2, 3, 7
Gasoline (Cracked)	200 300 400	93 149 204	35-45 15-25 3-6	5.4-7.0 2.3-3.9 0.5-1.0	B			A		A				2
Gasoline (Refined)	300	149	23	3.6	B	B	B	B	B	B	B	B		2, 5
Gasoline (Sour)			23	3.6	B	X	C	C	X	B	B	B		2, 3, 5
Glycerine (Glycerol)	300 500	149 260	15-20 3-5	2.3-3.1 0.5-0.8	B	A	A	A	A	A	A	A	A	
Grease (Liquid)			23	3.6	A									
Grease (Solid)			5	0.8	A									
Grey Nickel			23	3.6									A	1, 5
Hydrocarbons-Aliphatic			23-26	3.6-4.0	A	A	A	A	A	A	A	A		2
Hydrocarbons-Aromatic			23-26	3.6-4.0	A	A	A	A	A	A	A	A		2
Hydrochloric Acid (Dilute)			20-30	3.1-4.7	X	X	BC	BC	BC	X	X	AC	B	
Hydrochloric Acid (50%)			15-25	2.3-3.9	X	X	X	X	X	X	X	BC	X	
Hydrocyanic Acid (10%)					B	X	B	B	B	B	B			
Hydrofluoric Acid (Dilute)			23	3.6	X	X	BC	X	C	X	X	A	X	5
Hydrogen Peroxide (90%)			23-26	3.6-4.0	X	X	B	B	B	AC	AC	A	B	
Iridite™ - #4 - 75, #4 - 74, #14, #14 - 2, #14 - 9, #18 - P										A	A			1
Iridite™ - #1, #2, #3, #4-C, #4PC&S, #4P-4, #4-80, #4L-1, #4-2, #4-2A, #4-2P, #5P-1, #7, #7-P, #8, #8-P, #8-2, #12-P, #15, #17P, #18P					X	X	X	B	X	X	X	B	A	1

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Table III (continued)

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	Max. Operating Temperature °F °C		Max. Watt Density W/In ² W/cm ²		Carbon Steel	Copper	INCONEL® 600	INCOLOY® 800	MONEL® 400	304 and 321 SS	316 SS	C276 Hastelloy®	Titanium	Notes	
Heated Material	Corrosion Rating														
Iron Phosphate (Parkerizing™)												A	B	A	1
Isoprep™ Deoxidizer #187, #188												A			1
Isoprep™ Cleaner #186												A			1
Jetal™										A					1
Jet Fuel JP-4					B		A		B	BC	B	A	A		
Kerosene			23-26	3.6-4.0	B	BC	B	A	B	A	B	B			2
Lacquer Solvents			23-26	3.6-4.0	A	A	B	B	B	A	A		A		2
Lead Acetate					X	X	A	A	B	B	B	B	A		
Lead Acid Salts										B					1
Lime Saturated Water			23-40	3.6-6.2	B	B	B	B	B	B	A	A			
Linseed Oil	150	66	20	3.1	B	B	B	A	B	A	A				2
Lubricating Oil			23-26	3.6-4.0	A	A	A	A	B	B	B	B	A		7
Machine Oil			23-26	3.6-4.0	A		A	A	B	B	B	B	A		7
Magnesium Chloride					BC	B	A	B	B	C	B	A	A		
Magnesium Hydroxide					A	B	A	B	B	A	A	A	A		
Magnesium Nitrate					B	B	B	A	B	B	B	B	B		
Magnesium Sulfate					BC	BC	AC	B	A	B	B	B	B		
Mercuric Chloride					X	X	X	X	X	X	B	B	B		
Mercury			23-30	3.6-4.7	A	X	B	A	B	A	A	A	A		
Methanol (Methyl Alcohol)					B	B	A	A	A	B	B	A	A		2
Methyl Bromide					C	B	B	B	B	BC	A		A		
Methyl Chloride					X	B	B	C	B	AC	AC	B	A		
Methylene Chloride					BC	C	B	B	AC	B	B	A	A		
Milk			30-40	4.7-6.2	B	C	A	A	C	A	A	A			
Mineral Oil			23-26	3.6-4.0	B	B	A	AC	A	AC	B		A		
Molasses	100	38	4-5	0.6-0.8	A	A	A	A	A	A	A	A	A		
Naphtha					A	A	A	A	A	A	A		A		2
Nickel Acetate											A				1
Nickel Chloride			23	3.6	X	X	AC	B	B	BC	BC	A	A		1, 5
Nickel Plate-Bright			23	3.6	X		BC			C	C		B		1, 5
Nickel Plate-Dull			23	3.6	X		BC			C	C		B		1, 5
Nickel Plate - Watts Solution			23	3.6									A		1, 5
Nickel Sulphate					X	C	C	C	C	B	B				

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Heated Material	Corrosion Rating														
Nickel Copper Strike (Cyanide Free)											AC	AC			
Nitric Acid (20 - 30%)			15	2.3	X	X	BC	AC	X	AC	AC	AC	A		
Nitric & Hydrochloric Acid			15	2.3	X	X	C	X	X	BC	BC		X		
Nitric & 6% Phosphoric Acid			15	2.3							A				1
Nitric & Sodium Chromate											A				1
Nitric & Sulfuric Acid (50% - 50%)			15	2.3			X	X	X	AC	AC				
Nitrobenzene					B	BC	B	B	B	B	B	B	A		2
Oakites™ 20, 23, 24, 30, 51, 67, 90	210	99	30-40	4.7-6.2	A			A		A					1
Oil, SAE 10-20	250	121	15-20	2.3-3.1	A		A	A	B	A					
Oil, SAE 40-60	160	71	5-12	0.8-1.9	A		A	A	B	A					
Oleic Acid					BC	B	A	AC	BC	AC	AC	B	AC		
Olive Oil			23-26	3.6-4.0	B	B			B	B	B	AC	A		
Oxalic Acid (50%)					X	B	AC	AC	B	X	B	B	X		
Paint Stripper (High Alkaline)			30-40	4.7-6.2	A										1
Paint Stripper (Solvent)			23-26	3.6-4.0						A					1, 2
Paraffin	400	204	15-20	2.3-3.1	A	A	B	A	B	A	A	A			2, 7
Parkerizing™	SEE IRON PHOSPHATE														
Peanut Oil			23-26	3.6-4.0							B	A			
Perchloroethylene			23	3.6	A	B	A	A	A	AC	AC	B	A		
Petroleum Oils (Refined)			23-26	3.6-4.0	B	B			A	A	A				2, 3, 7
Petroleum Oils (Sour)			15-23	2.3-3.6	B	X			X	B	B				2, 3, 7
Phenol (Carbolic Acid)	SEE CARBOLIC ACID														
Phosphates (Generic)			23-40	3.6-6.2						BC	AC	B			1, 9
Phosphate Cleaners			23-40	3.6-6.2						BC	AC	B			1, 9
Phosphatizing			23	3.6							A				1, 5, 9
Phosphoric Acid (25% - 50%)			23	3.6	X	AC	BC	C	C	AC	BC		X		5, 9
Picric Acid					X	X	C	BC	X	BC	B	B			
Plating Solutions - Brass			23-35	3.6-5.4							B	AC	A		1
Plating Solutions - Cadmium			23-35	3.6-5.4							B	AC	A		1
Plating Solutions - Chrome (25%)			23-35	3.6-5.4	X	X	X	BC	X	BC	B	AC	X		1
Plating Solutions - Chrome (40%)			15-20	2.3-3.1	X	X	X	X	X	BC	B	AC	A		1
Plating Solutions - Cobalt			23-35	3.6-5.4						A					1

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Heated Material	Corrosion Rating													
Plating Solutions - Copper			23-35	3.6-5.4								AC	AC	1
Plating Solutions - Gold (Cyanide)			15-20	2.3-3.1						AC	AC	AC	AC	1
Plating Solutions - Gold (Acid)			15-20	2.3-3.1	A								A	1
Plating Solutions - Silver			23-35	3.6-5.4						AC	AC	AC	A	1
Plating Solutions - Tin			23-35	3.6-5.4							C	AC	X	1
Plating Solutions - Tin-Alkaline			15-20	2.3-3.1	A					A				1
Plating Solutions - Zinc			23-35	3.6-5.4								AC	A	1
Plating Solutions - Zinc Cyanide			15-20	2.3-3.1	A					A				1
Potassium Aluminum Sulphate					X	C				C	BC	BC	A	
Potassium Bichromate					C	C	B	B	B	B	B	B	AC	
Potassium Chloride (30%)					BC	X	AC	B	AC	AC	A	B	A	
Potassium Cyanide (30%)					BC	X	B	B	B	B	B	B	X	
Potassium Hydroxide (27%)					BC	C	B	B	B	BC	B	B	X	
Potassium Nitrate (80%)					B	BC	BC	B	B	B	B	B	A	
Potassium Sulphate (10%)					BC	BC	AC	BC	A	A	A	A	A	
Rochelle Salt - Cyanide					A					A				1
Santowax (C ₁₈ H ₃₄)	600	316	15-20	2.3-3.1	A			A		A				
Silicon Oils			23-26	3.6-4.0	B	AC				B	B			
Silver Bromide (10%)					X	X		AC	C	X	X	AC	A	
Silver Cyanide					C	X		AC	BC	AC	AC	AC	A	
Silver Lume										A				1
Silver Nitrate					X	X	BC	BC	X	B	AC	AC	AC	
Soap Solutions			55	8.5	BC	BC	AC	AC	BC	BC	BC	AC		3
Sodium Bichromate (Neutral)					B	C	B	B		B	B	B	C	
Sodium Bisulphate					C	X	BC	BC	BC	BC	BC	B	BC	
Sodium Bromide (10%)					C	C	B	B	B	C	BC	B	C	
Sodium Carbonate					C	BC	A	AC	A	BC	B	AC	A	
Sodium Chlorate					X	BC	A	AC	AC	BC	B	A	A	
Sodium Chloride (25% Solution)	100 150 200	38 66 93	55-75 50-55 25-30	8.5-11.6 7.8-8.5 3.9-4.7	C	B	AC	A	AC	C	C	B	A	11
Sodium Citrate					X	X	AC	AC	B	BC	B	BC	A	
Sodium Cyanide			30-40	4.7-6.2	X	X	BC	BC	X	AC	AC	BC	C	

Watt Density & Sheath Selection

Table III (continued)

Legend	Sheath Material													Notes
	Max. Operating Temperature °F °C	Max. Watt Density W/In ² W/cm ²	Carbon Steel	Copper	INCONEL® 600	INCOLOY® 800	MONEL® 400	304 and 321 SS	316 SS	C276 Hastelloy®	Titanium			
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available														
Heated Material	Corrosion Rating													
Sodium Dichromate (Hot Seal)					BC	X				BC	BC	AC	A	1
Sodium Hydroxide (50%)		15	2.3	C	X	AC	B	AC	AC	AC	AC	AC	AC	6, 8
Sodium Hypochlorite (20%)		20	3.1	X	X	X	X	X	X	X	X	X	A	
Sodium Nitrate		23	3.6	B	C	A	A	BC	AC	AC	BC	AC		5
Sodium Peroxide (10%)				BC	X	BC	B	B	BC	B	B			
Sodium Phosphate (Neutral)				B	B	B	B	B	B	B	B	B		
Sodium Salicylate				B		B	B	B	B	B				
Sodium Silicate				B	X	B	AC	A	BC	B	B	A	4	
Sodium Sulfate				B	BC	B	AC	BC	AC	A	B	C		
Sodium Sulfide (<50%)				X	X	B	AC	B	BC	BC	B	C		
Sodium Stannate				C		B	B	B	B	B				
Sodium Thiosulfate (Hypo)				X	X	B	B	BC	B	B	BC	AC		
Steam (Medium Pressure)		10-15	1.6-3.1	C	BC	A	A	AC	BC	BC	B			
Stearic Acid				C	BC	B	AC	C	BC	A	A	A		
Sugar Solution		10-23	1.5-3.6	A	A	A	A	A	A	A	A	A	7	
Sulfamate Nickel												A	1	
Sulfamic Acid				X	C				BC			AC		
Sulfur				X	X	A	A	BC	A	A	A	A		
Sulfur Chloride (Dry)				X	X	B	AC	X	BC	BC	B			
Sulfur Dioxide (Dry)		15-23	2.3-3.6	AC	BC	B	AC	B	B	B	B	A		
Sulfur Dioxide (Wet)		10-20	1.5-3.1	X	X	X	BC	X	X	B	AC	A		
Sulfuric Acid (10 - 50%)		15	2.3	X	X	X	BC	X	X	X	AC	X		
Sulfuric Acid (98%)		15	2.3	X	X	X	BC	X	X	BC	AC	X		
Sulfurous Acid				X	X	BC	A	X	X	BC	B	A		
Tannic Acid				X	C	B	B	B	B	B	B	AC		
Therminol™ 44 (Max. Bulk Temp. 425°F)	425	218	25-30	3.9-4.7	A		A		A					
Therminol™ 55 (Max. Bulk Temp. 575°F)	575	302	25-30	3.9-4.7	A		A		A					
Therminol™ 60 (Max. Bulk Temp. 600°F)	600	316	25-30	3.9-4.7	A		A		A					
Therminol™ 66 (Max. Bulk Temp. 650°F)	100	38	25-30	3.9-4.7	A		A		A					
	300	149	25-30	3.9-4.7										
	500	260	25-30	3.9-4.7										
	600	316	20-25	3.1-3.9										
650	343	10-15	1.6-2.3											

Watt Density & Sheath Selection

Table III (continued)

Legend	Sheath Material												Notes		
	Max. Operating Temperature °F °C		Max. Watt Density W/in ² W/cm ²		Carbon Steel	Copper	INCONEL® 600	INCOLOY® 800	MONEL® 400	304 and 321 SS	316 SS	C276 Hastelloy®		Titanium	
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available															
Heated Material	Corrosion Rating														
Therminol™ 88 (Max. Bulk Temp. 600°F) (Liquid only at 293°F)			30-40	4.7-6.2	A			A		A					
Therminol™ FR-1 (Chlorinated Biphenyl)	100	38	20-25	3.1-3.9											
	200	93	20-25	3.1-3.9											
	300	149	20-25	3.1-3.9	A			A		A					
	400	204	10-15	1.6-2.3											
	500	260	3-5	0.5-0.8											
Tin (Molten)			20	3.1		X	X		X	X	X				4
Trichloroethane					A	A	A	A	A	A	A	A	A		
Trichloroethylene	70		20-25												
	100		15-20		BC	A	AC	A	A	A	B	A	A		
	180		3-7												
Triethylene Glycol			23	3.6	A	A	A	A	A	A	A				
Trisodium Phosphate					BC	BC			BC	AC	AC	AC			
Turco™ 4181 (Alkaline Cleaner)											A				1
Turco™ 4008 (Descaler)											A				1, 5
Turco™ 4338 (Oxidizer)											A				1, 7
Turco™ Ultrasonic Solution											A				1
Turpentine	68	20	30-40	4.7-6.2				A			A				
Udylite™ #66			23	3.6									A		1, 5
Vegetable Oil	100	38	30-35	4.7-5.4											
	300	149	15-20	2.3-3.1											
	400	204	5-10	0.8-1.6	B			A		B	A				
	550	288	2	0.3											
Water, Deionized	100	38	75	11.6	X	B	A	A	C	A	A	B			10
	212	100	50-75	7.8-11.6											
Water, Demineralized	100	38	75	11.6	X	X	A	A	C	A	A	B			10
	212	100	50-75	7.8-11.6											
Water, Pure (Distilled)	100	38	75	11.6	X	X	A	A	A	A	A	A			10
	212	100	50-75	7.8-11.6											
Water, Process	100	38	75	11.6	X	B	A	A	B	BC	BC	B	A		10, 11
	212	100	50-75	7.8-11.6											
Water, Potable	100	38	75	11.6	X	B	A	A	B	BC	BC	B	A		10, 11
	212	100	50-75	7.8-11.6											
Water, Salt Brine			55	8.5	X	BC	AC	AC	B	C	B	A			10, 11
Water, Sea	100	38	75	11.6	X	BC	BC	AC	A	C	BC	AC	A		10, 11
	212	100	50-75	7.8-11.6											
Whiskey			55	8.5	X	BC	B		A	A	A	AC			2
Wines			55	8.5	X	BC			B	A	A	A			
Yellow Dichromate											A				1

Watt Density & Sheath Selection

Table III (continued)

Legend	Sheath Material												
	Max. Operating Temperature °F °C	Max. Watt Density W/in ² W/cm ²	Carbon Steel	Copper	INCONEL® 600	INCOLOY® 800	MONEL® 400	304 and 321 SS	316 SS	C276 Hastelloy®	Titanium	Notes	
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available													
Heated Material	Corrosion Rating												
Zinc Chloride				X	X	B	BC	BC	X	B	B	B	
Zinc Phosphate		23	3.6							A			1, 5
Zincate™				A					A				1

Notes:

- 1 - This solution contains an unknown mixture of various chemical compounds whose proportions could change without our knowledge. Consult the chemical supplier to confirm the suitability or for alternate sheath materials.
- 2 - Caution - Flammable material, maintain complete immersion.
- 3 - Exact chemical composition can vary widely. Consult the chemical supplier to confirm suitability.
- 4 - Direct immersion heaters are not normally suitable. Consider using a clamp-on heater on the outside of a pot.
- 5 - Element watt density should not exceed 23 w/in².
- 6 - For concentrations greater than 15% the element watt density should not exceed 15 w/in².
- 7 - Concentration vary widely, consult the supplier to confirm suitability.
- 8 - Remove crusts at the liquid level.
- 9 - Clean frequently.
- 10 - Passivate stainless steel for the maximum effectiveness.
- 11 - Stainless steel materials may be subject to chloride or stress corrosion cracking in this application.

Watt Density & Sheath Selection

Heating Metals – Table IV gives recommended watt densities and sheath selection for elements that are clamped or inserted. Allowable watt densities will vary with such factors as element fit in a machined opening and metal thickness.

This information should be used only as a guide. Heatrex cannot be responsible for heater failures due to corrosion or excessive temperatures in the application.

Table IV

Application	Maximum Metal Temperature °F	Recommended Watt Density W/Sq. In.	Recommended Sheath Material
Clamped to Flat Metal Surface	200	20	Steel
	200	30	304 SS
	400	20	304 SS
Inserted into Machined Grooves or Holes	200	25	Steel
	200	35	304 SS
	400	25	304 SS
	600	20	304 SS
	600	25	Incoloy
	800	15	Incoloy