

Corrosive Service Guide



CORROSIVE AGENT	Deg C	CONC %	RECOMMENDED MATERIAL
Acetic Acid (Glacial)	200	ALL	316 SS
Acetic Acid	140	80%	Hast. C
	200	50%	316 SS
	140	80%	Carp. 20*
Acetic Anhydride	130	ALL	Hast. C
	200	ALL	316 SS*
Acetone	200	ALL	316 SS
Acetylene	200	ALL	304 SS
Alcohol, Ethyl	90	ALL	Hast. C
	200	ALL	316 SS*
Aluminium Chloride (Aqueous)	140	ALL	Hast. B
	140	ALL	Nickel *
Aluminium Nitrate (Saturated)	90	ALL	446 SS
	90	ALL	316 SS*
Aluminium Sulfate (Saturated)	90	ALL	Titanium
	90	ALL	316 SS*
Ammonia (Anhydrous)	290	ALL	316 SS
Ammonia (Gas)	90	ALL	304 SS
Ammonium Chloride	90	ALL	Titanium
	290	ALL	Nickel *
	70	50%	Nickel
Ammonium Hydroxide	30	ALL	Steel
	80	ALL	Steel *
Ammonium Nitrate	90	ALL	Carp.20
Ammonium Sulfate	90	SAT	Hast. B
	140	SAT	304 SS*
	90	10-40%	Titanium
	200	10-40%	316 SS*
Amyl Acetate	140	ALL	304 SS
Aniline	250	ALL	304 SS
Barium Chloride (Saturated)	90	ALL	Hast. C
	290	ALL	Inconel *
Barium Hydroxide (Saturated)	100	50%	Carp. 20
	200	ALL	316 SS*
Beer	90		SS 304
Benzene (Benzol)	100	ALL	Carp. 20
	100	ALL	304 SS*
Benzoic Acid	200	ALL	Titanium
	200	ALL	304 SS*
Black Liquor	240	ALL	TFE
	190	ALL	FEP
	90	ALL	Carp. 20 *
Bleach (Active Chlorine)	60	12.50%	Hast. C
Borax	200	ALL	316 SS
Boric Acid	290	ALL	Hast C
	90	ALL	Nickel *
Brine Acid	60	ALL	Hast. C
	30	ALL	Brass *
Bromine (Liquid)	290	ALL	Tantalum
	90	ALL	Aluminum *
Butane	170	ALL	Steel
Butyl Acetate	90	ALL	Titanium
	190	ALL	316 SS *
Butyl Alcohol	200	ALL	316 SS
Butyric Acid	140	ALL	Carp. 20
	200	ALL	316 SS*
Calcium Disulfite	90	ALL	TFE
	190	ALL	FEP
	170	ALL	316 SS*
Calcium Chlorate	240	ALL	TFE
	190	ALL	FEP
	90	ALL	316 SS*
Calcium Chloride(Saturate)	170	ALL	Hast. C
	90	ALL	Cap 20*

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Calcium Hydroxide	90	50%	Hast. C
	90	SAT	304 SS *
Carbonic Acid	290	ALL	Carp. 20
	170	ALL	316 SS*
Carbonic Dioxide (Dry)	430	ALL	Brass
Carbonated Beverages	100	ALL	304 SS
Carbon Disulfide	90	ALL	Titanium
	200	ALL	316 SS *
Carbon Tetrachloride	90	ALL	304 SS
Chlorine (Gas)	90	ALL	Monel
	200	ALL	316 SS*
Chlorine (Gas - Moist)	70	ALL	Hast. C
Chloroform Acid	180	ALL	Hast. B
Chloroform	90	ALL	Nickel
	90	ALL	Carp. 20 *
Chromic Acid	90	50%	Titanium
	90	50%	Hast. C*
Citric Acid	130	ALL	Hast. C*
	90	ALL	Carp. 20*
Copper Chloride	90	ALL	Titanium
	90	ALL	Hast. C*
Copper Nitrate 300 ALL 304 SS	150	ALL	304 SS
Copper Sulfate 200 ALL Hast. C	90	ALL	Hast. C
	200	ALL	316 SS*
Corn Oil	240	ALL	TFE
	190	ALL	FEP
	170	ALL	316 SS*
Crude Oil	90	ALL	304 SS*
Cyanogen Gas	240	ALL	TFE
	190	ALL	FEP
	170	ALL	316 SS*
Ether	90	ALL	304 SS
Ethyl Acetate	90	ALL	Titanium
	200	ALL	316 SS*
Ethyl Chloride (Dry)	290	ALL	316 SS
Ethylene Glycol	90	ALL	Carp. 20
	90	ALL	304 SS*
Ethylene Oxide	20	ALL	Hast. C
	200	ALL	316 SS*
Fatty Acids	200	ALL	316 SS
Ferric Chloride	140	ALL	Titanium
	30	ALL	Hast. C*
Ferric Sulfate	50	ALL	Carp. 20
	90	ALL	316 SS
Ferrous Sulfate	30	ALL	Titanium
	90	ALL	304 SS*
Formaldehyde	50	50%	304 SS
	50-290	50%	304 SS*
Formic Acid (Anhydrous)	90	ALL	Cap. 20
Freon (F-11)	200	ALL	Monel
	200	ALL	316 SS*
Furfural	200		
	200	ALL	304 SS*
Gallic Acid	240	ALL	TFE
	190	ALL	FEP
	200	ALL	316 SS*
Gasoline (Unleaded)	150	ALL	Hast. C
	20	ALL	446 SS
	170		Steel*

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CORROSIVE AGENT	Deg C	CONC %	RECOMMENDED MATERIAL
Gasoline (Refined)	240 190 90		TFE FEP Steel*
Glucose	30 190	ALL	Nickel 316 SS*
Glue	30 60	ALL	Hast. B Steel*
Glycerine	130	ALL	304 SS
Iodine	250 20	ALL	Hast. C Nickel
Hydrogen Peroxide	90	90%	Hast. C
Hydrogen Sulfide (Dry)	70 290	ALL	316 SS 316 SS
Hydrobromic Acid	90 120	50%	Titanium Hast. B*
Hydrochloric Acid	60	38%	Hast. B
Hydrocyanic Acid	240 190 170	ALL	TFE FEP 316 SS*
Hydrofluoric Acid	240 190 90	ALL	TFE FEP Hast. C*
Hydrogen Chloride (Gas, Dry)	290	ALL	Carp
Hydrogen Fluoride (Dry)	40 200	ALL	304 SS 304 SS*
Kerosene	240 190 170	ALL	TFE FEP Hast. C
Ketones	30 130	ALL	Hast. C 316 SS*
Lactic Acid	150 120	ALL	Titanium Hast. B*
Lime (sulfur)	240 190 150	ALL	TFE FEP 316 SS*
Linseed Oil	60 30	ALL	Carp. 20 Steel*
Magnesium Chloride	140 90	ALL	Nickel Carp. 20*
Magnesium Hydroxide	90	ALL	304 SS
Magnesium Sulfate	90 170	60%	Nickel 316 SS*
Mercuric Chloride	140 80	ALL	Tantalum Hast. C*
Mercury	290	10%	304 SS
Methyl Chloride(Dry)	170	ALL	316 SS
Methylene Chloride	90	ALL	Carp. 20
Milk	90	304	SS 380
Naphtha	20 120	ALL	446 SS 304 SS
Natural Gas	240 190 40		TFE FEP Steel*
Nickel Chloride	90	80%	Hast. C 3040SS*
Nickel Sulfate	80 90	10%	Tantalum 304 SS*
Nitric Acid	20 90	ALL	304 SS 304 SS
Nitrobenzene	140 170	40%	304 SS Carp. 20
Oleic Acid	170	ALL	316 SS*
Oleum	140 50	ALL	316 SS Hast. C
Oxalic Acid	120 90	40%	316 SS*
Oxygen	90 270 20	ALL	Tantalum Carp. 20*
Palmitic Acid	240 190	ALL	Tantalum 446 SS
Phenol (Carbolic Acid)	170 240 190 200 290	ALL	316 SS*

CORROSIVE AGENT	Deg C	CONC %	RECOMMENDED MATERIAL
Phosphoric Acid	90	50-85%	Hast. C
Photographic Solutions	40	50-85%	Carp. 20
Picric Acid	170	ALL	316 SS
	30	ALL	Titanium
	20	ALL	Aluminum
	200	ALL	316 SS*
Potassium Bromide	90	30%	Titanium
	90	30%	446 SS
Potassium Carbonate	90	50%	304 SS
Potassium Chlorate	170	30%	316 SS
Potassium Hydroxide	90	50%	Nickel
Potassium Nitrate	170	80%	Aluminum
	280	80%	446 SS*
Potassium Permanganate	20	20%	Hast. C
	170	20%	316 SS*
Potassium Sulfate	170	10%	316 SS
Propane	60	ALL	446 SS
	30	ALL	Brass
Pyrogalllic Acid	30	ALL	Copper
	170	ALL	316 SS*
Salicylic Acid	120	ALL	Hast. C
	170	ALL	316 SS*
Sea Water (Stagnant)			Monel
Sea Water (Cavitation)	(20)		316 SS
Soap Solutions	20	ALL	446 SS
	50	ALL	Nickel*
Sodium Bicarbonate	170	20%	316 SS
Sodium Bisulfite	70	10%	316 SS
Sodium Carbonate	90	10-40%	Carp. 20
	90	30%	Carp. 20
	290	10-100%	Hast. B*
Sodium Chloride	30	30%	Nickel
Sodium Fluoride	70	ALL	Monel
	80	ALL	Carp. 20*
Sodium Hydroxide	100	70%	Monel
	70	ALL	316 SS*
Sodium Nitrate	170	60%	316 SS*
Sodium Nitrite	90	SAT	Titanium
	90	40%	304 SS*
Sodium Peroxide	20	10%	446 SS
Sulfur	290	ALL	304 SS
	70	ALL	Alloy 556
Sulfur Chloride (Dry)	30	ALL	Tantalum
	290	ALL	Nickel*
Sulfur Dioxide (Dry)	50	ALL	Steel
	290	ALL	316 SS*
Sulfur Trioxide (Dry)	240	ALL	TFE
	190	ALL	FEB
	290	ALL	304 SS*
Sulfuric Acid	40	100	Carp. 20
	120	60%	Hast. B
Sulfurous Acid	70	ALL	Titanium
	180	ALL	Carp. 20
Steam (Law Pressure)			Inconel
(Medium Pressure)			304 SS*
(High Pressure)			Nickel
Tannic Acid	90	10	304 SS*
	90	ALL	20% Titanium
	200	ALL	304 SS*
Tartaric Acid	30	ALL	304 SS
Titanium Tetrachloride	140	ALL	Carp.
Toulene (Toluol)	170	ALL	Titanium
	90	ALL	Steel
	90	ALL	304 SS
Trichloroacetic Acid	240	ALL	TFE
	190	ALL	FEP
	90	ALL	Hast. C*
Trichloroethylene	70	ALL	Inconel
Turpentine	90	ALL	304 SS
Whiskey and Wine		ALL	304 SS
Xylene (Xylo)	90	ALL	446 SS
Zinc Chloride	80	TO 70%	Titanium
	290	ALL	Hast. B
Zinc Sulfate	90	SAT	316 SS

EMITTANCE VALUES FOR POLISHED AND OXIDIZED METALS

WAVE LENGTH	0.6-1.1 μm		2-2.8 μm		5 μm		8 - 14 μm		SMOOTH OXIDIZED
	SMOOTH POLISH	SMOOTH OXIDIZED	SMOOTH POLISH	SMOOTH OXIDIZED	SMOOTH POLISH	SMOOTH OXIDIZED	SMOOTH POLISH	SMOOTH OXIDIZED	
Alimel	0.32	0.90	0.25	0.90	0.10	0.90	0.10	0.90	
Aluminium	0.15	0.25	0.10	0.20	0.05	0.15	0.08	0.15	0.9*
Brass	0.20	0.70	0.10	0.70	0.05	0.70	0.07	0.70	
Carbon Steel	0.33	0.75	0.25	0.75	0.11	0.75	0.15	0.75	0.8
Chromel	0.33	0.90	0.25	0.90	0.10	0.90	0.15	0.90	0.9
Chromium	0.40	0.70	0.30	0.70	0.19	0.70	0.25	0.70	
Cobalt	0.33	0.75	0.25	0.75	0.15	0.75	0.20	0.75	
Copper	0.10	0.70	0.04	0.70	0.02	0.70	0.03	0.70	
Graphite (Smooth)	0.80	-	0.80	-	0.80	-	0.80	-	0.8
Iron	-	-	0.25	0.70	0.09	0.70	0.15	0.70	0.8
Lead	0.25	0.70	0.15	0.70	0.08	0.70	0.10	0.70	
Manganese	0.45	0.90	0.30	-	0.20	0.90	0.22	0.90	
Molybdenum	0.38	-	0.28	0.90	0.18	-	0.15	-	-
Nichrome	0.36	0.90	0.26	0.90	0.17	0.90	0.22	0.90	0.9
Nickel	0.32	0.90	0.15	0.90	0.06	0.90	0.08	0.90	
Platinum	0.27	-	0.18	-	0.06	-	0.10	-	-
Silver	0.05	0.80	0.03	0.80	0.03	0.80	0.03	0.80	
Silicon	0.70	-	0.7	-	0.70	-	0.70	-	-
Stainless Steel	0.33	0.85	0.25	0.85	0.10	0.85	0.15	0.85	0.8
Tantalum	0.27	0.70	0.10	0.70	0.07	0.70	0.08	0.70	
Tin	0.35	0.60	0.22	0.60	0.18	0.60	0.18	0.60	
Tungsten	0.40	0.60	0.10	0.60	0.05	0.60	0.06	0.60	
Vanadium	0.36	0.75	0.29	0.75	0.18	0.75	0.25	0.75	
Zinc	0.20	0.50	0.07	0.50	0.03	0.50	0.15	0.50	
Zirconium	0.30	0.40	0.22	0.40	0.14	0.40	0.15	0.40	

*The values listed refer to flat polished specimens and to the oxides formed on these surfaces. Roughening of these surfaces raises the emittance values. A long narrow hole or crevice in any of the above produces a blackbody with $e=1.0$

**Electrolytically Anodized
Not Oxidised

Nominal Analysis of Metal Protection Tubes

AISI ASTM	EN DIN	C% Max	Mn% Max	Si% Max	S% Max	P% Max	Cr% Max	Ni% Max	Others %
202	-	0.15	7.5-10	1.00	0.030	0.060	17.00- 19.00	4.00- 6.00	-
303	1.4305	0.15	2.00	1.00	0.15 Min	0.20	17.00- 19.00	8.00- 10.00	Cu:1% max
304	1.4301	0.08	2.00	1.00	0.030	0.045	18.00- 20.00	8.00- 11.00	-
304L	1.4306	0.03	2.00	1.00	0.030	0.045	18.00- 20.00	8.00- 12.00	-
310	1.4841	0.25	2.00	1.50	0.030	0.045	24.00- 26.00	19.00- 22.00	-
316	1.4401	0.08	2.00	1.00	0.030	0.045	16.00- 18.00	10.00- 14.00	Mo: 2.00- 3.00
316L	1.4404	0.03	2.00	1.00	0.030	0.045	16.00- 18.00	10.00- 14.00	Mo: 2.00- 3.00
316Ti	1.4571	0.08	2.00	1.00	0.030	0.045	16.00- 18.00	10.00- 14.00	Ti : Min (5xC%), Mo: 2.00- 3.00
321	1.4541	0.08	2.00	1.00	0.030	0.045	17.00- 19.00	9.00- 12.00	Ti : Min (5xC%)
347 SS	-	0.80	2.00	1.00	0.030	0.045	17.00- 19.00	9.00- 13.00	Nb : 10x C%
446 SS	-	0.20	1.50	1.00	0.030	0.040	23.00- 27.00	-	N: 0.25
253 MA	-	-	0.6	1.7	-	-	21	11	Ce: 0.04 N: 0.17
Kanthal 1	-	-	-	-	-	-	22	-	Al: 5.8
Inconel 600	-	0.15	1.00	0.50	0.015	0.030	14.00- 17.00	72.00	Trace Co <Cu:0.50
Inconel 625	-	0.10	0.50	0.50	0.015	0.030	21.5	Bal.	Mo9 Nb+ Ta: 3.7
Inconel 825	-	0.05	1.0	0.50	0.03	0.030	19.5-23.5	38-46	Al: <0.2, Ti:0.6- 1.2, Mo:2.5- 3.5
Inconel 800	-	0.10	1.50	1.00	0.015	0.030	19.00- 23.00	30.00 35.00	Trace Cu, Trace Co, Al, Ti
UMCo-50	-	0.05- 0.15	0.30-1.00	1.00	0.020	0.020	26.00- 30.00	3.00	Co 50 Trace Mo
Hastelloy B	-	0.05	1.00	1.00	0.03	0.04	-	Bal.	Fe: 5.0, Mo: 28, Co: 2.5, V:0.6
Hastelloy C-276	-	0.002	1.00	0.08	0.03	0.04	14.5-16.5	Bal.	Mo: 15- 17 Trace W, Co, V
Hastelloy X	-	0.05	1.00	1.00	0.030	0.040	20.50- 23.00	Bal.	Mo: 8- 10.00, W:0.6, Co: 1.5, trace B
Monel 400	-	Monel 400	Monel 400	Monel 400	Monel 400	Monel 400	Monel 400	Monel 400	Monel 400