

CORROSION RESISTANCE OF SHEATH MATERIALS

24T: The following is a guideline to select an immersion heater sheath material for direct heating of corrosive materials. Based on known data and experience on the compatibility of standard materials and corrosive environments, the information should only be considered an initial step in the selection process. Other information can come from the manufacturer of the corrosive material and testing. The final selection comes from the end user's knowledge of the process.

Variables to consider include:

1. Solution chemistry
2. Possible contamination of the solution from other processes
3. Process temperature
4. Flow rate (velocity) across elements
5. Reducing heater watt density to keep element temperatures as low as possible
6. Accumulating sludge can impede heat transfer from the elements to the process and can accelerate corrosion.
7. The welding or other contact of dissimilar metals could generate galvanic corrosion
8. Provision should be made to periodically inspect the elements to

- insure the continuation of the process
9. See warranty statement pertaining to corrosion

*NOTES

1. This solution involves a mixture of various chemical compounds whose identity and proportions are unknown or subject to change without prior knowledge. Check supplier to confirm choice of sheath materials plus alternate sheath materials that may be used.
2. Caution – Flammable material
3. Chemical composition varies widely. Check supplier for specific recommendations.
4. Direct immersion heaters not practical. Use clamp-on heaters on outside surface.
5. Element watt density should not exceed 20 watts/sq. in.
6. For concentrations greater than 15%, element watt density should not exceed 20 watts/sq. in.
7. See suggested watt density chart.
8. Remove crusts at liquid level.
9. Clean often.
10. Do not exceed 12 watts/sq. in.
11. Passivate stainless steel, Inconel and Incoloy.

SOLUTION	SHEATH MATERIAL													
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304-321, 347 S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	
Acetic Acid	X	X	C	X	B	C	B	A	C	C	A	A	A	Note 2 Note 1 Note 1 Note 1, Note 9 Note 1
Acetone	X	X	B	A	A	B	B	B	A	A	A	A		
Alcohol	B	B	B	A	A	B	A	A	A	A	A	A		
Alcorite												A		
Alkaline Cleaners						B							X	
Alkaline Soaking Cleaners	B													Note 1
Alodine							A							Note 1
Aluminum Bright Dip												A	A	Note 1
Aluminum Chloride	X	X	X	X	X	X	X	X	X	X	C	A	A	Note 1
Aluminum Cleaners	C	C	X	X	A	A	A	B	A	X	B	X	X	Note 1
Aluminum Sulphate	X	X	X	X	X	A	A	A	X	X	A	A	A	Note 1
Alum	X	X	X	X	X	X	X	B	X	X	X	A		Note 1
Ammonia	X	X	C	X	X	X	X	X	C	B	A	A		
Ammonium Bifluoride	X	X	X	X	X	X	X	B	X	X	X	X	A	
Ammonium Chloride	X	X	X	X	C	C	C	C	C	C	A	A	A	
Ammonium Hydroxide	A	A	X	X	A	A	A	A	A	A	A	X	A	
Ammonium Nitrate	A	X	C	X	X	A	A	A	X	X	X	A	A	
Ammonium Persulphate	X	X	X	X	X	C	B	B	C	C		A	A	
Ammonium Sulphate	X	X	X	X	B	C	B	B	B	B	A	A		Note 2
Amyl Alcohol	A	B	C	A	B	B	B	B	B	B	A	A		Note 1 Note 1
Aniline	B	B	B	X	B	A	A	A	B	B	A	A		
Anodizing	X	X	X	X	X	X	X	A	X	X	X	A	A	
ARP-28														
ARP-80 Blackening Salt												A		
Arsenic Acid	X	X	X	X	X	C	B	B	X	X	X	A	A	Note 2
Asphalt	A	A	X	X	X	A	A	A	A	A	A	A	A	
Barium Hydroxide	B	B	X	X	B	B	A	A	B	B	X	A	A	
Barium Sulphate	B	B	B	B	B	B	B	B	B	B	A	A	A	
Black Nickel													A	
Black Oxide						A								
Boric Acid	X	X	X	C	C	C	C	C	C	C	A	A	A	Note 1 Note 1 Note 1 Note 1, Note 5 Note 1
Brass Cyanide						A						A		
Bright Copper-Acid														
Bright Copper-Cyanide	A					A					A	A		
Bright Nickel														
Bronze Plating	A					A								Note 1
Butanol	A	A	B	A	A	A	A	A	A	A	A	A	A	Note 2 Note 1 Note 1
Cadmium Black														
Cadmium Plating						A						A		
Calcium Chlorate	B	B	B	C	B	B	B	B	B	B				
Calcium Chloride	B	B	A	B	B	B	B	B	B	B	A	A	A	
Carbon Dioxide-Dry Gas	X	X	A	A	A	A	A	A	A	A	X	A	X	
Carbon Dioxide-Wet Gas	X	X	A	X	A	A	A	A	A	A	X	A	X	
Carbonic Acid	C	C	B	C	C	B	B	A	B	A	A	A	A	Note 6
Carbon Tetrachloride	X	X	X	A	A	A	A	A	A	A	A	A	A	
Castor Oil	A	A	A	A	A	A	A	A	A	A	A	A	A	
Caustic Etch	A	A	X	C	A	A	A	A	A	A	A	X		
Chlorine Gas-Dry	X	X	X	X	C	C	C	B	C	B	B	A	B	
Chlorine Gas-Wet	X	X	X	X	X	X	X	X	X	X	X	A	X	
Chloroacetic Acid	X	X	X	X	C	X	X	X	C	C	A	A	A	
Chromium Plating	X	X	X	X	X	X	X	X	X	X	A	A	X	Note 1
Chromic Acetate												A		
Chromic Acid	X	X	X	X	X	X	X	X	X	X	A	A	X	
Chromic Anodizing												A		

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SOLUTION	SHEATH MATERIAL													*NOTES
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	
Chromylite Citric Acid Clear Chromate Cobalt Nickel Cobalt Plating Cod Liver Oil	X	X	X	X	B	B	A	A	B	B	A	A A A A A	A	Note 1 Note 1 Note 1, Note 6 Note 1
Copper Acid Copper Bright Copper Bright Acid Copper Chloride Copper Cyanide Copper Fluoborate	X A	X A	X X	X X	X C B	X B B	X B B	X B B	X X B	X X B	A	A A A A	A A A	Note 1 Note 1 Note 1
Copper Nitrate Copper Pyrophosphate Copper Strike Copper Sulphate Creosote Cresylic Acid	X A X A C	X A X A C	X X X C C	X C B C	X A A X B B C	B A A B B B A	B B B B B B A	B B A C B B B	C C C C C	X X X B C		A A A A A A	A A A	Note 1 Note 1 Note 2 Note 2
Deionized Water Deoxidizer (Etching) Deoxidizer (3AL-13) Dichromic Seal Diethylene Glycol Diversey-DS9333	X B	X A	B	B	B	A A	SEE WATER A A	A A	A B			A A A	A	Note 1 Note 1, Non-Chromate Note 1
Diversey-511 Dur-Nu Electro Cleaner Electro Polishing Electroless Nickel Electroless Tin (Acid)	A					A					A A	A A A A		Note 1, Note 5 Note 1, Note 5 Note 1 Note 1 Note 1 Note 1
Electroless Tin (Alkaline) Ether Enthone Acid-80 Ethyl Chloride Ethylene Glycol Fatty Acids	B B A X	B B B X	B A A	B A B X	B B B B	B B B B	A B A A	A B B A	B B B B	B A B B	A A A A	A A A A	A A	Note 1 Note 2 Note 1 Note 2 Note 5
Ferric Chloride Ferric Nitrate Ferric Sulphate Fluoborate (high speed) Fluorine Gas, Dry Formaldehyde	X X X C X	X X X X X	X X X X B	X X X X B	X X X A B	X B B C A	X B B C A	X A B C A	X X C C B	X X C A B	A A A A A	A A A A C A	A	Note 1
Formic Acid Freon Fuel Oil-Normal Fuel Oil-Acid Gasoline-Refined Gasoline-Sour	X A A X A C	X A A X A C	B A A X A C	B A A X A C	B A B C B X	A A A C A B	X A A B A B	A A A C A A	B A B C B X	B A B C B X	C A A A	A		Note 2, Note 3, Note 7 Note 2, Note 3, Note 7 Note 2, Note 5 Note 2, Note 3, Note 5
Glycerin, Glycerol Gold Acid Gold-Cyanide Grey Nickel Hot Seal Sodium Dichromate Hydrocarbons-Aliphatic	B A	B	A	B	A	A A	A A	A A	A A	A A	A A	A A	A	Note 1 Note 1 Note 1, Note 5 Note 1 Note 2
Hydrocarbons-Aromatic Hydrochloric Acid Hydrocyanic Acid Hydrofluoric Acid Hydrogen Peroxide Indium	A X X X X	A X X X X	A X B X A	A X X X X	A X B X B	A X B X B	A X B X B	A X B X B	A X B X B	A X B X B	X X X X	A X A A A	A	Note 2 Note 5 Note 1
Iridite-#4-75, #4-73 #14, #14-2, #14-9, #18-P 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					A		Note 1 Note 1

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SHEATH MATERIAL														
SOLUTION	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	*NOTES
Iridite dyes- #12L-2, #40, #80 Irilac Iron Phosphate Isoprep Deoxidizer #187, #188 Isoprep Acid Aluminum Cleaner #186							A A A					A A	A A	Note 1 Note 1 Note 1 Note 1
Jeta. Kerosene Lacquer Solvent Lead Acetate Lead Acid Salts Lime Saturated Water	A A X B	 A X B	A A X X	A A X B	A B A B	A A A A B	A A A A A	A A A B	A B A B	A B A B	 A A A	 A A X		Note 1 Note 2 Note 2 Note 1
Linseed Oil Magnesium Chloride Magnesium Hydroxide Magnesium Nitrate Magnesium Sulfate McDermid #629	A X A B B	A X A B B	B X B B B	B B A B B	B B A B A	A C A B B	A B A B B	A A A B B	B B A B B	B A A X A	 A A B A	A A A A A	 A	Note 2 Note 1
Mercuric Chloride Mercury Methyl Alcohol Methanol Methyl Bromide Methyl Chloride Methylene Chloride	X A B C X X	X A B C C C	X X C X X C	X X B B A C	X B A B C C	X A B A C C	X A B A C C	X A B A C A	X A B B C C	X B A B C B	A A A A A A	A A A A A A		Note 2
Mineral Oil Muriato Naphtha Nickel Acetate Sea Nickel Chloride Nickel Plate-Bright	A A X	A B X	A A X	A A X	A A C	A A X	A A C	A A B	A A C	A A B	A A C	A A A A A	A A A	Note 1 Note 2 Note 1 Note 1, Note 5 Note 1, Note 5
Nickel Plate-Dull Nickel Plate-Watts Sol. Nickel Sulphate Nickel Copper Strike (Cyanide Free) Nitric Acid	 X X	 X X	 X X	 C X	 C X	 B C	 B C	 B B	 C X	 C X	A A	A A A A	A A A A	Note 1, Note 5 Note 1, Note 5 Note 1
Nitric Hydrochloric Acid Nitric 6% Phosphoric Acid Nitric Sodium Chromate Nitrobenzene Oakite #67 Oil	X A A	X B A	X B A	X B A	X B A	X B A	X A A B A	X A A	X B A	X B A	X A A A A	A A A A A	A A A	Note 1 Note 1 Note 2 Note 1 Note 7
Oleic Acid Oxalic Acid Paint Stripper (High Alkaline Type) Paint Stripper (Solvent Type) Paraffin Perchloroethylene	C X A A A	C X A A	C X A B	C B A B	B B A A	C X A A	B X A A	B B A A	B X A A	A B A A	B X A A	A A A A	A A	Note 1 Note 1, Note 2 Note 2, Note 7
Petroleum-Crude Phenol Phosphate Phosphate Cleaner Phosphatizing Phosphoric Acid	B B X	B B X	A B X	A C	A B C	A C X	A B A A B	A B B	B C	B C	A X	A A A	 X X X A	Note 2, Note 3, Note 7 Note 1, Note 5, Note 9 Note 1, Note 5, Note 9 Note 1, Note 5, Note 9 Note 5, Note 9
Picric Acid Potassium Acid Sulphate Potassium Bichromate Potassium Chloride Potassium Cyanide Potassium Hydrochloric	X C X C	X C X X	X B X X	X C X	X B B C	B B C B	B B A B	B B A B	C B B B	C C B	 A A A A A	A A A A A	A A A	Note 1 Note 1
Potassium Hydroxide Potassium Nitrate Potassium Sulphate Reynolds Brightener Rhodium Hydroxide Rochelle Salt Cyanide	X B C A	X B X A	X A A A	X B B A	B B A A	C B A A	C B A A	C B A A	C B B B	B B B A	C A A A A	X A A A A	A A A A	Note 1 Note 1

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SOLUTION	SHEATH MATERIAL													*NOTES
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S. S.	316 S. S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	
Ruthenium Plating														Note 1
Silver Bromide	X	X	X	X	C	X	X	C			A	A	A	
Silver Cyanide	C	C			B	A	A	A				A		Note 1
Silver Lume						A	A		A					
Silver Nitrate	X	X	X	X	X	C	C	B	C	C	A	A		Note 3
Soap Solutions	A	A	X		A	A	A	A						
Sodium-Liquid Metal	C	X	X	X	B	A		B	A	A	C	X		
Sodium Bisulphate	X	X	C		C	X	X	B	B	C	C	A		
Sodium Bromide	B	X	X	B	B	X	B	B	B	B		A	A	
Sodium Carbonate	C	C	X	A	B	B	B	B	B	B	A	C	A	
Sodium Chlorate	X	X	B	A	A	B	B	B	B	A	A	A	A	
Sodium Chloride	X	X	X	B	A	X	X	C	B	A	C	A		
Sodium Citrate	X	X	X	X		B	B	B				A	A	
Sodium Cyanide	X	B	X	X	X	A	A	A	A	A	C	A		
Sodium Dichromate														
(Sodium Bichromate)	A	A	C	X		B	B	B			C	A		
Sodium Hydroxide	C	C	X	X	C	X	C	C	B	B	C	X	A	Note 8. Note 6
Sodium Hypochlorite	X	X	X	X	X	X	X	B	X	X	A	A	A	
Sodium Nitrate	B	B	X	C	B	A	A	A	A	A	A	A		Note 5
Sodium Peroxide	B	A	B	X	B	B								
Sodium Phosphate	B	B	X	B	B	B	B	B	B	B	A	A	A	
Sodium Salicylate	B	C			B	B	B	B	B	B		A	A	
Sodium Silicate	B	B	X	B	B	B	B	B	B	B	A	A	A	Note 4
Sodium Sulphate	B	X	A	B	B	X	B	B	B	B	C	A	A	
Sodium Sulphide	X	X	X	X	B	X	C	C	B	C	C	C	A	
Solder Bath	X	B			X	X	X	X	X	X	X	X	X	
Sodium Stannate	C	C			B	B	B	B	B	B		A	A	Note 1
Stanostar														
Stearic Acid	C	C	B	X	X	C	A	B	B	A	A	A	A	Note 7
Sugar Solution	A	A	A	A	A	A	A	A	A	A	A	A	A	
Sulfamate Nickel														Note 1
Sulfuric Acid	X	X	X	X	X	X	X	B	X	X	A	A	A	
Sulfurous Acid	X	X	C	X	X	X	X	A	X	X	X	A	A	
Sulphamic Acid	X	X	X			X	X					A	A	
Sulphur	X	X	A	X	B	A	A	A	A	A	A	A	A	
Sulphur Chloride	X	X	X	X	C	C	C	C	C	B		A	A	
Sulphur Dioxide	C	C	C	C	X	C	B	B	C	C	A	A		
Tannic Acid	X	X			C	B	B	B	C	C				
Tin (Molten)			X	X	X	X	X	X		X			X	Note 4
Tin-Nickel Plating												A	A	Note 1
Tin Plating-Alkaline	A					A	A	A	A	A	A			Note 1
Trichloroethane	A	A	A	A	A	A	A	A	A	A	A	A		
Trichlorethylene	A	A	A	B	B	A	A	A	A	A	A	A		
Triethylene Glycol	A	A	A	A	A	A	A	A	A	A	A	A		
Trisodium Phosphate	A	A	X	C	C	C	C	C				X	X	
Trioxide (Pickle)												A	A	Note 1
Turco 4181 (Alk. Cleaner)							A							Note 1
Turco 4008 (Descaler)							A							Note 1. Note 5
Turco 4338 (Oxidizer)							A							Note 1. Note 7
Turco Ultrasonic Solution							A							Note 1
Ubec											A	A	A	Note 1
Udylite #66												A	A	Note 1. Note 5
Unichrome CR-110												A	A	Note 1
Unichrome 5RHS												A	A	Note 1
Water Deionized	X	X	X	X	A	A	A	A	A	A				Note 11
Water Demineralized	X	X	X	X	A	A	A	A	A	A				Note 11
Water Pure	X	X	X	X	A	A	A	A	A	A				Note 11
Water Potable	X	C	C	B	A	C	B	A	A	A	A	A	A	
Water Sea	X	X		X	A	C	C	A	B	B	A	A	A	
Watt's Nickel Strike														Note 1
Whiskey				A	A	A	A	A						Note 2
Wood's Nickel Strike														Note 1
Yellow Dichromate							A					A		Note 1
Zinc (Molten)			X	X	X	X	X	X	X	X	X	A	X	
Zinc Chloride	X	X	X	X	B	X	X	B	X	B	X	A	A	
Zinc Plating Acid														Note 1
Zinc Plating Cyanide	A					A								Note 1
Zinc Phosphate							A						X	Note 1 Note 5
Zincate	A					A								Note 1

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable