

Reference Data

Corrosion Guide for Electric Immersion Heaters

Corrosion Guide

The Corrosion Guide on the following pages provides suggested sheath materials for many applications. While it is by no means complete, the guide does include all of the readily available sheath materials and a wide variety of common chemicals and solutions. The compilation is based on available data and application experience and is furnished as a guide to the user. The recommendations are only suggestions and should not be interpreted as an absolute choice of sheath material in a particular application.

Types of Corrosion

In immersion heater applications, a protective or “passive” film forms on the surface of a metal sheath which protects it from further corrosion. As long as the film remains intact, the base metal is protected. Corrosion mechanisms destroy the protective film and allow the base metal to be attacked. Sheath corrosion takes a number of different forms. The most common are:

- General Corrosion
- Galvanic Corrosion
- Stress Corrosion Cracking
- Intergranular Corrosion.

Temperature accelerates the corrosion process. Austenitic stainless steels are particularly susceptible to stress corrosion cracking and intergranular corrosion.

Sheath Selection Process

Since it is the responsibility of the end user to make the final selection of sheath material for any particular application, the information in this guide may be used as a reference in the investigation of a particular process. Select the sheath material and watt density based upon your intimate knowledge of the chemicals and operating conditions which exist in the actual application. As part of the analysis, you should consider the anticipated operating temperatures, the recommendations of the chemical supplier and actual test results where available. Contact your Local Chromalox Sales office for assistance or sheath material recommendations for chemicals and solutions not shown in this list.

Terminal Enclosures

Corrosion of electric immersion heaters is not limited to the sheath material. Frequently, application problems are related to contamination or corrosion of heater terminals and electrical connections. When selecting a heating element sheath material, also consider the location and environment of the terminal enclosure. Select an appropriate heater electrical terminal enclosure.

Temperatures & Watt Densities

Consider your selection of a heater sheath material very carefully. Once the material has been selected, design the application for sheath watt densities as low as practical and economical. Remember, the sheath of an immersion heater functions as a heat transfer surface and thus operates at temperatures above the temperature of the surrounding media. The higher the watt density, the higher the sheath temperature. The elevated media temperatures and the fluid movement around the sheath accelerate chemical reactions and may create severe localized corrosive conditions on the metal surface. Materials recommended for construction of your tank or vessel may not be suitable as the sheath material for the immersion heater.

Operating & Maintenance Factors for Maximum Heater Life

Sheath selection is only part of the solution to resolving potential corrosion problems. The ultimate life of a heating element sheath in a particular application will also depend upon a number of operating and maintenance factors. These factors are usually within control of the end user. To ensure maximum heater life and minimize sheath corrosion, Chromalox recommends the user:

1. **Maintain** the chemistry of the solution. Avoid carry-over from other processes.
2. **Avoid** depletion of bath chemistry. Maintain bath chemistry at optimum levels.
3. **Filter** or remove accumulating sludge, since sludge impedes flow of heat from element sheath and accelerates corrosion.
4. **Keep** process temperatures stable and as low as possible. Excessive operating temperatures mean shorter heater life.

5. **Avoid** galvanic corrosion. Avoid contact of the element sheath with dissimilar metals.
6. **Keep** immersion heaters out of the space between anode and cathode in electroplating processes. The effects of plating current may damage the element sheath.
7. **Examine** immersion heaters periodically for corrosion and sludge accumulation. Take corrective action to maintain continuity of operation.
8. **Electrically Ground** metal sheath heaters to the tank and, in turn, to earth for safety and protection of personnel against electrical shock. Consider the use of a ground fault circuit interrupter (GFCI) for optimum safety.

Table Legend to the Corrosion Guide

- A** = Good to Excellent service life
B = Fair to Good service life, expect some sheath corrosion
C = Depends on Conditions such as solution concentration, operating temperature and fluid flow
X = Not Suitable or Not Recommended
Blank = Data Incomplete or Not Available

WARNING — **Hazard of Electric Shock.** Any installation involving electric heaters must be effectively grounded in accordance with the National Electrical Code to eliminate shock hazard. All electrical wiring to electric heaters must be installed in accordance with the National Electrical code or local electrical codes by a qualified person. For maximum equipment protection, the National Electrical Code recommends Ground Fault Protection be provided for each branch circuit supplying electric heating equipment.

Warranty Disclaimer

Many factors that affect the corrosion of heater sheath material are beyond the control of the heater manufacturer. For this reason, Chromalox assumes no responsibility for any electric Immersion heater failure that can be attributed to corrosion. This is in lieu of any warranties, written or verbal, relative to heater performance in a corrosive environment.

Reference Data

Corrosion Guide for Electric Immersion Heaters *(cont'd.)*

Legend	Sheath Material															Notes	
	Aluminum	Carbon Steel	Copper	Cast Iron	INCONEL® 600	INCOLOY® 800	Lead	MONEL® 400	304, 321, 347 SS	316 SS	20Cb-3 SS	C276 Hastelloy®	Quartz	Titanium	Teflon® 12		Suggest Density ¹²
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available	Corrosion Rating																
Solution																	
Acetic Acid (100%)	X	X	X	X	C	B	X	BC	A	BC	A	A	A	A	A	23	
Acetic Acid (50%)	C	X	X	X	X	B	X	B	C	A	AC	A	A	A	A	15	
Acetone (100%)	A	BC	A	X	A	A	B	A	B	A	B	BC	A	A	A		2
Actane 70™																	1
Actane 80™																	1
Actane Salt™	CONTACT FACTORY																
Alcoa Bright Dip R5™																	1
Allyl Alcohol	B	B	A	A	A	A	B	A	A	A	B	B	A	B	A	23 - 26	1
Alcohol	B	B	A	B	A	A	A	A	B	A	A	B	A	A	A		2
Alcorite™													A	A	A		1
Alkaline Cleaners																	
Alkaline Soaking Cleaners		B															
Alodine™	CONTACT FACTORY																
Aluminum (Molten)	CONTACT FACTORY																
Aluminum Bright Dip													A		A		1, 9
Aluminum Chloride (Aqueous)	X	X	X	C	X	X	X	X	X	X	C	A	A	B	A		1
Aluminum Cleaners	X	C	X	C	A	A	X	A	A	B	B	X	X	B	A		1
Aluminum Sulphate (Sat.)	X	X	X	X	X	BC	BC	X	X	BC	BC	BC	A	A	A		1
Alum	X	X	X	X	BC	BC	X	X	X	BC	BC	BC	A	A	A		1
Ammonia (Anhydrous)	C	A	X	X	A	C	C	A	B	A	A	A	A	A	A		
Ammonia (Gas)	X	C	X	X	B	C	X	X	A	B	A	A	A	A	A		
Ammonium Bifluoride	X	X	X	X	X	X	X	B	X	X	AC	B	X	X	A		
Ammonium Chloride (50%)	X	X	X	X	A	C	X	A	C	C	B	A	B	A	A		
Ammonium Hydroxide (25%)	B	BC	X	A	A	A	X	X	A	A	A	B	X	A	A		
Ammonium Nitrate	B	A	X	X	X	BC	X	X	A	A	A	A	A	C	A		
Ammonium Persulphate	B	X	X	X	C	C	C	X	C	B	B	B	A	A	A	23 - 26	2
Ammonium Sulphate (< 40%)	X	X	X	X	B	A	B	B	C	B	B	B	A	A	A		
Amyl Alcohol	C	A	A	B	B	B	BC	B	B	B	B	B	A	A	A		
Aniline	B	C	X	B	B	B	B	B	A	A	A	B	A	A	A		
Anodizing	X	X	X	X	X	X	A	X	X	X	A	A	A	X	A		
ARP 28™																	1
ARP 80™ Blackening Salt																	1
Arsenic Acid	X	X	C	X	X	B	X	X	B	B	B	C	A	X	A	6 - 10	2
Asphalt	X	A	X	A	A	A	X	X	BC	B	B	A	A	A	A		
Barium Hydroxide (Sat.)	X	B	X	B	B	B	X	C	B	B	B	B	A	AC	A		
Barium Sulphate	B	C	B	B	B	AC	B	B	B	B	B	B	A	A	A	55	
Beer	A	X	B		A	B	X	A	AC	A	A	A	A	B	A	30 - 40	
Black Nickel																	23
Black Oxide																	23
Black Liquor	X	X	X					BC	A	BC	BC	C				15	5
Bleach 5.5% Cl, Clorox™	X	X							BC	BC	BC	AC				15 - 23	
Bonderizing™	SEE ZINC PHOSPHATE																
Boric Acid	X	X	C	X	C	A	C	BC	BC	BC	C	A	A	A	A		1
Brass Cyanide									A								
Bright Nickel													A	A		23	1, 5
Brine (Salt Water)	X	X	BC		AC	AC		B	C	B		A				55	10, 11
Bronze Plating		A							A								1
Butyl Alcohol (Butanol)	BC	BC	A	A	A	A	A	A	A	A	B	A	B	A			2
Cadmium Black													A				1
Cadmium Fluoborate															A		1
Cadmium Plating									A								
Calcium Chlorate	B	B	X	B	B	B	C	B	BC	BC	B	B		B	A		

See notes at end of table.

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Corrosion Guide for Electric Immersion Heaters *(cont'd.)*

Legend	Sheath Material														Notes		
	Aluminum	Carbon Steel	Copper	Cast Iron	INCONEL® 600	INCOLOY® 800	Lead	MONEL® 400	304, 321, 347 SS	316 SS	20Cb-3 SS	C276 Hastelloy®	Quartz	Titanium		Teflon®12	Suggest Density ¹²
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																	
Solution	Corrosion Rating																
Calcium Chloride (Sat.)	BC	B	B	B	B	B	X	B	BC	B	B	A	A	A	A		
Carbon Dioxide - Dry Gas	A	B	BC	B	A	A	B	A	A	A	A	A	A	AC	A	10 - 23	
Carbon Dioxide - Wet Gas	A	X	X	X	A	A	A	A	B	B	A	B	A	BC	A	10 - 23	
Carbon Tetrachloride	X	C	AC	X	A	A	AC	A	A	A	A	AC	A	A	A	23 - 26	
Carbonic Acid (Phenol)	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		
Castor Oil	BC	A	AC	A	A	A	A	A	BC	B	A	A	A	A	A	23 - 26	6
Caustic Etch	X	A	C	A	A	A	X	A	A	A	A	BC	X	A	A	15 - 26	
Caustic Soda	SEE SODIUM HYDROXIDE																
Chlorine Gas - Dry	X	C	C	X	B	A	X	AC	C	BC	B	B	A	X	B		
Chlorine Gas - Wet	X	X	X	X	X	X	X	C	X	X	X	BC	A	X	B		
Chloroacetic Acid	X	X	X	X	C	C	X	C	X	X	C	AC	A	A	A		1
Chromic Acetate													A	A	A		1
Chromic Acid (40%)	X	X	X	X	X	X	B	X	BC	B	BC	B	A	A	X		1
Chromic Anodizing													A	A			
Chromylite													A	A			
Citric Acid (Conc.)	X	X	X	X	B	AC	X	B	BC	A	A	A	A	A	A		1
Clear Chromate										A	A	A	A	A			1, 6
Cobalt Nickel													A	A			
Cod Liver Oil					A	A			A	A	A					23 - 26	1
Copper Acid													A		A		
Copper Bright									A								1
Copper Bright Acid													A	A	A		1
Copper Chloride	X	X	X	X	X	B	X	X	X	X	X	B	A	A	A		
Copper Cyanide					BC	B			X	B	B	B	A	AC	A		
Copper Fluoborate	X				B	B		B	B	B	B	B	A	A	A		
Copper Nitrate	X	X	X	X	X	BC		X	A	A	A	C	A	B	A		1
Copper Pyrophosphate									A	A	A						1
Copper Strike		A		A					A	A	A						
Copper Sulphate	X	X	X	X	BC	B	A	X	B	B	B	B	A	A	A		2
Creosote	C	A	BC	A	B	B	X	B	B	B	B	B	A	A	A	6 - 15	
Cresylic Acid 50%	C	BC		C	C	C	X	X	B	A	B	B	A	B	A		2
Deionized Water	SEE WATER																
Deoxidizer (Etching)									A	A	A		A				1
Deoxidizer (3AL-13 Non-Chrome)									A	A	A	AC		A	A		1
Detergents	BC		A			B			A	B	A	AC		A	A	40 - 55	
Dichromic Seal		X		X					A	A	A						
Diethylene Glycol	B	AC	B	A	B	B	A	B	A	A	A	B	A	A	A		1
Diversey-DS9333™													A	A	A		1, 5
Diversey-511™													A				1
Diversey-514™															A		
Dowtherm™ (Diphenyl)	X	A	C		A			B	A	A	A	A				23	
Dur-Nu™									A				A	A		23	1,5
Electro Cleaner		A															1
Electropolishing													A	A	A		1
Electroless Nickel													A	A	A		1
Electroless Tin (Acid)													A		A		1
Electroless Tin (Alkaline)										A			A	A			1
Enthone Acid - 80																	1
Ethers, General	B	B	B	B	B	A	B	B	A	A	B	B	A	B	A		2
Ethyl Chloride	B	B	B	B	A	A	B	B	A	A	A	B	A	A	A		2
Ethylene Glycol	A	A	B	B	A	A	X	B	A	A	A	A	A	A	A		5
Fatty Acids	A	X	C	X	B	AC	X	B	BC	A	A	A	A	A	A		23 - 26
Ferric Chloride	X	X	X	X	C	X	X	X	X	X	X	BC	A	A	A		
Ferric Nitrate (< 50%)	X	X	X	X	X	BC	X	X	BC	B	A	BC	A	AC	A		
Ferric Sulphate	X	X	C	X	C	C	B	C	BC	AC	A	A	A	A	A		
Fluoborate													A	A	A		1
Fluoboric Acid	X	AC	X					B	BC	AC	AC	A		X	A		
Fluorine Gas (Dry)	AC	X	X	X	A	C	C	A	AC	A	A	BC	C	X	C		
Formaldehyde (< 50%)	B	X	B	X	B	B	X	B	AC	AC	A	B	A	A	A		

See notes at end of table.

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	Aluminum	Carbon Steel	Copper	Cast Iron	INCONEL® 600	INCOLOY® 800	Lead	MONEL® 400	304, 321, 347 SS	316 SS	20Cb-3 SS	C276 Hastelloy®	Quartz	Titanium		Teflon®12	Suggest Density ¹²
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																	
Solution	Corrosion Rating																
Formic Acid (10 - 85%)	B	X	C	X	B	B	X	B	AC	B	A	A	A	C	A		
Freon (F-11, F-12, F-22)	B	C	B		A	A	A	A	A	A	A	A	B	A	A	3 - 9	
Fruit Juices (Pulp)	B	X			B	A		A	BC	B	BC	A	B	A	A	30 - 40	
Fuel Oil (Normal)	B	A	B	A	B	C		B	A	A	B			A		6 - 15	2, 3, 7
Fuel Oil (Acid)	X	X	X	X	C	C		C	C	B	A			A		6 - 10	2, 3, 7
Gasohol	B	B	B	B	B	B		B	B	B	B					23 - 26	
Gasolene (Refined)	B	B	B	B	B	B		B	B	B	B		A			23	2, 5
Gasolene (Sour)	X	B	X	C	C	C	X	B	B	B	B		A		A	23	2, 3, 5
Glycerin (Glycerol)	A	B	A	B	A	A	B	A	A	A	A	A	A	A	A		
Grey Nickel													A	A	A	23	1, 5
Hydrocarbons-Aliphatic	A	A	A	A	A	A		A	A	A	A	A	A	A		23 - 26	2
Hydrocarbons-Aromatic	A	A	A	A	A	A		A	A	A	A	A	A	A		23 - 26	2
Hydrochloric Acid (Dilute)	X	X	X	X	BC	BC	X	BC	X	X	AC	B	B	A		20 - 30	
Hydrochloric Acid (50%)	X	X	X	X	X	X	X	X	X	X	BC	X	X	A	A	15 - 25	
Hydrocyanic Acid (10%)	B	B	X	X	B	B	X	B	B	X	B	A	A	A	A		
Hydrofluoric Acid (Dilute)	X	X	X	X	BC	X	B	C	X	X	B	A	X	X	A	23	5
Hydrogen Peroxide (90%)	A	X	X	X	B	B	X	B	AC	AC	AC	A	A	A	A		
Indium																	1
Iridite™ - #4 - 75, #4 - 73, #14, #14 - 2, #14 - 9, #18 - P										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													A				1
Iridite™ Dyes - #12L-2, #40, #80													A		A		1
Irilac™													A		A		1
Iron Fluoborate															A		1
Iron Phosphate (Parkerizing™)										A							1
Isoprep™ Deoxidizer #187, #188										A							1
Isoprep™ Cleaner #186																A	1
Isoprep™ #191 Acid Salts																	1
Jetal™									A	BC							1
Jet Fuel JP-4	B	B			A		B	B	B	B	BC	A		A			1
Kerosene	B	B	BC		B	A	B	B	B	B	B	B		A		23 - 26	2
Lacquer Solvents	A	A	A	A	B	B	A	B	A	A	A	B	A	A	A		23 - 26
Lead Acetate	X	X	X	X	A	A	X	B	B	B	B	B	A	A	A		2
Lead Acid Salts																	1
Lime Saturated Water	X	B	B	B	B	B	X	B	B	A	B	A	X		C	23 - 40	2
Linseed Oil	B	B	B	B	B	A	B	B	A	A	A	A	A	A	A	10 - 15	
Lubricating Oil	B	A	A	A	A	A	A	B	B	B	A	B	A	A	A	23 - 26	7
Machine Oil																23 - 26	7
Magnesium Chloride	X	BC	B	X	A	B	X	B	C	B	B	A	A	A	A		
Magnesium Hydroxide	B	A	B	B	A	B	X	B	A	A	A	A	A	A	A		
Magnesium Nitrate	B	B	B	B	B	A	X	B	B	B	B	B	A	A	A		
Magnesium Sulfate	B	BC	BC	B	AC	B	B	A	B	B	B	B	A	B	A		
McDermid™ #629													A				1
Mercuric Chloride	X	X	X	X	X	X	X	X	X	B	BC	B	A	B			
Mercury	X	A	X	A	B	A	X	B	A	A	A	A	A	A	A		
Methyl Alcohol (Methanol)	C	B	B	B	A	A	B	A	B	B	B	A	A	A	A		2
Methyl Bromide	X	C	B	C	B	B	B	B	BC	A	A	A	A	A	A		
Methyl Chloride	X	X	B	C	B	B	C	B	AC	AC	A	B	A	A	A		
Methylene Chloride	C	BC	C	BC	B	B	B	AC	B	B	AC	A	A	A	A		
Milk	A	B	C		A	A	X	C	A	A	A	A	A	A	A		
Mineral Oil	B	B	B		A	AC		A	AC	A	A	A	A	A	A	30 - 40	
																23 - 26	

See notes at end of table.

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A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																	
Solution	Corrosion Rating																
	SEE HYDROCHLORIC ACID																
Muriatic Acid	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A		2
Naphtha	X	X	X	X	AC	B	C	B	BC	BC	B	A	A	A	A	23	1, 5
Nickel Acetate	X	X	X	X	BC				C	C	C		A	B	A	23	1, 5
Nickel Chloride	X	X			BC				C	C	C		A	B	A	23	1, 5
Nickel Plate-Bright	X	X			BC				C	C	C		A	B	A	23	1, 5
Nickel Plate-Dull	X	X			BC				C	C	C		A	B	A	23	1, 5
Nickel Plate - Watts Solution	X	X	C	X	C	C	B	C	B	B	B		A	A	A	23	1, 5
Nickel Sulphate	X	X	C	X	C	C	B	C	B	B	B		A	A	A		(Cyanide Free)
Nickel Copper Strike	X	X	C	X	C	C	B	C	B	B	B		A	A	A		(Cyanide Free)
Nitric Acid (20%)	X	X	X	BC	BC	AC	X	X	AC	AC	A	AC	A	A	A	15	
Nitric & Hydrochloric Acid	X	X	X	X	C	X	X	X	BC	BC	C		A	X	A	15	
Nitric & 6% Phosphoric Acid	X	X	X	X	C	X	X	X	BC	BC	C		A	X	A	15	1
Nitric & Sodium Chromate	X	X	X	X	C	X	X	X	BC	BC	C		A	X	A	15	1
Nitric & Sulfuric Acid (50% - 50%)	X	X	X	X	C	X	X	X	AC	AC	AC		A	A	A	15	1
Nitrobenzene	BC	B	BC	B	B	B	X	B	B	B	A	B	A	A	A		2
Oakite™ #67	C	BC	B	BC	A	AC	X	BC	A	AC	B	B	A	AC	A	30 - 40	1
Oleic Acid	AC	B	B	BC	A	AC	X	BC	AC	B	B	AC	A	AC	A	23 - 26	
Olive Oil	X	X	B	X	AC	AC	X	B	X	B	B	B	A	X	A	23 - 26	
Oxalic Acid (50%)	X	X	B	X	AC	AC	X	B	X	B	B	B	A	X	A	30 - 40	1
Paint Stripper (High Alkaline)	X	X	B	X	AC	AC	X	B	X	B	B	B	A	X	A	23 - 26	1, 2
Paint Stripper (Solvent)	X	X	B	X	AC	AC	X	B	X	B	B	B	A	X	A	6 - 15	2, 7
Paraffin	A	A	A	A	B	A		B	A	A	A	A	A	A	A		
Parkerizing™	SEE IRON PHOSPHATE																
Peanut Oil	B	A	B	A	A	A	B	A	AC	AC	B	B	A	A	A	23 - 26	
Perchloroethylene	B	B	B	B	A	A		A	AC	AC	B	B	A	A	A	23	
Petroleum Oils (Refined)	X	B	B	B	A	A		A	A	A	A	A	A	A	A	23 - 26	2, 3, 7
Petroleum Oils (Sour)	X	B	B	B	A	A		X	A	A	A	A	A	A	A	15 - 23	2, 3, 7
Phenol (Carbolic Acid)	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		
Phosphates (Generic)	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		
Phosphate Cleaners	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		
Phosphatizing	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		
Phosphoric Acid (25% - 50%)	X	X	AC	X	BC	C	B	C	AC	BC	AC		A	X	A	23 - 40	1, 5, 9
Picric Acid	BC	X	X	X	C	BC	X	X	BC	B	B	B	A	A	A	23 - 40	1, 5, 9
Plating Solutions - Brass	BC	X	X	X	C	BC	X	X	BC	B	B	B	A	A	A	23	
Plating Solutions - Cadmium	BC	X	X	X	C	BC	X	X	BC	B	B	B	A	A	A	23	
Plating Solutions - Chrome (25%)	X	X	X	X	X	BC		X	BC	B	B	AC	A	X	A	23 - 35	1
Plating Solutions - Chrome (40%)	X	X	X	X	X	X		X	BC	B	B	AC	A	A	A	15 - 20	1
Plating Solutions - Cobalt									A				A	A	A	23 - 35	1
Plating Solutions - Copper									A				A	A	A	23 - 35	1
Plating Solutions - Gold (Cyanide)									AC	AC			AC	AC	A	15 - 20	1
Plating Solutions - Gold (Acid)		A							AC	AC			A	A	A	15 - 20	1
Plating Solutions - Nickel		A							AC	AC	AC	AC	A	A	A	23 - 35	1
Plating Solutions - Silver									AC	AC	AC	AC	A	A	A	23 - 35	1
Plating Solutions - Tin									AC	AC	AC	AC	A	X	A	23 - 35	1
Plating Solutions - Tin-Nickel									AC	AC	AC	AC	A	A	A	23 - 35	1
Plating Solutions - Tin-Alkaline		A							A				A	A	A	15 - 20	1
Plating Solutions - Zinc		A							A			AC	AC	A	A	23 - 35	1
Plating Solutions - Zinc Acid		A							A				A	A	A	15 - 20	1
Plating Solutions - Zinc Cyanide		A							A				A	A	A	15 - 20	1
Potassium Aluminum Sulphate	C	X	C	C	B	B		B	C	BC	A	BC	A	A	A		
Potassium Bichromate	B	C	C	C	B	B		B	C	BC	A	BC	A	A	A		
Potassium Chloride (30%)	X	BC	X	X	AC	B	C	AC	AC	A	AC	B	A	AC	A		
Potassium Cyanide (30%)	X	BC	X	X	B	B	X	B	B	B	B	B	A	X	A		
Potassium - Hydrochloric Solution	X	BC	C	X	B	B	X	B	BC	B	A	B	X	X	A		1
Potassium Hydroxide (27%)	X	BC	C	X	B	B	X	B	BC	B	A	B	X	X	A		1
Potassium Nitrate (80%)	A	B	BC	B	BC	B	B	B	B	B	B	B	A	A	A		
Potassium Sulphate (10%)	A	BC	BC	X	AC	BC	BC	A	A	A	A	A	A	A	A		

See notes at end of table.

Reference Data

Corrosion Guide for Electric Immersion Heaters *(cont'd.)*

Legend	Sheath Material														Notes			
	Aluminum	Carbon Steel	Copper	Cast Iron	INCONEL® 600	INCOLOY® 800	Lead	MONEL® 400	304, 321, 347 SS	316 SS	20Cb-3 SS	C276 Hastelloy®	Quartz	Titanium		Teflon®12	Suggest Density ¹²	
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																		
Solution	Corrosion Rating																	
Reynolds Brightener																		1
Rhodium Hydroxide																		1
Rochelle Salt - Cyanide																		1
Ruthenium Plating																		1
Silicon Oils	BC	B	AC						B	B							23 - 26	
Silver Bromide (10%)	X	X	X	X			AC		C	X	X	C	AC	A	A	A		
Silver Cyanide	X	C	X	C			AC		BC	AC	AC	AC	A	A	A			
Silver Lume																	1	
Silver Nitrate	X	X	X	X	BC	BC	X	X	B	AC	B	AC	A	AC	A		3	
Soap Solutions	B	BC	BC	C	AC	AC	C	C	BC	BC	BC	AC					55	
Sodium-Liquid Metal	X	C	X	X	A	AC	A	AC	BC	AC	A		X					
Sodium Bichromate (Neutral)	C	B	C	A	B	B			B	B	B	B	A	C	A			
Sodium Bisulphate	X	C	X	X	BC	BC	C	BC	BC	BC	BC	B	A	BC	A			
Sodium Bromide (10%)	X	C	C	X	B	B		BC	B	C	B	B	A	C	A			
Sodium Carbonate	X	C	BC	C	A	AC	X	A	BC	B	AC	BC	C	A	A			
Sodium Chlorate	B	X	BC	X	A	AC	B	AC	BC	B	B	A	A	A	A			
Sodium Chloride	X	C	B	X	AC	A	B	AC	C	C	B	A	A	A	A		11	
Sodium Citrate	X	X	X	X	AC	AC	B	B	BC	B	A	BC	A	A	A			
Sodium Cyanide	X	X	X	B	BC	BC	X	X	AC	AC	A	BC	A	C	A		30 - 40	
Sodium Dichromate (Hot Seal)	B	BC	X						BC	BC	AC	AC	A	A	A		1	
Sodium Hydroxide (50%)	X	C	X	C	AC	B	X	AC	AC	AC	B	AC	X	AC	A		15	
Sodium Hypochlorite (20%)	X	X	X	X	X	X	X	X	X	X	C	X	A	A	A		20	
Sodium Nitrate	AC	B	C	B	A	A	X	BC	AC	AC	AC	BC	A	AC	A		23	
Sodium Peroxide (10%)	B	BC	X	C	BC	B	X	B	BC	B	BC	B	C	A	A		5	
Sodium Phosphate (Neutral)	X	B	B	B	B	B		B	B	B	B	B	A	B	A			
Sodium Salicylate		B	C	C	B	B		B	B	B	B	B	A	A	A			
Sodium Silicate	C	B	X	B	B	AC	X	A	BC	B	B	B	A	A	A		4	
Sodium Sulfate	AC	B	BC	X	B	AC	X	BC	AC	A	B	B	A	C	A			
Sodium Sulfide (< 50%)	X	X	X	X	B	AC	X	B	BC	BC	BC	B	C	C	A			
Sodium Stannate		C		C	B	B		B	B	B	B	B	A	A	A			
Sodium Thiosulfate (Hypo)	C	X	X	C	B	B		BC	B	B	B	BC	A	AC	A			
Solder Bath	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X		4	
Steam (Medium Pressure)		C	BC		A	A		AC	BC	BC	BC	B	A	A	A		10 - 15	
Stearic Acid	B	C	BC	C	B	AC	X	C	BC	A	A	A	A	A	A			
Sugar Solution	A	A	A	A	A	A		A	A	A	A	A	A	A	A		10 - 23	
Sulfamate Nickel																	7	
Sulfamic Acid	X	X	C	X					BC		BC		A	A	A		1	
Sulfur	A	X	X	X	A	A	X	BC	A	A	A	A	A	A	A			
Sulfur Chloride (Dry)	X	X	X	X	B	AC	C	X	BC	BC	BC	B	A	A	A			
Sulfur Dioxide (Dry)	C	AC	BC	C	B	AC	B	B	B	B	B	B	A	A	A		15 - 23	
Sulfur Dioxide (Wet)	X	X	X	X	X	BC	BC	X	X	X	X	AC	A	A	A		10 - 20	
Sulfuric Acid (10% - 50%)	X	X	X	X	X	BC	A	X	X	X	B	AC	A	X	A		15	
Sulfuric Acid (98%)	X	X	X	X	X	BC	A	X	X	BC	AC	AC	A	X	A		15	
Sulfurous Acid	C	X	X	X	BC	A	X	X	X	BC	B	B	A	A	A			
Tannic Acid	X	X	C	X	B	B	X	B	B	B	B	B	A	AC	A			
Tin (Molten)	X	X	X	X	X	X	X	X	X	X	X	X	A	A	X		20	
Trichloroethane	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		4	
Trichlorethylene	AC	BC	BC	A	AC	AC	X	A	B	B	A	A	A	A	A		23	
Triethylene Glycol	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		23	
Trioxide (Pickle)																	1	
Trisodium Phosphate	X	BC	BC	A			X	BC	AC	AC	AC	AC	X					
Turco™ 4181 (Alkaline Cleaner)																	1	
Turco™ 4008 (Descaler)										A							23	
Turco™ 4338 (Oxidizer)										A							1, 5	
Turco™ Ultrasonic Solution										A							1, 7	
Ubac™										A							1	
Udylite™ #66													A				1	
Unichrome™ #66													A	A	A		1, 5	
Unichrome™ CR-110													A	A	A		1	
Unichrome™ 5RHS													A	A	A		1	

See notes at end of table.

Reference Data

Corrosion Guide for Electric Immersion Heaters *(cont'd.)*

Legend	Sheath Material														Notes	
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available	Aluminum	Carbon Steel	Copper	Cast Iron	INCONEL® 600	INCOLOY® 800	Lead	MONEL® 400	304, 321, 347 SS	316 SS	20Cb-3 SS	C276 Hastelloy®	Quartz	Titanium		Teflon® ¹²
Solution	Corrosion Rating															
Vegetable Oil	B	B	BC		B	A		B	B	B	A	AC				23 - 26
Water, Deionized	X	X	X	X	A	A		C	A	A	A	B				50 - 75
Water, Demineralized	X	X	X	X	A	A		C	A	A	A	B				50 - 75
Water, Pure (Distilled)	X	X	X	X	A	A		A	A	A	A	A				50 - 75
Water, Process	C	X	B		A	A		B	BC	BC	A	B	A	A	A	50 - 75
Water, Potable	C	X	B		AC	A		B	BC	BC	A	B	A	A	A	50 - 75
Water, Salt Brine	X	X	BC		AC	AC		B	B	BC	BC	AC	A	A	A	55
Water, Sea	X	X	BC	X	BC	AC		A	C	BC	BC	AC	A	A	A	55
Watts Nickel Strike																
Whiskey	X	X	BC		B			A	A	A	B	AC				55
Wines	X	X	BC					B	A	A	B	A				55
Wood's Nickel Strike													A			
Yellow Dichromate										A		A				
Zinc (Molten)	X		X		X	X	X	X	X	X	X			X	X	
Zinc Chloride	X	X	X	X	B	BC	X	BC	X	B	B	B	A	B	A	
Zinc Phosphate																
Zincate™		A							A							23
Actane™ - Ethone Inc. Alcoa™ - Aluminum Company of America Alcorite™ - Fredrick Gumm Chemical Co. Alodine™ - Amchem Products Inc. ARP™ - Allied-Kelite Products Div. Bonderizing™ - Parker Div. OMI Corp. Clorox™ - The Clorox Co. Diversey™ - Diversey Chemical Co. Dowtherm™ - Dow Chemical Co. Dur-Nu™ The Duriron Co., Inc. Iridite™ - Allied-Kelite Products Div. Irlac™ - Allied-Kelite Products Div. Isoprep™ - Allied-Kelite Products Div. Jetal™ - Technic Inc. MacDermid™ - MacDermid, Inc. Oakite™ - Oakite Products Inc. Parkerizing™ - Parker Div. OMI Corp. Turco™ - Turco Products Div., Purex Corp. Ubac™ - The Udylyte Co., OMI Corp. Udylyte™ - The Udylyte Co., OMI Corp. Unichrome™ - M & T Chemicals Inc. Zincate™ - Ashland Chemical																
Notes —																
1. This solution is a mixture of various chemical compounds or is a proprietary trade name whose identity and proportions are unknown or subject to change without our knowledge. Check the chemical supplier or manufacturer to confirm the choice of sheath material or alternate sheath materials that may be suitable.																
2. CAUTION — Flammable material.																
3. Chemical composition varies widely. Contact the chemical supplier for specific recommendations.																
4. Direct immersion heaters are usually not practical. Recommend using clamp-on heaters on the outside surface of a cast iron pot.																
5. Element surface loading should not exceed 23 watts per square inch.																
6. For concentrations greater than 15%, element surface loading should not exceed 15 watts per square inch.																
7. Concentrations vary widely. See suggested watt density chart or contact your Local Chromalox Sales office.																
8. Remove crusts at liquid level.																
9. Clean often.																
10. Passivate stainless steel for maximum corrosion resistance.																
11. Stainless steel materials may be subject to chloride or stress corrosion cracking in this environment.																
12. Suggested watt densities do not apply to Teflon® coated heaters. Lower watt densities may be required.																