

PREVENTING COASTAL CORROSION

TEA STAINING TECHNICAL BULLETIN

WHEN USED PROPERLY, STAINLESS STEEL ENJOYS A STRONG AND ENDURING REPUTATION FOR VISUAL APPEAL AND STRUCTURAL INTEGRITY IN A WIDE RANGE OF APPLICATIONS AND ENVIRONMENTS.

Incorrect specification, fabrication or subsequent handling in coastal environments may cause stainless steel to stain or discolour, impairing the overall look. This brown discolouration, or tea staining, has been identified in coastal applications in Australia and overseas.

Tea staining does not affect the structural integrity or the longevity of the material and it can be controlled.

The installation pictured at right shows the successful use of stainless steel in a coastal environment. After more than 14 years of service in a severe environment it shows little sign of deterioration. The installation pictured below however, shows significant staining after only a very brief period in service. This brown tea staining on the stainless steel is avoidable.



Successful use of stainless steel after more than 14 years service in a coastal environment.



Tea staining of stainless steel in a coastal environment shortly after installation.

WHERE DOES IT OCCUR?

Tea staining occurs most commonly within about five kilometres of the surf or a few hundred metres from a sheltered bay. It becomes progressively worse closer to the marine source.

However, wind exposure, industrial pollution levels and higher temperatures can create environments where tea staining might occur 20 kilometres from the sea. These same factors also increase corrosion rates of alternative metals.

IMPORTANT QUALIFICATION

The information in this Bulletin has been prepared from research undertaken by or made available to the Australian Stainless Steel Development Association (ASSDA) at the date of publication.

Adherence to the recommendations in this Bulletin may improve the cosmetic appearance of affected surfaces and minimise risk in new applications.

However, research into the causes of, and treatment for tea staining have not to date

resulted in definitive processes or recommendations for cure and prevention.

ASSDA accepts no responsibility for any opinion or recommendation expressed, for any error or omission occurring herein or for the failure of any recommendation contained in this Bulletin to achieve a satisfactory result in any particular application.

Before acting on any particular application, qualified advice particular to such application should be obtained.

MINIMISING THE RISK THROUGH CORRECT SPECIFICATION

So what should fabricators, specifiers and end users do to help avoid tea staining and enjoy the long life and clean appearance of stainless steel?

The relationships between the contributing factors are complex, but become increasingly critical closer to marine water especially surf coasts.

Plan To Get The Desired Result

Marine environments are the most aggressive for all building materials. Stainless steel's very slow corrosion rate in marine environments means that installations are likely to remain structurally sound for decades.¹

It must be recognised however, that keeping a pristine surface finish requires understanding, additional effort and usually extra costs. Determine your expectation of the structure and plan ahead to achieve and maintain the intended result.

Design, Fabrication and Handling

Poor design and fabrication can lead to tea staining or more serious corrosion of stainless steels.

Good designers will avoid crevices, such as intermittent welds, and areas where water can collect. Competent stainless steel fabricators will avoid carbon steel contamination.

Choose an ASSDA Accredited Fabricator or other designers and fabricators with extensive experience in stainless steel.

Appropriate Grade Selection

Exposure of a particular grade of stainless steel to a more aggressive environment than it can resist will contribute to tea staining.

Grade 316 should be selected as a minimum within five kilometres of a surf coast. For very aggressive applications (eg. splashed by sea water), unwashed areas, rough surfaces or those applications where no staining can be tolerated, higher grades of stainless steel such as 2205 or a 'super' grade may be required.

The less alloyed, and cheaper grades, (such as 304 or 430) will probably become tea stained or could suffer more severe corrosion.

Specify and Insist on a Smooth Surface Finish

Rough surface finishes promote tea staining, especially with the mechanically polished No.4 finish: the smoother the surface, the better. Smoother surface finishes stay cleaner between washes and don't have deep surface grooves where chlorides and other contaminants can collect and concentrate.

For a mechanically polished surface, a surface roughness (Ra) of less than 0.5 micrometres is strongly recommended. A No.4 finish will not always be within this limit unless specified; it is recommended that all No.4 finishes be specified this way. Typically, refinishing operations using 320 grit abrasives will achieve a finish better than 0.5 micrometres Ra.

Mill finishes (2B, BA) are generally smoother than No.4 finish, except for 2B above about 2mm thickness. Mirror polished (No.8) finish is even smoother than the mill finishes.

All the finishes can be made more corrosion resistant for use near the ocean by passivating with acid to remove surface contaminants. This is especially beneficial for No.4 and other abraded finishes. Apart from possible clouding of mirror polished materials, passivation has no effect on the appearance of the surface before it goes into service.

The mill finishes 2B and No. 1 or HRAP finish (on hot rolled material, at thicknesses of about 3mm or more) are

pickled in the final stages of processing at the mill, and get least benefit from final passivation, unless the surface has been contaminated during fabrication.

Surfaces can also be passivated by electropolishing. This process also reduces the surface roughness, which gives a further boost to corrosion resistance. The smoother surface is much brighter than the surface before electropolishing.

Rolled embossed finishes on sheet material may be suitable for some applications. These have very smooth surfaces but with a pattern that lowers reflectivity. Think carefully about the pattern and how it will be oriented to avoid pools of water sitting on the surface.

Other products including bars, pipe, tube, castings and plate have variable surface finishes. The best corrosion resistance will be achieved in each case if the finish is as smooth as possible and if it has been pickled or passivated or electropolished.

Electropolishing can effectively reduce the surface roughness (Ra) by about 0.2 micrometres and will produce a durable, passive and corrosion resistant film on stainless steel. However, electropolishing is a final finishing process and prior finishing may be necessary on rougher material to achieve an Ra of less than 0.5 micrometres.



A successful stainless steel coastal application, with no tea staining.



Coastal application, good surface finish — no tea staining

Weld Treatment

Welding scale and the chromium depleted layer underneath must be removed to restore corrosion resistance. Mechanical polishing to match the finish on the parent material is often used. Good resistance again requires an Ra of 0.5 micrometres or better. A final pickling or passivation step then gives the very best corrosion resistance.

AND AFTERWARDS?

Inspection

After installation, the completed structure should be inspected for installation damage.

After any repairs, the corrosion resistance should be restored by polishing, and it is really important to passivate to prevent corrosion starting before the passive film has time to regrow.

And beware of residual glue left on panels after plastic surface protection is removed. Clean the surface down with a suitable solvent.

Do Not Use Hydrochloric Acid

Hydrochloric acid is sometimes used to clean cement or mortar residues. This acid should never be used on or near stainless steel - it will frost the surface and usually causes pitting.

Wash Regularly

In coastal environments even smooth stainless steel finishes may tea stain if not washed regularly to remove salt. As a rule of thumb, it should be washed as regularly as the windows. Table 1 gives guidance.

FOR THE SPECIFIER AND FABRICATOR: KEY RECOMMENDATIONS FOR MINIMISING TEA STAINING

The following factors are all important for avoiding tea staining.

> Environment

One of the main causes of tea staining is salt deposited on the surface. Tea staining is most likely to occur up to five kilometres from a surf beach or a few hundred metres from still marine waters. There is no hard and fast rule: wind and weather conditions play a big part and the severity of the conditions increases sharply as you approach the surf.

AS 2312 suggests that in some special circumstances, 20 kilometres from

the coast can still constitute marine. The closer to the source of salt, the more critical it is to follow the recommendations in this Bulletin.

> Specify and insist on a smooth surface finish

To minimise the risk of tea staining, the smoother the surface finish the better. A surface roughness (Ra) of less than 0.5 micrometres is strongly recommended. A No.4 finish is often mis-interpreted to just mean any ground (finished) finish. Specifying a No.4 finish may be inadequate without indicating the required roughness. Typically, refinishing operations using 320 grit abrasives would achieve a finish better than 0.5 micrometres Ra.

Stainless steels are more resistant to tea staining if they are passivated, to remove surface contaminants, which may originate from the steel or be introduced during fabrication. Passivation does not change the appearance of the finish.

Electropolishing is also effective in passivating the surface, and it has the added benefit of smoothing the finish. Electropolishing will brighten the surface.

Smoother flat product mill finishes such as 2B, Bright Annealed (BA) or mirror polished (No. 8) are available in some products and these offer better resistance to collection of salt deposits and hence to tea staining. Rolled embossed finishes may be suitable for some applications. These have very smooth surfaces but with a pattern that lowers reflectivity. Think carefully about the pattern and how it will be oriented. Promote free, even draining and avoid pools of water sitting on the surface.

> Specify and insist on the right grade

Smooth surface finish and maintenance are important factors for all stainless steel grades in coastal environments

Grade 316 may be adequate if the environment is less severe, the job is not aesthetically critical or if the finished installation will be very well maintained.² Where there are high aesthetic expectations a number of more corrosion resistant stainless steel grades can be considered (the first step up from 316 is 2205 and then the super duplex grades, high molybdenum austenitics and high

¹ Perforation of roofs and gutters is possible depending on the application — seek advice if this is a failure criterion.

² Grade 304 has occasionally been successfully used in these environments, but it is not recommended.

molybdenum ferritics may also be useful). Smooth surface finish and maintenance are still important with these grades.

> Chemically treat the welds

For general architectural applications welds should comply with AS 1554.6 Level 2, Class B. Best resistance to tea staining is achieved with a Grade I finish, polished to 320 grit or finer finish, but Grade II, linished or pickled finishes (only) may be adequate for less critical applications. Where a linished finish is desired, 320 grit (or finer) silicon carbide abrasives should be used with lubrication if possible. In these circumstances a passivation treatment (nitric acid only) should be applied to the ground/polished area. In selecting abrasives consideration should be given to matching the surrounding finish.

Where linishing is not performed, pickling of site welds (using mixed acids — hydrofluoric plus nitric) should take place as a final step in the weld procedures. This treatment will remove any fabrication contaminants and restore the passive chromium oxide layer, resulting in a corrosion resistant surface. Pickling treatments are likely to alter the appearance of surface finishes.

> Perform regular maintenance

Washing removes contaminants (such as salt) that can cause corrosion and is necessary to avoid tea staining. Rain washing the surface is helpful in reducing tea staining, so design

the job to take advantage of the rain, but ensure good drainage.

Stipulate that the stainless steel also be washed when cleaning of the surrounding area takes place. For best results wash with soap or mild detergent and warm water followed by rinsing with clean cold water.

The appearance of the surface can be improved further if the washed surface is wiped dry. If routine cleaning of the surrounding area does not take place, washing frequency for the stainless steel is recommended as Table 1 shows.

Contract documents should stipulate that brick cleaning acids and fumes should not be allowed to come into contact with the stainless, which will be attacked and dulled by them.

FURTHER READING

ASSDA Answers to FAQ
Cleaning Exterior Stainless Steel
- download from www.assda.asn.au

Australian Standard AS 1554.6 Welding
Stainless Steel for Structural Purposes.

Nickel Institute
Japan Stainless Steel Association
Successful Use of Stainless Steel Building
Materials publication No 12 013.

Nickel Institute
Guidelines for the Welded Fabrication
of Nickel-containing Stainless Steels for
Corrosion Resistance Services No 11 007.

IMOA Stainless Steel Evaluation System
- download from www.imoa.org.uk

TABLE 1: RECOMMENDED CLEANING INTERVALS FOR 304 STAINLESS STEEL*

Building Element	Roof or wall washed by rain		Eave, soffit or under-eave wall not washed by rain	
	No deposits	Deposits accumulate	No deposits	Deposits accumulate
Structure	No deposits	Deposits accumulate	No deposits	Deposits accumulate
Cleaning+ in rural, suburban & residential areas	1/year	1/year	1-2/year	2-12/year
Cleaning+ for seaside#, industrial and severe areas	1/year	1/year	3-4/year	4-12/year

Notes:

* Cleaning frequency may be less for highly alloyed grades but is dependent on surface finish, design details, environment, cleaning procedure and expectations of performance.

+ Cleaning involves washing with potable, low chloride water or washing with a neutral detergent followed by rinsing with potable water. For details see Nickel Institute publication 12 013.

This listing does NOT imply that it is recommended that 304 stainless steel is satisfactory in marine environments.

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