

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	
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	23	
Acetic Acid (50%)	C	X	X	X	X	B	X	B	C	A	AC	BC	A	A	15	
Acetone (100%)	A	BC	A	X	A	A	B	A	B	A	B	BC	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	B	A	B	A	A		2
Alcohol	B	B	A	B	A	A	A	A	B	A	B	B	A	A	23 - 26	2
Alcorite™													A	A		1
Alkaline Cleaners																1
Alkaline Soaking Cleaners		B														1
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	C	A	A	B	A		1
Aluminum Cleaners	X	C	X	C	A	A	X	A	A	B	A	X	B	A		1
Aluminum Sulphate (Sat.)	X	X	X	X	X	BC	B	X	BC	BC	B	BC	A	A		1
Alum	X	X	X	X	BC	BC	X	X	X	BC	BC	BC	A	A		1
Ammonia (Anhydrous)	C	A	X	X	A	C	X	A	B	A	A	A	A	A		
Ammonia (Gas)	X	C	X	X	B	C	C	X	A	A	B	A	A	A		
Ammonium Bifluoride	X	X	X	X	X	X	X	B	X	B	AC	B	X	X		
Ammonium Chloride (50%)	X	X	X	X	A	C	X	A	C	C	B	A	B	A		
Ammonium Hydroxide (25%)	B	BC	X	A	A	A	X	X	A	A	A	B	X	A		
Ammonium Nitrate	B	A	X	X	X	BC	X	X	A	A	A	A	A	C		
Ammonium Persulphate	B	X	X	X	C	C	C	X	C	B	B	B	A	A		
Ammonium Sulphate (< 40%)	X	X	X	X	B	A	B	B	C	B	B	B	A	A	23 - 26	2
Amyl Alcohol	C	A	A	B	B	B	B	BC	B	B	B	B	A	A		
Aniline	B	C	X	B	B	B	B	B	A	A	A	B	A	A		
Anodizing	X	X	X	X	X	X	A	X	X	X	A	A	A	X		
ARP 28™														A		1
ARP 80™ Blackening Salt														A		1
Arsenic Acid	X	X	C	X	X	B	X	X	B	B	B	C	A	X		
Asphalt	X	A	X	A	A	A	X	X	BC	B	B	A	B	A	6 - 10	2
Barium Hydroxide (Sat.)	X	B	X	B	B	B	X	C	B	B	B	B	A	AC		
Barium Sulphate	B	C	B	B	B	AC	B	B	B	B	B	B	A	A	55	
Beer	A	X	B		A	B	X	A	AC	A	A	A	A	B	30 - 40	5
Black Nickel													A	A	23	
Black Oxide									A				A	A	23	5
Black Liquor	X	X	X					BC	BC	BC	BC	C		A	15	
Bleach 5.5% Cl, Clorox™	X	X							BC	BC		AC		A	15 - 23	
Bonderizing™	SEE ZINC PHOSPHATE															
Boric Acid	X	X	C	X	C	A	C	BC	BC	C	A	A	A	A		1
Brass Cyanide																1, 5
Bright Nickel													A	A	23	10, 11
Brine (Salt Water)	X	X	BC		AC	AC		B	C	B		A			55	1
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							1
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														Suggest Density ¹²	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
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	23	
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	B	A	B	A	A	A	A	BC	A	10 - 23	2
Carbon Tetrachloride	X	C	AC	X	A	A	AC	A	A	A	A	AC	A	A	A	23 - 26	1
Carbonic Acid (Phenol)	B	B	X	C	A	AC	X	AC	A	A	A	A	A	A	A		1
Castor Oil	BC	A	AC	A	A	A	A	A	BC	B	A	A	A	A	A	23 - 26	
Caustic Etch	X	A	C	A	A	A	X	A	A	A	A	BC	X	A		15 - 26	6
Caustic Soda	SEE SODIUM HYDROXIDE															2	
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		
Chromic Acid (40%)	X	X	X	X	X	X	B	X	BC	B	BC	B	A	A	X		1
Chromic Anodizing													A	A	A		1
Chromylite													A	A	A		1
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			1
Cobalt Nickel													A	A			1, 6
Cod Liver Oil					A	A			A	A	A					23 - 26	1
Copper Acid													A		A		1
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	X		X	A	BC	B		X	B	B	B	A	A	AC	A		
Copper Fluoborate					B	B		B	B	B	B				A		
Copper Nitrate	X	X	X	X	X	BC		X	A	A	A	C	A	B	A		
Copper Pyrophosphate									A	A	A						1
Copper Strike		A		A					A	A	A						1
Copper Sulphate	X	X	X	X	BC	B	A	X	B	B	B	B	A	A	A		6 - 15
Creosote	C	A	BC	A	B	B	X	B	B	B	B	B	A	A	A	6 - 15	2
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				1
Deoxidizer (3AL-13 Non-Chrome)									A	A			A				1
Detergents	BC		A			B			A	B	A	AC		A	A	40 - 55	
Dichromic Seal		X		X					A	A			A	A	A		1
Diethylene Glycol	B	AC	B	A	B	B	A	B	A	A	A	B	A	A	A		1
Diversey-DS9333™													A	A	A		1
Diversey-511™													A				1, 5
Diversey-514™															A		1
Dowtherm™ (Diphenyl)	X	A	C		A			B	A	A	A	A				23	5
Dur-Nu™													A	A		23	1.5
Electro Cleaner		A							A								1
Electropolishing													A	A	A		1
Electroless Nickel													A	A	A		1
Electroless Tin (Acid)													A	A	A		1
Electroless Tin (Alkaline)										A			A				1
Enthone Acid - 80															A		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	B	A	X	B	B	A	A	A	A	A	A	23 - 30	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	BC	B	A	BC	A	AC	A		
Ferric Sulphate	X	X	C	X	C	C	B	C	BC	AC	A	A	A	A	A		1
Fluoborate													A	A	A		
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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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	A	BC	B	BC	A	B	A	A	30 - 40	
Fuel Oil (Normal)	B	A	B	A	B	A		B	A	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	B				23 - 26	
Gasolene (Refined)	B	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	X	AC	B	B	A	20 - 30	
Hydrochloric Acid (50%)	X	X	X	X	X	X	X	X	X	X	X	BC	X	X	A	15 - 25	
Hydrocyanic Acid (10%)	B	B	X	X	B	B	X	B	B	B	B	B	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	B	A	23 - 26	
Indium													A		A		1
Iridite™ - #4 - 75, #4 - 73, #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	X	X	B	X	X	X	X	X	B	A	A	A		1
Iridite™ Dyes - #12L-2, #40, #80													A		A		1
Irilac™													A		A		1
Iron Fluoborate													A		A		1
Iron Phosphate (Parkerizing™)										A	B	B	A	A	A		1
Isoprep™ Deoxidizer #187, #188										A					A		1
Isoprep™ Cleaner #186										A							1
Isoprep™ #191 Acid Salts															A		1
Jetal™																	1
Jet Fuel JP-4	B	B			A		B	B	A	BC	B	BC	A		A		
Kerosene	B	B	BC		B	A	B	B	B	B	B	B	B			23 - 26	2
Lacquer Solvents	A	A	A	A	B	B	A	B	A	A	A	A	A	A	A	23 - 26	2
Lead Acetate	X	X	X	X	A	A	X	B	B	B	B	B	A	A	A		1
Lead Acid Salts																	
Lime Saturated Water	X	B	B	B	B	B	X	B	B	A	B	A	X		C	23 - 40	
Linseed Oil	B	B	B	B	B	A	B	B	A	A	A	A	A		A	10 - 15	2
Lubricating Oil	B	A	A	A	A	A	A	B	B	B	A	B	A	A	A	23 - 26	7
Machine Oil		A	A	A	A	A	A	B	B	B	B	B	A	A	A	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	B	A		
Magnesium Sulfate	B	BC	BC	B	AC	B	B	A	B	B	B	B	A	B	A		
McDermid™ #629																	1
Mercuric Chloride	X	X	X	X	X	X	X	X	X	B	BC	B	A	A	A	23 - 30	
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	C	C	B	AC	AC	AC	B	B	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				30 - 40	
Mineral Oil	B	B	B		A	AC	B	A	AC	B	AC	B	A	A	A	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																
Muriatic Acid	SEE HYDROCHLORIC ACID																
Naphtha	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A		2
Nickel Acetate	X	X	X	X	AC	B	C	B	BC	BC	B	A	A	A	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	AC	AC	AC		A		A		(Cyanide Free)
Nickel Copper Strike	X	X	C	X	C	C	B	C	AC	AC	AC		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	1
Nitric & 6% Phosphoric Acid	X	X	X	X	C	X	X	X	BC	BC	C		A		A	15	1
Nitric & Sodium Chromate	X	X	X	X	C	X	X	X	BC	BC	C		A		A	15	1
Nitric & Sulfuric Acid (50% - 50%)	X	X	X	X	C	X	X	X	AC	AC	AC		A		A	15	2
Nitrobenzene	BC	B	BC	B	B	B	X	B	A	B	A	B	A	A	A		
Oakite™ #67	C	BC	B	BC	A	AC	X	BC	AC	AC	B	B	A	AC	A	30 - 40	1
Oleic Acid	C	BC	B	BC	A	AC	X	BC	AC	AC	B	B	A	AC	A	23 - 26	
Olive Oil	AC	B	B	B	AC	AC	X	B	B	B	B	AC	A	A	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	A	X	AC	AC	X	B	X	B	B	B	A		A	23 - 26	1, 2
Paint Stripper (Solvent)	X	X	A	X	AC	AC	X	B	X	B	B	B	A		A	23 - 26	1, 2
Paraffin	A	A	A	A	B	A		B	A	A	A	A	A		A	6 - 15	2, 7
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	B	A	AC	AC	B	B	A	A	A	23	
Petroleum Oils (Refined)	X	B	B	B	A	A		A	A	A	A		A			23 - 26	2, 3, 7
Petroleum Oils (Sour)	B	B	X	B	A	A		X	A	B	B		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	1, 5, 9
Picric Acid	BC	X	X	X	C	BC	X	X	BC	B	B	B	A	A	A	23 - 35	1
Plating Solutions - Brass										B	AC	AC	A	A	A	23 - 35	1
Plating Solutions - Cadmium										B	AC	AC	A	A	A	23 - 35	1
Plating Solutions - Chrome (25%)	X	X	X	X	X	BC		X	BC	B	AC	AC	A	X	A	23 - 35	1
Plating Solutions - Chrome (40%)	X	X	X	X	X	X		X	BC	B	AC	AC	A	A	A	15 - 20	1
Plating Solutions - Cobalt									A				A		A	23 - 35	1
Plating Solutions - Copper													AC	A	A	23 - 35	1
Plating Solutions - Gold (Cyanide)									AC	AC			AC	A	A	15 - 20	1
Plating Solutions - Gold (Acid)		A							AC	AC			A	A	A	15 - 20	1
Plating Solutions - Nickel									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										C	AC	AC	A	X	A	23 - 35	1
Plating Solutions - Tin-Nickel													A		A	23 - 35	1
Plating Solutions - Tin-Alkaline		A							A				A		A	15 - 20	1
Plating Solutions - Zinc											AC	AC	A	A	A	23 - 35	1
Plating Solutions - Zinc Acid													A		A	15 - 20	1
Plating Solutions - Zinc Cyanide															A	15 - 20	1
Potassium Aluminum Sulphate	C	X	C						A	C	BC	A	BC	A	A		1
Potassium Bichromate	B	C	C	C	B	B		B	B	B	B	B	A	AC	A		
Potassium Chloride (30%)	X	BC	X	X	AC	B	C	AC	AC	A	AC	B	A	A	A		
Potassium Cyanide (30%)	X	BC	X	X	B	B	X	B	B	B	B	B	A	X	A		1
Potassium - Hydrochloric Solution	X	BC	C	X	B	B	X	B	BC	B	A	B	X	X	A		
Potassium Hydroxide (27%)	X	BC	C	X	B	B	X	B	BC	B	A	B	X	X	A		
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													Suggest Density ¹²	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		
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																			
Solution	Corrosion Rating																		
Reynolds Brightener														A			A		1
Rhodium Hydroxide														A			A		1
Rochelle Salt - Cyanide			A							A				A			A		1
Ruthenium Plating														A			A		1
Silicon Oils	BC	B	AC							B	B							23 - 26	
Silver Bromide (10%)	X	X	X	X						C	X	X	C	AC	A	A	A		
Silver Cyanide	X	C	X	C						BC	AC	AC	AC	AC	A	A	A		
Silver Lume														A			A		1
Silver Nitrate	X	X	X	X	BC	BC	X	X	B	AC	B	AC	A	AC	A	A			3
Soap Solutions	B	BC	BC	C	AC	AC	C	BC	BC	BC	BC	AC	AC	A			A	55	
Sodium Bichromate (Neutral)	C	B	C	A	B	B								A	C		A		
Sodium Bisulphate	X	C	X	X	BC	BC	C	BC	BC	BC	BC	B	A	BC	A	A			
Sodium Bromide (10%)	X	C	C	X	B	B								A	C		A		
Sodium Carbonate	X	C	BC	C	A	AC								AC	C		A		
Sodium Chlorate	B	X	BC	X	A	AC	B	AC	BC	BC	B	B	A	A	A	A			
Sodium Chloride	X	C	B	X	AC	A	B	AC	C	C	C	B	A	A	A	A			11
Sodium Citrate	X	X	X	X	AC	AC	X	B	BC	B	A	BC	A	A	A	A			
Sodium Cyanide	X	X	X	B	BC	BC	X	X	AC	AC	A	BC	A	C	A	A			30 - 40
Sodium Dichromate (Hot Seal)	B	BC	X											AC	A	A	A		1
Sodium Hydroxide (50%)	X	C	X	C	AC	B	X	AC	AC	AC	B	AC	X	AC	A	A			15
Sodium Hypochlorite (20%)	X	X	X	X	X	X	X	X	X	X	C	X	A	A	A	A			20
Sodium Nitrate	AC	B	C	B	A	A	X	BC	AC	AC	AC	BC	A	AC	A	A			23
Sodium Peroxide (10%)	B	BC	X	C	BC	B	X	B	BC	B	BC	B	C	A	A	A			5
Sodium Phosphate (Neutral)	X	B	B	B	B	B								A	B		A		
Sodium Silicofluoride														A			A		
Sodium Silicate	C	B	X	B	B	AC	X	A	BC	B	B	B	B	A	A	A			4
Sodium Sulfate	AC	B	BC	X	B	AC	X	BC	AC	A	B	B	A	C	A	A			
Sodium Sulfide (< 50%)	X	X	X	X	B	AC	X	B	BC	BC	BC	B	C	C	A	A			
Sodium Stannate														A			A		
Sodium Thiosulfate (Hypo)	C	X	X	C	B	B								BC	BC	A	AC	A	
Solder Bath	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X			4
Steam (Medium Pressure)	B	C	BC	C	A	A	X	AC	BC	BC	BC	B	A	A	A	A			10 - 15
Stearic Acid														A	A	A	A		
Sugar Solution	A	A	A	A	A	A	X	A	A	A	A	A	A	A	A	A			10 - 23
Sulfamate Nickel														A	A	A	A		1
Sulfamic Acid	X	X	C	X								BC		A	AC	A	A		
Sulfur	A	X	X	X	A	A	X	BC	A	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	A			
Sulfur Dioxide (Dry)	C	AC	BC	C	B	AC	B	B	B	B	B	B	A	A	A	A			15 - 23
Sulfur Dioxide (Wet)	X	X	X	X	X	BC	BC	X	X	B	BC	AC	A	A	A	A			10 - 20
Sulfuric Acid (10% - 50%)	X	X	X	X	X	BC	A	X	X	X	B	AC	A	X	A	A			15
Sulfuric Acid (98%)	X	X	X	X	X	BC	A	X	X	BC	AC	AC	A	X	A	A			15
Sulfurous Acid	C	X	X	X	BC	A	A	X	X	BC	B	B	A	A	A	A			
Tannic Acid	X	X	X	X	B	B	X	B	B	B	B	B	A	AC	A	A			
Tin (Molten)	X																X		20
Trichloroethane	A	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	B	A	A	A	A	A			23
Triethylene Glycol	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A			23
Trioxide (Pickle)														A			A		1
Trisodium Phosphate	X	BC	BC	A										A			A		
Turco™ 4181 (Alkaline Cleaner)														A			A		1
Turco™ 4008 (Descaler)														A			A		23
Turco™ 4338 (Oxidizer)														A			A		1, 5
Turco™ Ultrasonic Solution														A			A		1, 7
Ubac™														A			A		1
Udylite™ #66														A	A		A		1
Unichrome™ CR-110														A			A		1, 5
Unichrome™ 5RHS														A			A		1

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	20Ch-3 SS	C276 Hastelloy®	Quartz		Titanium	Teflon® 12
A = Good to Excellent B = Fair to Good C = Depends on Conditions X = Not Suitable Blank = Data Not Available																
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		A	A		B	BC	BC	A	B	A	A	A	50 - 75
Water, Salt Brine	X	X	BC		AC	AC		B	C	BC		A				55
Water, Sea	X	X	BC	X	BC	AC		A	C	BC	BC	AC	A	A	A	55
Watts Nickel Strike													A			1
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			1
Yellow Dichromate										A			A			1
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		A	B	A	
Zinc Phosphate										A					X	
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 – <ol style="list-style-type: none"> 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. CAUTION — Flammable material. Chemical composition varies widely. Contact the chemical supplier for specific recommendations. Direct immersion heaters are usually not practical. Recommend using clamp-on heaters on the outside surface of a cast iron pot. Element surface loading should not exceed 23 watts per square inch. For concentrations greater than 15%, element surface loading should not exceed 15 watts per square inch. Concentrations vary widely. See suggested watt density chart or contact your Local Chromalox Sales office. Remove crusts at liquid level. Clean often. Passivate stainless steel for maximum corrosion resistance. Stainless steel materials may be subject to chloride or stress corrosion cracking in this environment. Suggested watt densities do not apply to Teflon® coated heaters. Lower watt densities may be required. 																

Technical Information

NEMA Enclosures & Chromalox Equivalents



NEMA Enclosures for Non-Hazardous Areas

The National Electrical Manufacturer's Association (NEMA) publishes a classification system for electrical enclosures. The NEMA classification or type indicates the exposure or environment for which the enclosure was designed. While Chromalox E1, E2, E3 and E4 enclosures are designed for applications similar to the NEMA types, they are not identical due to modifications required to adapt the housings to heater configurations. Condensed descriptions of the NEMA non-hazardous enclosure types are listed below with the Chromalox equivalents indicated. The condensed descriptions are not intended to be complete representations of the National Electrical Manufacturers Association standards for electrical enclosures. For complete details on NEMA enclosure requirements refer to NEMA Std. No. 250.

Type 1 Enclosures — are for indoor use in locations where unusual service conditions do not exist. Intended primarily to provide protection against contact with the enclosed equipment and limited amounts of falling dirt. **(Chromalox E1 or General Purpose enclosures.)**

Type 2 Enclosures — are for indoor use providing protection against limited amounts of falling water and dirt.

Type 3 Enclosures — are for outdoor use providing protection against windblown dust, rain, and sleet and damage from external ice formation on the enclosure.

Type 3R Enclosures — are similar to Type 3 except Type 3R provides protection against falling rain.

Type 3S Enclosures — are for outdoor use protecting against windblown dust, rain, and sleet and providing for operation of external mechanisms when ice laden.

Type 4 Enclosures — are for indoor or outdoor use providing protection against windblown dust and rain, splashing water, and hose-directed water and remain undamaged by the formation of ice on the enclosure. **(Chromalox E4 Moisture Resistant or E2 Moisture and Explosion Resistant enclosures.)**

Type 4X Enclosures — are similar to Type 4 except Type 4X also protects against corrosion.

Type 5 Enclosures — are for indoor use and protects against dust and falling dirt.

Type 6 Enclosures — are for indoor or outdoor use providing protection against the entry of water during temporary submersion at a limited depth and remain undamaged by ice on the enclosure.

Type 6P Enclosures — are similar to Type 6 except Type 6P protects against the entry of water during prolonged submersion at a limited depth.

Type 12 Enclosures — are intended for indoor use providing protection against dust, falling dirt and dripping non-corrosive liquids. **(Chromalox E2 and E4 enclosures.)**

Type 12K Enclosures (knockouts) — are similar to Type 12 except they are provided with knockouts. Knockouts only permitted in either or both the top or bottom walls.

Type 13 Enclosures — are for indoor use providing protection against lint, dust, spraying of water, oil and non-corrosive coolant. **(Chromalox E2 enclosures may be used.)**

The table below lists a comparison of the characteristics of NEMA and Chromalox enclosures for Non-Hazardous areas.

Note — For Classified (Hazardous) Location enclosures, refer to NEMA Enclosures and Hazardous Location Heaters elsewhere in this section.

Comparison of Specific Applications of Enclosures for Non-Hazardous Locations

Provides a Degree of Protection Against the following Environmental Conditions	Type of Enclosure															Chromalox®			
	1	2	3	3R	3S	4	4X	5	6	6P	11	12	12K	13	E1	E2	E3	E4	
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing		X				X	X		X	X	X	X	X	X		X	X	X	
Dust, lint, fibers and flyings — Not Class III						X	X	X	X	X		X	X	X		X	X	X	
Hosedown and splashing water						X	X		X	X						X		X	
Oil and coolant seepage												X	X	X		X	X	X	
Oil or coolant spraying and splashing														X		X			
Windblown dust			X		X	X	X		X	X						X	X	X	
Rain, snow and sleet			X	X	X	X	X		X	X						X			
Sleet					X														
Corrosive agents							X			X	X								
Occasional temporary submersion									X	X									
Occasional prolonged submersion										X									