

## Right on the Coast

The installation in figure 1 depicts the successful use of stainless steel in a coastal environment. After a decade of service in a severe environment it shows little sign of deterioration. The installation in figure 2 however, shows significant staining after only a very brief period in service. This brown *tea staining* on the stainless steel is avoidable.

### MINIMISING THE RISK THROUGH CORRECT SPECIFICATION

This *Technical Bulletin* provides information on tea staining and what fabricators, specifiers and end users should do to help avoid it and enjoy the long life and clean appearance of stainless steel.



Figure 1: Successful use of stainless steel, after more than 10 years service, in a coastal environment.



Figure 2: Tea staining of stainless steel in a coastal environment shortly after installation.

Stainless steel enjoys a strong and enduring reputation for long term appearance and structural integrity. But like all materials, stainless steel may become stained or discoloured over time, impairing the overall look. This brown discolouration, tea staining,

has been identified in coastal applications in Australia and overseas. Factors surrounding tea staining have been researched by ASSDA and the information gathered has been supported by experiences from around the world.

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### IMPORTANT QUALIFICATION

The information in this Bulletin has been prepared from research undertaken by or made available to 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.

## WHAT IS TEA STAINING?

Tea staining can be defined as:

*Discolouration of the surface of stainless steel that does not affect the structural integrity or the longevity of the material.*

## CONTRIBUTING FACTORS... AND WHAT CAN BE DONE ABOUT THEM

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

### ENVIRONMENTAL FACTORS

Tea staining occurs most commonly within about five kilometres of the surf and becomes progressively worse closer to the marine source. However, wind exposure, pollution levels and higher temperatures can create environments where tea staining might occur 20 kilometres or more from sea water. These same factors also increase corrosion rates of alternative materials.

### SURFACE FINISH

Rough surface finishes promote tea staining: 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 cause problems.

### WELD TREATMENT

Pickling treatments after welding are a must for good performance of stainless steel near the coast.

This chemical treatment removes the welding oxide and rapidly restores the passive layer, which gives stainless steel its corrosion resistance.

### WASH REGULARLY

Even smooth stainless steel finishes in coastal environments may show tea staining if not washed regularly.

### DESIGN, FABRICATION AND HANDLING

Poor design and fabrication can lead to tea staining or more serious corrosion of stainless steels. For instance, 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 designers and fabricators experienced with stainless steel.

### INSTALLATION AND INSPECTION

After installation the completed structure should be inspected for surface imperfections or contaminants. If discovered, imperfections should be removed and the corrosion resistance chemically restored by pickling or passivating treatments or by electropolishing. Hydrochloric acid, sometimes used to clean cement or mortar residues, should not

be used on stainless steel — it will stain the surface and may start more serious corrosion.

### 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 the surf. For critical applications, unwashed areas or rough surfaces, higher grades of stainless steel such as duplex alloys or *super* grades may be required. The less expensive grades (such as 304 or 430) will probably become tea stained or even suffer more severe corrosion.

### 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.<sup>1</sup> It must be recognised however that keeping a pristine surface finish requires understanding and, usually, additional cost. Determine your expectation of the structure and plan ahead to achieve and maintain the intended result.



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



Coastal application, good surface finish — no tea staining

## 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 and one kilometre 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 just means a ground (linished) finish. Specifying a No.4 finish is inadequate. Typically, refinishing operations using 320 grit abrasives would achieve a finish better than 0.5 micrometres Ra.

Components used near the sea can be made more resistant to tea staining by pickling to remove surface contaminants. Electropolishing may be even more effective. However, it must be recognised that both processes can change the surface appearance — pickling tends to dull polished surfaces while electropolishing will brighten surfaces.

Smoother mill finishes such as 2B (flat products), 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 — 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. Use grade 316 unless the job is aesthetically critical and frequent maintenance is unlikely.<sup>2</sup> 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 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

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

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

any fabrication contaminants and restore the passive chromium oxide layer, resulting in a corrosion resistant surface. Pickling treatments may alter bright 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.

**TABLE 1: CRITERIA FOR CLEANING FREQUENCY**

Environment	Rural (including suburban and residential areas)				Seaside (including industrial and severe urban areas)			
	Roof and wall washed by rain water		Eave soffit and undereave wall unwashed by rain water		Roof and wall washed by rain water		Eave soffit and undereave wall unwashed by rain water	
Building element								
Structure	Deposits unaccumulated	Deposits accumulated	Deposits unaccumulated	Deposits accumulated	Deposits unaccumulated	Deposits accumulated	Deposits unaccumulated	Deposits accumulated
Cleaning criterion (for S30400) <sup>1</sup>	1 time/year	1 time/year	1-2 times/year	2-12 times/year	1 time/year	1 time/year	3-4 times/year	4-12 times/year

<sup>1</sup> Cleaning frequency may be less for other grades but is dependent on surface finish and precise details of design of the structure, environment, cleaning methods and expectation of performance.

Note: Cleaning involves washing with potable, low-chloride water or washing with a neutral detergent followed by rinsing with potable water. Source: JSSA/NiDI 12 013.

## Further reading

Australian Standard AS 1554.6 *Welding Stainless Steel for Structural Purposes*.

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

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

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