Corrosion of Stainless Steel

Normally, stainless steel is a very corrosion resistant material. Automatically, the steel is covered by an ultra-thin layer of oxides (chromium and iron), and despite being only a few nanometres thick, this invisible film protects the steel to such an extent that it stays “passive”. Sadly, this passive film is not invulnerable, and if it’s partially degraded or even removed completely, corrosion may take place. Depending upon the steel type and the conditions, five types of corrosion are possible:

**General corrosion** is also known as acid corrosion and is a quite rare type of corrosion, sometimes observed when the steel is exposed to very strong acids. Here, the whole oxide film is dissolved and the result is a rather uniform attack all over. As such, the loss of material is very high, however, the rate of penetration is usually low. Hot sulphuric acid is a typical environment causing general corrosion, and the topic is discussed further in SS&C Ch. 6.1 and SS-FP Ch. 4.1.

![Corrosion of Stainless Steel](image)

**Pitting corrosion** (photo above) is much more common and is caused by a local breakdown of the protective oxide layer. If no repassivation takes place, the corrosion is initiated on a very small “active” spot, while the rest of the surface remains passive. This galvanic coupling often produces very small loss of material, but quick penetration (SS&C Ch. 6.2 and SS-FP Ch. 4.2).

Usually, the risk of pitting (and crevice corrosion, see below) increases with increasing chloride concentration, increasing temperature, increasing corrosion potential (concentration of oxidants), and decreasing pH (SS&C Ch. 6.2.1, and SS-FP Ch. 4.2.1). Regarding the alloying elements, the resistance of the steel against initiation of pitting corrosion increases with its content of Cr, Mo and N, while the effect of Ni is rather small. Non-metallic impurities (S and P) tend to lower the resistance significantly (SS&C Ch. 6.2.5 and SS-FP Ch. 4.2.4).
Crevice corrosion (left photo, above) remind a lot of pitting corrosion, however, it initiates in crevices, pores and other geometrically narrow spots where the liquid flow is zero and where all the transport of ions is done through diffusion (SS&C Ch. 6.3 and SS-FP Ch. 4.3). The mechanism of crevice corrosion is close to that of pitting: Local activation, and local attacks; the importance of the steel composition and the operating conditions are almost the same as for pitting corrosion. A notable difference is Ni, which is proven beneficial against crevice corrosion.

Stress corrosion cracking (SCC, right photo above) produces cracks in the steel and is by far the most destructive type of corrosion. Almost exclusively attacking the common austenites, SCC often ends up with very rapid penetration causing the equipment to be scrapped. For the operating conditions, the two “key parameters” are the chloride concentration and, in particular, the temperature. At a mere 60-70 °C, common stainless steel (the 4301 group) may prove inadequate, while the “acid resistant” 4401 group lasts better – usually 100-110 °C. SCC is thoroughly discussed in SS&C (Ch. 6.4.2-3) and SS-FP (Ch. 4.4.1-2).

Intergranular corrosion (IC) is a type of corrosion caused by the local formation of chromium carbides along the grain boundaries, which in turn causes selective attacks there. IC is the very reason why carbon is viewed upon as a harmful element in the steel, and IC is easily fought by using low-carbon steel (i.e. 4307, 4404, 4432 and 4435), or the titanium-stabilised steel (4541 and 4571). IC is discussed in detail in SS&C Ch. 6.5, and SS-FP Ch. 4.5.