Technical Bulletin

Stainless steel can survive fire damage

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Introduction

The use of austenitic stainless steel types has made a huge difference in the chemical, pharmaceutical and food industries. Stainless steel's corrosion-resistant properties are derived from the very thin chromium oxide layer which spontaneously forms in an oxidising environment.

Stainless steel can be subject to many forms of corrosion caused by a variety of circumstances, including fire. The principal surface contaminations or changes that occur due to fire are organic and inorganic contaminants.
Organic contamination is often caused by the heavy mineral, bituminous substances that occur when many kinds of plastics and other flammable substances are affected to some extent by fire damage. Organic contamination is characterised by its greasy and strongly adhesive properties.
Any contamination with strong adhesive properties on stainless steel surfaces can be potential sources for corrosion.
The protective chromium oxide layer is very thin (less than 0.01 micron), which renders it very vulnerable. This chromium oxide layer has the capacity to be restored in an oxidising environment (presence of oxygen). If sufficient oxygen can be supplied, the oxide layer remains intact. However, if any contamination of the surface restricts the supply of oxygen, which certainly occurs in the event of fire, a corrosive environment may develop beneath the contaminated area. This contamination may give rise to various forms of corrosion which are sometimes collectively referred to as under-deposit corrosion, or differential aeration pitting. The presence of chloride in particular can lead to pitting corrosion.

Pitting corrosion is a locally-occurring type of corrosion which can penetrate deep into the material in a short period of time. Once pitting corrosion occurs, the process is virtually irreversible. This type of corrosion can progress at a rapid rate (0.5 mm in just a few days).
Sensitivity to pitting corrosion is strongly influenced by the alloy composition of the stainless steel. For example, the presence of 2-3% molybdites in AISI 316 renders the steel much less susceptible to this type of corrosion compared with AISI 304.

Crevice corrosion is another type of corrosion that can occur due to the presence of contaminations on a stainless steel surface.
Inorganic contaminants are salts that may be present in either a dissolved or undissolved form. In an undissolved form, thus in the form of a solid contamination, the problem will be similar to the under-deposit corrosion referred to.
In a dissolved form, the salts may lead to corrosion.
Chloride is released when plastic products that contain chloride such as PVC (polyvinyl chloride) are exposed to fire. This chloride reacts with water, giving rise to a reactive product called hydrochloric acid.
In this acid state, the chloride will severely impair the chromium oxide layer.
Such high concentrations of chloride, combined with an acid environment and the presence of solid contaminations which hinder the supply of oxygen, are all conditions that may lead to corrosion.

Oxide formation of the surface

Even in relatively low temperatures, stainless steel surfaces may become discoloured due to oxide formation. Under such relatively low temperature conditions (around 300 °C), an oxide layer may occur which is extremely susceptible to corrosion. The discolouration arises due to the thickening of the oxide layer coupled with the occurrence of various mixes of iron, nickel and chromium oxides.
Temperatures ranging from 550-750 °C may lead to a chromium carbide excretion of the crystals. If the chromium is depleted locally below the critical limit of 12%, this may lead to an unexpected strong occurrence of corrosion called intergranular corrosion. For this phenomenon, see also TB "Heat treatment and intergranular corrosion".
It is important, therefore, to know after the occurrence of a fire whether the material has been exposed to temperatures falling within the range of this critical limit. This temperature range is a condition that may lead to chromium carbide excretion of the crystals, but it does not definitely guarantee that this will happen. However, if preliminary studies have shown this to be the case, cleaning the surface will be superfluous: on the one hand, because of the risk of degradation during the pickling stage, and on the other, because material in this condition is unsuitable for reuse — it might deteriorate (by corrosion). The only option then is to anneal at a temperature of 900 °C which renders the formed carbides resoluble, followed by rapid cooling. In practice, however, this tends to be unfeasible.

Treatment of the surface after a fire

Several steps need to be taken to remove the various contaminants and restore the chromium oxide layer.

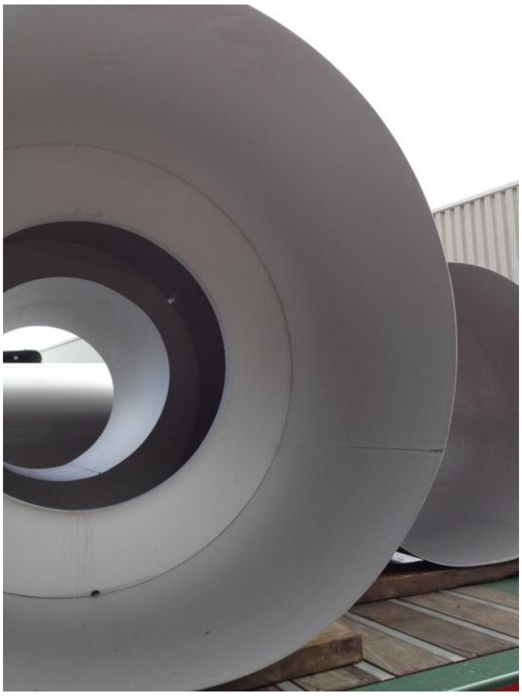
- Ice blasting: helps to remove heavy organic contaminants such as heavy mineral or bituminous substances.
- Degreasing: removal of organic contaminants preferably by means of an alkaline water-based product containing adequate surface active substances. (See also: TB “Degreasing of Stainless steel).
- Pickling and passivating based on hydrofluoric acid and nitric acid. (See also: TB “Surface Treatment of Stainless steel).

Summary

Once exposed to fire damage, it is imperative that stainless steel be properly treated. Improper or delayed treatment can lead to severe corrosion problems in the future. In many cases, costly installations containing stainless steel can be retained.

During the treatment process, specific measures need to be in place to guarantee safety, particularly where the environment is concerned. If the opportunity of treating the stainless steel is restricted, this can give rise to intergranular corrosion. If it is plausible that stainless steel has been exposed for any period to the critical temperatures referred to, it is recommended that a preliminary study be carried out by a consultancy firm specialised in corrosion.

Where disassembly and/or transport is possible, remedial treatment by a specialist firm such as a metal laundry would be preferable because they have specific expertise and experience in the area of stainless steel treatment.



Colour ranges in stainless steel

Temperature °C	**Colour**
290	pale yellow
340	straw yellow
370	dark yellow
390	brown
420	purple brown
450	dark purple
540	blue
600	dark blue

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