Care and Maintenance of Stainless Steel in Pool Environments

The following information addressed the care and maintenance of any exposed stainless steel.

Natare Corporation uses a low carbon Type 304, or in some cases Type 316, stainless steel for our equipment because it has been demonstrated to be the best material for the intended purpose and has the best balance between corrosion resistance, strength, and relative cost. We take particular pride and concern to make certain our fabricated systems are both functional and attractive. The owner and operator of the swimming pool, however, must participate in a program of periodic maintenance if the equipment is to retain its original attractive appearance.

We want to ensure that your new systems are maintained in top condition, and we want to discuss the unique characteristics and maintenance requirements of stainless steel, which could lead to maintenance concerns or even the appearance of rusting and corrosion. In order to take better care of your pool and hopefully prevent or resolve housekeeping problems, it is necessary to understand exactly what stainless steel is and how it chemically responds to certain environmental and man-made situations.

In a natural environment, stainless steel is basically rust and corrosion-free. There are some chemicals that can corrode stainless steel, but in nature, these chemicals do not appear in high enough concentrations to affect this alloy. In an altered environment such as a pool, many 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. In order to help minimize the possibility of corrosion when such chemicals are present, it becomes necessary to understand exactly what is happening and why. With proper maintenance and chemical control, problems with stainless steel corrosion should be minimal.

Common occurrences include "rust" spots, streaks, staining, or a reddish discoloration of the stainless steel material. These conditions are generally symptoms of corrosion, and that is the term we will use for the entire range of occurrences. In discussing these matters, it is important to address numerous misunderstandings regarding "rusting" which arise from a misconception in the mind of the public with regard to stainless steel.

> 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.

General Corrosion Resistance of Stainless Steel

The general corrosion resistance of stainless steel is achieved by the use of chromium as an alloying element. The chromium combines with oxygen to form a thin transparent protective film on the surface of the steel. The process that causes this film to form is similar to the manner in which a rust film occurs on mild steel. In the case of stainless steel, this oxide film is quite stable and actually protects the steel in normal atmospheric or mild aqueous environments. Although this protective layer is quite tough, it can be pitted or broken down by the presence of concentrated halide salts. Halide salts (compounds containing chlorine, bromine, iodine, etc.) are among the most aggressive agents that contribute to the tarnishing or pitting of stainless steel, as they break down the thin protective film on the surface. Halide salts are always present because chlorine, bromine, and iodine are used as disinfectants in the treatment of pool water.

Chlorides are the most common form of halides in a pool environment and have been demonstrated to be extremely aggressive toward all metals, including stainless steel and aluminum. Chloride levels in pool water can approach those found in ocean water. Furthermore, a variety of maintenance chemicals and pH adjustment compounds either contain or produce halide salts. The destructive effects of halide salts are magnified by potentially wide swings in pH and temperature.

These halide salts are most damaging when splashed, sprayed or carried onto stainless steel surfaces and allowed to evaporate. The process of evaporation intensifies the level of these salts by many times over and leaves a concentrated solution or deposit on the stainless steel surface that quickly attacks the passive surface.

The only answer to halide salt concentrations and other forms of chemical attack is a conscientious and regular program of preventative maintenance coupled with knowledgeable and appropriate swimming pool operation. Careful control of swimming pool chemistry, along with recognition of the destructive effect of many cleaning compounds, will help to protect the swimming pool walls and gutter. When discoloration or tarnishing of the stainless steel occurs, a variety of specialty cleaners can be used.

As you are probably aware, the “hand broadcasting” of maintenance, cleaning or water treatment chemicals directly into the pool is somewhat common. Cleaning or maintenance chemicals are often applied directly to swimming pool decks and other surrounding areas. Such practices can also lead to staining or rusting problems.

The best possible cure for these problems is a concentrated effort toward the reduction of compounds that contain or produce halide salts in order to minimize the effect of long-term contact between these materials and the stainless steel. Rusting, staining or corrosion problems are almost always linked to chemical concentration or pH. In many pools, chemical levels are frequently too high and chemical consumption is much greater than that required for proper operation. By adjusting these levels to a proper chemical balance, you will have, at the very least, minimized your problem. Combine conscientious chemical control with regular flushing and cleaning of the metal surfaces, and corrosion problems will most likely be eliminated.

The surface of stainless steel can often be contaminated by contact with strong industrial cleaning compounds or through contact with “tramp” or stray metals. Stainless steel is quite hard and will abrade the surface of mild steel on contact. This scraping action leaves myriad pieces and particles of the mild steel impregnated in the surface of the stainless steel. As you might expect, the surface of the stainless steel then begins to show signs of rusting due to the deterioration of these steel particles.

From time to time, pool operators attempt to clean stainless steel materials with a steel wool pad causing devastating results. It is also possible that mild steel can become impregnated in the stainless steel surface from construction activities such as sandblasting, concrete finishing (steel trowels!) or reinforcing steel installation. Even some pool cleaning tools and accessories are made from mild or carbon steel. Aluminum will also be abraded by stainless steel and can produce localized staining or black, rust-like deposits. Even steel SCUBA tanks can impart mild steel to stainless steel pool equipment.

Many chemicals used to clean or treat concrete or ceramic tile will also establish conditions that are conducive to rusting or corrosion. Proper care during construction and a thorough cleaning of all stainless steel equipment immediately after the pool is first filled will eliminate many of these potential problems.

Increasing staff’s knowledge concerning the use of chemical disinfectants and cleansers is of immediate importance. There are pool operator courses and scores of literature to help efficiently operate a facility. The first step is to gather information on your particular chemical levels and to maintain pool water chemistry at recommended levels. Subsequently, the stainless steel must be thoroughly cleaned and neutralized or "passivated" (a process of re-establishing the oxide film). With a conscientious and constant program of pool maintenance, the problems of corrosion will be eliminated.

A Regular Cleaning Program is a Must!

No saltwater sailor would think of putting his boat away without first washing down the railings and stainless steel fittings with fresh water. Likewise, no diver would store his gear without first rinsing away all traces of saltwater. No cook would consider leaving his stainless steel cookware and countertops un-cleaned. **Stainless steel in a swimming pool environment is no different and requires the same care and attention.**

A regular cleaning program consisting of thorough and complete flushing with fresh water and wiping down of the stainless surface will minimize or eliminate the need for heavy cleaning and will greatly reduce or eliminate rusting and corrosion. Stainless steel railings, bulkhead trim sections, exposed edges of stainless steel gutter systems and other areas that are not regularly submerged will also benefit from a regular wiping down with a rag lightly coated with lemon oil polish or silicone spray. This will remove various scale and corrosion products while helping to protect the stainless steel. A high quality wax can be applied to stainless steel (above the water line) to seal and protect the surface. Small scrapes and scratches should be buffed out or polished to eliminate a crevice for corrosive materials to deposit.

This concept is best observed by inspecting your handrails or ladders. Most likely, you will find the area where your hands regularly grab the stainless steel tubing to be clean, shiny and free of corrosion. The lower parts of the tubing, particularly those just next to the deck, will generally be stained or rusty. This occurs because the wet hands regularly "clean" the tubing in certain areas while those next to the deck are seldom cleaned.

When traces of rust, surface deposits or corrosion do appear, more complete cleaning is required. This process consists of washing, cleansing and flushing the stainless steel surface with a specialized cleaner to remove all traces of the corrosive oxide scale which is seen as rust, film, or streaks. One product that is ideal for regular cleaning is *Natare's SS SuperClean*, which is also safe to use in a pool environment. Light scrubbing of the steel surface in the direction of the metal grain with the appropriate cleaning solution on a green Scotch Brite™ pad will also help remove this scale. Once all traces of surface deposits or rust are removed, the surface must again be flushed with clear water. Of course, proper safety precautions must be followed in accordance with the recommendations of the cleaning product manufacturer.

For cleaning in cases where corrosion, rusting or staining is well established or where surface contamination is suspected, professional, trained maintenance personnel can use special cleaning solutions to remove even heavy corrosion. Natare can assist with recommendations and procedures for dealing with such problems.

It is important to note that even mild or other chemical solutions can be dangerous, cause severe burns or blindness. Always wear protective clothing, eyewear and gloves, and strictly follow proper safety procedures.

ScotchBrite™ is a registered trademark of the 3M Corporation.

Acids, cleaning solutions and other chemicals can be extremely dangerous. Skin irritation, severe burns or blindness can result from improper use. Always read instructions carefully, have trained personnel assist with the use of such products and dispose of properly.

Natare Cleaning Products

Natare also provides cleaning products that are recommended for use in cleaning stainless steel materials in a swimming pool environment. These products have are tested by Natare and are approved as safe and satisfactory for cleaning of Natare stainless steel products. Natare SS Super Clean is an organic cleaner intended for regular cleaning and conditioning of stainless steel in a swimming pool or marine environment. Natare SS Clean and Brightener* is available for regular cleaning and brightening of stainless steel and is suitable for removing light corrosion. These products are available in 22 oz bottles and 1 gallon units. Natare has other products available when more advanced corrosion or rusting is occurring, but such products are professional cleaning products intended for use in commercial and industrial cleaning by careful, trained maintenance personnel. They are not intended for casual or residential use.

A number of proprietary cleaning products are commercially available which purport to clean and protect stainless. As a general rule, any cleaning product labeled and intended for cleaning surfaces in a pool or spa will be safe to use as long as directions are carefully followed and the cleaned area thoroughly flushed with water. Regardless, while many of these compounds could be quite effective, we do not have formulation information or know whether a particular product or products are safe for use with swimming pool water.

** Natare SS Clean and Brighten Solution is an extremely aggressive reagent and should be used sparingly and with extreme caution and proper safety equipment including clothing, eye goggles and gloves.*

Get specific advice and recommendations from your supplier before using such chemicals on your equipment and systems. Stainless steel can be damaged or stained quite extensively by incorrect product selection or the wrong cleaning technique, and many chemicals can actually be hazardous to swimmers if trace amounts enter pool water during the cleaning process.

By following these operation and maintenance guidelines, your stainless steel systems should remain functional and attractive for many years. If Natare can be of further assistance in keeping your new systems “Like New”, or should you have further questions or comments, please Natare or an authorized Natare distributor at any time.

Effects of Elevated TDS Levels on Stainless Steel Pools and Spas

Over the past decade, many pool operators have consciously reduce the amount of make-up water added to pools in an effort to control the cost of water. Additionally, the use of salt chlorine generation systems is beginning to be seen in public and commercial pools. At the same time, some "pool experts" have been promoting the idea that TDS (total dissolved solids) no longer matters in pool maintenance, which is contradictory to the long accepted practice of maintaining TDS at 1,500-ppm or lower.

Stainless steel is generally regarded as low maintenance and typically does not corrode in a properly maintained pool environment. Natare has been manufacturing stainless steel pools and pool equipment for decades and each piece of equipment undergoes an extensive and through cleaning after fabrication and the stainless steel is passivated prior to shipment. Typically, corrosion or rusting is related to water chemistry, improper cleaning techniques or a lack of regular maintenance, but often TDS (total dissolved solids) are found to be the root cause for the continuing problems with corrosion and rusting. Excessively high levels of total dissolved solids in pool water promote corrosion and exacerbate the tendency for saline attack.

What is TDS?

TDS is the measure of all combined content of all inorganic and organic substances contained in a liquid that are present in a molecular, ionized, or micro-granular (colloidal) suspended form. This measure is expressed as PPM (parts per million) or mg/ml (milligrams per liter), and the terms can be used interchangeably. TDS are indefinitely suspended in solution and are differentiated from total suspended solids (TSS), which affect the clarity of pool water, but which can be removed from the pool water by filtration. TDS cannot be reduced by filtration, nor will TDS ever "settle-out".

In the case of a swimming pool, the major component of TDS is salt or a "chloride", which is the end product of the chemical treatment of pool water. The primary swimming pool disinfectant and oxidizer is hypochloric acid, and this acid combines with various alkaline or "base" compounds to form chlorides. Furthermore, calcium and sodium based chlorinating compounds by nature are extremely alkaline and contribute to the "hardness" of pool water.

Corrosion in a high TDS environment where chlorides constitute a large percentage of the TDS levels can occur in many forms, and many different corrosion types occur simultaneously. Commonly, one type of corrosion can accelerate the development of other forms, and any corrosion creates the opportunity for deterioration. Crevice corrosion occurs spontaneously in the present of high TDS and chlorides, and stress corrosion cracking in weldments and fabricated stainless components can also occur. Once corrosion is present, the rate of corrosion increases exponentially.

As TDS increases, so does the conductivity of a solution. In fact, conductivity is the tool used to measure TDS. Since corrosion is electrical and involves a flow or exchange of electrons, the propensity for corrosion increases proportionately with an increase in TDS. Electrolysis, stray current and galvanic corrosion can begin when TDS reaches threshold levels while such corrosion would not be prevalent at lower TDS levels. Increased conductivity and the evaporation cycle on wetted surfaces of stainless steel in a pool environment create an ideal environment for corrosion when subjected to high TDS.

TDS and Associated Concerns

Some sources have suggested that corrosion will not be a problem at elevated TDS levels, but such comments are simplistic. Elevated TDS is typically the result of high chlorides, and there is considerable scientific literature that discusses the relationship of chloride concentration to corrosion of stainless steel alloys as well as other metals and metal alloys. It has been well documented that even lower concentrations of chlorides can promote pitting in stainless steels and localized attack, particularly in weld joints. In locations receiving significant and repeated pool water misting, but limited cleaning or flushing such as those under the grating and above the perimeter gutter, the evaporation of pool water makes the local environment far more aggressive than the TDS measurements suggest.

In short, the presence of high TDS causes the pool water to become corrosive towards many pool components. While the first attack, and typically the most sever corrosion is seen on areas subject to the evaporation cycle, corrosion can and will occur on metallic items above and below the water line as well as in any metallic components of the mechanical plant. Even concrete and the internal reinforcing steel will ultimately be attacked by high TDS pool water.

Corrosion of stainless steel from high TDS in a pool environment is caused by a chain of events beginning with water from the pool surface falling and splashing into stainless steel or where surface evaporation and agitation causes pool water to become areolized. Water is splashed onto the surface of the stainless steel, but is rarely cleaned or removed thus concentrating the corrosion tendencies of the pool water and accelerates the corrosion process. High TDS in the fluid, mist or vapor that deposits onto the stainless steel dramatically concentrates the TDS and triggers or accelerates the corrosive process.

Corrosive deterioration begins where localized forms of corrosion are typically concentrated at and radiating outward from epicenter where the corrosive event began. This epicenter is usually the result of the concentration of a halide or salt solution where the evaporation of water containing salts forms a concentration cell. Surface roughness, damage, or scratches in the material can contribute to the onset of corrosion, but simple evaporation can create a point of salt concentration that will destroy the passive or corrosion-resisting surface of stainless steel.

Corrosion related to high TDS is typically seen on the bottom of pool ladders, on exposed stainless steel immediately above the water line, on starting platforms, pool lifts, and on on structural members immediately below bulkhead grating. Stainless steel members that extend over perimeter gutter systems often show evidence of such corrosion. However, very little if any corrosion is seen on stainless steel below water.

Stainless steel areas such as crevices, areas under the cladding of a bulkhead or below the top surface of a starting platform are rarely, if ever cleaned, and the corrosive process continues unchecked. Similar evidence of is commonly seen on ladders, lifeguard chairs and other stainless steel equipment in the area just above the pool deck where regular cleaning may not be occurring. When the level of corrosion becomes advanced or results in pitting, advanced because of the high TDS in the pool water which means that even regular cleaning is inadequate to remove the surface contamination before damage occurs.

Many water quality standards set an upper limit for TDS of 1,000-ppm. In pools, however, the accepted levels for TDS have historically been 1,500-ppm. Regardless, we believe that 1,500-ppm should be considered a maximum value so that the corrosive tendencies of swimming pool water are minimized. It is well documented that the presence of TDS levels in excess of 1000-ppm in combination with organic acids, organic compounds and halides can and will contribute to corrosion in the form of rusting, pitting and pin-hole corrosion. Such corrosion begins on any metallic items in the pool and pool area. High TDS can also contribute to excessive turbidity of a lack of clarity in pool water and can also cause the precipitation of suspended matter in pool water or cause material in suspension to undergo a phase change from solution to suspension.

Based upon direct observation and testing pool water, we have often observed TDS levels in a range of 3,000 to 6,000-ppm (parts per million), despite the industry standard recommendation that TDS should never be allowed to exceed 1500-ppm. Many sources recommend TDS maintained below 1200-ppm. Such levels are consistent with normal operating standards for pool facilities and are considered to be the best practice for TDS in swimming pool water. For comparison, the upper limit for “fresh water” is considered to be 500-ppm and the United States has established a similar water quality standard for palatability of drinking water. In addition to being a trigger for a variety of corrosive conditions, high TDS levels in swimming pool water can distort pool water chemistry test results and cause a variety of water balance and operation issues.

To compensate for the hardness added to the pool water by water treatment chemicals, acidic compounds such as muriatic acid are added to pool water to maintain proper pH, alkalinity, and hardness levels. These acids react with the base (alkaline) portion of pool water treatment chemicals to form salt or "halides". All halides, and in particular chlorides such as sodium chloride, are the natural enemy of stainless steel as they break down the passive layer on the surface of the stainless steel, which is what provides the corrosion resistance. This attack upon the passive layer promotes the process of corrosion.

As a result of evaporation and continual addition of water treatment chemicals to the pool, TDS levels will increase unless the amount of fresh water added to the pool is adequate to dilute or offset such increase. In most pools, this requires that significant amounts of make-up water are added to the pool each day. To do so, an equivalent amount of water must be drained from the pool, lost through splash-out or other forms of water loss. In pools with high bather loads requiring high chemical dosing rates, the amounts of makeup water required to maintain TDS at appropriate levels can be quite substantial and may often amount to replacing a large percentage of pool volume each month. There are no reasonable or efficient ways to reduce TDS other than the addition of makeup water, and that makeup water must have a lower TDS levels than the pool. While TDS reduction can be accomplished through reverse osmosis, that process is neither efficient, nor cost effective for swimming pools.

Unfortunately for some pool facilities, the quality of pool makeup water available in many parts of the country can create difficulties in maintaining TDS as the locally supplied water may have a TDS level at or above the recommended pool levels. In such cases, little can be done to reduce TDS through dilution and the only solution lies in reducing the amounts of water treatment chemicals, even more attention to maintaining "steady-state" pool conditions or the adoption of ozone or UV treatment systems to enhance the oxidation of organic matter in the pool without increasing chemical dosing.

The addition of large amounts of fresh water is not an unusual event. In fact, fresh water is highly recommended, particularly where the fresh water supplies are of good quality. Most experts in pool sanitation and water chemistry agree that regular dilution through fresh water is critically important to proper pool operation. In many pools, water replacement rates can exceed 20% per month of pool volume or higher. While the addition of large volumes of fresh water can be a cost item, the benefits to both the users and the facility far outweigh the cost. Given the requirements of the EPA for TDS in portable water, the quality of the water is in most municipal systems is quite acceptable. On the other hand, well water can often have high amounts of TDS. Testing is source water is important in determining dilution programs and overall water chemistry maintenance.

300 Series stainless steel is typically used in swimming pool environments, and type 316 stainless is somewhat less susceptible to corrosion than type 304, which is the standard for metallic pool items such as gutter systems, filters, pool equipment, and bulkheads. However, conditions that lead to significant corrosion in type 304 will also result in corrosion to 316 in long term exposure.

With proper control of TDS and a reduction of halides through reduced water treatment chemicals, the conditions for rusting and other forms of corrosion in in a pool environment will be reduced significantly and stainless steel will perform quite satisfactorily. However, if corrosion is allowed to continue through neglect or inadequate maintenance, extensive cleaning may be required to remove the corrosion product and passivation of the surface to return the stainless steel to its original corrosion-resistant condition.

Recommended Pool & Spa Water Chemistry Standards

Proper pool and water feature operation requires careful attention to water chemistry and chemical levels. Pool operators must understand water chemistry and pay careful attention to maintaining those levels.

WARNING: Improper water chemistry and/or chemical levels that exceed recommended values or the improper addition of chemicals to a swimming pool or spa can be dangerous to users and may cause serious damage to equipment or pool systems.

Oxidation reduction potential (ORP)	**750 - 900** millivolts (mV) (commercial)
	865 mV to kill (Cryptosporidium, Giardia and viral inactivation)
Free available chlorine	**1.5 - 3.0 ppm - mg/1** or as needed to maintain a 750 mV ORP
Combined available chlorine	**< 0.3 ppm**
Total available chlorine	**No more than 0.2 ppm higher than free available chlorine**
Super chlorination	**As required for breakpoint, but no more than 10 ppm.**
Total bromine	**3.0 - 6.0ppm** or as needed to maintain a 750 mV ORP
Polymeric biguanide (PHMB)	**30 - 50 ppm *(never combine with chlorine)***
Hydrogen peroxide	**30-100 ppm**
Salinity (electrolytic cells only)	2,500 - 6,000 ppm (4,000 ppm ideal) - *See Total Dissolved Solids*
Sulfates	**< 200 ppm**
pH	**7.2 - 7.6**
Acid or base demand	**Neither**
Total alkalinity	**100 - 120 ppm**
Calcium hardness	**220 - 400 ppm** (dependent upon sanitizer used)
Langlier Saturation Index	**(-.5) to (+.5); 0 is preferred; *damage will occur outside these values!***
Total dissolved solids (TDS) *recommended*	**< 1,200 ppm or 1,000 ppm above start-up levels, whichever is less.**
Total dissolved solids (TDS) *recommended*	**< 800 ppm or 500 ppm above start-up levels, whichever is less**
Nitrate	**< 10 mg/L** (Uncontrollable algae growth at 25 mg/L)
Phosphates	**0.2 - 0.5 maximum**
Clarity	**Crystal clear** (silver dollar at deepest point)
	0.25 Nephelometric Turbidity Units (NTU)
	0.2 Jackson Turbidity Units (JTU)
Turnover time	
Multiple-use and competitive swimming pools	Four to six hours
Therapy pools, warm-water pool or heavy	Two hours
Wading pools, activity, splash pools	30-minutes
Spas	< 30 minutes
Water temperature (desirable)	104° F (maximum spas)
Therapy pools	86° - 94° F
Multiple-use and recreational pools	83° - 85° F
Competitive, lap or exercise pools	78° - 82° F
Total coliforms	
Presence/absence test:	Absent
Standard agar plate count:	< 200 bacteria per millimeter
Pseudomonas aeruginosa	
Presence/absence test:	Absent
Membrane filter technique:	< TNTC (too numerous to count)

In addition to these recommended values, the presence of copper, iron, or other metals can and will cause staining, discoloration and permanent damage to your pool systems. If metals are present in your pool or staining occurs, always seek professional advice to ensure that proper conditions are maintained.