



Stainless Steel In Pool Environments

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Durable & Strong

Stainless steel is by far the most durable and trouble-free material available for use in a swimming pool, spa or aquatic environment. The unique characteristics of stainless steel that make it so ideal include strength, durability and corrosion resistance. Stainless steel simply doesn't shrink, spall, become porous, crack, peel or fail like most other materials used in aquatic construction.

The life expectancy of stainless steel is measured in a span of decades, not years.

Stainless characteristics

In order to understand how stainless steel can be used in the pool environment, it is necessary to understand the origin of stainless steel and how it chemically responds to certain environmental and man-made conditions. Stainless steel is a common chromium-nickel alloy steel used in thousands of products from ocean-going yachts to tableware.

Proper design and fabrication practices coupled with the right care and maintenance where stainless may be exposed to corrosive elements will help keep stainless steel beautiful and functional for years to come. Metal does rust, but in most environments, stainless steel is basically rust and corrosion-free. When properly maintained, stainless provides excellent luster, strength, and durability. In most aquatic environments, stainless will not rust or stain even after many years of service

Chemicals and stainless

There are some chemicals that can corrode stainless steel, but these chemicals do not typically appear in high enough concentrations to affect this alloy. In a pool environment, chemicals can be present which can affect stainless steel adversely. Because these same chemicals would be virtually devastating to other materials or metals, stainless steel is used. While stainless steel has tremendous corrosion resistance, it is neither stain-free nor corrosion-free. It can and will tarnish or corrode under certain circumstances. Nonetheless, these conditions are not representative of a normal or proper pool environment, nor do they typically affect the structural capacity of the materials. Properly selected and maintained, stainless steel is rust and corrosion free.

Stainless Types

Aside from steel, stainless steel is the most common construction metal. There are many different types of stainless steels, divided into five major categories by crystal structure type. The austenitic stainless steel alloys, with AISI numbers from 200 to 399, are usually nonmagnetic.

The alloys having numbers of 300 or above contain more nickel than those with numbers below 300 and have better chloride resistance.

300 series alloys are very corrosion resistant, and are used for many architectural and construction applications, particularly in a swimming pool or aquatic environment. The 300-series alloys will usually show no appreciable corrosion in fresh water or in properly maintained pool environments.

The 400-series ferritic and the martensitic alloys are usually magnetic, stronger, and less corrosion resistant than the austenitic alloys. Since 400 series are susceptible to rusting, they are not used in pool or aquatic environments.

Stainless Finishes

Stainless steel in the aquatic environment typically has a “polish” finish ranging from the standard number 3 polish finish to the mirror-like surface found in a number 7 polish.

The corrosion resistance of stainless steel is directly proportionate to the smoothness of the surface so the higher the polish, the less effect chlorines and other halogen salts will have on the surface.

Rough surfaces such as scratches, grooves or blasted or abraded areas provide myriad valleys that trap and concentrate the effects of halides. In many ways, the process is similar to the way the rough finish of a file will catch dirt and debris while the smooth finish of a glass lets debris simply wash away. Once corrosion begins and the protective or passive film breaks down, the deterioration increases dramatically.

Stainless Selection

Corrosion can and will occur on stainless steel swimming pools, spas and other aquatic environments if the wrong grade of stainless steel is selected, if poor fabricating or finishing techniques are used, or if the designer simply ignores well understood aspects of corrosion prevention. In the vast majority of cases where corrosion occurs in a swimming pool or aquatic environment, the specific causes are related to environment factors such as maintenance, chemical dosing, inadequate or non-existent cleaning, and similar problems that can easily be avoided with appropriate care.

Swimming Pool Material Selection

The proper grade of stainless steel for a swimming pool or aquatic environment is 304 or 316 stainless steel.

Type 304 is quite suitable for most interior and exterior aquatic environments, even with minimal maintenance. In situations where limited or no maintenance is performed or where other environment factors will produce a most aggressive and corrosive environment, the significantly more expensive 316 stainless steel may be justified.

When welding is to be performed, the stainless steel is typically specified to be to be “L” grade, which indicates that the carbon content of the stainless steel is in the range of .03% or lower.

Lower carbon content can reduce potential problems that arise from improper welding techniques or a lack of skill on the part of the welders performing the work.

Chemical Compositions of Stainless Steels

Wrought Stainless Steels									
Alloy	C	Mn	P	S	Si	Cr	Ni	Mo	Others
304	0.08	2.00	0.045	0.030	1.00	19.00	9.25	-	-
304L	0.03	2.00	0.045	0.030	1.00	19.00	10.0	-	-
316	0.08	2.00	0.045	0.030	1.00	17.00	12.0	2.5	-
316L	0.03	2.00	0.045	0.030	1.00	17.00	12.0	2.5	-

316 stainless steel differs from 304 in that 316 has slightly higher levels of Nickel along with molybdenum to improve corrosion resistance, particularly to chlorides.

Below Water Applications

When the primary use of stainless steel is below water, there is little justification for the selection of 316 stainless rather than 304. Assuming a proper pool environment, the conditions giving rise to corrosion simply are not present under water. When used above water, the cyclic splashing and drying of the stainless steel concentrates the chlorides present in pool water, which can lead to a corrosive attack on any grade of stainless steel although 316 stainless is more resistant to surface or pitting corrosion than 304 stainless. However, improper conditions resulting in corrosion on 304 stainless will eventually cause similar corrosion or deterioration on 316 stainless steel.

General or Diffused Surface Corrosion

General corrosion occurs when there is an overall breakdown of the passive film formed on the surface of stainless steel. It is the easiest to recognize as the entire surface of the metal shows a uniform “sponge-like” appearance or has a diffuse “rust-like” appearance. The rate of attack is affected by the chemical concentration, temperature, fluid velocity and stress in the stainless steel surfaces subject to attack.

As a rule, the rate of attack will double with an eighteen degree Fahrenheit rise in temperature (10° C), or a 25 percent increase in chemical concentration.

This form of corrosion often occurs because the surface of the metal has become contaminated with steel, which has little resistance to the rusting process. Such contamination can occur from virtually any contact between steel and the stainless steel. Since stainless steel is harder than steel, the steel is abraded and deposited on the surface of the stainless steel where it is available to quickly rust.

Pitting and Localised Corrosion

Pitting is accelerated form of corrosive attack where the rate of corrosion is greater in some areas of the metal and is typically seen in later or more advanced stages of corrosion. Pitting occurs when the corrosive environment destroys the passivated film in specific areas as opposed to the overall surface, such as the penetration of a specific area from a halide crystal or a speck of ferrous iron metal or steel.

This attack can be the result of environmental factors such as

- physical abuse,
- acid or halide attack,
- metal contamination
- or any highly localized conditions that remove the protective film and keep a new protective film from forming.

Once present, the iron oxide or foreign material products accelerates the corrosion process and the rate of deterioration increases significantly in comparison to the surrounding metal surface. In a moisture-laden environment, the area with localized corrosion that has become “active” through the destruction of the passive film layer reacts galvanically with the passive areas. The difference in the surface area and mass of the two areas accelerates the corrosion process and the pitting penetrates deeper into the metal surface. As the corrosion product and moisture fills the pit, oxygen no longer reaches the exposed metal and passivation does not occur prevents the oxygen from passivating the active metal so the corrosion continues unabated and becomes even worse as different corrosion processes become involved.

Concentrated Cell or Crevice Corrosion

Concentration cell corrosion or crevice corrosion occurs when a crack, crevice or other area is limited flow or interaction with a surrounding fluid or if the area is intermittently exposed, then isolated from moisture containing chlorides, such as chlorinated pool water. Such corrosion is common under nut and bolt surfaces, o-rings, gaskets or areas where stainless steel sections are touching. Painted or coating surfaces that trap moisture under the coating or that allow limited exchange with the surrounding fluid create conditions that are conducive to such corrosion.

The corrosion mechanism begins with physical or chemical attack on the surface, which forms localized pitting or when surface preparation leaves a rough, profiled surface. The pitting and corrosive attack occurs and intensifies when the solution becomes concentrated through evaporation or the lack of fluid exchange or flushing with the surrounding fluid. Oxygen is not present to restore the passive layer on the active stainless surface and the corrosion continues at an accelerating pace from direct attack and galvanic processes, as the pitted area is anodic to the remainder of the surface.

Metal Leaching

Leaching occurs when the fluid in contact with the stainless steel selectively removes metal ions from the interior surfaces of piping or other conduits that are exposed to concentrated liquid flows.

The corrosion occurs because of deionizing or demineralized fluids tending to replace missing metallic components. Heat and velocity accelerate the process. Metal leaching is far less common in a swimming pool or aquatic environment.

Biological Corrosion Micro Organisms

Biological corrosion is common in steel vessels and results from the action of microorganisms that can convert the carbon in steel to other forms. Microbially influenced corrosion of stainless steel is rarely encountered in an aquatic environment with stainless steel, but such organisms can attack the surface through a variety of means including damage to the protective passive layer through organic substances produced by the organism, the formation of concentration cells or promotion of galvanic corrosion. These tiny organisms can be aerobic, which need oxygen; anaerobic which exist in the absence of oxygen; and facultative organisms have the capability for both aerobic and anaerobic growth.

Galvanic Corrosion

If dissimilar metals or alloys in a common electrolyte such a water with chloride ions, an electric current will flow between the two metals that can be measured with volt meter. This is the basic principal of a battery. As the current flows, material is removed from one of the

metals or alloys (the ANODIC metal) and dissolves into the electrolyte, where it is carried to the other metal other metal (the CATHODIC metal)

Galvanic Series in water containing chlorides:

This well known series indicates the relative nobility of different metals and alloys in seawater, based on the measurement of corrosion potentials. In a galvanic cell, the more noble material in this series will become the cathode (no metal dissolution), while the less noble material will corrode as the anode. The greater separation of the materials in the galvanic series, the greater the potential difference between the materials; which predicts a greater degree of galvanic incompatibility when coupled.

Note that this galvanic series was derived for one specific electrolyte (water with chlorides), and materials react differently in different environments and at different temperatures. The series is based on (averaged) corrosion potential data and therefore does not give a direct indication of the rate of galvanic corrosion. Selected metals/alloys are shown below in a simplified version of this series:

Noble, cathodic end (PROTECTED)

- Platinum, Gold
- Graphite
- Titanium
- Silver
- HastelloyC
- Austenitic stainless steels (passive condition) (304, 316 series stainless steel)
- Iron-chromium alloys (passive condition)
- Inconel (passive)
- Nickel
- Monel
- Cupronickel alloys
- Bronzes
- Copper
- Brasses
- Inconel (active)
- Nickel (active)
- Tin
- Lead
- 18-8 Austenitic stainless steels (active, under attack, abnormal state)
- 13% Chromium stainless steel (active, under attack, abnormal state)
- Cast iron
- Mild steel and iron
- Cadmium
- Aluminum alloys
- Zinc
- Magnesium



Active, anodic end (CORRODED)

Metals towards the anodic end will tend to corrode, and the further apart two metals are located on the Galvanic Series chart, the greater the probability that the one towards the anodic end will corrode when an electrical pathway is formed by a conducting Water containing chlorides is one excellent conductor. The rate at which corrosion potentially occurs is determined by the distance separating the metals on the galvanic series chart and the temperature and concentration of the conducting solution. Higher temperatures result in faster reactions. Stray electrical currents in the conducting solution can also increase the probability and rate of corrosion. Furthermore, the relative size (mass) of the two pieces of metal also affects the rate of corrosion. An anodic metal with larger area will corrode as quickly or extensively as a smaller piece.

Intergranular Corrosion

All Austenitic stainless steels (the 300 series, the types that “work harden”, is one of them) contain a small amount of carbon in solution in the austenite. Carbon is precipitated out at the grain boundaries of the steel in the temperature range of 1050° F. (565° C) to 1600° F. (870° C.). This is a normal temperature range during the welding of stainless steel.

This carbon combines with the chrome in the stainless steel to form chromium carbide, starving the adjacent areas of the chrome they need for corrosion protection. In the presence of some strong corrosives, an electrochemical action is initiated between the chrome rich and chrome poor areas with the areas being low in chrome becoming attacked. The grain boundaries are then dissolved and become non-existent. To combat this tendency, low carbon content stainless steel is used when welding is to be done. A carbon content of less than 0.05% will not precipitate into a continuous film of chrome carbide at the grain boundaries, and such stainless materials are used in combination with controlled heat welding to limit the development of intergranular corrosion

Chloride Stress Corrosion

If the metal piece is under tensile stress, either because of operation or residual stress left during manufacture, the pits mentioned in a previous paragraph will deepen even more. Since the piece is under tensile stress, cracking will occur in the stressed piece. Usually there will be more than one crack present that causes the pattern to resemble a spider's web. Chloride stress cracking is a common problem in industry and not often recognized. However the threshold values required for stress cracking to occur typically are not experienced in a swimming pool or aquatic environment. The residual tensile stress, chloride levels, elevated temperature and the 300 series of stainless steel that are required for stress corrosion cracking **are not present in a normal pool or aquatic environment.**

At the same time, chlorides are the problem when using the 300 series grades of stainless steel. The 300 series is the one most commonly used in the swimming pool industry because of its good corrosion-resistance. Outside of water, chloride is the most common

chemical found in nature, and the most common swimming pool or aquatic water treatment is the addition of chlorine.

Insulating or painting stainless steel can exacerbate conditions that would normally not be conducive to such corrosion, and elevated temperatures can cause the metal to experience conditions beyond the threshold values for such corrosive deterioration.

Erosion Corrosion

This is an accelerated attack resulting from the combination of mechanical and chemical wear. Excessive velocity in stainless steel conduits, channels or piping can prevent the protective oxide passive layer from forming on the metal surface while suspended solids in the solution can abrade the passive layer, which increases the probability for galvanic corrosion or general surface corrosion. Erosion corrosion rarely occurs in an aquatic environment, even in high flow conditions.

Conclusions

1. Stainless steel is the most appropriate material for use in a swimming pool or aquatic environment.
2. Its durability, strength and low maintenance characteristics make stainless steel the perfect choice.
3. Proper design, correct material selection and reasonable maintenance will keep stainless steel corrosion-free, bright and attractive for years.
4. However, the first sign of corrosion must be properly addressed to prevent aesthetic damage.

For more information on stainless steel swimming pools or moving pool floors contact Wrightfield Pools on 01379 872800 or email sales@wrightfieldpools.co.uk



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Wrightfield Exclusive Natare Sales Agent, Manufacturer
& Installer for the UK & Ireland

Wrightfield Pools

Progress Way, Mid Suffolk Business Park
Eye, Suffolk, IP23 7HU, UK

Telephone: +44 (0)1379 872800

Fax: +44 (0)1379 872801

E-Mail: sales@wrightfieldpools.co.uk

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