# CHEMICAL SURFACE TREATMENTS ON STAINLESS STEEL

*Max Russell - Public Relations Coordinator ASSDA*

Successfully using stainless steel depends on the environment, grade selected, surface finish, the expectations of the customer and the maintenance specified. Stainless steels provide robust solutions, but in harsh or borderline environments with high expectations for durability, surface finish will have a substantial impact on performance. Surface finishes can be applied mechanically (usually with abrasives) and chemically.

Understanding how chemical and mechanical treatments will affect the characteristics of the surface will enable the best possible outcome for the client and the structure. Chemical treatment can be used to improve the corrosion performance of the steel.

Stainless steels resist corrosion best if they are clean and smooth. Clean means being free of contaminants on or in the surface that can either react with the steel (like carbon steel or salt) or that create crevices or other initiation points where corrosion can start.

Smooth means having a low surface area at the 'micro' level. Mechanically abrading the surface can roughen the steel's surface and may also embed unwanted particles.

The common feature of chemical treatments is that they all clean the surface of the steel. They may also smooth or roughen the steel surface, or leave it unaffected depending on which process is chosen. But if carried out properly, they all increase the corrosion resistance.

## STAINLESS STEEL PRODUCTS

During steel making, sulphur in the steel is controlled to very low levels. But even at these levels sulphide particles are left in the steel, and can become points of corrosion attack. This imperfection can be improved greatly by chemical surface treatment.

Most bar products will be slightly higher in sulphur when produced, so chemical treatment to remove inclusions in the surface of these products becomes more important.

Generally mill finishes for flat products (sheet, plate and strip) will be smoother as their thickness decreases.

A No 1 finish on a thick plate may have dimples or other imperfections and a surface roughness of 5 to 6 micrometres $R_a$.

A typical 2B cold rolled finish on 1.7mm thick sheet might have a surface roughness of 0.2 micrometres $R_a$ or better as shown in section 5.1 of *ASSDA's Reference Manual*.

New surfaces will be created during fabrication processes, (eg cutting, bending, welding and polishing). The corrosion performance of the new surfaces will generally be lower than the mill supplied product because the surface is rougher, or sulphide inclusions sitting just under the surface have been exposed or mild steel tooling contamination may have occurred.

Chemical treatments correctly performed can clean the surface and ensure the best possible corrosion performance.

Chemical surface treatments can be grouped into four categories:

- Pickling - acids that remove impurities (including high temperature scale from welding or heat treatment) and etch the steel surface. 'Pickling' means some of the stainless steel surface is removed.
- Passivation - oxidising acids or chemicals which remove impurities and enhance the chromium level on the surface.
- Chelating agents are chemicals that can remove surface contaminants.

*Electropolishing of stainless steel can enhance its corrosion resistance. The item on the right has been electropolished.*

- Electropolishing - electrochemical treatments that remove impurities and have the added beneficial effect of smoothing and brightening the surfaces.

## PICKLING

Mixtures of hydrofluoric (HF) and nitric acid are the most commonly used and are generally the most effective. Acids are available as a bath, a gel or a paste.

Commercially available mixtures contain up to about 25% nitric acid and 8% hydrofluoric acid. These chemicals etch the stainless steel which can roughen and dull the surface.

Care is required with all these chemicals because of both occupational health and safety and environmental considerations. HF is a Schedule 7 poison which has implications for sale or use in most states. See *ASSDA's Technical Bulletin* on this subject.

## PASSIVATION

Nitric acid is most commonly used for this purpose. Passivation treatments are available as a bath, a gel or a paste. Available formulations contain up to about 50% nitric acid and may also contain other oxidisers such as sodium dichromate. Used correctly, a nitric acid treatment should not affect the appearance of the steel although mirror polished surfaces should be tested first.

Passivation works by dissolving any carbon steel contamination from the surface of the stainless steel, and by dissolving out sulphide inclusions breaking the surface. Nitric acid may also enrich the proportion of chromium at the surface - some chelants are also claimed to do this.

## CHELANTS

Chelants have chemical 'claws' designed to selectively clean the surface.

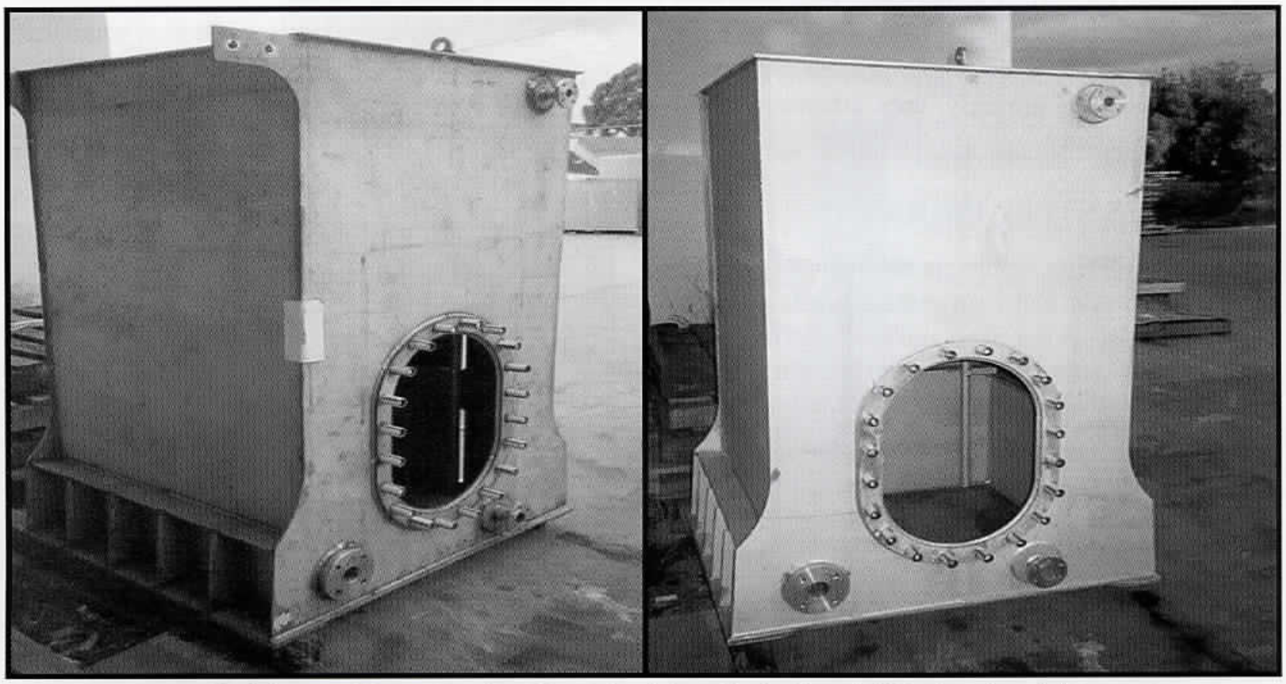
The carboxylic acid group COOH is the basis for many chelants which are used in cleaners, water softening and lubricants. The pH and temperature must be correct for the chelant to do its job. Turbulent rinsing of pipes and vessels afterwards is important. Cleaning by chelating agents tends to be based on proprietary knowledge and systems, and is less standardised than the other methods described.

The successful use of these systems needs to be established on a case by case basis.

## ELECTROPOLISHING

Most commonly phosphoric and sulphuric acids are used in conjunction with a high current density to clean and smooth (by metal removal) the surface of the steel. The process preferentially attacks peaks and rounds valleys on the surface and raises the proportion of chromium at the surface.

The technique can have substantial effect on the appearance increasing lustre and brightness while



*This helicopter fuel storage tank used for storing fuel on ships has been pickled and passivated after fabrication - finished vessel on right. (Photo courtesy of Alloy engineers and MME Surface Finishing)* only changing the measured roughness by about 30%.

## PRECAUTIONS

For chemical processes that etch the stainless steel, reaction times will increase with increasing grade.

More care is required with 'free machining' grades and these will usually require substantially less aggressive chemicals. The sulphur addition in these steels makes them readily attacked by chemical treatments. Care is also required when treating martensitic or low chromium ferritic stainless steels.

Detailed recommendations for each grade of stainless steel are given in the Standards.

Dirt and grease will mask the surface from treatments outlined above. Therefore, the steel surfaces must be free of these agents before applying chemical treatments.

Many of the chemical treatments described contain strong acids. Before disposal they will require neutralisation. Check with your local authority concerning the requirements for trade waste, neutralisation and disposal.

Many of the chemicals described above will be classified as hazardous substances under State OHS legislation, with implications for purchasing, transport, storage and handling.

Chemical treatments are useful tools in cost effectively achieving peak performance with stainless steels. With appropriate training, hazards associated with their use can be managed.

## STANDARDS AND THE FOUR CATEGORIES OF TREATMENT

The four categories of treatment are detailed in a number of Standards, but the most commonly used are:

- ASTM A380 Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment and Systems
- ASTM A967 Chemical Passivation Treatments for Stainless Steel Parts
- ASTM B912 Passivation of Stainless Steels using Electropolishing

These very useful documents give detailed recommendations on many aspects of selection, application and evaluation of these treatments.

For further information, contact ASSDA:

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## New Research Reveals Better Performance for Hot Dip Galvanized Coatings

*Contnued from page 18*

The hot dip galvanized test panels were processed to produce three Australian Standard AS/NZS 4680 compliant coating thicknesses: 55 microns, 70 microns and 85 microns. The difference in thickness on each of these samples is reflected in the thickness or their respective alloy layers.

The average corrosion rate measured for the duration of the tests which totaled 1086 days was around 12 microns per year for the hot dip galvanized samples compared to 38 microns a year for the zinc and 430 microns per year for the mild steel.

Based on these results, the corrosion rate of hot dip galvanized steel in this severe marine environment is about 1/3 that of zinc – a remarkable difference that will significantly influence the estimates of hot dip galvanized coating service life.

## SUMMARY

Field testing of installed hot dip galvanized steelwork has long shown a lower measured rate of corrosion in service than established corrosion data has indicated.

The CSIRO tests at Port Fairy are a step towards better quantifying the long-term performance of hot dip galvanized coatings, and recognizing them as being in a coating category of their own, rather than as simply another type of zinc coating.

For a full copy of this test report, contact:

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*Editor.*

# CONTENTS





Cover:

While not readily visible in this photograph, the main structural angles on an upper section of this 330KV tower at Sandgate, NSW show that the hot dip galvanized coating is reaching the end of its service life. Only one segment is affected, indicating that the sections used elsewhere on the tower had a heavier galvanized coating originally.

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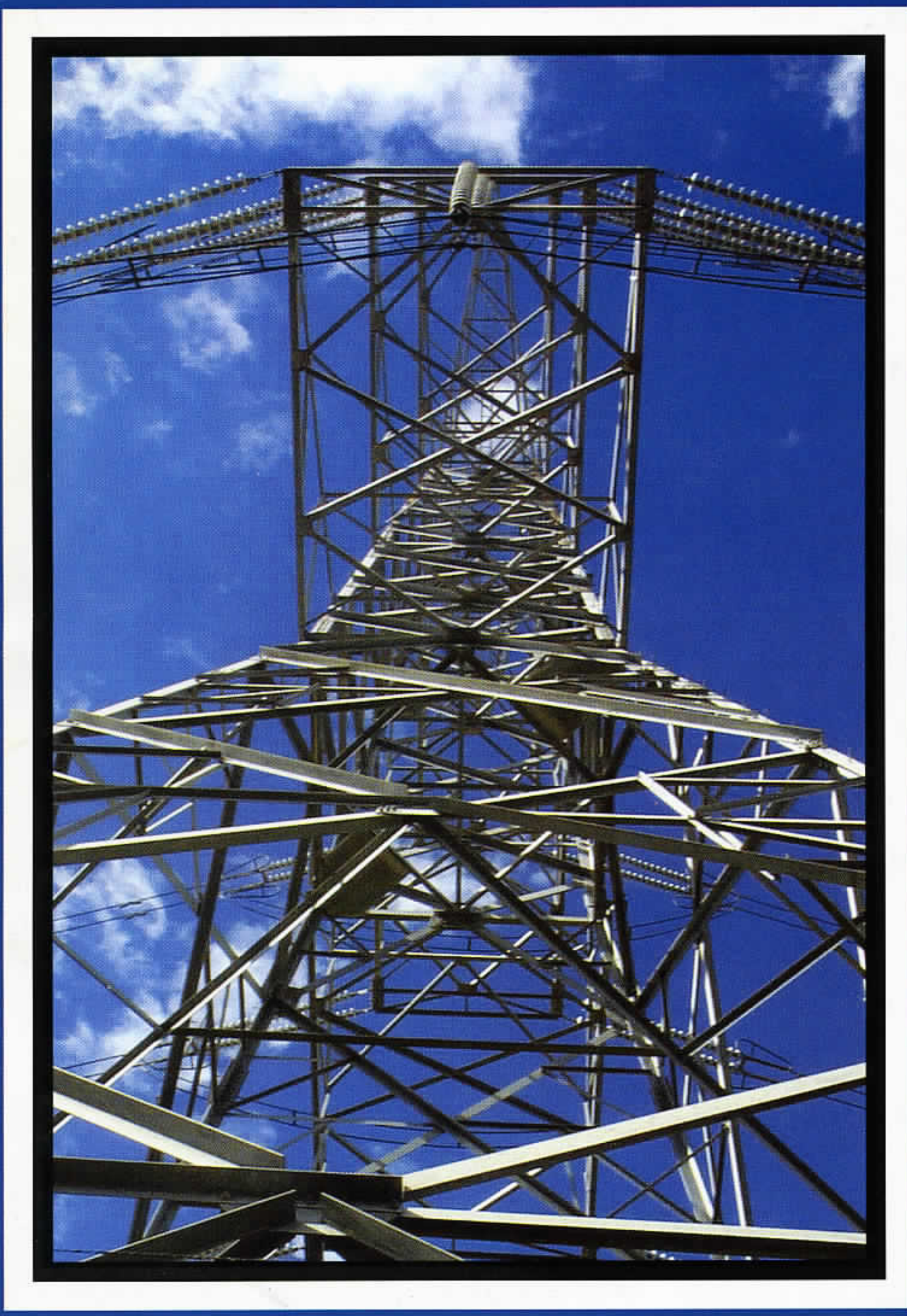

## IN THIS ISSUE:

- A Survey of Durability Standards
- Restoring Serviceable Galvanized Structures
- Design and Material Solutions To Corrosion Problems
- New Research Reveals Better Performance for Hot Dip Galvanized Coatings
- Chemical Surface Treatments on Stainless Steel