

**Table 8-2 Typical corrosion failures and their prevention (continued)**

Solvent	Type <sup>a</sup>	Condi- tions, <sup>b</sup> °C	Components, impurities	Metal corroded	Type of attack <sup>c</sup>	Prevention	Ref.
<b>Acids and compounds (continued)</b>							
Acetic acid + toluene	p; 3C	90	Oxygen	C or 17% Cr steel	0.5 mm/yr 0.2 mm/yr	AISI 316	157
Mono- + tri- chloroacetic acid	p; 2C	RT		AISI 316 Ti, Zr	Uniform	Silicon iron	158, 159
Mono- + di- + trichloro- acetic acid	p; 5C	150	Cl <sub>2</sub> + HCl	All metals	Uniform	Enamel coating	160
42% Butyl- acetate + 30% acetic acid + 18% propionic acid + 9% propylacetate	p; 4C	BP		AISI 316	Pitting	Ti	156, 158
Cyanogen chloride + dichloro- methane	ap; 4C	20	Cl <sub>2</sub> + HCl	AISI 316	4 mm/yr	Nickel plating	161
Dimethyl- formamide	ap; 4C	100	H <sub>2</sub> O + formic acid + di- methylamine	Carbon steel	Uniform	Eliminate H <sub>2</sub> O < 0.1% H <sub>2</sub> O	162
Butyric aldehyde	ap; 3C	RT	<b>Aldehydes, esters, amines, mercaptans</b> Air + butyric acid	Cu	Discoloration	Eliminate air + acid	150

Benzaldehyde	ap: 2C	RT	Chlorides	Al, Al alloys	Uniform	Eliminate Cl	147
Benzaldehyde	ap: 2C	BP	Chlorides	AISI 316	Pitting	Eliminate Cl	147
Methylcetyl ketone	ap: 2C	RT	H <sub>2</sub> O	Carbon steel, steel, cast iron	Discoloration	Desaeration, drying, use galvanized steel	147
Ethyl acetate	ap: 3C	RT	Acetic acid	Carbon steel, cast iron	Discoloration	Desaeration, drying, use galvanized steel	147
Methylamines	p: 2C	RT	Oxygen	Al, Cu, Cu alloys	Uniform (SCC)	Carbon steel, cast iron	57, 164
Triethanolamine	p: 2C	RT	Oxygen	Cu, Cu alloys	Uniform (SCC)	Carbon steel, cast iron	163, 165
Aniline	p: 2C	BP	Oxygen	Al, steel	Uniform	AISI 316, eliminate air	165
Pyridine sulfate	ap: XC	102	H <sub>2</sub> SO <sub>4</sub> + cathodic oil	AISI 304, 316	Pitting, crevice corrosion	Niobel, Carpenter 20	147
Ethylene oxide	ap: 1C	RT		Cu, Cu alloys	Explosive	AISI 304	147
Ethyl mercaptan	p: 1C	100		Steel, cast iron, Cu, Cu alloys, Ni, Pb, Ag	Uniform, voluminous products	Al, Al alloys, Cr plating	147, 167
Mercaptan in naphtha	p: XC	RT	H <sub>2</sub> O, oxygen	Cu, Cu alloys, Ni, Ni alloys, Ag	Uniform	Al, Al alloys, Cr plating	147
<b>Hydrocarbons, halogenated hydrocarbons</b>							
Chloroform	ap: 3C	BP	H <sub>2</sub> O + HCl	Al, Al alloys, AISI 304, 316	Pitting (SCC)	Stabilization (0.1% aniline, < 0.05% H <sub>2</sub> O)	66, 168
Epichlorohydrin	ap: 3C	RT	H <sub>2</sub> O + HCl	Cu alloys, AISI 304, 316	Pitting (SCC)	Enamel coating	146

(continued)

**Table 8-2 Typical corrosion failures and their prevention<sup>a</sup>**

Solvent	Type <sup>b</sup>	Condi- tions, <sup>c</sup> °C	Components, impurities	Metal corroded	Type of attack <sup>d</sup>	Prevention	Ref.
<b>Alcohols</b>							
Methanol	p: 1C	BP	<0.05% H <sub>2</sub> O	Al	Uniform + pitting	Add 1% H <sub>2</sub> O	58
Methanol	p: 2C	RT	Chlorides	Ti	SCC + HE	Eliminate Cl, add H <sub>2</sub> O	59, 81
Methanol	p: 2C	RT	Methyl formiate	Carbon steel, Zn	Uniform	Eliminate methyl formiate	146
Ethanol	p: 2C	RT	20% HCl	Ti	5 mm/yr	9–30% H <sub>2</sub> O	61
Ethanol	p: 1C	BP	<0.05% H <sub>2</sub> O	Al	Pitting	Add 1% H <sub>2</sub> O	58
Ethanol	p: 3C	RT–BP	Halogenides, oxygen	Steel, cast iron	Uniform, pitting	Deseration, eliminate chlorides	147
Glycol monomethyl ether	p: 1C	40	—	Al	Pitting	Add 1% H <sub>2</sub> O	58
Ethylene glycol, glycerol	p: 3C	140	NaCl, H <sub>2</sub> O	AISI 304, 316	Pitting, crevice, corrosion	Use Monel, Inconel, nickel	148
Phenol	p: 2C	120–180	<0.3% H <sub>2</sub> O	Al	Pitting	Add >0.3% H <sub>2</sub> O	97, 149
Cresole	p: 2C	180	Na phenolate	Carbon steel	Uniform	Use AISI 304	147
	ap: 3C	125	H <sub>2</sub> O + HCl	Monel, Si bronze	Uniform	Enamel, porcelain, glass	166

Benzene	ap; 3C	RT	Butyric acid, oxygen	Carbon steel	0.7 mm/yr	Eliminate oxygen	169
Hydrocarbons	ap; 3C	RT	H <sub>2</sub> O + HCl	Carbon steel	Uniform	Eliminate HCl, H <sub>2</sub> O < 0.3·H <sub>2</sub> O sat.	67, 170
Hydrocarbons + aqueous solution	p; 4C 2P	RT	H <sub>2</sub> O + NaCl + oxygen	Carbon steel	Uniform, crevice- corrosion	Inhibition	174, 175 176
Crude oil	ap; XC	220	Naphthenic acids	Steel, 6% Cr steel, AISI 304	Uniform, pitting, erosion corrosion	Neutralization of acids + AISI 316, Cr 25 Ni 20 steel Ni alloys	171
Diphenyl	ap; 3C	230	H <sub>2</sub> O + chlorides	AISI 304	Rusting, pitting, ISCC	Eliminate Cl and H <sub>2</sub> O	143

\*Key: p, protic; ap, aprotic; 1C, one component; 2C, two components; 3C, three components; XC, components unknown; 2P, two phases.

<sup>b</sup>RT, room temperature; BP, boiling point.

<sup>c</sup>HE, hydrogen embrittlement; ISCC, intergranular stress corrosion cracking; TSCC, transgranular stress corrosion cracking.

Monel: 63–70% Ni, max. 2.5% Fe, 0.3% C, remainder Cu.

Inconel 600: min. 72% Ni, 14–17% Cr, 6–10% Fe, max. 0.15% C.

Carpenter 20: 20% Cr, 29% Ni, 2% Mo, 3% Cu, 1% Si

Hastelloy C: 14.5–15.5% Cr, 15–17% Mo, 4–7% Fe, max. 0.08 C, remainder Ni.

Hastelloy B: 26–30% Mo, 4–6% Fe, max. 0.05% C, max. 1% Cr, remainder Ni.

Source: Ewald Heitz, Corrosion of Metals in Organic Solvents, in *Advances in Corrosion Science and Technology*, vol. 4, pp. 226–229, Plenum Press, New York, 1974.