Technical Bulletin

Number: 2005/11 July 2005

NECESSITY OF REMOVAL OF HEAT TINTS ON STAINLESS STEELS TO AVOID OR MINIMIZE CORROSION

Introduction

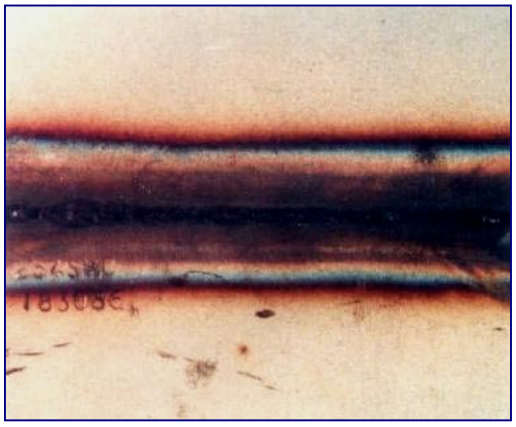
During welding of stainless steels, coloured surface oxide films may be developed in case a perfect inert gas protection (such as Argon) is missing. Of course these coloured surface oxides may be formed also during other heat treatments of stainless steels in presence of oxygen.

First of all these coloured metal oxide films, referred to as heat tints (although the term weld discolouration is also used), may lead to an unacceptable appearance of the equipment. Secondly, during operation of the equipment the porous oxide layer may lead to contamination of the process media. A third, and generally the most serious consequence of thick, porous metal oxide films, is a higher vulnerability to several types of local forms of corrosion.

The corrosion resistance of stainless steels is dependent on the presence of a thin, protective, passive chromium oxide layer on the metal surface

As a result of the heat input from welding (or other heat treatment), chromium diffuses outward from the base metal into the surface oxide film, leaving a thin chromium-reduced layer in the underlying base metal at locations of heat tints. This is an important reason of the diminished corrosion resistance. Additionally, in the porous heat tints, chlorides are selectively adsorbed resulting in higher chloride concentrations and lower pH values.

This photo shows a heat tint at the root side of a GTAW weld in duplex stainless steel X2CrNiMoN22-5-3.



The presence of heat tints makes stainless steels vulnerable to several types of localized forms of corrosion due to the lack of a coherent passive oxide film. Possible forms of localized attack are:

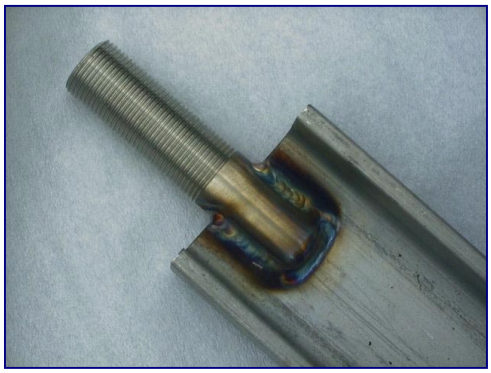
- Pitting corrosion
- Stress corrosion cracking
- Crevice corrosion
- Microbiologically induced corrosion (MIC)

To avoid these forms of corrosion it is essential that heat tints are properly removed before the stainless steel equipment or piping is exposed to aggressive or aqueous environments.
An exception can be made in case stainless steel equipment and piping are applied in fluids that have a pickling effect, such as nitric acid. In case of doubt, the decision whether to allow or to reject the presence of heat tints, has to be taken in consultancy with a corrosion specialist.

Removal of heat tints can be performed by means of mechanical or chemical methods or combinations thereof.

Mechanical cleaning methods
Stainless steels may be mechanically cleaned as follows:
- by sanding with 360 grit or higher (rotary disk) or
- by brushing with a 3M nylon or stainless steel rotary brush or
- by sandblasting

Chemical cleaning methods
Chemical industrial cleaning by means of pickling can be performed with a solution of
- nitric acid + hydrofluoric acid
- sulphuric acid + hydrofluoric acid + hydrogen peroxyde



Left: stainless steel with heat tint.
Right: the heat tint has been removed by pickling. The corrosion resistance has been fully renewed.

Before starting the pickling procedure the material shall be free of impurities such as dirt, grease , paint, self-adhesive tape, etc.
If the regular pickling agent performs inadequately, a stronger agent may be used. Such treatment should be closely monitored.

It is experienced that from point of view of corrosion, a chemical cleaning has to be preferred above mechanical cleaning. In literature it is mentioned that a pickled stainless steel surface is the best pre-requisite for optimal corrosion resistance. This improved corrosion behaviour is explained by an increase of chromium content in the outer layer of the stainless steel.
To avoid over pickling in case of the presence of a thick oxide layer, a mechanical cleaning followed by a chemical cleaning can be performed. The resultant corrosion resistance is equivalent to that obtained by 'regular' pickling.

Conclusions and recommendations
- Presence of heat tints accelerates initiation of localised types of corrosion like stress corrosion cracking, pitting and MIC.
- To minimize the risk of localised types of corrosion heat tints have to be removed.
- From point of view of corrosion, a chemical cleaning by means of pickling has to be preferred above a mechanical cleaning.

The following two Technical Bulletins will go deeper into this matter in the form of two case studies.

Author: G. Notten (Senior Corrosion Engineer)
Reactions and/or questions: e-mail: tb@vecom.nl