

Chemical durability in accordance with manufacturer's info

Acid resistant joint elements

Austenitic manganese steel A1, A2, A4 get their corrosion resistance through a surface protecting oxide layer. If this is damaged, it is reformed by the oxygen in the air. If the oxygen is prevented from reaching the surface due to the design or fouling, even these steels corrode!

Avoid: Cuts, divided designs, accumulations of water; bad ventilation, dirt sediments.

Rules of thumb: A2 Above water surface, inland climate.
A4 Under water surface, coastal climate.
A1 To achieve a good shaping ability this steel contains small amounts of sulphur. Its corrosion resistance is lower than for A2 steels. This is also the case for C1-C4.

The corrosion resistance can be negatively affected if the surface has been treated (no air reaches the steel), chemically blackened or buffed.

Chloric mediums can under certain conditions cause dangerous corrosion due to non-visible intercrystalline corrosion, which can result in that the steel component suddenly collapses.

The tables below give rules of thumb for the corrosion resistance for steel groups A2 and A4. The facts are based on laboratory results which in critical cases must absolutely be confirmed by performing practical tests on the final design. For these tests we gladly provide you with sample screws.

Table 81

Group	Weight loss g/m ² h	Wear mm/year	Remarks
0	0,1	Less than 0,1	Completely durable (see also L)
1	0,1-1	0,11-1,1	Small attacks, usable in some cases
2	1-10	1,1-11	Hardly durable, almost useless
3	More than 10	More than 11	Completely useless
L	Risk of hole corrosion, also when durable		

The presented durability values are only guide values, but give good possibility to comparisons.

Table 81.1

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Acetone	CH ₃ COCH ₃		all concentrations	20°	0	0
Acetyl chloride	CH ₃ COCl	L		20° and boiling	1	0
Aluminium	Al		melted	750°	3	3
Aluminium chloride	AlCl ₃ , 6H ₂ O	L	5%	50°	2	1
Aluminium nitrate	Al(NO ₃) ₃ + 9H ₂ O			20°	0	0
Aluminium sulphate	Al ₂ (SO ₄) ₃		20%	20° boiling	0	0
Ammonia alum (Potassium aluminium sulphate)	KAl(SO ₄) ₂ + 12H ₂ O		10% warm saturated	20° boiling	0	0
Ammonium	NH ₃				0	0
Ammonium water solution	NH ₄ OH		all concentrations	20° and boiling	0	0
Ammonium bicarbonate	(NH ₄)HCO ₃		all concentrations	20°	0	0
Ammonium hydroxide	NH ₄ OH		every	20° boiling	0	0
Ammonium	NH ₄ OH		all concentrations	20° and boiling	0	0
Ammonium carbonate	(NH ₄) ₂ CO ₃		cold saturated	20° and boiling	0	0
Ammonium chloride	NH ₄ Cl	L	10% 50% saturated saturated	boiling boiling 20° boiling	0 1 0 1	0 0 0 0
Ammonium chloride with Cu and Zn chlorides	NH ₄ Cl	L	cold saturated		3	3
Ammonium nitrate	NH ₄ NO ₃		cold saturated charge	20° and boiling 169°	0 1	0 0

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Ammonium perchlorate	NH ₄ ClO ₄	L	10%	20° boiling	0	0
Ammonium sulphate	(NH ₄) ₂ SO ₄		all concentrations	20° boiling	0	0
Ammonium sulphite	(NH ₄) ₂ SO ₃ + H ₂ O		saturated	20° boiling	0	0
Ammonium hydrogen difluoride	NH ₄ F·HF	L	cold saturated	20°	1	0
Aniline	C ₆ H ₅ NH ₂			20°	0	0
Anilinehydrochloride	C ₆ H ₅ ·NH ₂ ·HCl	L		20°	3	3
Antimony(III)chloride	SbCl ₃			20°	3	3
Exhaust with sulphuric acid				up to 40°	0	0
Exhaust without sulphuric acid				up to 40°	0	0
Benzene	C ₆ H ₆			20° and boiling	0	0
Benzine			all concentrations	20°	0	0
Benzoic acid (Benzol acid)	C ₆ H ₅ ·COOH		all concentrations	20°	0	0
Blood					0	0
Lead nitrate	Pb(NO ₃) ₂			20°	0	0
Ink (Ferro gallic ink)					0	0
Boric acid	H ₃ BO ₃		all concentrations	20° boiling	0	0
Bromine	Br	L		20° boiling	3	3
Lemon juice				20°	0	0

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Citric acid			1% 10% 25% 50%	20° 20° 20° 20°	0 0 0 0	0 0 0 0
Dinatrium Hydrogen phosphate	Na ₂ HPO ₄ +12H ₂ O			20° and boiling	0	0
Drinking and fresh water				20° and boiling	0	0
Ethanol (alcohol)	C ₂ H ₅ OH		all concentrations	20° and boiling	0	0
Ether Diethyl ether	(C ₂ H ₅) ₂ O			20° and boiling	0	0
Phenol	C ₆ H ₅ OH		pure +10% H ₂ O raw=90% phenol	boiling boiling 20° boiling	0 0 0 0	0 0 0 0
Fatty acid (Oleic acid) technical	C ₁₇ H ₃₃ COOH		at 30 bar	150° 180° 235° 300°	0 0 1 2	0 0 0 0
Fixing solution		L		20°	0	0
Waterborne				20°	0	0
Hydrofluoric acid	HF	L	10%	20° 100°	2 3	2 3
Floating soap				20°	0	0
Formaldehyde	HCHO		40%	20° and boiling	0	0
Phosphoric acid, chemically pure	H ₃ PO ₄		1% 10% 45% 60%	20° 20° 20° 20°	0 0 0 0	0 0 0 0
Developing fluid (Agfa-glycerine-developer)				20°	0	0
Fruit stone (SO ₂ -bearing)					0	0
Fruit juices and fruit acids				20°	0	0
Spinning bath			up to 10% H ₂ SO ₄	70°	2	1
Colour bath, alcalic or neutral				20° boiling	0 0	0 0
Colour bath, organic, sour				20° boiling	0 0	0 0
Colour bath, weakly sulphuric acid reacting			below 1% H ₂ SO ₄	20° boiling	0 1	0 0
Tannic acid=tannin			5%	20°	0	0
Glycerol	C ₃ H ₅ (OH) ₂		concentrated	20° and boiling	0	0
Pit water			sour	20°	0	0
Pit water, sour				20° and boiling	0	0
Vegetables				boiling	0	0
Sea water (Local conditions have conclusive importance)		L		20°	0	0
Fluorosilicic acid	H ₂ SiF ₆		steam	100°	1	1
Crystalline acetic acid			100%	20° boiling	0 1	0 1
Iodine	I	L	dry damp	20° 20°	0 1	0 0
Iron phosphate (Bonder solution)				98°	0	0
Iron (III)-chloride	FeCl ₃ +6H ₂ O	L	10%	20° and boiling	3	3

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Iron (III)-nitrate	Fe(NO ₃) ₃ +9H ₂ O		all concentrations		0	0
Iron (III)-sulphate	Fe ₂ (SO ₄) ₃		10%	20° boiling	0 0	0 0
Coffee				20° and boiling	0	0
Calcium chloride	CaCl ₂	L		20° and boiling	0	0
Potash alum (Potassium alum. sulphate)	KAl(SO ₄) ₂ +H ₂ O		10% hot saturated	20° boiling boiling	0 1 2	0 0 1
Potash lye (Hydrate of potash)	KOH		25% hot saturated charge	20° and boiling boiling 360°	0 0 3	0 0 3
Potash nitrate	KNO ₃		50% charge	20° boiling 550°	0 0 0	0 0 0
Potassium acetate	CH ₃ ·COOK		charge	292°	0	0
Potassium hydrogenfluoride	KHF ₂	L	cold saturated	20°	0	0
Potassium dichromate	K ₂ Cr ₂ O ₇		25%	20° boiling	0 0	0 0
Potassium hydrogentartrate	KC ₄ H ₅ O ₆		cold saturated at 110 degrees saturated	20° boiling	0 2	0 1
Potassium hydrogensulphate	KHSO ₄		2% 5%	90° 20° 90°	3 2 2	2 0 2
Potassium bromide	KBr	L		20°	0	0
Potassium cyanate	KCNO			20°	0	0
Potassium cyanide	KCN		all concentrations	20°	0	0
Potassium carbonate (Neutral potash)	K ₂ CO ₃		50°C	20° boiling	0 0	0 0
Potassium chlorate	KClO ₃		hot saturated	boiling	0	0
Potassium chloride	KCl	L	hot saturated	20° and boiling	0 0	0 0
Chromic potassium sulphate	KCr(SO ₄) ₂ +12H ₂ O		saturated	20° boiling	1 3	0 3
Potassium nitrate (Salpetre)	KNO ₃		25 and 50% charge	20° boiling 550°	0 0 0	0 0 0
Mineral chameleon	KMnO ₄		10%	20° boiling	0 0	0 0
Potassium sulphate	K ₂ SO ₄		all concentrations	20° and boiling	0	0
Lime water (Calcium hydroxide)	Ca(OH) ₂			20° boiling	0 2	0 1
Chloramine-T	CH ₃ ·C ₆ H ₄ ·SO ₂ ·NNaCl+3H ₂ O	L		20° and boiling	1	0
Chlorobenzene	C ₆ H ₅ Cl			boiling	0	0
Chlorine gas, dry, damp	Cl ₂	L L		20° 20°	0 3	0 3
Chloride of lime, dry damp	3CaCl(OCl)·Ca(OH) ₂ ·5H ₂ O	L L		20° 20°	0 1	0 1
Chloroform	CHCl ₃			20° and boiling	0	0
Chlorosulfonic acid	ClSO ₂ ·OH	L L	10% concentrated	20° 20°	3 0	3 0
Sulphur monochloride	S ₂ Cl ₂	L L	concentrated	20° boiling	0 0	0 0
Chloric acid	HClO ₂	L		20°	3	3
Chlorine water		L	saturated	20°	1	1
Hydrochloric acid gas	HCl	L L L L		20° 50° 100° 400°	1 1 2 3	1 1 1 3

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Chloroacetic acid (mono-)	CH ₂ Cl·COOH		50% and concentrated	20°	3	3
Carbon dioxide (Carbon acid)	CO ₂		dry damp	hot hot	0	0
Carbon disulphide	CS ₂		pure	20° and boiling	0	0
Carbon tetra-chloride	(C Cl ₄)		dehydrated	20° and boiling 20°	0	0
Copal varnish					0	0
Copper (II)-chloride	CuCl ₂	L	all concentrations	20°	3	3
Verdigris	Cu(CH ₃ ·COO) ₂ + H ₂ O			20° and boiling	0	0
Cupric nitrate	Cu(NO ₃) ₂ + 6H ₂ O		50%	20° and boiling	0	0
Copper(II)oxide saturated in 50% ammonia solution	Cu(NH ₃) ₄ O			20°	0	0
Sulphate of copper (Blue vitriol)	CuSO ₄ ·5H ₂ O		saturated 50% + 3% H ₂ SO ₄ + 10% H ₂ SO ₄ up to 5 bar	20° and boiling	0	0
				boiling	0	0
				boiling	0	0
				20°	0	0
Creosote			+3% salt	20°	0	0
				boiling	0	0
				20°	0	0
Chromic acid	CrO ₃		10% pure 50% pure	20° 20°	0	0
Aqua regalis	3HCl+HNO ₃	L		20°	3	3
Mercury	Hg			20° and 50°	0	0
Buttermilk				20°	0	0
Meat					0	0
Linseed oil			+3% H ₂ SO ₄	20° and hot	0	0
				20°	0	0
				200°	0	0
Lysoform (soap and formalin)				20° and boiling	0	0
Maleic acid	HOOC·CH·CH·COOH		50%	100°	0	0
Manganese chloride	MnCl ₂ +4H ₂ O	L	10% 50%	boiling	0	0
				boiling	0	0
Manganous sulphate	MnSO ₄ +7H ₂ O		all concentrations	20°	0	0
Methyl alcohol (Methanol) Wood alcohol	CH ₃ OH		all concentrations	20°	0	0
				65°	0	0
Methylene chloride, dehydrated	CH ₂ Cl ₂	L		20° and boiling	0	0
Milk			fresh sour	up to 70° up to 70°	0	0
Lactic acid	CH ₃ CHOH COOH		1.5% 80%	20° 20°	0	0
Lactic acids (Nitric sulphuric acid)	50% H ₂ SO ₄ + 50% HNO ₃ 75% H ₂ SO ₄ + 25% HNO ₃ 20% H ₂ SO ₄ + 15% HNO ₃ 70% H ₂ SO ₄ + 10% HNO ₃ 30% H ₂ SO ₄ + 5% HNO ₃			50°	0	0
				50°	1	0
				50°	0	0
				50°	0	0
				90°	0	0
Chloroacetic acid	CH ₂ Cl COO H	L	50%	20°	1	1

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Formic acid	H·COOH		10% 50% 100%	20°	0	0
				20°	0	0
				20°	0	0
Sodium acetate	CH ₃ COO Na+ 3H ₂ O		varm saturated	boiling	0	0
Sodium bicarbonate	NaHCO ₃		all concentrations	20°	0	0
Sodium bisulphate	NaHSO ₄ ·H ₂ O		10%	20° boiling	0	0
Sodium bisulphite	NaHSO ₃		50%	20° and boiling	0	0
Sodium citrate	Na ₃ C ₆ H ₅ O ₇ + 2H ₂ O		3.5%	20°	0	0
Sodium fluoride	NaF		5%		—	0
Caustic soda (Sodium hydrate)	NaOH		30% 50% charge	20°	0	0
				boiling	1	1
				20° boiling	0	0
Sodium carbonate, soda	Na ₂ CO ₃		cold saturated charge	320°	2	2
				900°	2	2
Sodium chlorate	NaClO ₃	L	30%	20° and boiling	0	0
Sodium chloride (Salt)	NaCl	L L L	cold saturated hot saturated	20°	0	0
				100°	0	0
				100°	1	1
Sodium nitrate (Chile nitre)	NaNO ₃		concentrated charge	20° and boiling 360°	0	0
Sodium nitrite	NaNO ₂		varm saturated	boiling	0	0
Sodium perborate	NaBO ₂ ·H ₂ O ₂ 3H ₂ O		saturated	20°	0	0
Sodium perchlorate	NaClO ₄ +H ₂ O		10%	20° boiling	0	0
Sodium peroxide	Na ₂ O ₂		10%	20° 100°	0	0
Salicylic acid, sodium salt	NaC ₇ H ₅ O ₃		saturated	20°	0	0
Sodium silicate	Na ₂ SiO ₃		saturated	20° and boiling	0	0
Sodium sulphate	Na ₂ SO ₄ + 10H ₂ SO ₄ +		saturated 5%	20° boiling	0	0
Sodium sulphide	Na ₂ S+9H ₂ O		20% 50% varm saturated	20°+boiling	0	0
				boiling 100°	1	0
Sodium sulphite	Na ₂ SO ₃ +7H ₂ O		50%	20° and boiling	2	2
Sodiumtetraborate (Borax)	Na ₂ B ₄ O ₇ + 10H ₂ O		saturated charge	20° and boiling	0	0
Sodiumthiosulphate	Na ₂ S ₂ O ₃ + 5H ₂ O	L	25%	20° and boiling	3	3
Nickel chloride	NiCl ₂ +6H ₂ O	L		20°	0	0
Nickel nitrate	Ni(NO ₃) ₂ + 6H ₂ O		5-10%	20°	0	0
Nickel sulphate	NiSO ₄ +7H ₂ O		varm saturated	boiling	0	0
Novocain				20°	0	0
Oil (lubricating oil)				20°	0	0
Oil (vegetable)				20°	0	0
Quick lime (Calcium oxide)	CaO			20° and boiling	0	0
Cheese				20°	0	0
P3-detergent				95°	0	0
Paraffin, melted					0	0

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Petrol				20° and boiling	0	0
Crude oil					0	0
Salicylic acid	HO-C ₆ H ₄ -COOH			20°	0	0
Nitrous acid	HNO ₂		concentrated	20°	0	0
Nitric acid	HNO ₃		up to 25%	20-80°	0	0
			25- 40%	20-70°	0	0
			40- 60%	20-60°	0	0
			60- 80%	20-55°	0	0
			80-100%	20-50°	0	0
			5%	boiling	0	0
			10%	boiling	0	0
			25%	boiling	0	0
			50%	boiling	0	0
			65%	boiling	1	1
			99%	boiling	2	2
Brine		L		20°	0	0
Chlorhydric acid	HCl	L	0.2%	20°	1	0
				50°	2	1
		L	0.5%	20°	1	0
				50°	3	2
		L	1%	20°	2	1
				50°	3	2
		L	2%	20°	3	3
				50°	3	3
Mustard		L		20°	0	0
Silver nitrate	AgNO ₃		10%	20° and boiling	0	0
			charge	250°	0	0
Fresh water		L		20° boiling	0	0
					2	-
Butyric acid	C ₃ H ₇ COOH		100%	20°	0	0
Solution of sugar				boiling	0	0
Soda	Na ₂ CO ₃			20° and boiling	0	0
			charge	320°	2	2
Stearic acid	CH ₃ (CH ₂) ₁₆ COOH			20° and 80°	0	0
				130°	0	0
Sulphite gases, exhaust gases from boiling of cellulose			up to 8 bar	160°	0	-
Sulphite lye (fresh pulping liquor or spent liquor)				20°	0	0
				80°	2	0
				140°	3	0
Superphosphate			+3% H ₂ SO ₂	20°	0	0
Sauerkraut water		L			2	1
Sulphur	S		melted boiling	130° 445°	0 2	0 2
Sulphur anhydride	SO ₂			20°-100° 100°-500°	0 2	0 0
Sulphur mono-chloride	S ₂ Cl ₂	L	100%	20° boiling	0 0	0 0
Sulphuric acid	H ₂ SO ₄		0.1%	100°	-	0
			1%	20°	1	0
				boiling	1	1
			5%	20°	1	1
				70°	1	1
				boiling	2	2
			10%	20°	2	1
				70°	2	2
				boiling	3	2
			20%	20°	1	1
				70°	2	2
				boiling	3	3
			40%	20°	1	1
				70°	2	2
				boiling	3	3
			60%	20°	3	2
				70°	3	3
				boiling	3	3
			80%	20°	1	1
				70°	3	2
				boiling	3	3
			98%	20°	0	0
				70°	2	2
				boiling	2	2

Attacker	Chemical formula	Hole corrosion trend	Concentration	Temperature °C	Steel group	
					A2	A4
Sulphuric acid	H ₂ SO ₄		steaming 11% free SO ₃	20°	0	0
			11% free SO ₃	100°	1	0
			steaming 60% free SO ₃	20°	0	0
			15%+1% CuSO ₄	80°	0	0
			15%+1% iron sulphate	boiling	0	0
			15%+peroxide	50°	0	0
Sulphurous acid	H ₂ SO ₃		3-6% at 4 bar at 5-8 bar at 10-20 bar	20° 135° 160° 180°-200°	1 1 2 2	0 1 1 1
Hydrogen sulphide	H ₂ S		dry	20° 100° above 200°	0 0 0	0 0 3
			damp	20°	0	0
Tannin (Tannic acid)	C ₇₆ H ₅₂ O ₄₆		10%	20° and boiling	0	0
Mercapto acetic acid	HS·CH ₂ ·COOH			20° and boiling	-	0 1
Tar, pure				20° and hot	0	0
Toluole	C ₆ H ₅ ·CH ₃			20° and boiling	0	0
Trichlorethylene	CHCl·CCl ₂	L L		20° boiling	0 1	0 0
Trichloroacetic acid	CCl ₃ ·COOH		all concentrations	20°	3	3
Trisodium phosphate	Na ₃ PO ₄ ·12H ₂ O		cold saturated	20° and boiling	0	0
Turpentine				20° and hot	0	0
Soap				20°	0	0
Urine		L		20°	0	0
Vaseline				20° and varn	0	0
Water, distilled	H ₂ O			20° and boiling	0	0
Water steam with SO ₂ with CO ₂				400°	0 1 0	0 0 0
Wine (white or red wine)				20° hot	0 0	0 0
Tartaric acid	COOH(CHOH) ₂ COOH		10%	20°	0	0
			50%	20°	0	0
Hydroperoxide, pure technical stabilised	H ₂ O ₂		30% 85%	20° and varn 70°	0 -	0 0
Zinc	Zn		melted	500°	3	3
Zinc chloride, damp	ZnCl ₂	L	20%	20° 90°	0 0	0 0
White vitriol, damp	ZnSO ₄ +7H ₂ O		varn saturated	boiling	0	0
Malic acid	(COOH) ₂ CH ₂ CH OH		up to 50%	20°	0	0
Apple wine				20°	0	0
Vinegar				20°	0	0
Acetic acid	CH ₃ COOH		10%	20°	0	0
			50%	20°	0	0
Acetic acid Hydroperoxide	CH ₃ COOH+ H ₂ O ₂		10 and 50%	20°	0	0
				50°	0	0
				90°	0	0
Beer				20°	0	0