Corrosion resistance of ALLOY STEEL - STAINLESS

1. General information

As well now, stainless steel presents, compared to those unalloyed and low alloyed, a clearly improved corrosion resistance. It is resistant against many aggressive media and does not need further surface protection. This passivity is achieved by alloying min. 10,5% Cr to the iron. When mechanically damaged, the passive layer forms-out again, spontaneously. The corrosion resistance of alloy steel-stainless is priority dependent of the alloy composition, besides of its surface and of the structure condition. Therefore the choice of the correct steel grade with the correct heat treatment condition and with the correct surface treatment is substantial for the corrosion resistance.

2. Types of corrosion.

Removing surface corrosion
Removing surface corrosion is characterized by uniform or approximate uniform erosion. Usually an erosion rate under 0.1 mm/year is regarded as a sufficient resistance against surface corrosion. For stainless steel, for mass-losses per area unit is valid following relation: 1g/h x m^2 = 1.1 mm/a. Uniform surface corrosion of stainless steel can arise only in acids or strong caustic solutions. It is substantially determined by the alloy composition. So, for example, 17% chrome steel is substantial more resistant than 13% chrome steel. A still increased resistance against surface corrosion presents the austenitic chrome-nickel steel. Moreover, the resistance can be further increased, in many cases, by adding molybdenum into the alloy.

Pitting
Pitting can occur if the passive layer breaks through local. If there are chloride ions, particularly by higher temperatures, then, at these locations, can appear holes - many times only needle shaped. Through erosion, roast from external sources, cinder remainders and annealing colors on the surface, the danger of pitting appearance is amplified.
By further increase of the chrome content, in particular by addition of molybdenum and partially of nitrogen, the resistance of stainless steel against pitting is increased. This is expressed through the so-called effect-sum:

$$W = \% \, Cr + 3,3 \times \% \, Mo$$

For very highly alloyed austenitic steel, the alloying element nitrogen is also included, with different factors, into the effect-sum.

Crack corrosion.
Crack-corrosion is - as the denomination already indicates - crack bound. This may be caused by constitution or operation (i.e. stratification). Sins crack

corrosion is essentially subject to the same mechanisms as pitting; the exposion from above applies, including alloy influence and effect-sum, also here.

Stress-fissure corrosion
The fissures appearing with this corrosion type are developing generally transcrystallin with stainless steel. Only if the following three conditions are present at the same time, stress-fissure corrosion is possible:

a) the surface of the part is subject to tensile stress;

b) effects of a specifically acting medium (usually chloride ions);

c) inclination of the material to stress corrosion.

With tensile stresses it is indifferent, if they are applied from exterior through tensile or bending stresses or as internal stresses (i.e. by welding, cold-rolling or deep-drawing). Tensile stresses can be diminished by blasting.
Austenitic Cr-Ni and Cr-Ni-Mo standard steel is more sensitive in chloride solutions against stress-fissure corrosion then ferritic and austenitic-ferritic steel. With austenitic steel the stress corrosion resistance can be substantially improved by increasing the nickel content.

Vibration corrosion
During pure vibration stress (without corrosion stress) there is a lower alternating stress, below which no more break is observed: the fatigue strength. On the contrary, with vibration corrosion a fatigue strength is many times missing an the steel can break also under this limit. In contrast to the stress-fissure corrosion, which occurs only in specifically acting media (see above), vibration corrosion can occur, on principle, in all corrosive acting media, in connection

-with alternating stress.
The resistance against vibration corrosion increases- with increasing corrosion resistance of the material in the given medium

- with increasing strength of the steel.

This corrosion type does not occur in many fields, i.e. in the building industry and in the consumption goods range.

Intercrystallin corrosion
The intercrystalline corrosion does not more present a problem today, with a suitable choice of the material. Intercrystalline corrosion can occur in sour media, when through heat effect (between 450 and 850 C with austenitic steel, above 900 C with ferritic steel) chrome carbides separate at grain boundaries. Such heat effect arises i.e. by welding in the proximity of the welding seam (heat influence zone).It causes local chrome deplitition in the surrounding of the

separated chrome carbides. In practice the intercrystalline corrosion with austenitic steel is met by strongly lowering the carbon content or by binding the carbon by addition of titanium or niobium. Carbon solubility in ferritic steel is by far smaller. Therefore with this steel is not possible to hamper the chrome carbide elimination at cooling from the solution glowing temperature. Chrome depletition at the grain boundaries and the inclination to intercrystalline corrosion can be however reversed by a stabilizing annealing at 750 to 850 ^{0}C. Since these materials are supplied with such a heat treatment, they are resistant to intercrystallin corrosion, only if a natural elimination of chrome carbides occurs through a heat treatment (i.e. welding).But this can be also prevented by addition of titanium or niobium. A sufficient resistance against intercrystalline corrosion cannot be obtained, with ferritic steel, only be a carbon decrease.

Contact corrosion
Contact corrosion can develop, if different metallic materials are together in contact and are moistened by electrolytes. The less noble material (anode) is attacked at the contact point and goes into the solution. The nobler material (cathode) is not attacked. In practice the stainless steel compared with many other metallic materials, like unalloyed or low-alloyed steel as well as aluminum, is the nobler material. Contact corrosion can occur, in particular, if the surface of the nobler material is large in report with the surface of the less noble material.

3. Application mode

Steel 1.4301 and 1.4541 are resistant in normal outer atmosphere and therefore equally suitable for interior and exterior applications. Steel 1.4571 is, to a certain degree, also largely resistant in an atmosphere with chloride respective sulphur oxide content at room temperature and therefore suitable to be used in industrial atmosphere as at coast vicinity.

[Source: above text was extracted from instruction card 821 of the Information center alloy steel-stainless].