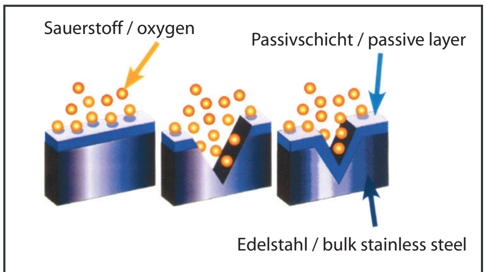
Non-corroding stainless steel in water supply systems

Stainless steels are alloy steels with a chromium content of at least 10.5% and a carbon content of less than 1.2%.

A dense and chemically resistant layer of chromium oxide (passive layer) forms on the material surface in conjunction with oxygen. This can resist many aggressive media and requires no further surface protection.

The corrosion resistance of stainless steels results solely from the formation of oxide layers on the surface of the steel. A high chromium component is essential for this. As a carbide former, titanium increases resistance to intercrystalline corrosion. Like chromium, molybdenum has a tendency towards passivity and thus strengthens the passive layer. Stainless steels containing molybdenum are resistant to nonoxidizing acids and lyes, to their salts and in particular to oxidizing agents such as ozone or media containing chloride.



Quelle / source: euro inox

Selv-healing effect

As a rule, the passive layer will reform itself Self-healing following damage. However, this requires effect the surface to be metallically pure and the chromium content to be sufficiently high.

The main stainless steel groups

The main Nickel influences the crystal structure of the steel (as do carbon, cobalt, manganese and stainless steel nitrogen). Depending on the nickel content, a distinction is made between groups

- Austentic stainless steel (non-magnetic) - cubic face-centered structure
- Ferritic stainless steel (magnetic) - cubic body-centered structure
- Duplex steel - mixed structure
- Martensitic stainless steel (hardenable).

Properties

Non-corroding stainless steel

- Resistant to corrosion and heat, long service life
- Has low service life costs and is fully recyclable
- Is biologically neutral and easy to clean.

Working

If the surface is machined or damaged, the uppermost layers of the material can be contaminated by iron oxides (extraneous ferrite, scale, temper colours, martensite formation, tensions, chromium depletion etc.).
These layers are loosened and removed by brushing, grinding and polishing or pickling and rinsing. The passive layer forms during rinsing with water or by using passivating agents.

Pickled surfaces are

- metallically pure
- homogenously low-luster and
- highly corrosion-resistant.

Stainless steel for the drinking water supply

Securing the highest drinking water quality on a permanent basis calls for the use of suitable materials with a long service life and inert materials that boast excellent hygienic properties. In water sector, it is preferred to use the following noncorroding steels - depending on requirements.

INOX steel

Austenitic steels with material numbers 304, 321 and also 316L and 316Ti are generally familiar. Austenitic steels cannot be magnetized and have a greater ductility than ferritic steels.The most frequently used chromium-nickel steel worldwide is the steel 304. 321 also contains traces of titanium, while 316L and 316Ti also contain 2.1% molybdenum. The physical properties of these four steels are for the most part identical. Which steel type will be selected depends on the corrosion resistance required.

Duplex steel

For some years, duplex steels and (where high stresses can be expected) the super-duplex steel S32205 have also been used in the drinking water sector. Due to the significantly higher mechanical strength, it is normally possible to work with less material input.
Duplex steels have both ferritic and austenitic components. Due to the chromium content, the corrosion resistance of Duplex steels is the same as or (in the case of S32205) is higher than that of 316Ti, which covers a wide range of applications.

Composition and strength of important stainless steels

		Typical Composition in %						MPa at 20 °C*	
EN	ASTM	C	N	Cr	Ni	Mo	sonstige	$R_{P0,2}$	R_m
1.4301	304	0.04	0.04	18.1	8.3	–	–	210	520
1.4541	321	0.04	0.01	17.3	9.1	–	Ti	200	500
1.4404	316L	0.02	0.04	17.2	10.2	2.1	–	220	520
1.4571	316Ti	0.04	0.01	16.8	10.9	2.1	Ti	220	520
1.4062	S32202	0.025	0.20	23.0	2.5	< 0.3	1.3 Mn	550	750
1.4162	S32101	0.03	0.22	21.5	1.5	0.3	5 Mn	450	650
1.4362	S32304	0.02	0.10	23.0	4.0	0.2	–	400	600
1.4462	S32205	0.02	0.17	22.0	5.7	3.1	–	460	640

*** Minimum values in acc. with EN:**
MPa - MegaPascal (1 Pa = 1 N/mm²), $R_{P0,2}$ - 0,2% technical elastic limit, R_m - tensile strength

Areas of application

The standard steels 304, 321 and S32202, S32101 are generally used for normal water. Where the chloride ions content is greater or the water is more aggressive, the molybdenumalloy steels (austenitic and Duplex steels) or (in the case of greater stresses) S32205 are preferred.
In the case of water treatment plants with oxidative media, material 316Ti is normally used. All steel qualities are used in water distribution installations and water storage tanks, and here it should be noted that in virtually every case the qualities 304, 321 and S32202, S32101 will suffice.

Corrosion resistance

Thanks to their corrosion resistance, stainless steels can be used in a wide range of applications. Prerequisites for a long service life are
- selecting the correct material
- a correct design
- correct processing
- and careful after-treatment.

Surface corrosion Surface corrosion describes even material removal. This type of corrosion cannot be observed in drinking water applications with non-corroding stainless steel.

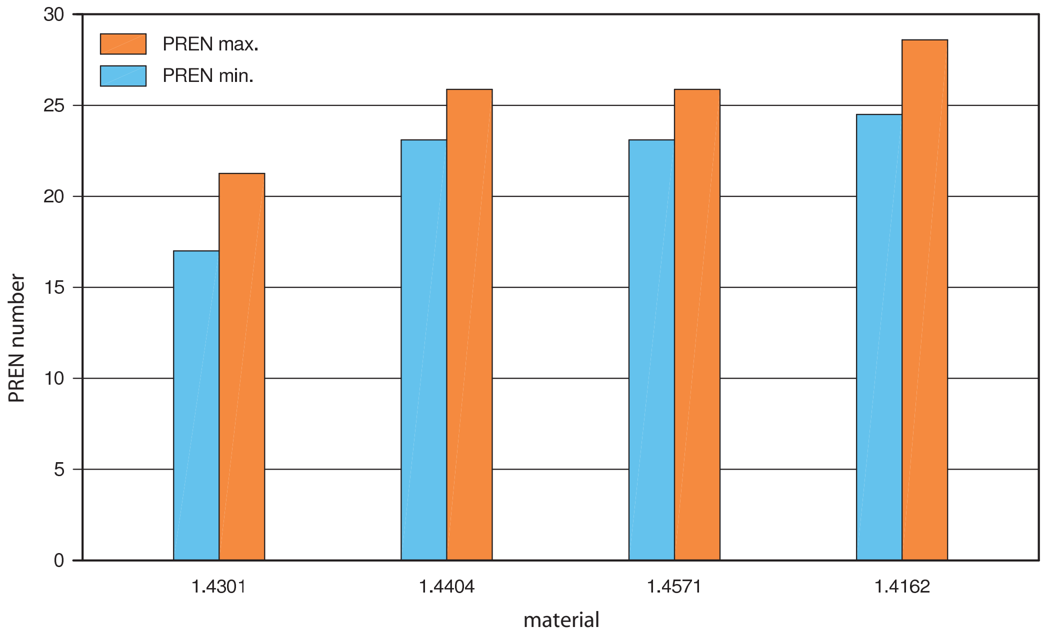
Pitting and crevice corrosion In stainless steels, resistance to pitting and crevice corrosion is of central importance. This resistance is for the most part determined by the chromium content, and is expressed by what is known as the PRE number* (or PREN index).

***PRE** = **P**itting **R**esistance **E**quivalent

DThe PRE number is calculated on the basis of the following formula:

PRE = %Cr + 3.3 • %Mo + 16 • %N

The higher the number, the higher the resistance of the respective steel to corrosion.



Material composition as defined by EN

When the passive layer is intact, Duplex steels display a resistance to pitting that is significantly above that of the material 304 and approximately in the same range as that of the materials 316 and 316Ti.

Influencing variables on the medium side

The probability of pitting and crevice corrosion occurring increases particularly as the amount of chloride ions in the water increases.

Other influencing variables are the pH value, the temperature, the flow conditions (stagnation), the oxidizing agent content and other water impurities (e.g. nitrates and sulfates).
Experience has shown that the probability of pitting corrosion in steels that do not contain molybdenum is high when the chloride contents in cold water are above 100 mg/, or above 50 mg/l in heated water. (also see DIN 50930 T4)

Possible material selection depending on the chloride content and temperature for drinking water, mineral water or process water.

max. chloride contents*

20 °C	70 °C	possible stainless steels
< 100 mg/l	< 50 mg/l	304, 321, S32202, S32101
< 250 mg/l	< 150 mg/l	316Ti, 316L, S32304, S32205

*** Limit value drinking water regulations: 250 mg/l**

When using the limit concentrations from the table above, it must be noted that besides correct processing and operation, other water impurities also exert a significant influence.

Additional anions in the water in addition to the chlorides in most cases improve the resistance.This means that heavily mineralized natural waters with high anion contents (sulfates, nitrates, hydrogen carbonates) are much less corrosive than pure NaCl solutions.

The oxidizing agent content is another important influencing variable. As the water's oxidation power (redox potential) increases, there is a particular increase in the risk of pitting and crevice corrosion. Heavy oxygen oversaturation of the type that can occur during water treatment with ozone is particularly critical.

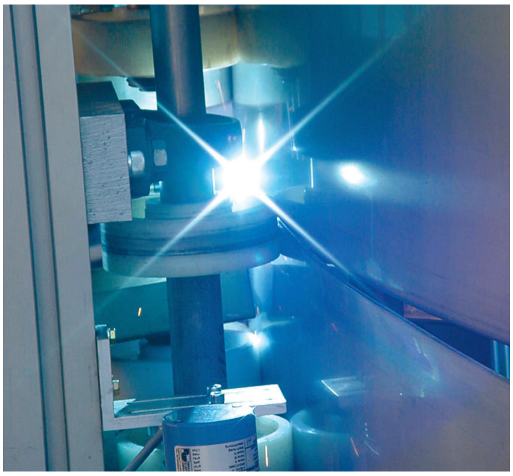
Other influencing variables

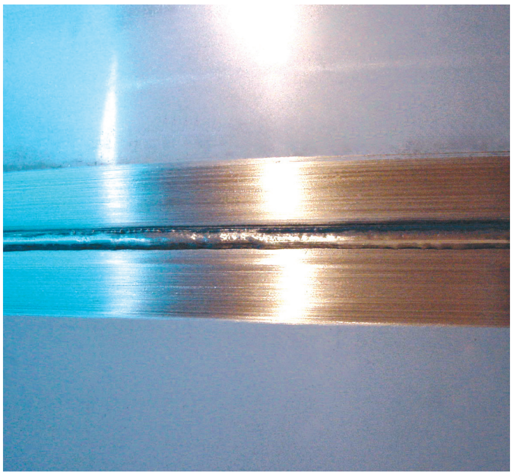
If possible, the design should always preclude gaps on the medium side. Gaps can also form during operation as a result of deposits.

Generally An optimum surface with a continuous passive layer is absolutely crucial for high corrosion resistance. Contact with base metals must also be avoided on the medium side (galvanic element).

Preventing corrosion Whether corrosion damage will occur depends not only on the resistance of the steel and the aggressiveness of the medium attacking it, but also crucially on the design and processing of the components and on the operating conditions.
Particularly problematic are extended periods with stagnating operating conditions as well as scaling and deposits.

On-site welding If welding is to be carried out on site, after-treatment of the weld seam must be done correctly and carefully in order to produce an unbroken passive layer.
When welding is carried out, the quality of the welding filler must be observed and documented. Overheating must also be avoided.


Automatic welder


Weld seam after brushing

Whenever welding is required on pipelines, care should be taken to ensure forming on both sides (an envelope of protective inert gas) in the vicinity of the weld. In addition, the welding areas must be properly after-treated by brushing, pickling and passivating and / or grinding.

Cleaning of stainless steel

Stainless-steel surfaces are hard, smooth and free of pores. No cavities for dirt and microorganisms can therefore come into being. All the same, stainless steel components need regular cleaning and disinfection, with the initial cleaning being particularly important.

To prevent extraneous rust, never use tools (spatulas, steel wool) made of normal steel to remove construction dirt as this may result in surface damage and the depositing of foreign material. If chemical cleaning agents are used, it is essential to ensure they do not contain hydrochloric acid. If they do, the result may be pitting or crevice corrosion.

Suitable agents for removing calcareous, cement or rust deposits are phosphoric acid or cleaning agents containing this acid.

Stainless-steel tank system with installation

Booster pumps

Organic acids, such as citric acid, formic acid or tartaric acid, are objectionable from the point of view of drinking-water hygiene and should not therefore be used.
Cleaning-agent residues should be disposed of properly. For this reason, chemical cleaning agents should only be used in exceptional cases.
Thorough flushing with cold water gets rid of all the cleaning agent residues in pipes and tanks.

The cleaning agents should be agreed with the manufacturer or supplier of the stainless steel structures.
Additional information in file „Cleaning of stainless steel".

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