WATER SERVICES ASSOCIATION
of Australia

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STAINLESS STEEL FABRICATION

Introduction

More than ever before the water industry is using stainless steel for individual components and structural items. When the appropriate grade of stainless steel is chosen and correctly designed and fabricated into a structure or component, many years of low maintenance life can be expected. However, if some basic fundamentals are not specified and followed during manufacture, corrosion of stainless steel can result in rapid and premature failure. The following information has been prepared by the WSAA Materials Network to advise designers, specifiers and users about the pitfalls that need to be avoided in the manufacture of fabricated stainless steel structures. This fact sheet should be read in conjunction with Fact Sheet No 2, *Selection of Stainless Steels for Use in the Water Industry*.

Like mild steel, stainless steel can be fabricated into almost any structural shape. Machining, forming and perhaps the most common process, welding, can all be readily carried out.

The Protective Oxide Film

Like aluminium and titanium, stainless steel achieves its excellent corrosion-resistant properties by forming a protective surface oxide film. Corrosion can occur at any point on the surface if this film is not allowed to form or is ruptured. So the aim is to fabricate stainless steel and clean it before service in such a way that the protective oxide film will be strong and continuous. This is best achieved with a stainless steel surface which is as clean and smooth as possible. Hence the importance of passivation.

Passivation—This is the term used to describe the process whereby stainless steel forms the protective surface oxide film which gives it corrosion resistance. If the surface is clean and smooth, passivation occurs naturally in the presence of oxygen, and this is commonly referred to as ‘air passivation’. The process can be hastened by the use of a passivating chemical such as dilute nitric acid – the same solution as can be used to remove surface iron particles. Chemical passivation does not normally affect the surface finish, as distinct from pickling with nitric-hydrofluoric acid that will dull the surface.

Care During Fabrication

Errors in stainless steel fabrication can be expensive and difficult to correct once the structure is in service. Furthermore, because stainless steel is normally used uncoated, a high standard of surface condition is necessary. Because of this, a ‘get it right the first time’ approach to fabrication is essential to ensure satisfactory performance and minimise maintenance costs. Surface damage, defects and contamination arising during fabrication are all potentially harmful to the protective oxide film. Therefore, ideally a stainless steel fabricator will have a completely separate work area where only stainless steel fabrication is carried out.

It is important that scratches and gouges are avoided during fabrication since such defects constitute crevices that allow the entrapment of process chemicals or contaminants, providing ideal locations for corrosion. Scratches may also contain carbon steel or other contaminants embedded by the object that caused the scratch. Scratches will also raise customer concerns in situations where appearance is important. Mechanical grinding and polishing is the most effective way to remove them.

Preparation for Welding

Since stainless steel weld metal is somewhat less fluid with reduced depth of penetration compared to carbon steel, it is important that weld joints be more open with a thinner land. Joint designs are set out in AS/NZS 1554.6 and in NiDI publication No. 11007.

After preparing the joint, the weld area must be cleaned for 50-75 mm either side of the joint. Any heavy oxide scales must be removed, normally by grinding. Removal is also necessary for contaminants containing elements such as sulphur, carbon, phosphorus, lead, copper and tin. These elements are commonly present oil, grease, marking crayons, paint and shop dirt and can cause cracking and other weld defects. The method of removal will depend on the nature of the contaminant but cleaning with a non-chlorinated solvent is the most common.

It is important that iron particles should not be embedded in the surface during cleaning. Wire brushes should be stainless steel and grinding wheels must be clean and not previously used for grinding carbon steel.

Welding

Stainless steels can be welded by all common welding processes but there are important physical differences between them and ordinary carbon steels – in particular, stainless steels have lower thermal conductivity and higher thermal expansion and this can lead to distortion if not controlled. Fixturing, tack welding and the welding sequence employed are important, as is the control of heat input, and recommendations are set out in NiDI publication No. 11007**.**

At the high temperatures associated with welding, deleterious oxides of chromium can form on the weld and heat affected zone. This is commonly referred to as 'heat tint'. Underneath the heat tint is a thin chromium-depleted zone that is low in corrosion resistance. The formation of both the heat tint and the underlying chromium-depleted zone must be avoided during welding, or they must be removed after welding.. In particular, heat tint must be avoided inside pipes during welding, because of the difficulty in subsequent removal, so the issue of purging during pipe root welding is most important. Recommendations are set out in NiDI publication No. 11007.
Undercut, spatter, slag and stray arc strikes must be minimised, as they are potential sites for crevice corrosion.

Post-Fabrication Cleaning

All too often, it is assumed that the stainless steel structure is ready for service after the final weld is made. However, post-fabrication cleaning may be as important as any of the steps so far discussed. Several of the most important considerations are:

- ***Removal of heat tint.*** This can be done by chemical, mechanical, or electrochemical means.

The most common method is by *acid pickling*, usually with a nitric-hydrofluoric acid mixture, either in a bath or as a paste.
If removing heat tint *mechanically*, wire brushing is not recommended since it tends to smear the surface rather than removing the heat tint. Clean abrasive disks and clean flapper wheels are commonly used, as is glass bead blasting. Blasting with stainless steel shot or cut wire or new, iron-free sand (garnet is a common choice) is also used. While all of these mechanical processes can effectively remove heat tint, they can introduce secondary problems. In particular, they can produce a rough surface finish that is then susceptible to crevice corrosion. So if mechanical means are used, care must be taken to select a sequence of operations that will produce as smooth a surface finish as possible.
Electropolishing, either in baths or with hand held equipment, can also be used very effectively, since it both removes the heat tint and smooths the surface.

- ***Removal of embedded iron.*** If particles of embedded iron are present in the surface of stainless steel when it is put into service, the particles will first rust but over time can also produce pitting in the underlying stainless steel. It is important that they are avoided through cleanliness and care during fabrication or that they are removed after fabrication. Tests are available to detect their presence (see NiDI publication No. 11007) and they can then be removed either by chemical passivation or pickling.

Chemical passivation involves washing the surface of the stainless steel with dilute nitric acid and this is generally effective in removing surface iron particles. However, if the particles are more deeply embedded, it is necessary to employ a pickling solution, as is used for removing heat tint.

Welding Specifications

To facilitate the achievement of satisfactory welding it is essential to ensure the appropriate welding requirements are specified. Australian Standard AS/NZS 1554.6, *Welding stainless steel for structural purposes*, provides details of performance requirements for weld design, quality and post-weld treatments. There are a number of alternatives for weld quality and post-weld treatments so it is important to state these specific requirements rather than just quote AS/NZS 1554.6. Guidelines for the specific requirements are discussed in the standard.

Storage, Handling and Installation

The principles that apply to stainless steel fabrication should also apply to its storage and handling prior to and during installation. Site conditions likely to cause contamination, particularly from carbon steel, must be avoided. It is best to cover stainless steel while on site in order to avoid contamination from grinding dusts, weld spatter and general dirt.

Summary

Stainless steel is a robust and relatively forgiving material. However attention to appropriate practice in its preparation, welding and cleaning is most important to ensure satisfaction from customers and suppliers alike.

References

Australian Standards

AS/NZS 1554.6—*Welding stainless steel for structural purposes*

ASSDA—(1998) *Reference Manual*

Stainless Fabrication Group New Zealand

Code of Practice for the Fabrication of Stainless Steel Plant and Equipment

Nickel Development Institute (NIDI)

Specifying Stainless Steel Surface Treatments, NiDI publication No. 10068

Cleaning Stainless Steel Surfaces Prior to Sanitary Service, NiDI publication No. 10080

Guidelines for the welded fabrication of nickel-containing stainless steels for corrosion resistant services, NiDI publication No. 11007

*Design Manual for Structural Stainless Steel (*NiDI) publication No. 12011

Useful Web Sites

www.assda.asn.au

www.nidi.org

www.bssa.org.uk

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