

Corrosion Resistance Guide

The following table has been compiled as a guide for selecting appropriate cable trays for various industrial environments. The information can only be used as a guide because corrosion processes are dictated by the unique circumstances of any particular assembly.

Corrosion is significantly affected by trace impurities which, at times, can become concentrated through wet/dry cycles in locations that are prone to condensation and evaporation. It is not uncommon to find aggressive mists created from contaminant species, notably from sulfur or halogen sources.

Temperature greatly influences corrosion, sometimes increasing the rate of metal loss, [a rule-of-thumb guide is that a 30°C change in temperature results in a 10X change in corrosion rate]. Sometimes corrosion attack slows down at higher temperatures because oxygen levels in aqueous solutions are lowered as temperatures increase. If an environment completely dries out then there can be no corrosion.

Stress-associated corrosion might occur when assemblies are poorly installed and/or fabricated, e.g., on-site welding or mechanical fastening. Premature failure can result from: corrosion fatigue, which can occur in any environment; **stress corrosion cracking**, which occurs in the presence of a specific chemical when the metal is under a tensile stress, which may be residual or applied, (e.g., from poor fabrication or welding); fretting, where two adjacent surfaces (under load) are subjected to an oscillatory motion across the mating surfaces.

Design - good design should minimize the risk of stress concentrations within a structure. Examples include sharp profiles, abrupt section changes, and threaded screws. These measures are particularly important for metals that are prone to stress corrosion cracking in specific media.

Design plays a significant role in exacerbating corrosion. Non-draining locations create liquid traps; local metal-to-metal (or metal-to-non-metal) contact points (e.g., mechanical assemblies (bolts) with washers or spacers), permit **crevice corrosion** and/or **galvanic corrosion** to occur. Areas that are poorly maintained, (e.g., surfaces are not regularly (or properly) washed and stubborn deposits remain on the metal surface), are particularly prone to localized corrosion damage due to different levels of oxygen under and adjacent to the location in question (differential aeration). Resulting damage from these situations is in the form of small holes (pits). In each of the examples just quoted there is a restricted supply of oxygen. Thus, metals (e.g., aluminum, stainless steels, zinc) that rely on oxygen to form protective corrosion films (oxides, hydroxides, carbonates, etc.,) may be prone to localized **pitting** and/or **crevice corrosion**.

A further example of localized corrosion occurs when **dissimilar metals** contact each other in the presence of a corrodent, i.e., **galvanic corrosion**. Each metal will corrode but the one that is most active [anode] can be more corroded especially when there is a large surrounding area of the less active [cathodic] metal. It is wise to avoid small anodic areas. Some examples include: steel bolts [small area of anodic metal] in stainless steel plate, [large area of cathodic metal]; steel bolts in copper plate - the steel corrodes). There can be environmental influences, for example a fluid that contains active metallic species, for example copper ion contact with aluminum (copper picked up from aqueous solutions conveyed in copper pipe) - the aluminum corrodes. A further dramatic example is provided when trace quantities of mercury contact aluminum - the aluminum corrodes very rapidly. These are examples of **deposit corrosion**.

Key to Symbols in Table

The following symbols have been used throughout the TABLE in order to provide an indication about the suitability of a potential candidate material for a specific chemical environment.

NOTE: These tables should be regarded only as GUIDES to anticipated performance because of possible contributions from temperature, pollutant (contaminant) species, etc. Further details have been given elsewhere.

SYMBOLS:

++	first choice; very low corrosion rate, typically <5 mpy, or <0.005 inch/year, (1 mil = 1/1000 inch).
+	good choice; low corrosion rate, typically <20 mpy, or <0.02 ipy.
-	can use; corrosion rate up to 50 mpy (0.05 ipy); some limitations may apply.
X	not recommended.
(-)	brackets indicate probable limitations, e.g., at higher temperatures, [symbol "T"]; at higher concentrations, [symbol "C"]; due to pitting, [symbol "P"]; due to local grain boundary attack in the metal - intergranular corrosion, [symbol "I"]; or, due to stress corrosion cracking, [symbol "S"].
nd	no available data

Chemical Species

	Aluminum	HDG/Steel	316SS
Acetaldehyde	++	+	++
Acetic acid - aerated	(+) ^{TC}	.X	(++) ^T
Acetic acid - not aerated	(+) ^{TC}	.X	(++) ^T
Acetone	++	++	++
Acetylene	++	.nd	++
Allyl alcohol	+	.nd	++
Aluminum chloride - dry	+	.nd	(+) ^{TP}
Aluminum chloride - wet	X	.X	(-) ^P
Aluminum sulfate - satd.	X	.nd	+
Ammonia - anhydrous	++	++	++
Ammonia - gas	-	+	(+) ^T
Ammonium acetate	+	.nd	+
Ammonium bicarbonate	-	.nd	(+) ^T
Ammonium carbonate - satd.	+	.X	+
Ammonium chloride - 28%	X	.X	(+) ^{PS}
Ammonium chloride - 50%	X	.X	.X
Ammonium hydroxide	+	+	(++) ^C
Ammonium nitrate	+	.X	(++) ^S
Ammonium phosphate - 40%	X	.nd	+
Ammonium sulfate - to 30%	X	-	+
Amyl acetate	++	++	++
Asphalt	++	+	+
Beer	++	.X	++
Benzene (benzol)	++	+	(+) ^P
Benzoic acid	+	.nd	+
Benzol - see benzene			
Boric acid (boracic acid)	++	.nd	(++) ^{TP}
Bromine - wet	X	.X	.X
Butadiene (butylene)	+	+	+
Butyl alcohol (butanol)	++	++	++
Butyric acid	+	.X	+
Cadmium sulfate	+	.nd	++
Calcium carbonate	-	.nd	+

Chemical Species (cont'd)

	Aluminum	HDG/Steel	316SS
Calcium chloride - satd.	+	.X	.(+) ^S
Calcium hydroxide - satd.	X	.nd	.+
Calcium hypochlorite - satd.	X	.X	.(-) ^P
Carbon dioxide - wet	++	.+	.+
Carbon disulfide (bisulfide)	++	.+	++
Carbon tetrachloride.	X	.+	.(++) ^{PS}
Carbolic acid - see phenol			
Carbonic acid - see carbon dioxide			
Caustic potash - see potassium hydroxide			
Caustic soda - see sodium hydroxide			
Chlorine gas - wet	X	++	.(-) ^{PS}
Chloroform	(+)dry	.+	.(+) ^{TS}
Chromic acid	+	.nd	.(+) ^P
Citric acid - dilute	(+) ^{T,C}	.X	.(++) ^P
Copper chloride	X	.X	.(-) ^P
Copper nitrate	X	.nd	++
Copper sulfate	X	-	.+
Cresol.	+	.+	.+
Crude oil	++	++	++
Diethylamine.	+	++	++
Dimethyl ketone - see acetone			
Ethyl acetate.	(++) ^{dry}	++	.+
Ethyl alcohol (ethanol)	++	++	++
Ethylene dichloride	(-) ^{dry}	++	.(+) ^{PS}
Ethylene glycol (glycol)	++	++	++
Ferric chloride.	X	.X	.X
Ferric nitrate - 10%	X	.nd	.+
Ferrous sulfate	+	.nd	.(+) ^P
Formaldehyde (methanal)	(+) ^P	++	.(++) ^{T,C}
Fluorine gas - moist	X	.X	.X
Formalin - see formaldehyde			
Formic acid (methanoic acid) - 10%	(+) ^T	.X	.(+) ^{PC}

Chemical Species (cont'd)

	Aluminum	HDG/Steel	316SS
Furfural (furfuraldehyde)	+	.nd	+
Furol - see furfural			
Gelatin.	++	+	++
Glycerine (glycerol)	++	++	++
Hexamine - 80%	++	.nd	++
Hydrobromic acid	X	.X	.X
Hydrochloric acid (muriatic acid)	X	.X	.X
Hydrocyanic acid - dilute	+	.nd	+
Hydrocyanic acid - conc	X	.nd	+
Hydrofluoric acid	X	.X	.X
Hydrogen chloride gas - dry	X	.X	(++) ^S
Hydrogen chloride gas - wet	X	.X	+
Hydrogen fluoride	(-) ^T	.nd	+
Hydrogen peroxide - to 40%	++	.nd	+
Hydrogen sulfide - wet	(+) ^P	.nd	(+) ^{PS}
Hypo - see sodium thiosulfate			
Hypochlorous acid	X	.X	.X
Iodine solution - satd.	X	.X	.X
Lactic acid	(+) ^T	.nd	(+) ^{PI}
Latex	++	-	++
Lithium chloride - to 30%	X	.nd	++
Linseed oil	+	.nd	++
Magnesium chloride - 50%	X	.X	(+) ^{PS}
Magnesium hydroxide	+	.nd	++
Magnesium sulfate	+	.X	+
Maleic acid (maleinic acid) - 20%	+	.nd	+
Methyl alcohol (methanol)	++	++	++
Methyl ethyl ketone	+	++	+
Milk	++	.X	++
Molasses	+	.nd	++
Naptha	+	+	+
Natural fats	++	++	++
Nickel chloride	X	.nd	(+) ^{PS}

Chemical Species (cont'd)

	Aluminum	HDG/Steel	316SS
Nickel sulfate	X	.nd	.+
Nitric acid	X	.X	.(++) ^I
Oleic acid . . . . .	.(++)^T	.nd	.++
Oxalic acid - dilute	-	.nd	.+
Oxalic acid - saturated . . . . .	.(+)^T	.X	.X
Paraformaldehyde - to 30%	+	.nd	.++
Perchloroethylene	+	.X	.(++) ^P
Phenol (carbolic acid)	+	+	.++
Phosphoric acid - dilute	X	.X	.++
Phosphoric acid - 50%	X	.X	.(++) ^I
Picric acid	++	.nd	.+
Potassium bicarbonate - 30%	X	.nd	.++
Potassium carbonate	X	.nd	.++
Potassium chloride - to 25%	X	.X	.(++) ^P
Potassium dichromate - 30% . . . . .	.(++)^T	.X	.++
Potassium hydroxide	X	.nd	.(+) ^S
Potassium nitrate	++	++	.+
Potassium sulfate	++	++	.++
Propionic acid (propanoic acid) . . . . .	.(+)^T	.X	.(+) ^T
Propyl alcohol (propane)	++	++	.++
Prussic acid - see hydrocyanic acid			
Pyridine	+	.nd	.++
Soaps	+	-	.+
Sodium bicarbonate - 20%	+	.nd	.++
Sodium bisulfate	X	.X	.(+) ^T
Sodium bisulfite	X	.X	.+
Sodium chloride - to 30%	X	.X	.(+) ^{PS}
Sodium cyanide	X	.nd	.(+) ^T
Sodium hydroxide - 10-30%	X	.X	.(+) ^S
Sodium hydroxide - 50%	X	.X	.(++) ^S
Sodium hydroxide - conc	X	.X	.++
Sodium hypochlorite - conc	X	+	.(-) ^{PS}

Chemical Species (cont'd)

	Aluminum	HDG/Steel	316SS
Sodium nitrate	++	.X	++
Sodium peroxide - 10%	+	.nd	+
Sodium silicate	++	.nd	++
Sodium sulfate	(++) ^{30%}	.X	++
Sodium sulfide - to 50% . . . . .	.X	.nd	(+) ^T
Sodium thiosulfate	+	.nd	++
Steam	(+) ^P	++	++
Stearic acid	+	.nd	++
Sorbital (hexahydric alcohol)	++	+	++
Sulfur dioxide - dry	+	+	++
Sulfur dioxide - wet . . . . .	.X	.X	(+) ^T
Sulfuric acid - to 80% . . . . .	.X	.X	.X
Sulfuric acid - 80-90% . . . . .	.X	.X	(-) ^I
Sulfuric acid - 98% . . . . .	.X	.X	(+) ^I
Tannic acid (tannin) . . . . .	.X	.X	+
Tartaric acid - to 50%	(+) ^T	.nd	++
Toluene (Toluol; methyl benzene)	++	++	++
Trichloroethylene	(++) ^T	+	(+) ^P
Turpentine	+	++	++
Water - acid, mine . . . . .	.X	-	(++) ^P
Water - potable	+	+	++
Water - sea	+	+	++
Xylene	++	.nd	++
Zinc chloride - dilute	++	.nd	(++) ^{PS}