

Tea staining of stainless steels is a relatively common occurrence in coastal locations. Visually, it is a discoloration of the metal surface, which tends to follow the 'grain' of any surface finish. Although unpleasant to look at, it is not a serious form of corrosion, and in general does not affect the structural integrity, or longevity of the balcony.

Aesthetically however tea staining is not ideal, and so the information herein is in an attempt to help identify the causes and suggest possible solutions.

Stainless Steel

The term "stainless" steel derives from the development of the specialty steels for modern cutlery industry. It has now been adopted as a generic name for steels developed for any corrosion or oxidation (rust) resistant applications.

The corrosion resistant characteristics of stainless steels are a result of chromium-rich oxide film that forms naturally on the metal surface. Although this film is extremely thin, it is chemically stable and 'self-repairing'.

Other types of steel such as mild steel suffer from general corrosion where large areas of the surface are affected, but stainless steels, due to their oxide film, are normally resistant to this form of attack.

Common stainless steels used in the enclosure industry are 304 and 316. Both are iron alloys with additional chromium, and nickel. The nickel content in 316 grades is slightly higher than with 304 grades, and the chromium content is slightly lower. However, the most important difference is that the 316 grades have molybdenum as an additive, to improve its resistance to pitting corrosion, which is usually the result of chloride or saline attack. 316 stainless is preferred by balcony and handrail manufacturers due to this superior corrosion resistance, even though it is a higher cost material.

Tea staining of balcony handrails

Tea staining can be defined as the "discoloration of the surface of stainless steel mainly as a result of chloride attack"

As a first step it is useful to try to understand why, and in what circumstances tea staining can occur. Tea staining of stainless steels is a phenomenon that occurs where water with significant chloride content is in regular contact with the metal surface. This is a common occurrence along the coastal areas of the United Kingdom.

How is tea staining caused?

Although research on the root cause of tea staining has been limited, there seems to be little research on the root cause of tea staining. However the mechanisms involved can be inferred by the pattern of the corrosion, and known factors that can help counter the effect. One of the most common factors linked with tea staining is the surface finish of the material. Smoother, polished surfaces often do not show any signs of staining, so from this it can be said that grooves or troughs in the material are a root cause of the problem. Surface roughness (Ra) is measured in

units of micrometers (μm), and is defined as the average deviation of the height of the surface from the mean height. Higher Ra values or irregular profiles are often associated with increased tea staining.

It is reasonable to assume that the base cause of this corrosion is similar to that of many of the other common types of corrosion. The association of tea staining with proximity to salt water means that chloride attack is the most likely cause of the problem. However you would not normally expect the low level of chlorides present in sea water, for example, to have such a dramatic effect. The reasons why this occurs can be deduced by the locations and one of the solutions to tea staining problems.

Reducing the effect of tea staining on stainless steel balconies

One of the most common ways to prevent problems associated with tea staining on stainless steel balconies is to ensure that the surface is washed regularly with fresh, clean water. This would infer that the corrosion is being caused not by the initial contact with salt water, but with deposits of salt building up on the surface and pours of the handrails. Though microscopic the chloride concentration would build up in any surface troughs. As the water evaporates it leaves a deposit of salt in the trough, and the next time the surface becomes wet this deposit concentrates the chlorides naturally present, and increases the corrosive effects. Over time therefore the chloride concentration in these troughs can become high enough to cause corrosion. Note that this would be consistent with the effect that an increasing surface roughness will have on the tea staining effect, i.e. a deeper groove will trap more salty water, which will give a higher chloride concentration.

The location of particular areas prone to tea staining also implies that higher temperatures and humidity have an effect, as does intermittent exposure (for example, spray from rough seas). High temperatures increase the rate of corrosion, but elevated humidity will increase the time taken for the water on the surface to evaporate, and hence increase the time that the higher concentration chloride solution will be in contact with the metal, and it is this contact with the solution that causes corrosion rather than with the resultant solids.

When ordering stainless steel balconies and handrails, the following is a list of factors that should be considered in particular in areas close to the ocean, or where high levels of chlorides occur naturally, or are found in wash waters.

This starts with basic initial material selections, and proceeds into maintenance of the balustrades to ensure a long life, and therefore maximum value for the balcony.

Material Selection – Initial material selection for the enclosure is of critical importance to the longevity of the balustrades. Stainless steel of grade 316 or above should be used as minimum, as lower grades such as 304 are significantly less resistant to chloride attack due to the absence of molybdenum.

Surface Finish – The rule of thumb for surface finishes is that the smoother the finish, the better will be the resistance to tea staining.

Cleaning stainless steel handrails – Regular washing with clean, fresh water or even rain water has a significant effect on reducing the incidence of tea staining in the environments that can cause concern. Where tea staining still occurs despite regular washing, additional protection can be provided by a special coating procedure using a bespoke polymeric resin

Conclusion

Tea staining of stainless steel handrails, balconies and surfaces can be a problem where there are significant levels of chlorides in water that comes into contact with the metal surface. This can be around the coastal locations, or in the interior where ground water contains significant chlorides. Although it does not look very pleasant it tends to be a surface phenomenon only, and does not affect the structural integrity or longevity of the balcony. The cause of tea staining has been examined in some details to help evaluate the potential remedies for the condition. Recommendations to help prevent tea staining include correct specification of the grade of stainless steel to be used, surface finishes to help reduce the problem as well as maintenance procedures, and preventative coating treatments.