

KRUPP THYSSEN NIROSTA

Chemical resistance of NIROSTA® steels



New Companyname since February 2002
ThyssenKrupp Nirosta GmbH

Chemical resistance of NIROSTA® steels

General corrosion

Stainless steels are defined as being characterized by particularly high resistance to chemical attack by aqueous media. In general, they contain at least 12% by weight of chrome and a maximum of 1.2% carbon.

The reason for their high resistance to corrosion is a passive layer that forms on the surface. This consists of a metal oxide or hydroxide layer, rich in chrome, only a few Ångstrom units thick, separating the actual metal from the attacking medium.

After sufficient time has passed, the passive layer of a stainless steel exhibits a constant composition and remains in a state of equilibrium with the surrounding medium. Once formed, such a layer cannot therefore be transferred to another medium. Following any mechanical damage of the surface, a new layer can generally be expected to form spontaneously at that point.

If in some medium a satisfactory passive layer cannot form, or if an existing layer is locally damaged or completely destroyed, corrosion can occur.

The decisive element responsible for the formation of a passive layer is chrome. A chrome content above the quoted value of some 12% inhibits rusting under normal atmospheric conditions. Further increases in the chrome content and, according to the application, the addition of molybdenum and other alloys permit corrosion resistance to be extended to much more aggressive media.

Only those alloy contents dissolved in the metal are effective in achieving passivation. The highest resistance to corrosion is thus given with a segregation-free matrix whose chrome or molybdenum contents are not reduced by precipitations of the formation of non-metallic phases. The right heat treatment for achieving an ideal structure is described in the particular material sheets.

Stainless steels may suffer general corrosion or various types of localised corrosion. Resistance to general corrosion is usually classified as follows:

- 0 = resistant to general corrosion (mass loss rate $< 0.1 \text{ g/h} \cdot \text{m}^2$ corresponding to a corrosion rate $< 0.11 \text{ mm thickness reduction/year}$)
- 1 = slight susceptibility to general corrosion, suitable for some applications ($0.1 - 1.0 \text{ g/h} \cdot \text{m}^2$ corresponding to $0.11 - 1.10 \text{ mm thickness reduction/year}$)
- 2 = low resistance to general corrosion, unsuitable for virtually all applications ($1.0 - 10.0 \text{ g/h} \cdot \text{m}^2$ corresponding to $1.1 - 11.0 \text{ mm thickness reduction/year}$)
- 3 = no resistance to general corrosion ($> 10.0 \text{ g/h} \cdot \text{m}^2$ corresponding to $> 11.0 \text{ mm thickness reduction/year}$)

The following warning is provided for the major forms of localised corrosion

- L = risk of pitting, crevice corrosion or stress-corrosion cracking, even in resistance class 0

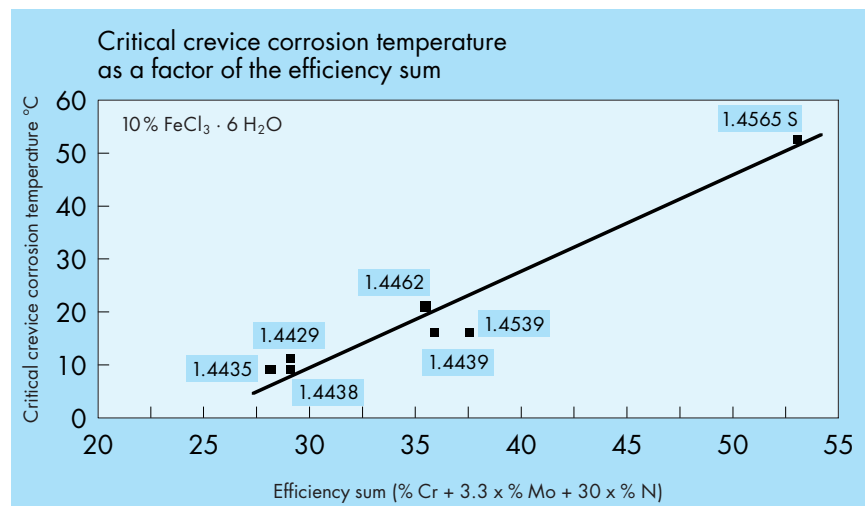
General corrosion is to be expected primarily in acids and strong alkaline solutions. Pitting, crevice corrosion or stress-corrosion cracking are most frequently caused by chloride ions but they may also be induced by the rarer halides bromide and iodide, while stress-corrosion cracking can also occur in the presence of other species.

Pitting and crevice corrosion

Pitting corrosion is initiated by interaction between halide ions and the passive film, the latter being locally punctured. Hollows the size of pin pricks are formed and grow into pit sites which can vary greatly in severity. The risk of pitting increases with

- increasing concentrations of halide ions
- increasing temperature
- an increase in the electrochemical potential of the steel in the relevant electrolyte, caused for example by the effects of an oxidising agent.

Crevice corrosion arises in crevices where fluid exchange with the surrounding environment is limited. Crevices of this nature are design or production related and occur e.g. on flanges, tube sheets, beneath seals or even under scale/deposits.



The corrosion mechanism is largely the same as for pitting, although crevice geometry and the type of materials forming the crevice exert an additional influence. Since crevice attack occurs under less serious corrosion conditions than pitting, attempts should be made to design out crevices in components to be used in chloride-bearing media.

Assuming a homogeneous distribution of alloying elements, a rough guide to the pitting and crevice corrosion resistance of stainless steel is the efficiency sum (W) of % Cr + 3.3 x % Mo + 30 x % N (see Fig.). The influence of nitrogen as an alloying element is, however, more complex than expressed by this equation. The high efficiency expressed in the factor of 30 will only apply in full in the case of high-alloy steels with increased molybdenum contents.

A material's inherent resistance to pitting and crevice corrosion can only be fully achieved if the surface quality of the material is pristine, i. e. bright metallic. It is therefore important to remove any heat tinting or scale left after welding, iron particles or rust from other sources, grinding residue etc.

Stress-corrosion cracking

Stainless steels in media containing specific components – in particular chloride ions – and subjected at the same time to tensile stresses may suffer corrosion attack and cracking, even if the steel displays adequate resistance to the medium when not under mechanical load. This phenomenon is known as stress-corrosion cracking and is not caused exclusively by service stresses; the blame frequently lies with internal stresses applied during processing, e.g. welding, grinding or cold forming.

As with pitting and crevice corrosion, the risk of chloride-induced stress-corrosion cracking becomes greater as the temperature and chlo-

ride concentration increase. There are, however, other material-related variables. For example, austenitic steel grades 18/10-CrNi and 17/12/2-CrNiMo are at particular risk of chloride-induced stress-corrosion cracking when temperatures exceed 50 °C. Resistance can be distinctly enhanced by increasing the molybdenum and in particular the nickel content of the material. In comparison, ferritic and austenitic-ferritic stainless steels are relatively insensitive to corrosion of this type.

How to use the table

Even though the figures provided in the following have been calculated in laboratory tests using pickled specimens with the best possible microstructure – annealed, tempered or quenched – they provide a basic guide to applicability.

It must however be emphasised that under practical conditions agents rarely occur in such pure form, and

that even slight additions, e. g. of oxidising or reducing materials, can weaken or intensify corrosive attack. Deposits, such as those occasionally found on the walls above the bath surface or at other points, and condensation in the steam chamber of an enclosed apparatus can under certain circumstances greatly modify the conditions for corrosive attack.

Exact knowledge of corrosive conditions is thus vital in selecting the right grade of steel. The best (and sometimes only) way of gaining information on the resistance of a material in the corrosive medium in question is to carry out tests on a specimen under actual service conditions, taking into consideration not only the composition and concentration of the corrosive medium but also the temperature, the pH value and other variables.

We would be pleased to provide specimens of the relevant materials for test purposes.

Classification of NIROSTA®-/ASTM grades by group

Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
4000/ 410 S			4301/ 304				
4002/ 405			4303/ (305)	4401/ 316			
4003/ A240/ A240M			4306/ 304 L	4404/ 316 L			
4006/ 410	4016/ 430		4307/ 304 L	4429/ 316 LN			
4021/ (420)	4057/ 431		4310/ (301)	4435/ 316 L			
4024/ (410)	4120		4311/ 304 LN	4436/ 316			
4028/ (420)	4305/ 303		4315/ 304 N	4438/ 317 L			
4031 (420)	4427/ 316 F		4318/ 301 LN	4439			
4034/ (420)	4509/ 441		4541/ 321	4462			
4313	4510/ 439	4113/ 434	4544	4501			
4512/ (409)	4511	4521/ 444	4546	4561/ 316 Ti			
4589	4520	4568 631	4550/ 347	4571/ 316 Ti	4465	4539	4565 S

Table of steel grades

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NIROSTA®	Material no.	Abbreviation as per EN 10 088-2	DIN/SEW	ASTM grade	UNS
4000	1.4000	X 6 Cr 13	17440	410 S	S 41008
4002	1.4002	X 6 CrAl 13	17440	405	S 40500
4003	1.4003	X 2 CrNi 12	SEW 400	A 240/A 240 M	soon: S 40977
4006	1.4006	X 12 Cr 13	17440	410	S 41000
4016	1.4016	X 6 Cr 17	17440/41	430	S 43000
4021	1.4021	X 20 Cr 13	17440	(420)	(S 42000)
4024	1.4024	X 15 Cr 13		(410)	(S 41000)
4028	1.4028	X 30 Cr 13	17440/41	(420)	(S 42000)
4031	1.4031	X 39 Cr 13		(420)	(S 42000)
4034	1.4034	X 46 Cr 13		(420)	(S 42000)
4057	1.4057	X 17 CrNi 16-2	17440	431	S 43100
4113	1.4113	X 6 CrMo 17-1		434	S 43400
4120	1.4120	X 20 CrMo 13	SEW 400		
4301	1.4301	X 5 CrNi 18-10	17440/41	304	S 30400
4303	1.4303	X 4 CrNi 18-12	17440	(305)	(S 30500)
4305	1.4305	X 8 CrNiS 18-9	17440	303	S 30300
4306	1.4306	X 2 CrNi 19-11	17440/41	304 L	S 30403
4307	1.4307	X 2 CrNi 18-9		304 L	S 30403
4310	1.4310	X 10 CrNi 18-8		(301)	(S 30100)
4311	1.4311	X 2 CrNiN 18-10	17440/41	304 LN	S 30453
4313	1.4313	X 4 CrNi 13-4			S 41500
4315	1.4315	X 5 CrNiN 19-9	SEW 400	304 N	S 30451
4318	1.4318	X 2 CrNiN 18-7		301 LN	
4401	1.4401	X 5 CrNiMo 17-12-2	17440/41	316	S 31600
4404	1.4404	X 2 CrNiMo 17-12-2	17440/41	316 L	S 31603
4427	1.4427	X 4 CrNiMoS 18-11	SE list	316 F	S 31620

NF	SIS	BS	CSN	JIS	GOST	NIROSTA®
Z 8 C 12	2301	403 S 17	17020	SUS 410 S	08 Ch 13	4000
Z 8 CA 12		405 S 17		SUS 405		4002
						4003
Z 10 C 13	2302	410 S 21	17021	SUS 410	12 Ch 13	4006
Z 8 C 17	2320	430 S 17	17040	SUS 430	12 Ch 17	4016
Z 20 C 13	2303	420 S 37	17022	SUS 420 J 1	20 Ch 13	4021
		420 S 29		SUS 410 J 1	15 Ch 13 L	4024
Z 33 C 13	2304	420 S 45	17023	SUS 420 J 2	30 Ch 13	4028
Z 33 C 13	2304	420 S 45	17024	SUS 420 J 2	40 Ch 13	4031
Z 44 C 14			17024		40 Ch 13	4034
Z 15 CN 16-02	2321	431 S 29		SUS 431	20 Ch 17 N 2	4057
Z 8 CD 17-01		434 S 17		SUS 434		4113
Z 20 CD 14						4120
Z 7 CN 18-09	2332/33	304 S 31	17240	SUS 304	08 Ch 18 N 10	4301
Z 8 CN 18-12		305 S 19		SUS 305	06 Ch 18 N 11	4303
Z 10 CNF 18-09	2346	303 S 22				4305
Z 3 CN 18-10	2352	304 S 11	17249	SUS 304 L	03 Ch 18 N 11	4306
						4307
Z 11 CN 17-08	2331	301 S 21		SUS 301	07 Ch 16 N 6	4310
Z 3 CN 18-10 AZ	2371	304 S 61		SUS 304 L		4311
Z 6 CN 13-04	2385	425 C 11				4313
Z 6 CN 19-09 AZ						4315
Z 3 CN 18-07 AZ				SUS 301 LN		4318
Z 7 CND 17-11-02	2347	316 S 31	17346	SUS 316	03 Ch 17 N 13 M 2	4401
Z 3 CND 17-12-02	2348	316 S 11	17349	SUS 316 L	03 Ch 17 N 13 M 2	4404
						4427

Table of steel grades

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NIROSTA®	Material no.	Abbreviation as per EN 10 088-2	DIN/SEW	ASTM grade	UNS
4429	1.4429	X 2 CrNiMoN 17-13-3	17440/41	316 LN	S 31653
4435	1.4435	X 2 CrNiMo 18-14-3	17440/41	316 L	S 31603
4436	1.4436	X 3 CrNiMo 17-13-3	17440/41	316	S 31600
4438	1.4438	X 2 CrNiMo 18-15-4	17440/41	317 L	S 31703
4439	1.4439	X 2 CrNiMoN 17-13-5	17440/41		S 31726
4462	1.4462	X 2 CrNiMoN 22-5-3	SEW 400		S 31803 S 32205
4465	1.4465	X 1 CrNiMoN 25-25-2	SEW 400		
4501	1.4501	X 2 NiCrMoCuWN 25-7-4			S 32760
4509	1.4509	X 2 CrTiNb 18	SE list	441	
4510	1.4510	X 3 CrTi 17	17440/41	439	S 43900
4511	1.4511	X 8 CrNb 17			
4512	1.4512	X 2 CrTi 12		409	S 40900
4520	1.4520	X 2 CrTi 17			
4521	1.4521	X 2 CrMoTi 18-2		444	S 44400
4539	1.4539	X 1 NiCrMoCuN 25-20-5			N 08904
4541	1.4541	X 6 CrNiTi 18-10	17440/41	321	S 32100
4544	1.4544				
4546	1.4546	X 5 CrNiNb 18-10			
4550	1.4550	X 6 CrNiNb 18-10	17440/41	347	S 34700
4561	1.4561	X 1 CrNiMoTi 18-13-2	SEW 400	316 Ti/316 L	S 31603
4565	1.4565	X 2 CrNiMnMoNbN 25-18-5-4	SEW 400		S 34565
4568	1.4568	X 7 CrNiAl 17-7	17224	631	S 17700
4571	1.4571	X 6 CrNiMoTi 17-12-2	17440/41	316 Ti	S 31635
4589	1.4589	X 5 CrNiMoTi 15-2	5512 p.3		

NF	SIS	BS	CSN	JIS	GOST	NIROSTA®
Z 3 CND 17-12 AZ	2375	316 S 63		SUS 316 LN		4429
Z 3 CND 17-13-03	2353	316 S 13		SUS 316 L	03 Ch 17 N 14 M 2	4435
Z 6 CND 18-12-03	2343	316 S 33	17352	SUS 316		4436
Z 3 CND 19-15-04	2367			SUS 317 L		4438
Z 3 CND 18-14-05 AZ				SUS 317		4439
				SUS 329 J 3 L		4462
Z 2 CND 25-22 AZ						4465
						4501
Z 3 CTNb 18						4509
Z 4 CT 17			17041	SUS 430 LX	08 Ch 17 T	4510
Z 4 CNb 17						4511
Z 3 CT 12		409 S 19		SUS 409		4512
						4520
				SUS 444		4521
Z 2 NCDU 25-20	2662	904 S 13				4539
Z 6 CNT 18-10	2337	321 S 31	17247	SUS 321	08 Ch 18 N 10 T	4541
						4544
						4546
Z 6 CNNb 18-10	2338	347 S 31		SUS 347	08 Ch 18 N 12 B	4550
						4561
						4565
Z 9 CNA 17-07	2388			SUS 631	09 Ch 17 N 7 Ju	4568
Z 6 CNDT 17-12	2350	320 S 31	17848	SUS 316 Ti	10 Ch 17 N 13 M 2 T	4571
						4589

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Acetic acid	CH ₃ COOH		10%
Acetic acid	CH ₃ COOH		10%
Acetic acid	CH ₃ COOH		50%
Acetic acid	CH ₃ COOH		50%
Acetic acid with hydrogen peroxide	CH ₃ COOH + H ₂ O ₂		10% and 50%
Acetic acid with hydrogen peroxide	CH ₃ COOH + H ₂ O ₂		10% and 50%
Acetic acid with hydrogen peroxide	CH ₃ COOH + H ₂ O ₂		10% and 50%
Acetic anhydride	(CH ₃ CO) ₂ O		
Acetic anhydride	(CH ₃ CO) ₂ O		
Acetochloride	CH ₃ COCl		
Acetone	CH ₃ COCH ₃		all concentrations
Acetone	CH ₃ COCH ₃		all concentrations
Acetosalicic acid	HOCC ₆ H ₄ OCOCH ₃		
Activin	see p-toluene sulfonchloramide sodium		
Alcohol	see methyl and ethyl alcohol		
Alum	see potassium aluminium sulphate		
Aluminium	Al	molten	
Aluminium acetate	Al(CH ₃ COO) ₃	cold saturated	
Aluminium acetate	Al(CH ₃ COO) ₃	cold and hot saturated	
Aluminium ammonium sulphate	Al(NH ₄ (SO ₄) ₂ · 12H ₂ O		all concentrations
Aluminium ammonium sulphate	Al(NH ₄ (SO ₄) ₂ · 12H ₂ O	cold and hot saturated	
Aluminium chloride	AlCl ₃ · 6H ₂ O		5%
Aluminium chloride	AlCl ₃ · 6H ₂ O		25%
Aluminium nitrate	Al(NO ₃) ₃ · 9H ₂ O		
Aluminium sulphate	Al ₂ (SO ₄) ₃ · 18H ₂ O		10%
Aluminium sulphate	Al ₂ (SO ₄) ₃ · 18H ₂ O		10%
Aluminium sulphate	Al ₂ (SO ₄) ₃ · 18H ₂ O	cold saturated	
Aluminium sulphate	Al ₂ (SO ₄) ₃ · 18H ₂ O	cold and hot saturated	
Ammonia	NH ₃		
Ammonium alum	see aluminium ammonium sulphate		
Ammonium bicarbonate	NH ₄ HCO ₃		all concentrations
Ammonium bifluoride	NH ₄ HF ₂	cold saturated	
Ammonium carbonate	(NH ₄) ₂ CO ₃ · H ₂ O	cold saturated	
Ammonium carbonate	(NH ₄) ₂ CO ₃ · H ₂ O	hot saturated	
Ammonium chloride (sal ammoniac)	NH ₄ Cl		10%
Ammonium chloride (sal ammoniac)	NH ₄ Cl		25%
Ammonium chloride (sal ammoniac)	NH ₄ Cl		50%
Ammonium chloride (sal ammoniac)	NH ₄ Cl	cold saturated	
Ammonium chloride (sal ammoniac)	NH ₄ Cl	cold and hot saturated	
Ammonium chloride (sal ammoniac)	NH ₄ Cl	cold saturated with copper and zinc chlorides	

Classification of NIROSTA®-/ASTM grades by group

0 = resistant to general corrosion
 1 = slight susceptibility to general corrosion
 2 = low resistance to general corrosion
 3 = no resistance to general corrosion
 L = risk of pitting, crevice corrosion or stress-corrosion crating

4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C		0	0	0	0	0	0	0
boiling	2	2	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	1	1	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
50 °C	2	0	0	0	0	0	0	0
90 °C	3	1	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	1	0	0	0	0	0	0
boiling	2 L	1 L	1 L	1 L	0 L	0 L	0 L	0
20 °C		0	0	0	0	0	0	0
boiling			0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
750 °C	3	3	3	3	3	3	3	3
20 °C		0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C			0	0	0	0	0	0
boiling				3	2	0	0	0
50 °C				2 L	1 L	0 L	0 L	
20 °C				3 L	2 L	2 L	0 L	0
20 °C	0	0	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	2	1	0	0	0	0
20 °C	2	2	2	1	0	0	0	0
boiling	3	3	3	2	1	0	0	0
50 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	3	3	2	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
boiling	1 L	0 L	0 L	0 L	0 L	0 L	0 L	0 L
boiling	1 L	1 L	2 L	1 L	1 L			
boiling				2 L	1 L	1 L	1 L	
20 °C		0 L	0 L	0 L	0 L	0 L	0 L	0
boiling				2 L	1 L	1 L	1 L	
boiling	3 L	3 L	3 L	3 L	3 L			

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Ammonium hexachlorostannate (pink salt)	$(\text{NH}_4)_2(\text{SnCl}_6)$	cold saturated	
Ammonium hexachlorostannate (pink salt)	$(\text{NH}_4)_2(\text{SnCl}_6)$		
Ammonium hydroxide	NH_4OH		all concentrations
Ammonium nitrate	$\text{NH}_4\text{NO}_3 \cdot 9\text{H}_2\text{O}$	cold saturated	
Ammonium nitrate	$\text{NH}_4\text{NO}_3 \cdot 9\text{H}_2\text{O}$	cold and hot saturated	
Ammonium oxalate	$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$	cold and hot saturated	
Ammonium oxalate	$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$	cold and hot saturated	
Ammonium perchlorate	NH_4ClO_4		10%
Ammonium perchlorate	NH_4ClO_4		
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$	cold saturated	
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$	cold saturated	
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$		with 5% sulphuric acid
Ammonium sulphite	$(\text{NH}_4)_2\text{SO}_3$	cold saturated	
Ammonium sulphite	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$	cold and hot saturated	
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$		
Aniline hydrochloride	$\text{C}_6\text{H}_5\text{NH}_2\text{HCl}$		5%
Antichlor	see sodium thiosulphate, sodium perborate		
Antimony	Sb	molten	
Antimony chloride	SbCl_3		
Aqua regia	$\text{HCl} + \text{HNO}_3$		
Aqueous ammonia	see ammonium hydroxide		
Arsenic acid	$\text{H}_3\text{AsO}_4 \cdot 1/2\text{H}_2\text{O}$		all concentrations
Aspirin	see acetosalicylic acid		
Atmosphere ¹⁾			
Barium chloride	BaCl_2	fused	
Barium chloride	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$	saturated solution	
Barium chloride	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$	saturated solution	
Barium hydroxide	$\text{Ba}(\text{OH})_2$	cold saturated	
Barium hydroxide	$\text{Ba}(\text{OH})_2$	cold and hot saturated	
Barium nitrate	$\text{Ba}(\text{NO}_3)_2$		all concentrations
Beer ²⁾			
Benzoic acid	$\text{C}_6\text{H}_5\text{COOH}$		all concentrations
Benzole	C_6H_6		
Bleach liquor	see sodium hypochlorite		
Bleach solution	see chlorinated lime		
Bleaching lye	see sodium hypochlorite		
Blood ³⁾			
Bonder's solution	see iron phosphate		
Borax	see sodium tetraborate		
Boric acid	H_3BO_3		all concentrations
Boric acid	H_3BO_3		all concentrations

¹⁾ Corrosion by the atmosphere depends on the amounts of factory gases, sea water, volcanic gases etc. contained in the air. The corrosion rate will be higher in coastal areas or in the vicinity of factories than in non-industrial areas. The highest resistance to corrosion is only achieved with a polished surface and appropriate maintenance.

²⁾ The taste of beer is not affected by contact with austenitic steels.

³⁾ Pitting and crevice corrosion may occur in the presence of salt, especially with pigs' blood.

Classification of NIROSTA®-/ASTM grades by group

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 2 = low resistance to general corrosion
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 L = risk of pitting, crevice corrosion or stress-corrosion crating

4000/410 S				4301/304				
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4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	2 L	2 L	1 L	1 L	0 L			
60 °C	3 L	3 L	3 L	3 L	3 L			
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling	2	2	1	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	2	2	1	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling	2	2	1	1	1	0	0	0
100 °C	3	3	1	1	1	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	2	2	1	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	3 L	3 L	3 L	3 L	3 L	2 L		
650 °C	3	3	3	3	3	3	3	3
20 °C	3 L	3 L	3 L	3 L	3 L	3 L		
20 °C	3	3	3	3	3	2	2	2
20 °C	0	0	0	0	0	0	0	0
	1	1	0	0	0	0	0	0
fused	3	3	3	3	3	3		
20 °C	1 L	0 L	0 L	0 L	0 L	0 L	0 L	0 L
boiling	2 L	2 L	1 L	1 L	0 L	0 L	0 L	0 L
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C and 70 °C				0	0	0	0	0
20 °C and boiling		0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
				0 L	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	1	1	0	0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Brandy ¹⁾			
Bromine	Br ₂		
Bromine water			0.03 %
Bromine water			0.3 %
Bromine water			1 %
Buttermilk			
Butyric acid	C ₃ H ₇ COOH		100 %
Butyric acid	C ₃ H ₇ COOH		100 %
Cadmium	Cd		
Calcium bisulphite ²⁾ (sulphite lye)	CaH ₂ (SO ₃) ₂	cold saturated	
Calcium bisulphite (sulphite lye)	CaH ₂ (SO ₃) ₂	cold and hot saturated	
Calcium bisulphite (sulphite lye)	CaH ₂ (SO ₃) ₂	20 bar	
Calcium chloride	CaCl ₂ · 6H ₂ O	cold saturated	
Calcium chloride	CaCl ₂ · 6H ₂ O	cold saturated	
Calcium hydroxide (slaked lime)	Ca(OH) ₂		
Calcium hydroxide (slaked lime)	Ca(OH) ₂		
Calcium hypochlorite	Ca(OCl) ₂ · 4H ₂ O	cold saturated	
Calcium sulphate	CaSO ₄	saturated	
Calcium sulphite	CaSO ₃	cold saturated	
Camphor	C ₁₀ H ₁₆ O		
Carbolic acid	see phenol		
Carbon dioxide (carbonic acid)	CO ₂	dry	
Carbon dioxide (carbonic acid)	CO ₂	moist	
Carbon disulphide	CS ₂		
Carbon tetrachloride ³⁾	CCl ₄	anhydrous	
Carbon tetrachloride ³⁾	CCl ₄	anhydrous	
Carnallite	KClMgCl ₂ · 6H ₂ O	cold saturated	
Carnallite	KClMgCl ₂ · 6H ₂ O	cold and hot saturated	
Caustic potash solution	see potassium hydroxide		
Caustic soda solution	see sodium hydroxide		
Cheese			
Chloramine-T	see p-toluene sodium sulfonchloramide		
Chloric acid	HClO ₃		concentrated
Chlorinated lime	[3CaCl(OCl) · Ca(OH) ₂] · 5H ₂ O	dry	
Chlorinated lime	[3CaCl(OCl) · Ca(OH) ₂] · 5H ₂ O	moist	
Chlorinated lime (bleach solution)	[3CaCl(OCl) · Ca(OH) ₂] · 5H ₂ O		2.5 g Cl/l
Chlorine (damp gas)	Cl ₂		
Chlorine (damp gas)	Cl ₂		
Chlorine (dry gas)	Cl ₂		
Chlorine water	cold water saturated with chlorine		
Chloroacetic acid	see mono- and trichloroacetic acid		

¹⁾ In individual cases of prolonged exposure, the taste may be affected.

²⁾ Enhanced concentrations on condensation in steam rooms can lead to corrosive attack.

³⁾ Even if only traces of hydrochloric acid (HCl) are formed by moisture, there is a danger of pitting, crevice and stress corrosion cracking.

Classification of NIROSTA®-/ASTM grades by group

0 = resistant to general corrosion
 1 = slight susceptibility to general corrosion
 2 = low resistance to general corrosion
 3 = no resistance to general corrosion
 L = risk of pitting, crevice corrosion or stress-corrosion cracing

	4000/410 S			4301/304				
	4002/405			4303/(305)	4401/316			
	4003/A240...			4306/304 L	4404/316 L			
	4006/410	4016/430		4307/304 L	4429/316 LN			
	4021/(420)	4057/431		4310/(301)	4435/316 L			
	4024/(410)	4120		4311/304 LN	4436/316			
	4028/(420)	4305/303		4315/304 N	4438/317 L			
	4031/(420)	4427/316 F		4318/301 LN	4439			
	4034/(420)	4509/441		4541/321	4462			
	4313	4510/439	4113/434	4544	4501			
	4512/409	4511	4521/444	4546	4561/316 Ti			
	4589	4520	4568/631	4550/347	4571/316 Ti	4465	4539	4565 S
Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C and boiling				0	0	0	0	0
20 °C and boiling	3 L	3 L	3 L	3 L	3 L	3 L	3 L	
20 °C				0 L	0 L			
20 °C				1 L	1 L			
20 °C				3 L	3 L			
20 °C	1	0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	2	2		1	0	0	0	0
molten				2	2			
20 °C	2	2	0	0	0	0	0	0
boiling	3	3	2	2	0	0	0	0
200 °C	3	3	3	3	0	0	0	0
20 °C				0 L	0 L	0 L	0 L	0
boiling				1 L	1 L	0 L	0 L	0 L
20 °C	0	0	0	0	0	0	0	0
boiling				0	0	0	0	0
up to 40 °C				2 L	1 L	0 L	0 L	
20 °C				0	0	0	0	0
20 °C				0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
hot	0	0	0	0	0	0	0	0
hot	1	1	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C	2 L	2 L				0 L	0 L	0
boiling	3 L	3 L	1 L	1 L	1 L	0 L	0 L	0 L
20 °C				0	0	0	0	0
20 °C				3 L	3 L	1 L		
20 °C				0	0	0	0	0
20 °C	3 L	3 L	2 L	1 L	1 L	0 L	0 L	
20 °C	3 L	3 L	2 L	1 L	0 L	0 L	0 L	
20 °C	3 L	3 L	3 L	3 L	3 L			
100 °C	3 L	3 L	3 L	3 L	3 L			
20 °C	0	0	0	0	0	0	0	0
20 °C	3 L	3 L	3 L	1 L	1 L	0 L	0 L	

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Chlorobenzene ¹⁾	C ₆ H ₅ Cl	dry	
Chlorobenzene ¹⁾	C ₆ H ₅ Cl	dry	
Chloroform ¹⁾	CHCl ₃	anhydrous	
Chlorosulphonic acid	HSO ₃ Cl		10 %
Chlorosulphonic acid	HSO ₃ Cl		100 %
Chocolate			
Chrome alum	see potassium chrome sulphate		
Chrome sulphate	Cr ₂ (SO ₄) ₃ · 18H ₂ O	saturated	
Chromic acid	CrO ₃		10 % pure, free of SO ₃
Chromic acid	CrO ₃		10 % pure, free of SO ₃
Chromic acid	CrO ₃		50 % pure, free of SO ₃
Chromic acid	CrO ₃		50 % pure, free of SO ₃
Chromic acid	CrO ₃		50 % tech., containing SO ₃
Chromic acid	CrO ₃		50 % tech., containing SO ₃
Cider			
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		1 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		1 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		10 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		10 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		25 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		25 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		50 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O		50 %
Citric acid	HOC(CH ₂ COOH) ₂ COOH · H ₂ O	3 bar	5 %
Coffee			
Copper acetate	(CH ₃ COO) ₂ Cu · H ₂ O	cold saturated	
Copper acetate	(CH ₃ COO) ₂ Cu · H ₂ O	cold and hot saturated	
Copper carbonate	CuCO ₃ Cu(OH) ₂		all concentrations
Copper chloride	CuCl ₂ · 2H ₂ O	cold saturated	
Copper cyanide	Cu(CN) ₂	hot saturated	
Copper nitrate	Cu(NO ₃) ₂ · 3H ₂ O		50 %
Copper nitrate	Cu(NO ₃) ₂ · 3H ₂ O		50 %
Copper sulphate	CuSO ₄ · 5H ₂ O		all concentrations
Copper sulphate (blue vitriol + 3% H ₂ SO ₄)	CuSO ₄ · 5H ₂ O		
Copper sulphate (blue vitriol + 3% H ₂ SO ₄)	CuSO ₄ · 5H ₂ O		
Creosote			
Creosote			
Cresol	CH ₃ C ₆ H ₄ (OH)		
Crude oil			
Developer	see photographic developer		
Dichloroethane ¹⁾	CH ₂ ClCH ₂ Cl	anhydrous	

¹⁾ Even if only traces of hydrochloric acid (HCl) are formed by moisture, there is a danger of pitting, crevice and stress corrosion cracking.

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4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	2	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	3 L	3 L	3 L	3 L	3 L			
20 °C	3 L	3 L		0 L	0 L			
20 °C	0	0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	3	3		1	1	0		
20 °C	3	3	2	1	1	0		
boiling	3	3	3	2	2	2	2	
20 °C	3	3	2	1	1			
boiling	3	3	3	3	3	2	2	
20 °C				0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
boiling	2	1	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	3	2	2	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	3	2	2	1	0	0	0
140 °C	2	1	1	1	0	0	0	0
20 °C and boiling				0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	3 L	3 L	3 L	3 L	3 L	2 L	2 L	0 L
boiling	3	2	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	2	2	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling	2	1	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C								
20 °C				0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Dichloroethylene ¹⁾	CHClCHCl	anhydrous	
Disulphur dichloride ¹⁾	S ₂ Cl ₂	anhydrous	
Disulphur dichloride ¹⁾	S ₂ Cl ₂	anhydrous	
Dripping			
Dye bath (alkaline or neutral)			
Dye bath (organic acid)			
Dye bath (organic acid)			
Dye bath (strong sulphuric acid or organic + strong sulphuric acid) (H ₂ SO ₄ more than 1%)			
Dye bath (strong sulphuric acid or organic + strong sulphuric acid) (H ₂ SO ₄ more than 1%)			
Dye bath (weak sulphuric acid or organic + sulphuric acid) (H ₂ SO ₄ less than 1%)			
Dye bath (weak sulphuric acid or organic + sulphuric acid) (H ₂ SO ₄ less than 1%)			
Epsom salts	see magnesium sulphate		
Ethyl chloride ¹⁾	C ₂ H ₅ Cl	anhydrous	
Ethyl ether	(C ₂ H ₅) ₂ O		
Ethyl glycol	CH ₂ OHCH ₂ OH		
Ethylalcohol (spirit)	C ₂ H ₅ OH		all concentrations
Ethylene chloride	see dichloroethane		
Fatty acid (oleic acid) + traces of H ₂ SO ₄	C ₁₇ H ₃₃ COOH		
Fatty acid (oleic acid)	C ₁₇ H ₃₃ COOH	30 bar	technical
Fatty acid (oleic acid)	C ₁₇ H ₃₃ COOH	30 bar	technical
Fatty acid (oleic acid)	C ₁₇ H ₃₃ COOH	30 bar	technical
Fatty acid (oleic acid)	C ₁₇ H ₃₃ COOH	30 bar	technical
Ferric chloride	FeCl ₃		30 %
Ferric chloride	FeCl ₃		50 %
Ferric nitrate	Fe(NO ₃) ₃ · 9H ₂ O		all concentrations
Ferric sulphate ²⁾	Fe ₂ (SO ₄) ₃		10 %
Ferric sulphate ²⁾	Fe ₂ (SO ₄) ₃		10 %
Ferrous sulphate	FeSO ₄ · 7H ₂ O		all concentrations
Fixing salt	see photographic fixing bath		
Fluosilicic acid	H ₂ SiF ₆	vapours	
Formaldehyde (formalin = methyl aldehyde)	HCHO		40 %
Formic acid	HCOOH		10 %
Formic acid	HCOOH		10 %
Formic acid	HCOOH		10 %
Formic acid	HCOOH		50 %
Formic acid	HCOOH		50 %
Formic acid	HCOOH		50 %

¹⁾ Even if only traces of hydrochloric acid (HCl) are formed by moisture, there is a danger of pitting, crevice and stress corrosion cracking.

²⁾ Can sometimes prevent austenitic chrome-nickel steels from being attacked by sulphuric acid.

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	4021/(420)	4057/431		4310/(301)	4435/316 L			
	4024/(410)	4120		4311/304 LN	4436/316			
	4028/(420)	4305/303		4315/304 N	4438/317 L			
	4031/(420)	4427/316 F		4318/301 LN	4439			
	4034/(420)	4509/441		4541/321	4462			
	4313	4510/439	4113/434	4544	4501			
	4512/409	4511	4521/444	4546	4561/316 Ti			
	4589	4520	4568/631	4550/347	4571/316 Ti	4465	4539	4565 S
Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
boiling	0	0	0	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling	2	2	2	0	0			
20 °C	0	0	0	0	0	0	0	0
20 °C and boiling			0	0	0	0	0	0
20 °C			0	0	0	0	0	0
boiling			1	0	0	0	0	0
20 °C			1	1	0	0	0	0
boiling			1	1	1	0	0	0
20 °C			0	0	0	0	0	0
boiling			1	1	0	0	0	0
boiling	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
hot			3	2	1	0	0	0
150 °C	0	0	0	0	0	0	0	0
180 °C	2	2	1	1	0	0	0	0
235 °C	3	2	2	1	0	0	0	0
300 °C	3	3	2	2	0	0	0	0
20 °C	3 L	3 L	3 L	3 L	2 L	1 L	1 L	0
50 °C	3 L	3 L	3 L	3 L	3 L			
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	1	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
100 °C	3	2	1	1	1	1	1	1
20 °C and boiling		0	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
70 °C	3	2	1	1	0	0	0	0
boiling	3	3	2	2	1	0	0	0
20 °C	2	2	0	0	0	0	0	0
70 °C	3	2	1	2	1	0	0	0
boiling	3	3	3	3	1	1	1	1

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Formic acid	HCOOH		80 %
Formic acid	HCOOH		80 %
Formic acid	HCOOH		100 %
Formic acid	HCOOH		100 %
Fruit juices and fruit acids			
Fruit pulp (containing SO ₂)			
Gallic acid	C ₆ H ₂ (OH) ₃ COOH	saturated	
Gallic acid	C ₆ H ₂ (OH) ₃ COOH	hot saturated	
Glacial acetic acid			100 %
Glacial acetic acid			100 %
Glauber's salt	see sodium sulphate		
Glue (also acid)			
Glycerine	C ₃ H ₅ (OH) ₃	concentrated	
Hydrazine sulphate	(NH ₂) ₂ · H ₂ SO ₄		10 %
Hydrochloric acid	gas, see hydrogen chloride gas		
Hydrochloric acid	HCl		0.50 %
Hydrochloric acid	HCl		0.50 %
Hydrocyanic acid	HCN		
Hydrofluoric acid	HF		40 %
Hydrogen chloride gas	HCl		
Hydrogen chloride gas	HCl		
Hydrogen chloride gas	HCl		
Hydrogen chloride gas	HCl		
Hydrogen fluoride	HF	dry gaseous	
Hydrogen peroxide ²⁾	H ₂ O ₂		
Hydrogen sulphide	H ₂ S	dry	< 4 %
Hydrogen sulphide	H ₂ S		< 4 %
Hydrogen sulphide	H ₂ S		< 4 %
Hydrogen sulphide	H ₂ S	moist	< 4 %
Hydroxylamine sulphate	(NH ₂ OH) ₂ · H ₂ SO ₄		10 %
Industrial air	see atmosphere		
Ink	see iron gallate ink		
Iodine	J ₂	dry	
Iodine	J ₂	moist	
Iodoform ³⁾	CHI ₃	vapour	
Iron gallate ink ⁴⁾			
Iron phosphate ⁵⁾			
Lactic acid	CH ₃ CH(OH)COOH		2 %
Lactic acid	CH ₃ CH(OH)COOH		2 %
Lactic acid	CH ₃ CH(OH)COOH		10 %
Lactic acid	CH ₃ CH(OH)COOH		10 %

¹⁾ Discolouring of the pulp.

²⁾ At 20 °C there is no corrosive, catalytic influence. This starts at temperatures above 80 °C.

³⁾ Even if only traces of hydrogen iodide (HI) are formed by moisture, there is a danger of pitting and crevice corrosion.

⁴⁾ Take care with inks containing salts.

⁵⁾ Solution by Bonder's process.

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4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	2	2	0	0	0	0	0	0
boiling	3	3	2	2	1	1	1	1
20 °C	1	1	0	0	0	0	0	0
boiling	3	3	2	2	1	0	0	0
20 °C and boiling				0	0	0	0	0
		1 ¹⁾		0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
boiling	3	2	2	1	1	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
boiling			0	0	0	0	0	0
20 °C	3 L	2 L	2 L	1 L	1 L	0 L	0 L	0
boiling	3 L	3 L	3 L	3 L	3 L	1 L	1 L	1 L
20 °C		0	0	0	0	0	0	0
20 °C	3	3	3	3	3			
20 °C	3 L	2 L		1 L	1 L			
50 °C	3 L	2 L	1 L	1 L	1 L			
100 °C	3 L	3 L	2 L	2 L	1 L			
400 °C	3	3	3	3	3			
100 °C	3	3	1	1	1			
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
100 °C	0	0	0	0	0	0	0	0
< 400 °C	2	2	1	0	0	0	0	0
	3	3	1	0	0	0	0	0
20 °C and boiling			0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	2 L	2 L	1 L	1 L	0 L	0 L	0 L	0 L
20 °C and 60 °C	0	0	0	0	0	0	0	0
20 °C	1 L	0 L	0 L	0 L	0	0	0	0
98 °C	1	0	0	0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
boiling		1	0	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling	3	3	2	1	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Lactic acid	CH ₃ CH(OH)COOH		80 %
Lactic acid	CH ₃ CH(OH)COOH		80 %
Lactic acid	CH ₃ CH(OH)COOH		concentrated
Lactic acid	CH ₃ CH(OH)COOH		concentrated
Lead ¹⁾	Pb		molten
Lead acetate (sugar of lead)	Pb(CH ₃ COO) ₂ · 3H ₂ O		all concentrations
Lead acetate (sugar of lead)	Pb(CH ₃ COO) ₂ · 3H ₂ O		all concentrations
Lead nitrate	Pb(NO ₃) ₂		
Lemon juice			
Linseed oil (+3% H ₂ SO ₄)			
Linseed oil (+3% H ₂ SO ₄)			
Liqueurs			
Lubricating oils	see oil		
Lysoform			
Lysol			
Magnesium carbonate	MgCO ₃		all concentrations
Magnesium chloride	MgCl ₂ · 6H ₂ O		10 %
Magnesium chloride	MgCl ₂ · 6H ₂ O		30 %
Magnesium sulphate (Epsom salts)	MgSO ₄ · 7H ₂ O	cold saturated	
Magnesium sulphate (Epsom salts)	MgSO ₄ · 7H ₂ O	cold and hot saturated	
Maleic acid	(CHCOOH) ₂		50 %
Malic acid	COOHCH ₂ CHOHCOOH		up to 50 %
Malic acid	COOHCH ₂ CHOHCOOH		up to 50 %
Malic acid	COOHCH ₂ CHOHCOOH		up to 50 %
Manganese chloride	MnCl ₂ · 4H ₂ O		10 %
Manganese chloride	MnCl ₂ · 4H ₂ O		50 %
Manganese sulphate	MnSO ₄ · 7H ₂ O		
Meat			
Mercuric acetate	Hg(CH ₃ COO) ₂	cold saturated	
Mercuric acetate	Hg(CH ₃ COO) ₂	hot saturated	
Mercuric chloride	HgCl ₂ (sublimate)		0.10 %
Mercuric chloride	HgCl ₂ (sublimate)		0.10 %
Mercuric chloride	HgCl ₂ (sublimate)		0.70 %
Mercuric chloride	HgCl ₂ (sublimate)		0.70 %
Mercurous nitrate	(HgNO ₃) ₂ · 2H ₂ O		all concentrations
Mercury	Hg		
Mercury cyanide	Hg(CN) ₂		all concentrations
Methyl alcohol	CH ₃ OH		all concentrations
Methyl aldehyde	see formaldehyde		
Methyl chloride ²⁾	CH ₃ Cl	anhydrous	
Methylene chloride ²⁾	CH ₂ Cl ₂	anhydrous	

¹⁾ Iron or iron alloys are not attacked by lead. Even high-alloy steels are, however, attacked by lead oxide at points exposed to the atmosphere.

²⁾ Even if only traces of hydrochloric acid (HCl) are formed by moisture, there is a danger of pitting, crevice and stress corrosion cracking.

Classification of NIROSTA®-/ASTM grades by group

0 = resistant to general corrosion
 1 = slight susceptibility to general corrosion
 2 = low resistance to general corrosion
 3 = no resistance to general corrosion
 L = risk of pitting, crevice corrosion or stress-corrosion crating

4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	1	1	0	0	0	0	0	0
boiling	3	2	2	2	1	1	1	1
20 °C	1	1	0	0	0	0	0	0
boiling	3	2	2	2	1	1	1	1
600 °C				1				
20 °C		0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
20 °C				0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
200 °C			1	0	0	0	0	0
	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	2 L	1 L	0 L	0 L	0 L	0 L	0 L	0
20 °C	2 L	1 L	0 L	0 L	0 L	0 L	0 L	0
20 °C	2	1	0	0	0	0	0	0
boiling				0	0	0	0	0
100 °C	2	1	1	0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
60 °C	2	2	1	0	0	0	0	0
100 °C	3	3	2	1	0	0	0	0
boiling				0 L	0 L	0 L	0 L	0 L
boiling				0	0 L	0 L	0 L	0 L
20 °C	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	2 L	1 L	0 L	0 L	0 L	0	0	0
boiling	3 L	2 L	1 L	1 L	0 L	0 L	0 L	0
20 °C	2 L	2 L	1 L	1 L	1 L	0	0	0
boiling	3 L	3 L	2 L	2 L	2 L	1 L	0 L	0 L
boiling	0	0	0	0	0	0	0	0
20 °C and 50 °C	0	0	0	0	0	0	0	0
20 °C	2	2		0	0	0	0	0
20 °C and 65 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Milk		fresh	
Milk		sour	
Milk of lime	see calcium hydroxide		
Mixed acids (nitrating acids)			50% H ₂ SO ₄ + 50% HNO ₃
Mixed acids (nitrating acids)			50% H ₂ SO ₄ + 50% HNO ₃
Mixed acids (nitrating acids)			50% H ₂ SO ₄ + 50% HNO ₃
Mixed acids (nitrating acids)			75% H ₂ SO ₄ + 25% HNO ₃
Mixed acids (nitrating acids)			75% H ₂ SO ₄ + 25% HNO ₃
Mixed acids (nitrating acids)			75% H ₂ SO ₄ + 25% HNO ₃
Mixed acids (nitrating acids)			20% H ₂ SO ₄ + 15% HNO ₃
Mixed acids (nitrating acids)			20% H ₂ SO ₄ + 15% HNO ₃
Mixed acids (nitrating acids)			70% H ₂ SO ₄ + 10% HNO ₃
Mixed acids (nitrating acids)			70% H ₂ SO ₄ + 10% HNO ₃
Mixed acids (nitrating acids)			70% H ₂ SO ₄ + 10% HNO ₃
Mixed acids (nitrating acids)			30% H ₂ SO ₄ + 5% HNO ₃
Mixed acids (nitrating acids)			30% H ₂ SO ₄ + 5% HNO ₃
Mixed acids (nitrating acids)			15% H ₂ SO ₄ + 5% HNO ₃
Mixed acids (nitrating acids)			2% H ₂ SO ₄ + 1% HNO ₃
Monochloroacetic acid	CH ₂ ClCOOH		50%
Mustard			
Nickel chloride	NiCl ₂ · 6H ₂ O	cold saturated	
Nickel nitrate	Ni(NO ₃) ₂ · 6H ₂ O	cold saturated	
Nickel sulphate	NiSO ₄ · 7H ₂ O	cold saturated	
Nitrating acid	see mixed acids		
Nitric acid	HNO ₃		7%
Nitric acid	HNO ₃		7%
Nitric acid	HNO ₃		10%
Nitric acid	HNO ₃		10%
Nitric acid	HNO ₃		25%
Nitric acid	HNO ₃		25%
Nitric acid	HNO ₃		37%
Nitric acid	HNO ₃		37%
Nitric acid	HNO ₃		50%
Nitric acid	HNO ₃		50%
Nitric acid	HNO ₃		66%
Nitric acid	HNO ₃		66%
Nitric acid	HNO ₃		99% (high concentration)
Nitric acid	HNO ₃		99% (high concentration)
Nitrosylsulphuric acid 60° Bé with 4–5% nitro content			
Nitrosylsulphuric acid 60° Bé with 4–5% nitro content			
Nitrous acid	HNO ₂		concentrated

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	4000/410 S			4301/304				
	4002/405			4303/(305)	4401/316			
	4003/A240...			4306/304 L	4404/316 L			
	4006/410	4016/430		4307/304 L	4429/316 LN			
	4021/(420)	4057/431		4310/(301)	4435/316 L			
	4024/(410)	4120		4311/304 LN	4436/316			
	4028/(420)	4305/303		4315/304 N	4438/317 L			
	4031/(420)	4427/316 F		4318/301 LN	4439			
	4034/(420)	4509/441		4541/321	4462			
	4313	4510/439	4113/434	4544	4501			
	4512/409	4511	4521/444	4546	4561/316 Ti			
	4589	4520	4568/631	4550/347	4571/316 Ti	4465	4539	4565 S
Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
up to 70 °C		0	0	0	0	0	0	0
up to 70 °C		1	0	0	0	0	0	0
50 °C	3	2	1	0	0	0	0	0
90 °C	3	3	2	1	1			
120 °C	3	3	3	2	2			
50 °C	3	2	1	1	0	0	0	0
90 °C	3	3	1	1	1			
157 °C	3	3	3	3	3			
50 °C	3	3	1	0	0	0	0	0
80 °C	3	3	2	1	0	0	0	0
50 °C	3	3	1	0	0	0	0	0
90 °C	3	3	3	1	0	0	0	0
168 °C	3	3	3	3	3			
90 °C	3	3	1	0	0	0	0	0
110 °C	3	3	2	1	0	0	0	0
134 °C	3	3	2	1	1			
boiling	3	3	2	2	0	0	0	0
20 °C	3 L	3 L	2 L	1 L	1 L	0 L	0 L	
20 °C	2 L	0 L	0 L	0 L	0 L	0	0	0
20 °C				1 L	1 L	0 L	0 L	0
20 °C	0			0	0	0	0	0
20 °C and boiling				0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	1	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	1	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	1	1	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	1	1	1	1	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	3	2	2	1	1	1	1	1
20 °C	2	1	1	1	2	1	1	1
boiling	3	3	3	2	2			
20 °C	0	0	0	0	0	0	0	0
75 °C					1	1		
20 °C			0	0	0	0	0	0

Chemical resistance of NIROSTA® steels

Corrosive agent	Formula	Condition	Concentration
Novocain			
Oil (lubricating oil)			
Oil (vegetable oil)			
Oleic acid	see fatty acids		
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		5%
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		5%
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		10%
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		10%
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		25%
Oxalic acid	$(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$		50%
P-toluene sulfonchloramide sodium (chloramin T)	$\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NCINa} \cdot 3\text{H}_2\text{O}$	cold saturated	
P-toluene sulfonchloramide sodium (chloramin T)	$\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NCINa} \cdot 3\text{H}_2\text{O}$		cold and hot concentrated
Paraffin			
Persil			
Petrol			all concentrations
Petroleum			
Petroleum ether			
Phenol (carbolic acid)	$\text{C}_6\text{H}_5\text{OH}$		pure
Phenol (carbolic acid)	$\text{C}_6\text{H}_5\text{OH}$		with 10 % H_2O
Phenol (carbolic acid)	$\text{C}_6\text{H}_5\text{OH}$		raw 90 % phenol
Phosphate detergents			
Phosphoric acid	H_3PO_4 chem. pure		1%
Phosphoric acid	H_3PO_4 chem. pure		1%
Phosphoric acid	H_3PO_4 chem. pure		10%
Phosphoric acid	H_3PO_4 chem. pure		10%
Phosphoric acid	H_3PO_4 chem. pure		45%
Phosphoric acid	H_3PO_4 chem. pure		45%
Phosphoric acid	H_3PO_4 chem. pure		60%
Phosphoric acid	H_3PO_4 chem. pure		60%
Phosphoric acid	H_3PO_4 chem. pure		70%
Phosphoric acid	H_3PO_4 chem. pure		70%
Phosphoric acid	H_3PO_4 chem. pure		80%
Phosphoric acid	H_3PO_4 chem. pure		80%
Phosphoric acid	H_3PO_4 chem. pure		concentrated
Phosphoric acid	H_3PO_4 chem. pure		concentrated
Phosphoric acid anhydride (phosphorus pentoxide, dry or moist)	P_2O_5		
Photographic developer (Agfa-glycine developer)			

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4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0
boiling		3	3	1	1	0	0	0
20 °C		1	2	1	0	0	0	0
boiling			3	2	2	1	1	1
boiling			3	2	2	1	1	1
20 °C				1 L	0 L	0 L	0 L	0
boiling				1 L	0 L	0 L	0 L	0 L
20 °C and molten	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
boiling	2	1	1	1	0	0	0	0
boiling	3	1	1	1	0	0	0	0
boiling	3	3	1	1	0	0	0	0
95 °C	0	0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	1	1	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	2	2	0	0	0	0	0	0
20 °C	2	2	1	0	0	0	0	0
boiling	3	2	2	2	1	0	0	0
20 °C	2	2	1	0	0	0	0	0
boiling	3	3	2	2	1	0	0	0
20 °C	2	2	1	0	0	0	0	0
boiling	3	3	2	2	2	1	1	1
20 °C	2	2	1	1	0	0	0	0
boiling	3	3	3	3	2			
20 °C	2	2	1	1	0	0	0	0
boiling	3	3	3	3	3			
20 °C			1	1	0	0	0	0
20 °C	1	0	0	0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Photographic fixing bath ¹⁾			
Pickling liquid			
Picric acid	$C_6H_2(NO_2)_3OH$		all concentrations
Pink salt	see ammonium hexachlorostannate		
Potash	see potassium carbonate		
Potassium acetate	CH_3COOK	molten	
Potassium aluminium sulphate (alum)	$KAl(SO_4)_2 \cdot 12H_2O$		10 %
Potassium aluminium sulphate (alum)	$KAl(SO_4)_2 \cdot 12H_2O$		10 %
Potassium aluminium sulphate (alum)	$KAl(SO_4)_2 \cdot 12H_2O$	cold saturated	
Potassium aluminium sulphate (alum)	$KAl(SO_4)_2 \cdot 12H_2O$	cold and hot saturated	
Potassium bifluoride	KHF_2	cold saturated	
Potassium bisulphate	$KHSO_4$		2 %
Potassium bisulphate	$KHSO_4$		5 %
Potassium bisulphate	$KHSO_4$		5 %
Potassium bisulphate	$KHSO_4$		15 %
Potassium bitartrate (tartar)	$KHC_4H_4O_6$	cold saturated	
Potassium bitartrate (tartar)	$KHC_4H_4O_6$	cold and hot saturated	
Potassium bromide	KBr		
Potassium carbonate (potash)	K_2CO_3	cold saturated	
Potassium carbonate (potash)	K_2CO_3	cold and hot saturated	
Potassium chlorate	$KClO_3$	hot saturated	
Potassium chloride	KCl		
Potassium chloride	KCl	cold and hot saturated	
Potassium chrome sulphate (chrome alum)	$KCr(SO_4)_2 \cdot 12H_2O$	cold saturated	
Potassium chrome sulphate (chrome alum)	$KCr(SO_4)_2 \cdot 12H_2O$	cold and hot saturated	
Potassium cyanate	$KOCN$		
Potassium cyanide	KCN		5 %
Potassium dichromate	$K_2Cr_2O_7$		25 %
Potassium dichromate	$K_2Cr_2O_7$		25 %
Potassium ferricyanide	$K_3[Fe(CN)_6]$	cold saturated	
Potassium ferricyanide	$K_3[Fe(CN)_6]$	hot saturated	
Potassium ferrocyanide	$K_4[Fe(CN)_6] \cdot 3H_2O$	cold and hot saturated	
Potassium hydroxide (caustic potash solution)	KOH		20 %
Potassium hydroxide (caustic potash solution)	KOH		20 %
Potassium hydroxide (caustic potash solution)	KOH		50 %
Potassium hydroxide (caustic potash solution)	KOH		50 %
Potassium hydroxide (caustic potash solution)	KOH	hot saturated	
Potassium hydroxide (caustic potash)	KOH	fused	
Potassium hypochlorite	$KClO$		approx. 15 % free chlorine
Potassium hypochlorite	$KClO$		
Potassium iodide	KI	cold saturated	

¹⁾ Even corrosion-resistant steels must be handled and cleaned carefully.

No fixing salt may be allowed to dry anywhere on the surface, since pitting could easily occur at these points.

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4000/410 S				4301/304				
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4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	3 L	3 L	3 L	0 L	0 L			
20 °C	1 L	0 L	0 L	0 L	0 L	0 L	0 L	0 L
20 °C		0	0	0	0	0	0	0
				0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
boiling	2	2	1	1	0	0	0	0
20 °C	2	2	1	0	0	0	0	0
boiling	3	3	3	1	0	0	0	0
20 °C	3	2	1	0	0	0	0	0
90 °C				3	2	0	0	0
20 °C			1	1	0	0	0	0
90 °C				3	2	0	0	
90 °C				3	2	1	1	
cold				0	0	0	0	0
boiling			2	2	1	0	0	0
20 °C		0 L	0 L	0 L	0 L	0 L	0 L	0 L
20 °C	0	0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	1 L	0 L	0 L	0 L	0 L	0 L	0 L	0 L
boiling	3 L	1 L	0 L	0 L	0 L	0 L	0 L	0 L
20 °C	2	2	1	0	0	0	0	0
boiling	3	3	3	3	3	1	1	
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	3	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	
20 °C	0	0	0	0	0	0	0	0
boiling	2	1	1	0	0	0	0	0
boiling	2	1	1	0	0	0	0	0
360 °C	3	3	3	3	3			
20 °C				2 L	1 L	0 L	0 L	
150 °C				2 L	1 L	0 L	0 L	0 L
20 °C	2 L	1 L	0 L	0	0 L	0 L	0 L	

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Potassium nitrate (saltpetre)	KNO ₃		25%
Potassium nitrate (saltpetre)	KNO ₃		25%
Potassium nitrate (saltpetre)	KNO ₃		50%
Potassium nitrate (saltpetre)	KNO ₃		50%
Potassium nitrate (saltpetre)	KNO ₃	molten	
Potassium oxalate	K ₂ C ₂ O ₄ · H ₂ O		all concentrations
Potassium oxalate	K ₂ C ₂ O ₄ · H ₂ O		all concentrations
Potassium permanganate	KMnO ₄		all concentrations
Potassium permanganate	KMnO ₄		all concentrations
Potassium sulphate	K ₂ SO ₄	cold and hot saturated	
Precipitation bath	see spinning bath		
Prussic acid	see hydrocyanic acid		
Pulp	see fruit pulp		
Pyrogallic acid (pyrogallol)	C ₆ H ₃ (OH) ₃		all concentrations
Quinine sulphate			
Sal ammoniac	see ammonium chloride		
Salicylic acid	HOC ₆ H ₄ COOH		all concentrations
Salt of hartshorn	NH ₄ HCO ₃ + (NH ₄) ₂ CO ₃	cold saturated	
Salt/acid mixtures	10% H ₂ SO ₄ + 10% copper sulphate		
Salt/acid mixtures	10% H ₂ SO ₄ + 2% ferrous sulphate		
Saltpetre	see potassium nitrate/sodium nitrate		
Sauerkraut liquor			
Schweinfurt green	Cu(CH ₃ COO) ₂ · 3Cu(AsO ₂) ₂		
Seawater ¹⁾			
Seawater ¹⁾			
Silver bromide	AgBr	saturated	
Silver chloride	AgCl	saturated	
Silver nitrate	AgNO ₃		10%
Silver nitrate	AgNO ₃	fused	
Slaked lime	see calcium hydroxide		
Soap			
Soda	see sodium carbonate		
Sodium acetate	CH ₃ COONa · 3H ₂ O	saturated	
Sodium bicarbonate	NaHCO ₃		all concentrations
Sodium bisulphate	NaHSO ₄ · H ₂ O		10%
Sodium bisulphite	NaHSO ₃		50%
Sodium bromide	NaBr		20%
Sodium carbonate (soda)	Na ₂ CO ₃ · 10H ₂ O		10%
Sodium carbonate (soda)	Na ₂ CO ₃ · 10H ₂ O	fused	
Sodium carbonate (soda)	Na ₂ CO ₃ · 10H ₂ O	fused	
Sodium chlorate	NaClO ₃		30%

¹⁾ Depending on operating conditions.

Classification of NIROSTA®-/ASTM grades by group

- 0 = resistant to general corrosion
- 1 = slight susceptibility to general corrosion
- 2 = low resistance to general corrosion
- 3 = no resistance to general corrosion
- L = risk of pitting, crevice corrosion or stress-corrosion cracing

4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
550 °C	3	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	3	2	2	1	0	0	0	0
20 °C and boiling		0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
boiling	2	1	1	0	0	0	0	0
boiling	3	2	2	1	1	0	0	0
20 °C				2 L	1 L	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C		0 L	0 L	0 L	0 L	0 L	0 L	0
boiling				2 L	1 L	0 L	0 L	0 L
20 °C		0 L	0 L	0 L	0 L			
		1 L		1 L	1 L	0 L	0 L	0 L
boiling	0	0	0	0	0	0	0	0
250 °C	3	2	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling			1	1	0	0	0	0
boiling			1	0	0	0	0	0
80 °C						0 L	0 L	
boiling	0	0	0	0	0	0	0	0
100 °C	0	0	0	0	0	0	0	0
900 °C	3	3	3	3	3			
20 °C and boiling				0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Sodium chloride (table salt)	NaCl	cold saturated	
Sodium chloride (table salt)	NaCl	hot saturated	
Sodium chlorite	NaClO ₂		5 %
Sodium chlorite	NaClO ₂		5 %
Sodium fluoride	NaF		5 %
Sodium hydrogen phosphate	Na ₂ HPO ₄ · 12H ₂ O		
Sodium hydroxide(caustic soda solution)	NaOH		25 %
Sodium hydroxide(caustic soda solution)	NaOH		25 %
Sodium hydroxide(caustic soda solution)	NaOH		50 %
Sodium hydroxide(caustic soda)	NaOH	fused	
Sodium hypochlorite (bleaching liquor)	NaClO		5 %
Sodium hypochlorite (bleaching liquor)	NaClO		5 %
Sodium nitrate (Chile saltpetre)	NaNO ₃		
Sodium nitrate (Chile saltpetre)	NaNO ₃		
Sodium nitrate (Chile saltpetre)	NaNO ₃	fused	
Sodium nitrite	NaNO ₂	hot saturated	
Sodium perborate	NaBO ₃ · 4H ₂ O	cold saturated	
Sodium perchlorate	NaClO ₄ · 4H ₂ O		10 %
Sodium peroxide (sodium superoxide)	Na ₂ O ₂		10 %
Sodium peroxide (sodium superoxide)	Na ₂ O ₂		10 %
Sodium peroxide (sodium superoxide)	Na ₂ O ₂		10 % stabilised with sodium silicate
Sodium phosphate sec.	Na ₂ HPO ₄ · 12H ₂ O	cold saturated	
Sodium phosphate tert.	Na ₃ PO ₄ · 12H ₂ O	cold saturated	
Sodium salicylate	HOC ₆ H ₄ COONa	cold saturated	
Sodium silicate	Na ₂ SiO ₃		
Sodium sulphate (Glauber's salt)	Na ₂ SO ₄ · 10H ₂ O	cold saturated	
Sodium sulphate (Glauber's salt)	Na ₂ SO ₄ · 10H ₂ O	cold saturated	
Sodium sulphide	Na ₂ S · 9H ₂ O		25 %
Sodium sulphide	Na ₂ S · 9H ₂ O		sat. solution
Sodium sulphite	Na ₂ SO ₃ · 7H ₂ O		50 %
Sodium tetraborate (borax)	Na ₂ B ₄ O ₇ · 10H ₂ O	saturated	
Sodium tetraborate (borax)	Na ₂ B ₄ O ₇ · 10H ₂ O	saturated	
Sodium tetraborate (borax)	Na ₂ B ₄ O ₇ · 10H ₂ O	molten	
Sodium thiosulphate (anti-chlorine)	Na ₂ S ₂ O ₃ · 5H ₂ O		25 %
Sodium thiosulphate (anti-chlorine)	Na ₂ S ₂ O ₃ · 5H ₂ O		25 %
Soft soap			
Spinning bath (viscose bath)			up to 10 % H ₂ SO ₄
Spinning bath (viscose bath)			over 10 % H ₂ SO ₄
Spirit	see ethyl alcohol		
Stannic chloride	SnCl ₄		
Stannic chloride	SnCl ₄		

Classification of NIROSTA®-/ASTM grades by group

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4000/410 S				4301/304				
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4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	1 L	0 L	0 L	0 L	0 L	0 L	0 L	0
100 °C	3 L	2 L	1 L	1 L	1 L	0 L	0 L	0 L
20 °C				2 L	2 L	1 L	0 L	
boiling				3	2	2 L	1 L	1 L
20 °C					0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	2	2	2	1	1	0	0	0
boiling	3	2	2	1	1	0	0	0
320 °C	3	3	3	3	3	3	2	2
20 °C	3 L	2 L	2 L	1 L	1 L	0 L	0 L	
boiling	3 L	3 L	2 L	1 L	1 L	1 L	1 L	1 L
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
360 °C	0	0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	2	2	1	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	0	0	0	0	0	0
up to 80 °C	3	2	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
boiling		2	1	0	0	0	0	0
100 °C				1	1			
boiling	2	2	1	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
	3	3	3	3	3	2	2	2
20 °C		0	0	0	0	0	0	0
boiling		0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
70 °C	3	3	2	2	1	0	0	0
70 °C	3	3	3	3	3	1	1	1
20 °C	3 L	3 L	3 L	3 L	2 L			
boiling	3 L	3 L	3 L	3 L	3 L			

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Stannous chloride	$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$	hot saturated	
Stannous chloride	$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$	hot saturated	
Steam			
Stearic acid	$\text{C}_{17}\text{H}_{35}\text{COOH}$		
Stearic acid	$\text{C}_{17}\text{H}_{35}\text{COOH}$		
Sublimate	see mercuric chloride		
Sugar of lead	see lead acetate		
Sugar solution			
Sulphite liquor	see calcium bisulphite		
Sulphur chloride	see disulphur dichloride		
Sulphur dioxide	see sulphurous acid (gas)		
Sulphur, dry		molten	
Sulphur, dry		boiling	
Sulphur, wet			
Sulphuric acid ¹⁾	H_2SO_4		1%
Sulphuric acid ¹⁾	H_2SO_4		1%
Sulphuric acid ¹⁾	H_2SO_4		1%
Sulphuric acid ¹⁾	H_2SO_4		2.5%
Sulphuric acid ¹⁾	H_2SO_4		2.5%
Sulphuric acid ¹⁾	H_2SO_4		2.5%
Sulphuric acid ¹⁾	H_2SO_4		5%
Sulphuric acid ¹⁾	H_2SO_4		5%
Sulphuric acid ¹⁾	H_2SO_4		5%
Sulphuric acid ¹⁾	H_2SO_4		7.5%
Sulphuric acid ¹⁾	H_2SO_4		7.5%
Sulphuric acid ¹⁾	H_2SO_4		7.5%
Sulphuric acid ¹⁾	H_2SO_4		10%
Sulphuric acid ¹⁾	H_2SO_4		10%
Sulphuric acid ¹⁾	H_2SO_4		10%
Sulphuric acid ¹⁾	H_2SO_4		20%
Sulphuric acid ¹⁾	H_2SO_4		20%
Sulphuric acid ¹⁾	H_2SO_4		20%
Sulphuric acid ¹⁾	H_2SO_4		40%
Sulphuric acid ¹⁾	H_2SO_4		40%
Sulphuric acid ¹⁾	H_2SO_4		40%
Sulphuric acid ¹⁾	H_2SO_4		60%
Sulphuric acid ¹⁾	H_2SO_4		60%
Sulphuric acid ¹⁾	H_2SO_4		60%
Sulphuric acid ¹⁾	H_2SO_4		80%
Sulphuric acid ¹⁾	H_2SO_4		80%
Sulphuric acid ¹⁾	H_2SO_4		80%

¹⁾ Oxidising conditions can considerably expand the applications of stainless steels. Please enquire with the manufacturers.

Classification of NIROSTA®-/ASTM grades by group

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4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
50 °C	3 L	2 L	2 L	1 L	0 L			
boiling	3 L	3 L	3 L	3 L	3 L			
400 °C	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
130 °C			0	0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
130 °C	0	0	0	0	0	0	0	0
445 °C	3	3	3	2	2			
20 °C		1		1	0	0	0	0
20 °C	3	3	2	1	0	0	0	0
70 °C	3	3	2	1	0	0	0	0
boiling	3	3	3	1	1	0	0	0
20 °C	3	3	3	1	0	0	0	0
70 °C	3	3	3	1	0	0	0	0
boiling	3	3	3	2	2	0	0	0
20 °C	3	3	3	1	0	0	0	0
70 °C	3	3	3	1	1	0	0	0
boiling	3	3	3	3	2	1	1	1
20 °C	3	3	3	1	0	0	0	0
70 °C	3	3	3	1	1	0	0	0
boiling	3	3	3	2	2	1	1	1
20 °C	3	3	3	2	1	0	0	0
70 °C	3	3	3	2	2	0	0	0
boiling	3	3	3	3	2	1	1	1
20 °C	3	3	3	1	1	0	0	0
70 °C	3	3	3	2	2	1	1	1
boiling	3	3	3	3	3	2	2	2
20 °C	3	3	3	1	1	0	0	
70 °C	3	3	3	2	2	2	1	2
boiling	3	3	3	3	3	2	2	2
20 °C	3	3	3	3	2	0	0	
70 °C	3	3	3	3	3		1	
boiling	3	3	3	3	3			
20 °C	3	3	3	1	1	1	1	1
70 °C	3	3	3	3	2	2	2	2
boiling	3	3	3	3	3	2	2	2

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Sulphuric acid ¹⁾	H ₂ SO ₄		98 % (concentrated)
Sulphuric acid ¹⁾	H ₂ SO ₄		98 % (concentrated)
Sulphuric acid ¹⁾	H ₂ SO ₄		98 % (concentrated)
Sulphuric acid ¹⁾	H ₂ SO ₄		98 % (concentrated)
Sulphuric acid ¹⁾	fuming (11 % free SO ₃)		
Sulphuric acid ¹⁾	fuming (11 % free SO ₃)		
Sulphuric acid ¹⁾	fuming (60 % free SO ₃)		
Sulphuric acid ¹⁾	fuming (60 % free SO ₃)		
Sulphurous acid	H ₂ SO ₃	saturated	
Sulphurous acid	H ₂ SO ₃	4 bar	
Sulphurous acid	H ₂ SO ₃	5–8 bar	
Sulphurous acid	H ₂ SO ₃	10–20 bar	
Sulphurous acid, gas (SO ₂)	moist, free of SO ₃		
Sulphurous acid, gas (SO ₂)	moist, free of SO ₃		
Sulphurous acid, gas (SO ₂)	moist, free of SO ₃		
Sulphurous acid, gas (SO ₂)	moist, free of SO ₃		
Super phosphate	Ca(H ₂ PO ₄) ₂ + CaSO ₄ + 3 % H ₂ SO ₄		
Tannic acid (tannin)			5 %
Tannic acid (tannin)			5 %
Tannic acid (tannin)			10 %
Tannic acid (tannin)			10 %
Tannic acid (tannin)			50 %
Tannic acid (tannin)			50 %
Tannin	see tannic acid		
Tar, pure			
Tartar	see potassium bitartrate		
Tartaric acid	COOH(CHOH) ₂ COOH		10 %
Tartaric acid	COOH(CHOH) ₂ COOH		10 %
Tartaric acid	COOH(CHOH) ₂ COOH		50 %
Tartaric acid	COOH(CHOH) ₂ COOH		50 %
Thioglycolic acid	HSCH ₂ COOH		
Thioglycolic acid	HSCH ₂ COOH		
Tin	Sn	molten	
Tin	Sn	molten	
Tin	Sn	molten	
Tincture of iodine			
Toluene	C ₆ H ₅ CH ₃		
Trichloroacetic acid	CCl ₃ COOH		80 %
Trichloroethylene ²⁾	C ₂ HCl ₃	anhydrous	
Trisodium phosphate	see sodium phosphate tert.		
Turpentine			

¹⁾ Oxidising conditions can considerably expand the applications of stainless steels. Please enquire with the manufacturers.

²⁾ Even if only traces of hydrochloric acid (HCl) are formed by moisture, there is a danger of pitting, crevice and stress corrosion cracking.

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4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C		0	0	0	0	0	0	0
70 °C	2	2	2	2	2	1	1	1
150 °C	3	3	3	2	2			
boiling	3	3	3	3	3			
20 °C		0	0	0	0	0	0	0
100 °C	3	3	3	1	0	0	0	0
20 °C		0	0	0	0	0	0	0
80 °C	3	3	3	0	0	0	0	0
20 °C	3	2	0	0	0	0	0	0
135 °C	3	2	0	1	0	0	0	0
160 °C	3	3	1	2	1			
180–200 °C	3	3	2	2	1			
up to 100 °C	3	2	0	0	0	0	0	0
up to 300 °C	3	3	1	1	0	0	0	0
up to 500 °C	3	3	3	1	1			
900 °C	3	3	3	3	2			
20 °C				0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	1	1	1	0	0	0	0	0
20 °C and hot	0	0	0	0	0	0	0	0
20 °C	1	0	0	0	0	0	0	0
boiling	2	2	0	0	0	0	0	0
20 °C	2	1	0	0	0	0	0	0
boiling	3	2	2	2	1	0	0	0
20 °C					1	0	0	0
boiling					1	0	0	0
200 °C	2	2	0	0	0	0	0	0
400 °C	3	3	1	1	1			
600 °C	3	3	3	3	3			
20 °C	2 L	2 L	1 L	1 L	1 L	0 L	0 L	0 L
20 °C and boiling	0	0	0	0	0	0	0	0
20 °C				2 L	1 L	0 L	0 L	
boiling	0	0	0	0	0	0	0	0
20 °C and hot	0	0	0	0	0	0	0	0

Chemical resistance of NIROSTA® steels

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Corrosive agent	Formula	Condition	Concentration
Urea	$\text{CO}(\text{NH}_2)_2$		
Urine			
Varnish (copal varnish)			
Vaseline			
Vaseline			
Vegetables			
Vinegar (wine vinegar)			
Vinegar (wine vinegar)			
Washing powder			
Water ¹⁾ (tap water)			
Water ²⁾ [pit water (acid water)]			
Water glass			
Water glass			
Wine ³⁾ (white and red wines)			
Wine ³⁾ (white and red wines)			
Wine vinegar	see vinegar		
Xylene	$\text{C}_6\text{H}_4(\text{CH}_3)_2$		
Zinc	Zn	molten	
Zinc chloride	ZnCl_2	cold and hot saturated	
Zinc chloride	ZnCl_2	cold saturated	
Zinc chloride	ZnCl_2	cold and hot saturated	
Zinc sulphate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	cold saturated	
Zinc sulphate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	cold saturated	
Zinc sulphate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	hot saturated	
Zink cyanide	$\text{Zn}(\text{CN})_2$ moistened with water		

¹⁾ With tap water, the composition of the water (in particular the chloride content) has a decisive influence on the corrosion resistance of the steels. Enquiry recommended.

²⁾ Pitting and crevice corrosion highly dependent on composition of pit water, in particular the chloride concentration.

³⁾ Materials from Group 5 upwards have no effect on the taste.

Classification of NIROSTA®-/ASTM grades by group

0 = resistant to general corrosion
 1 = slight susceptibility to general corrosion
 2 = low resistance to general corrosion
 3 = no resistance to general corrosion
 L = risk of pitting, crevice corrosion or stress-corrosion crating

4000/410 S				4301/304				
4002/405				4303/(305)	4401/316			
4003/A240...				4306/304 L	4404/316 L			
4006/410	4016/430			4307/304 L	4429/316 LN			
4021/(420)	4057/431			4310/(301)	4435/316 L			
4024/(410)	4120			4311/304 LN	4436/316			
4028/(420)	4305/303			4315/304 N	4438/317 L			
4031/(420)	4427/316 F			4318/301 LN	4439			
4034/(420)	4509/441			4541/321	4462			
4313	4510/439	4113/434		4544	4501			
4512/409	4511	4521/444		4546	4561/316 Ti			
4589	4520	4568/631		4550/347	4571/316 Ti	4465	4539	4565 S

Temperature	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	4465	4539	4565 S
20 °C	0	0	0	0	0	0	0	0
20 °C			0 L	0 L	0 L	0	0	0
	0	0	0	0	0	0	0	0
20 °C	0	0	0	0	0	0	0	0
hot	0	0	0	0	0	0	0	0
boiling				0	0	0	0	0
20 °C		0	0	0	0	0	0	0
boiling	2	1	0	0	0	0	0	0
	0	0	0	0				
20 °C	0 L	0 L	0 L	0	0	0	0	0
20 °C	1 L	1 L	0 L	0 L	0 L	0	0	0
20 °C	0	0	0	0	0	0	0	0
boiling	0	0	0	0	0	0	0	0
20 °C				0	0	0	0	0
hot				0	0	0	0	0
20 °C and boiling	0	0	0	0	0	0	0	0
500 °C	3	3	3	3	3			
20 °C	1 L	1 L	1 L	0 L	0 L	0 L	0 L	0 L
45 °C				2 L	1 L	0 L	0 L	0 L
boiling	3 L	3 L	3 L	3 L	2 L	1 L	1 L	1 L
20 °C				0	0	0	0	0
boiling				0	0	0	0	0
boiling	2	2	0	0	0	0	0	0
20 °C	1	1	0	0	0	0	0	0

All statements as to the properties or utilization of the materials and products mentioned in this brochure are for the purpose of description only. Guarantees in respect of the existence of certain properties or utilization of the material mentioned are only valid if agreed upon in writing.