Ask!Marine Care;

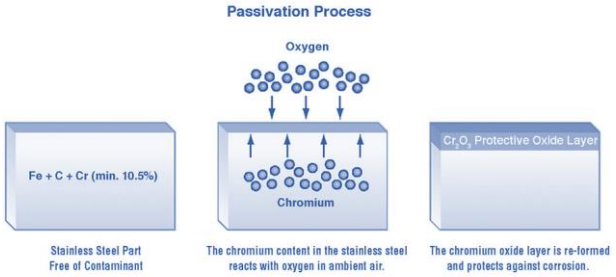
Stainless Steel tanks – what can I do to check the quality?

Avoid guessing and assumptions leading to corrosion

Stainless steel

The corrosion resistance properties of stainless steel is due to the Chromium element of the stainless steel alloy. The Chromium will form a closed and passive Chromium oxide layer, protecting the underneath stainless steel material. Other elements, like Nickel and Molybdenum, can enhance the corrosion resistance of stainless-steel alloys. These corrosion resistant properties of stainless-steel ensure the self-healing effect. When the passive Chromium oxide layer is *physically* damaged, the passive layer will be restored again by the reaction of the Chromium in the stainless steel and Oxygen from the air. (see fig 1.).

Fig 1. Self-healing effect of stainless steel.



There are many types of stainless-steel alloys, but one could divide these into four major groups, based on their crystal structures:

- Martensitic
- Ferritic
- Austenitic
- Duplex

Martensitic and Ferritic are Ferro magnetic steel alloys with at least 12% Chromium content. Austenitic alloys contain at least Chromium and Nickel and are not Ferro magnetic.
Higher grades of Austenitic stainless steels can contain Molybdenum for better corrosion resistance towards chlorides. Duplex types of alloys are a mixture of Austenitic and Ferritic structures of very high Chromium content, making this type of alloy extremely resistant to corrosion by chlorides.

Table 1: Stainless steel Alloys

Alloy	Magnetic	Elements	Corrosion resistance
Martensitic	Yes	Fe, Cr	Low
Ferritic	Yes	Fe, Cr	Low
Austenitic	No	Fe, Cr, Ni	High
Duplex	Yes	Austenitic / Ferritic	Very High

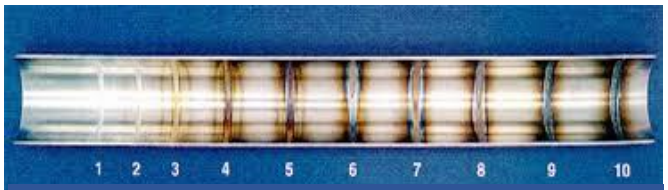
Stainless steel storage tanks are mainly fabricated with Austenitic stainless steel and most commonly two types known as AISI 304 and AISI 316. For tanks with exceptional corrosion resistance properties, Duplex stainless steel can be used. The corrosion resistance of AISI 316 is higher than AISI 304, due to the Molybdenum content in AISI 316.

Table 2: Common Austenitic types

Alloy name	Main Content	Other names
AISI 304 / SAE 304	Ni 8% Cr 18%	1.4301 X5CrNi18-10 A2 stainless steel
AISI 316 / SAE 316	Ni 10% Cr 16% Mo 2%	1.4401 X5CrNiMo17-12-2

Welding

Stainless steel is sensitive to high temperatures. Specially at temperatures between approximately 400 and 800 °C. At these temperatures the chromium reacts with carbon which deposits at the edges of the crystal structures inside the material, which can cause local chromium depletion and lower corrosion resistance. Second, high temperature will form oxides on the stainless-steel surface that do not form a close and passive layer. These 'wrong' oxides are clearly visible as discoloration (so called heat tints). Welding stainless steel, induces heat into the material and leaving these heat tints on both sides of the welds. These heat tints lower the corrosion resistance of the stainless steel significantly.



Heat tints in increasing scale

Heat tints after welding can be removed mechanically by brushing / polishing or chemically by means of pickling and passivation (Careclean Pickling Liquid).
A mechanical treatment of stainless-steel, leaves the stainless-steel surface active and mechanical treatment can contaminate the stainless-steel surface. One of the more serious problematic contamination is by iron particles. These particles can have their origin from carbon steel or from the weld decay itself, as ferrite can be formed during welding of stainless steel. A mechanical treatment of the welds could therefor enhance the corrosion problems.
To ensure all iron contamination is removed and the stainless-steel surface is passive it is advised to always perform a passivation of the stainless steel.

Background

At Marine Care we have a vast experience with corrosion on stainless steel surfaces. With this experience we have developed a range of kits and equipment to execute easy and reliable various essential tests. All of them help to understand

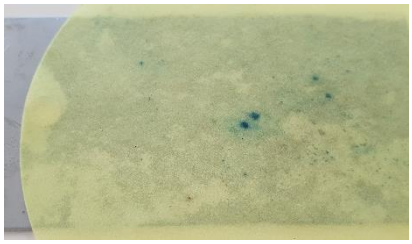
better what the condition of the stainless-steel surface is and what corrosion resistance to expect.

Standard austenitic stainless steel (304/316) or duplex?

The two most common types of stainless-steel used as cargo tanks are grades AISI 304 and 316. The essential difference between these two alloys is the presence of Molybdenum in the alloy AISI 316. Molybdenum in the alloy AISI 316 increases the corrosion resistance against aggressive elements, in comparison to AISI 304 grade. There is no visual difference between the two alloys, so only a simple drop test can tell in minutes if Molybdenum is present or not.
This is the **Moly Drop test**; after applying 3 to 4 drops onto the surface. The gel-like liquid can discolor after several minutes. If it does, molybdenum is present, and the alloy is 316 or higher quality (duplex). By checking if the surface is magnetic, can tell whether it is 316 (not magnetic) or Duplex (magnetic).

Is the surface contaminated with free iron?

During maintenance on stainless steel tanks, it often happens that carbon steel tools are being used on or near the stainless-steel tank surfaces. This can result in contamination with free iron particles on the stainless-steel surface that can induce a (quick) galvanic corrosion process resulting into pitting corrosion. With a **Ferroxyl Test kit** the iron particles are made visible for the human eye. By wetting a contact paper with the reagent liquid and applying it on the surface, a blue discoloration will show if the stainless-steel surface is contaminated with iron particles. The method is according to ASTM 380A.



Are the self-passivating properties correct?

Corrosion resistance of Stainless steel is based on a reaction of oxygen and chromium, resulting in a thin chromium oxide layer. Under the right conditions, this layer builds up to a minimal passive value. Factors that can disturb the buildup are for instance chlorides, carbon steel particles, aggressive chemicals and mechanical surface treatments like grinding. There are 2 methods to determine if the chromium oxide layer is sufficiently present; a passivation test kit with a reagent to be dropped on the surface and a more accurate and easier device that measures the resistance and is pre-programmed for 304, 316 and duplex steel: The Oxilyser III (manufactured by Marine Care).

Which passivation test method to use?

As described, there is a **Passivation Test Kit** where a palladium chloride reagent is used. As the reagent contains Hydrochloric acid it is highly corrosive to the stainless-steel surface. Another complexing factor is that the reagent has a water like viscosity, so will not adhere long enough on any surface other than horizontal.
An alternative method to measure the passivity of the stainless-steel surface is with the **OXILISER III.** It analyzes the quality of the chromium oxide layer by measuring the electrical surface resistance between 2 points on the stainless-steel surface using an electrode. The type of stainless-steel surface to be measured can be chosen on the machine. A red/green LED indicates if the value is acceptable as passive whilst the LCD display shows the exact resistance value of the chromium oxide layer. The device works on any angle of surface since only a wetted filter paper is pressed onto the surface with the electrode, and no other liquid is needed. When a passivity analysis needs to be done frequently (multiple readings per week) the Oxilyser III is also much more economic in use compared to the traditional ASTM passivation test.

How to improve life expenditure of stainless steel

In general, cleaning the surface with a mild pH water-based cleaner (Careclean Multiclean) is enough to keep the stainless steel in good condition. Under corrosive conditions an acid cleaner, for instance phosphoric acid based (Careclean Rust), is required. Passivation of the stainless-steel surface is done with Nitric or Citric acid (Careclean PL-Con, Careclean PL-CA) based cleaners. Hydrochloric Acid should be avoided on stainless steel. Once treated with dilutions of the proper acidic products in fresh (!) water, the surface must always be rinsed with fresh water with a low chloride level (< 20 ppm) again be given the chance to react with oxygen, the passivation process, which takes up to 4 hours after an oxidizing acid treatment. The passivation process can take up to 48 hours when only a freshwater rinse is done.

Products

Testing stainless steel:

- Ferroxyl Test Kit
- Moly Drop Test Kit
- Passivation Test Kit
- Oxilyser (III) Passivity Tester

For more information or questions please feel free to contact Marine Care.

Authors: B.J. Jongenotter, marketing & sales manager
Thomas van Os, Technical Application manager
Marine Care Group (www.marinecare.nl)