

CORROSION PROBLEMS OF STAINLESS STEEL COMPONENTS IN INDOOR SWIMMING POOLS

KORROSIONSPROBLEME VON BAUTEILEN AUS NICHTROSTENDEM STAHL IN HALLENSCHWIMMBÄDERN

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SUMMARY

Indoor pool atmosphere shows a high level of corrosivity towards metallic components, including those made of stainless steel: Humidity and temperature are comparatively high, water films on the components are strongly acidic due to water disinfection using the chlorine gas process and in addition salt aerosols are deposited. Although a set of standards precisely regulates the use of stainless steels under these conditions, there is always extensive corrosion damage due to incorrect material selection at an early stage.

This article presents such corrosion damage and the requirements for stainless steels for use in the atmosphere of indoor swimming pools. Stainless steels for load-bearing components which are not cleaned regularly or which are subject to high visual requirements (no rust formation) require the highest level for stainless steel with the designation 1.4565, 1.4529 and 1.4547.

ZUSAMMENFASSUNG

Hallenbadatmosphäre zeigt eine hohe Korrosivität gegenüber metallischen Bauteilen, einschließlich solchen aus Nichtrostendem Stahl: Die Luftfeuchtigkeit und die Temperatur sind vergleichsweise hoch, Wasserfilme auf den Bauteilen sind aufgrund der Desinfektion des Wassers mit dem Chlorgas stark sauer und zusätzlich werden Salzaerosole abgeschieden. Obwohl eine Reihe von Normen die Verwendung von Nichtrostenden Stählen unter diesen Bedingungen genau regelt, kommt es immer wieder aufgrund einer falschen Materialauswahl frühzeitig zu umfangreichen Korrosionsschäden.

Dieser Artikel dokumentiert derartige Korrosionsschäden und die Anforderungen an Nichtrostende Stähle zur Verwendung in Hallenbädern. Tragende Bau-

teile, die nicht regelmäßig gereinigt werden und die hohen visuellen Anforderungen unterliegen (keine Rostbildung), erfordern Stähle mit hoher Korrosionsbeständigkeit der Werkstoff-Nr.1.4565, 1.4529 und 1.4547.

1. INTRODUCTION

Stainless steel is widely used in indoor swimming pools, both in contact with water (pool, shower, etc.) and in the atmospheric area. In the atmosphere, stainless steels are used for components inside the indoor swimming pool, these are often safety-relevant such as suspensions for ceilings or railings on galleries, but also for components of general equipment such as showers, handrails, storage racks and door fittings. The main reasons for using stainless steel in indoor swimming pools are

- the corrosion resistance of sufficiently high alloyed materials,
- optical advantages due to polished, shiny surfaces,
- the possibility to easily clean the components and
- hygienic aspects.

Despite the possibility of using sufficiently corrosion-resistant steels and cleaning surfaces from corrosion-triggering deposits by means of existing cleaning methods, there is always damage due to corrosion possible. Be it that surfaces become rusty or fail due to corrosion [1 to 5]. The causes of this corrosion damage are almost exclusively an incorrect choice of material for the intended application in the indoor swimming pool atmosphere. The atmosphere of indoor swimming pools is particularly critical from a corrosion-chemical point of view, especially for stainless steels. Due to the water composition, the frequently used disinfectant chlorination of the bathing water, a high air humidity adjacent to the pool and also the higher temperatures in indoor swimming pools, there is a critical corrosion exposure against stainless steel, which is why only specially alloyed materials can be used. Contrary to popular opinion, the use of galvanized steel in the atmosphere of indoor swimming pools operated with tap water is comparatively unproblematic from the point of view of safety [5]. However, components with such metallic coatings have disadvantages from the point of view of optics and cleaning compared to stainless steel and are therefore preferably suitable for use in invisible areas, such as for hangers of suspended ceilings. A major advantage of galvanized structural steel compared to stainless steels is the fact that they are completely unproblematic with regard to stress corrosion cracking, whereas stainless steels with an insufficient alloy content in the swimming pool atmosphere have a significant sensitivity to corrosion due to crack formation (stress corrosion cracking).

The problem of the corrosion sensitivity of insufficiently high-alloyed stainless steels was recognized by construction supervision bodies and experts. Regarding load-bearing components and fasteners in indoor swimming pools, there exist clear provisions regarding the required selection of materials [6, 7], which, however, have been repeatedly ignored in construction. It should be noted, however, that the prescribed higher quality steels are very expensive and not always available for the products to be used.

The author of this report examined around 30 indoor swimming pools with corrosion damage to metallic components. Section 3 shows some typical damage patterns from this activity. The focus is on the so-called pitting corrosion of stainless steels, which leads to rust discoloration of the surfaces, and stress corrosion cracking, which can yield failure of load-bearing components.

As corrosion mechanism and damage patterns are also influenced by special features of the respective indoor pool atmosphere, the corrosion exposure (corrosiveness) of the swimming pool atmosphere is first discussed in Section 2. Subsequently (in Section 4) the corrosion behavior of stainless steels under indoor swimming pool conditions is characterized and the requirements for stainless steels in the atmosphere of indoor swimming pools including corresponding standards are presented.

2. CORROSIVENESS OF THE INDOOR POOL ATMOSPHERE

The corrosiveness of an indoor pool atmosphere for metal parts, including components made of stainless steel, is increased by the following causes [1, 5, 8]:

- Increased water vapor content and increased temperature of the air,
- occasional condensation,
- deposits of saline aerosols and
- disinfection treatment of the pool water.

2.1 THE HUMIDITY IN THE INDOOR SWIMMING POOL

Due to the evaporation of water, the indoor pool air is always "damp" to a certain degree and the existing air humidity is a burden for people present and for the existing building materials. The amount of evaporation mainly depends on the temperature conditions in the pool area, pool size and wave motion (the greater the movement on the water surface, the higher the amount of evaporation).

In order to have a comfortable stay for the bathers and to avoid health risks (condensate is a breeding ground for e.g. molds), suitable ventilation and air conditioning measures (replacement of humid air with fresh air) must be taken to ensure

that a so-called humidity limit in the indoor pool area is not exceeded. According to VDI 2089 [9], the humidity limit for undressed people is 14.3 g (water)/kg (dry air). At an indoor air temperature of 30°C, for example, this corresponds to a relative air humidity of around 55 to 60%. Limiting the air humidity is also necessary in order to make condensation more difficult and to avoid damage to the building.

2.2 SALINITY IN THE AIR

Convection is used to remove salts such as sodium chloride NaCl dissolved in the finest water droplets from the bath water and deposit them on metal parts in the atmospheric area. While the chloride content in the water of freshwater swimming pools is in the range of 0.1 g/liter Cl⁻, mineral or brine water contains a multiple of chloride depending on the composition. Up to 5 % by mass of chlorine was found in deposited solids on metallic components in the atmosphere of indoor swimming pools operated with tap water; in a mineral bath 18% by mass and in a brine bath 40% by mass of chlorine (both present as chloride) were measured [1].

Although the indoor pool atmosphere is usually not so humid that water films exist on the surfaces of metal parts, due to their hygroscopic character, some salts can form saturated salt solutions in the usual dry interiors, and thus also in interiors such as indoor swimming pools create critical corrosion conditions [2, 8]. The ability to form corrosion-aggressive salt solutions depends on the type of salts and the content of these salts in the indoor pool atmosphere. "Hygroscopic" means the behavior of a salt to bind vaporous water from the air and to separate it as liquid water. As pronounced hygroscopic substances, some salts promote the formation of aqueous solutions even at low relative humidity. With the so-called saturation moisture (Fig. 1), a characteristic relative humidity for each salt, salts form saturated salt solutions. Above the saturation moisture level, the salt continues to absorb water and "flows away" with increasing relative humidity. This additional water absorption is accompanied by an increasing dilution of the saline solution.

Concerning the salinity of tap water, sodium chloride governs. Sodium chloride has a comparatively high saturation moisture of 78%. When deposited on components and fastenings above the water surface, it only has a corrosive effect if, for example, condensation forms or splash water has access. In mineral and brine waters, the strongly hygroscopic salts calcium and magnesium chloride are often contained at elevated contents, which liquefy even in dry indoor climates with air humidity of little more than 30% and attack stainless steel as a highly concentrated salt solution.

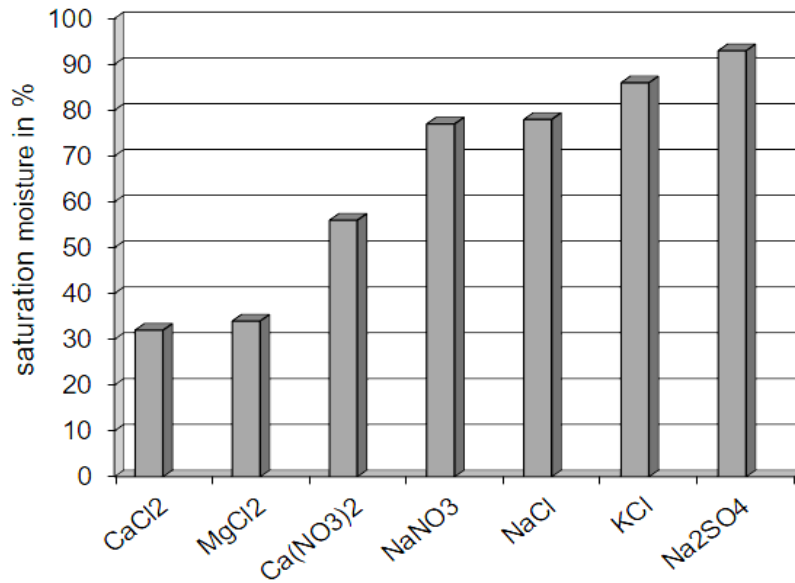


Fig. 1: Saturation moisture of some neutral salts [8]

Fig. 2 demonstrates this behavior for the example of calcium chloride. Here, small particles of calcium chloride were placed on an insufficiently resistant stainless steel.



Fig. 2: Liquefaction of calcium chloride on sheet steel 1.4401 in dry air ($\approx 45\%$ relative air humidity) (Source: Lecture Nürnberg)

Within a short time, the salts liquefied, formed a highly concentrated salt solution by absorbing moisture from the surrounding atmosphere and attacked the stainless steel.

2.3 DISINFECTION TREATMENT

Another peculiarity of the corrosiveness of the atmosphere in indoor swimming pools results from the disinfection treatment of pool water [1 to 5]. Disinfection is predominantly carried out using the chlorine gas process. The chlorine added to the bath water reacts with water to form hypochlorous acid HOCl and hydrochloric acid HCl



HOCl with a strong oxidizing effect is the disinfectant. In pool water, the hypochlorous acid reacts with all organic oxidizable substances and compounds, so it is consumed. It continues to decay in water according to

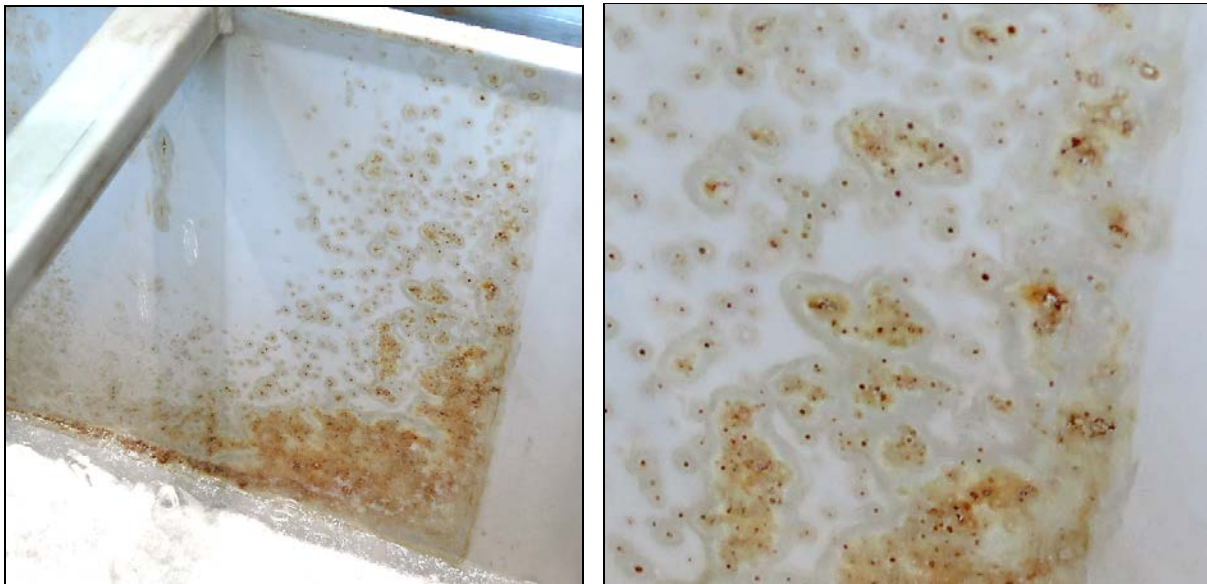


To maintain the disinfecting effect, the free chlorine content should be at least 0.3 mg/l, but not exceed 0.5 to 0.6 mg/l. By reversing the reaction (1) above the swimming pool, chlorine gas can always form again from the excess chlorine, which is predominantly present as HOCl, and escapes into the environment. Due to the content of free chlorine and chloride salts in the hall air (Section 2.2), these substances can settle on metal parts and also concentrate, especially if the components are neither cleaned nor washed around with water. The formation of hydrochloric acid and hypochlorous acid is possible in existing electrolyte films. The latter is a strong oxidizing agent, which increases the risk of corrosion, particularly in the case of passive metals such as stainless steels.

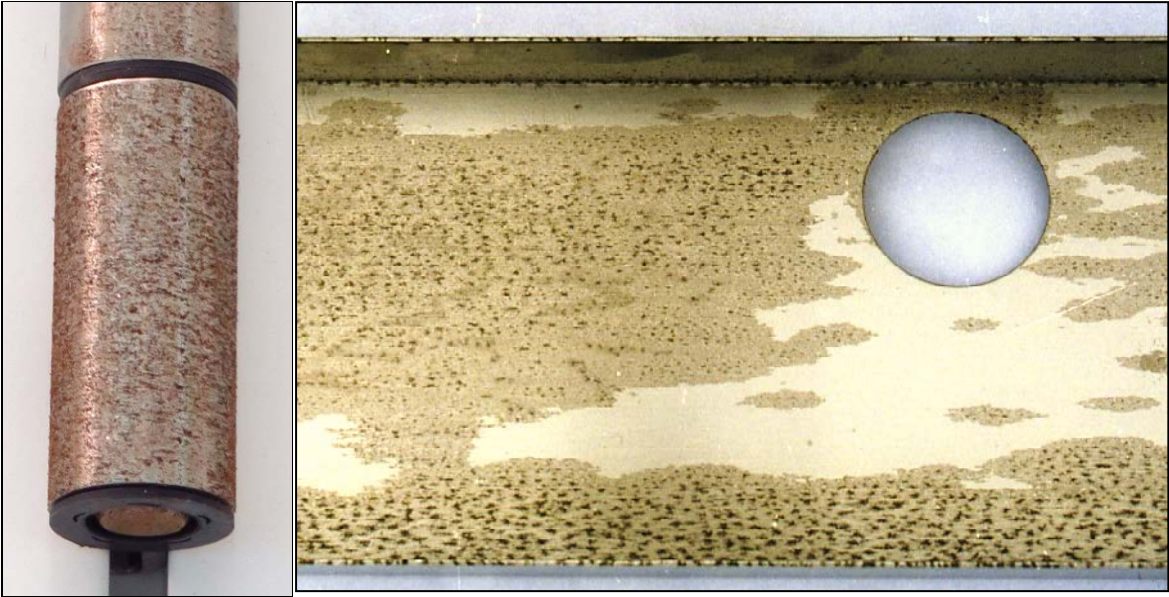
All in all, it should be noted that, due to the nature of the operation, surface films are formed that are rich in salt and acid. These also have a strong corrosive effect on stainless steels, which is why only materials with a specially coordinated chemical composition may be used. These materials made of stainless steel are regulated in building provisions and must be taken into account when planning stainless steel equipment in indoor swimming pools (see Section 5).

3. DAMAGE PATTERNS OF STAINLESS STEELS IN TAP WATER OPERATED INDOOR SWIMMING POOLS

In the atmosphere of indoor swimming pools with disinfection treatment based on chlorine gas, there is pitting corrosion (Section 4.2) and stress corrosion cracking (Section 4.3) of insufficiently alloyed stainless steels possible on non-cleaned components. Repeatedly both types of corrosion occur simultaneously. Only components that are not permanently flushed with water and components that are not or only rarely cleaned in the swimming pool atmosphere are affected. These are load-bearing components in the ceiling area, railings, posts of railings, diving boards, pool borders and pool overflows with occasional water wetting, fittings on doors and windows. Figs. 3 to 13 show typical signs of corrosion from indoor swimming pools that are operated with tap water and in which the water is disinfected using the chlorine gas process: Figs. 3 to 8 indicate pitting corrosion and rust formation, Figs. 9 to 13 demonstrate stress corrosion cracking.



Figs. 3 and 4: Pitting corrosion on the occasionally water-wetted outflow surface at the pool overflow, stainless steel 1.4404, after 2 years



Figs. 5 and 6: Pitting corrosion on door hinge (left) and lamp cover (right) made of stainless steel 1.4301 after one year

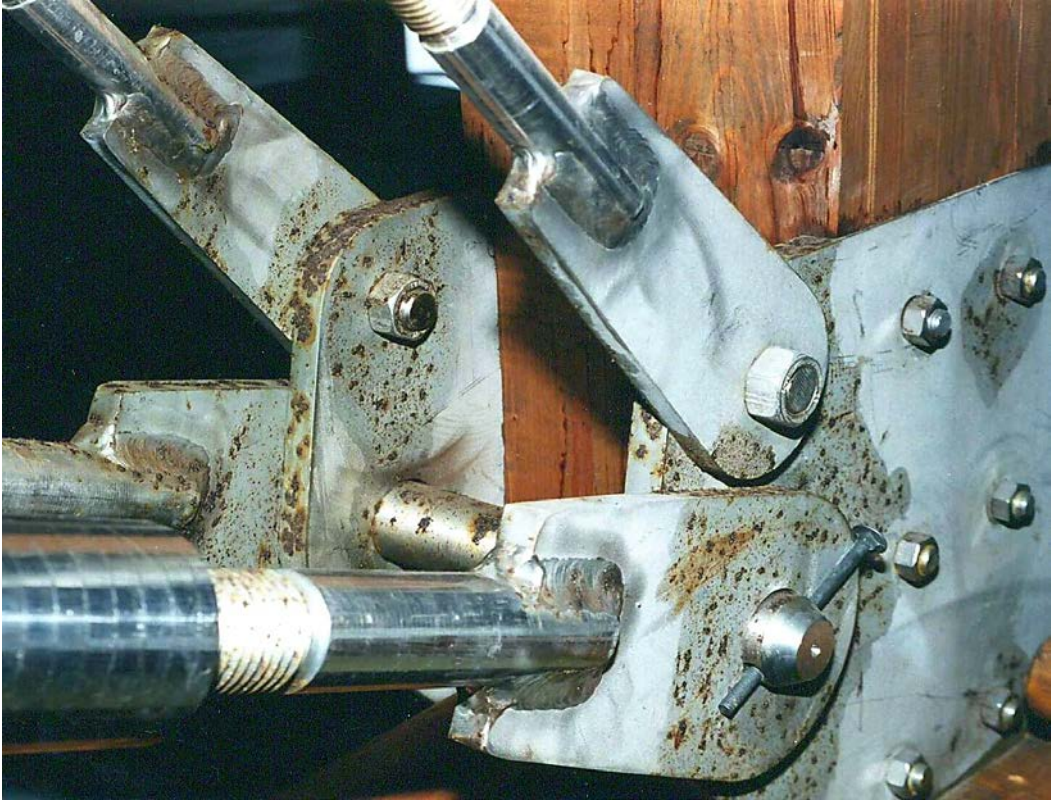


Fig. 7: Pitting corrosion on tension bars made of stainless steel 1.4571 after 9 years



Fig. 8: Pitting corrosion and rust formation on fittings made of stainless steel 1.4301 in the technical room after 3 years

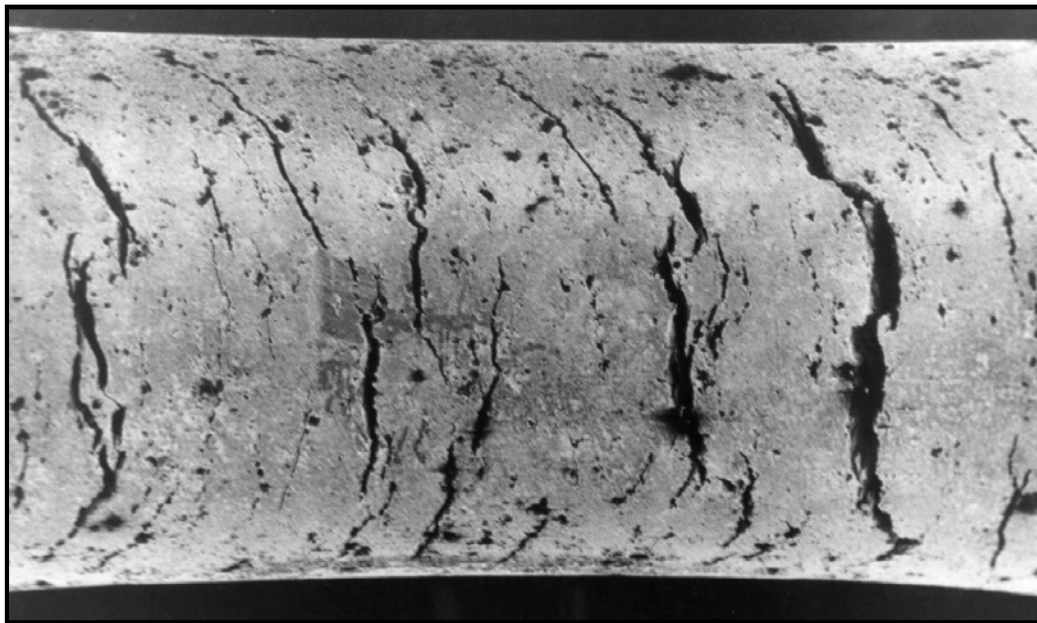
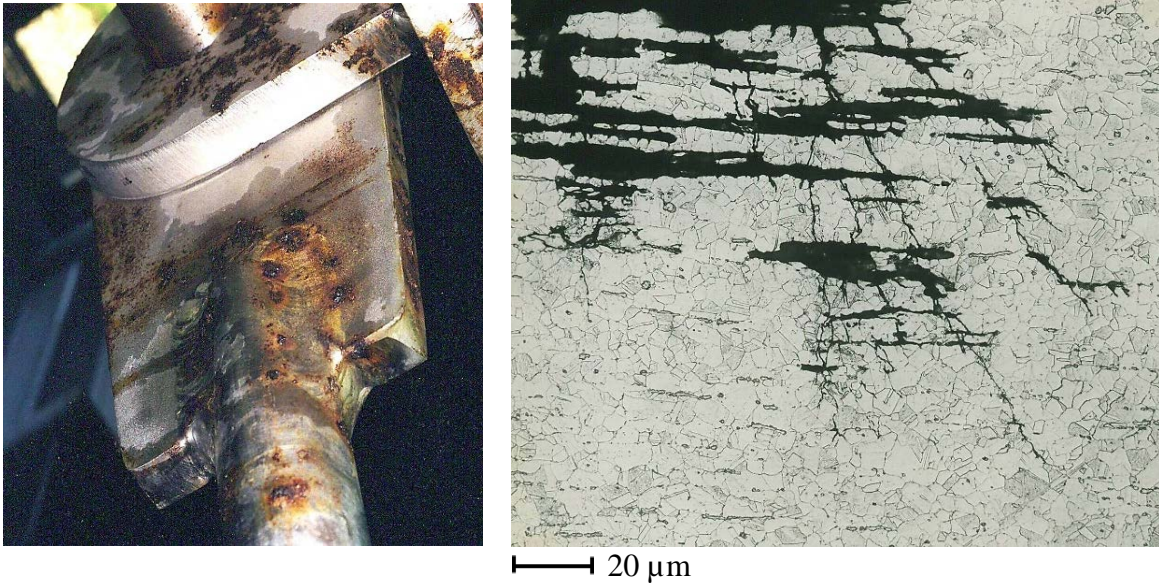


Fig. 9: Stress corrosion cracking on the clamp of a lamp made of stainless steel 1.4571 after 2 years



Figs. 10 and 11: Stress corrosion cracking of welded joint on tension bars made of stainless steel 1.4571 after 9 years



chemically cleaned

Figs. 12 and 13: Pitting and stress corrosion cracking (see: arrow) on cap nuts made of stainless steel 1.4401 after 13 years

4. PROPERTIES OF STAINLESS STEELS [8 AND 10]

4.1 GENERAL RELATIONSHIPS

“Stainless steels” are high-alloy steels in which, in contrast to unalloyed and low-alloy steels, there is no uniform corrosion and rust formation under normal environmental conditions and in aqueous, almost neutral aqueous media. For this reason, additional corrosion protection is generally not necessary. A prerequisite for this behavior is a chromium content (Cr) of the steel of at least about 11% by mass and the presence of an oxidizing agent such as oxygen in the surrounding medium. This creates a passivation of the surface by forming a chromium oxide

layer and thus protection against corrosion against a variety of chemical attacking substances. The corrosion resistance of the steel compared to the possible types of corrosion is further improved by higher contents of chromium and/or alloying of further elements such as nickel (Ni) and molybdenum (Mo) and nitrogen (N).

With the selection and content of the alloying elements, a special structural condition is created for the stainless steels. For this reason, these materials are classified into ferritic, austenitic, ferritic-austenitic and martensitic steels according to their structural state. They differ in their physical, mechanical and corrosion properties. However, martensitic steels are not used in structural engineering.

In structural engineering, austenitic steels, which have high levels of the alloying elements chromium, nickel and molybdenum, are mainly used because of their very good properties compared to normal environmental conditions:

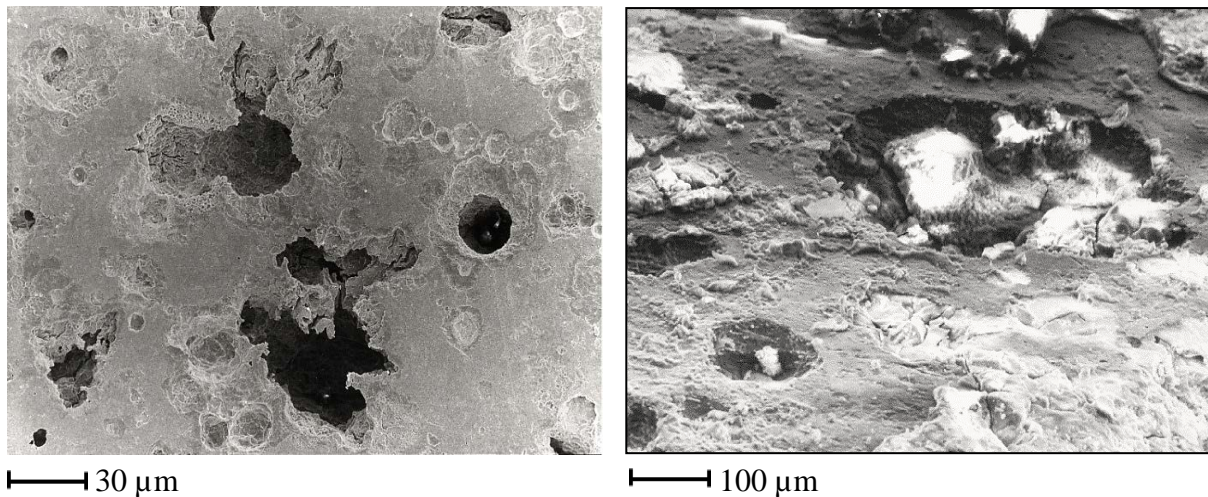
- Chromium stabilizes the passive layer,
- molybdenum improves the corrosion resistance in the presence of chlorides and
- nickel is primarily responsible for the acid resistance.

If the alloy content is insufficient in saline and acidic environments (atmospheres, aqueous solutions), passive steels suffer local corrosion attack (pitting corrosion) and stress corrosion cracking, an attack that involves cracking of the component.

4.2 PITTING CORROSION

4.2.1 Mechanism

Pitting corrosion (Figs. 14 and 15) on components made of stainless steel in the atmosphere of indoor swimming pools is the result of an attack by the chloride salts deposited on the surfaces (Section 2.2). These can liquefy due to their hygroscopic behavior or they form highly concentrated salt solutions when dissolved in thin water films.



Figs. 14 and 15: Pitting corrosion (Fig.14: Corrosion products chemically removed)

Pitting corrosion is initiated by an interaction between chloride ions and the passive layer, whereby this protective chromium oxide layer is locally broken. Hole-like deepenings develop and due to their growth pitting corrosion spots are formed. These corrosion holes, which are often only visible to the eye as small brown spots (e.g. Figs. 3 to 6) and usually reach a maximum of a few tenths of a millimeter in depth, are the "source" of rust formation on the surface. The rust spreads like a streak across the surface (Figs. 3 and 4) and colors it brown (Fig. 8). The visual influence of pitting corrosion is therefore considerably more pronounced under atmospheric corrosion conditions than the influence on the load-bearing capacity.

The resistance of stainless steels to pitting corrosion is favoured by influences of the environment, material and surface condition.

4.2.2 Influence of environment

The presence of chloride ions is decisive for triggering pitting and crevice corrosion (see below). On the part of the environment, pitting corrosion is increased by increasing chloride levels and temperatures as well as falling pH values (acidification). Acidic media enriched with chloride ions in a warm atmosphere are therefore particularly critical. In this respect, components made of stainless steel are particularly exposed to corrosion in an indoor pool atmosphere:

- Depending on the salt content of the pool water, more or less high salt concentrations accumulate on the components (Section 2.2).
- Because of the water treatment using the chlorine gas process, water films on metallic surfaces are very acidic. (Section 2.3). On the surfaces of stainless

steels in indoor swimming pools, pH values around 3 were measured on corrosion products [1].

- In addition, the air is humid and warm (Section 2.1). Indoor pools have a comparatively high temperature of over 30 ° C. The air humidity is also high due to the large water surface and elevated temperature of approx. 14.3 g (water) / kg (dry air from the point of view of corrosion).

4.2.3 Influence of material

On the material side, pitting corrosion is influenced in particular by the alloying elements chromium, molybdenum and nitrogen, and also by nickel:

- Chromium, molybdenum and nitrogen in steel limit the influence of chloride
 - and nickel limits the influence of acids
- to pitting corrosion.

The resistance to chlorides, dissolved in almost neutral aqueous media, can be approximated estimated by the so-called Pitting Resistance Equivalent (PRE)

$$\text{PRE} = \% \text{Cr} + 3.3 \cdot \% \text{Mo} + 16 \cdot \% \text{N} \quad (3)$$

(Cr stands for the chromium content, Mo for molybdenum and N for nitrogen). The resistance to chloride-induced local corrosion increases with increasing PRE (Section 5, Table 1).

Increased nickel contents in the steel are required

- to improve the resistance to chloride-induced pitting corrosion in acidic media
- and / or if design-related crevice corrosion (see below) plays a role
- and / or stress corrosion cracking (Section 4.3) is possible.

4.2.4 Influence of surface

In addition to the content of alloying elements, the corrosion resistance of stainless steels is also governed by the surface condition of the materials. The pitting corrosion resistance of stainless steels is generally better, the smoother and more homogeneous the surface is. From the point of view of corrosion technology, the surface quality therefore increases in the order of scaled - blasted - ground - stained - polished. Cold-formed surfaces correspond roughly to the state of grinding in terms of their susceptibility. Polished surfaces (e.g. the handrails of a swimming pool) are more corrosion-resistant than cold-rolled stainless steel (e.g. sheets around the pool). Compared to the influence of the materials analysis, however, the influence of the surface is comparatively small.

4.2.5 Influence of welded joint

Welding the stainless steels also leads to a surface in the vicinity of the welded connection that is less favorable in terms of corrosion chemistry. Welded connections that are not created under protective gas have next to the weld seam so-called tarnishing colors (thin oxide layers that form due to the prevailing high temperatures of the arc from 3000 to 4000 °C). Then the corrosion behavior (the passivation) of stainless steels can be adversely affected at these locations. For the purpose of corrosion protection, but also for optical and hygienic reasons, the tarnish colors should be removed from welded constructions in indoor swimming pools.

4.2.6 Influence of design

If components are in contact with one another, crevice corrosion is possible. This refers to pitting corrosion in narrow crevices when assembling components. Resistance to pitting corrosion in crevice-free areas is always reduced in crevices between components which are in contact. Under crevice corrosion conditions there is an oxygen depletion in the crevice and therefore passivation is more difficult. A chloride supply allows for a concentration of chloride ions in the crevice and a hydrolysis of the corrosion products. This leads to acidification of the electrolyte due to hydrolysis of iron chloride (FeCl_2):



This can cause the pH value to drop to about 4 to 5. Strong acidifications with $\text{pH} < 2$ are possible through hydrolysis in stainless steel existing chromium ions Cr^{3+} . As a reason for the preferred hydrolysis of the chromium can be seen the increase in solubility for chromium through the presence of chloride ions. Corrosion in crevices therefore occurs with stainless steels in the presence of pollutants such as chlorides, even with a weaker corrosion exposure than pitting corrosion in crevice-free areas. The addition of sufficiently high nickel contents to the steel also improves the resistance to chloride-induced crevice corrosion.

4.3 STRESS CORROSION CRACKING

4.3.1 Mechanism

Stress corrosion cracking is corrosion that occurs through cracking. This type of corrosion occurs when the following conditions apply at the same time:

- The surface of the component is under increased tensile stress. In metal construction and also in components in an indoor swimming pool, these are generally no stresses resulting from increased loads, but residual stresses resulting from cold forming or welding.
- A specifically effective media acts on the component.
- There is a specific susceptibility of the steel to this type of corrosion.

4.3.2 Influence of environment

Stress corrosion cracking is primarily to be expected in media containing chloride ions, whereby the risk generally increases with increasing chloride content, falling pH value and increasing temperature. These influences also favor pitting corrosion in stainless steels, which means that both types of corrosion, pitting and stress corrosion cracking, often occur simultaneously. Based on the following relationships, it can also be assumed that the chloride-induced pitting corrosion also favours stress corrosion cracking in a special way. In the chloride-containing media of an indoor pool atmosphere, you will therefore very often find stress corrosion cracking induced by pitting corrosion:

- In a first step, corrosion pits form as a result of a chloride attack. In this corrosion reaction, metal salts such as iron chloride FeCl_2 are developed.
- In a second step, the hole electrolyte is acidified via a hydrolysis reaction of the corrosion product (see above).

In the acidic hole electrolyte, the environmental requirements for crack formation due to stress corrosion cracking are high (Figs. 16 to 18) [2, 8].

4.3.3 Influence of material

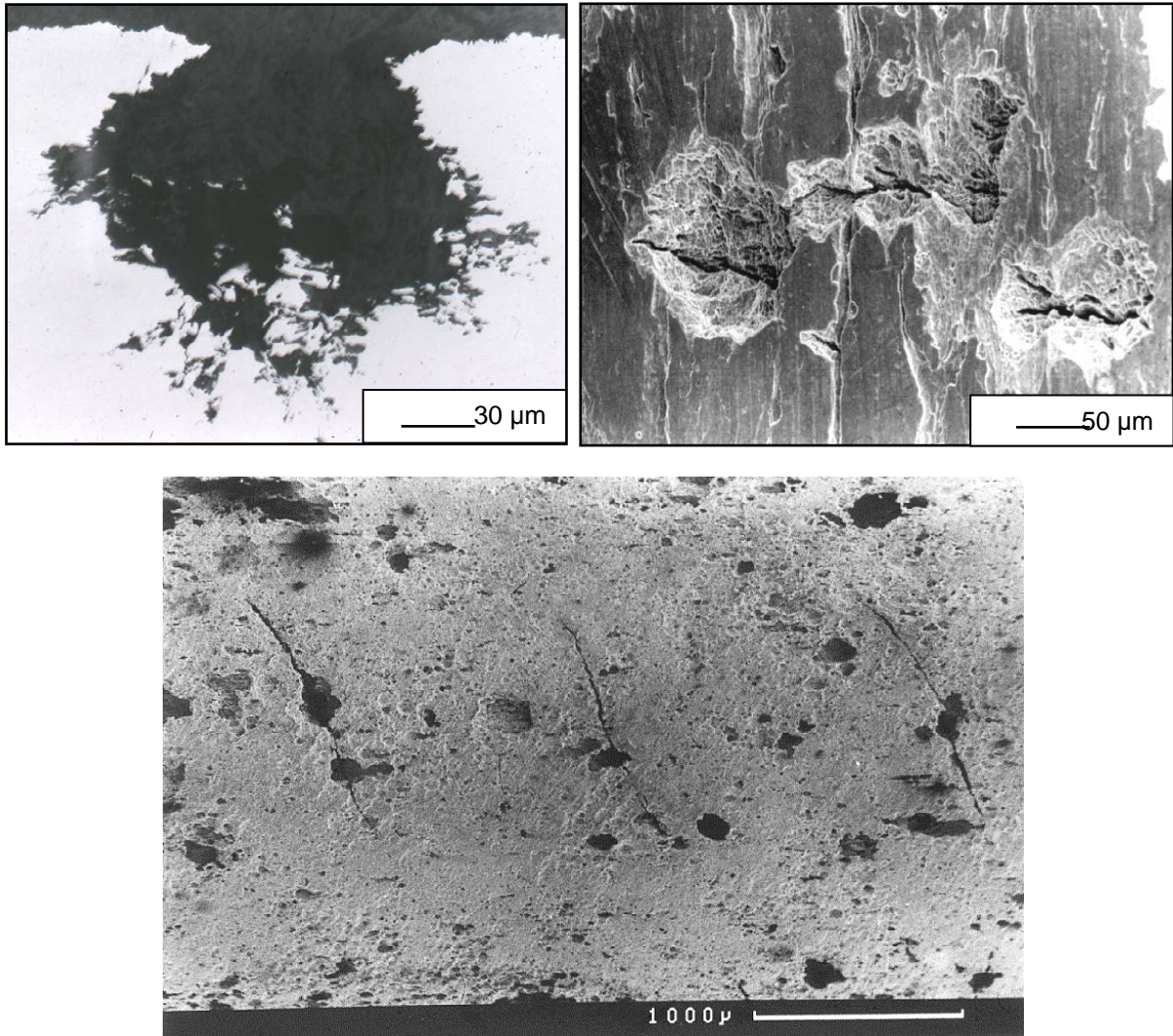
The stainless steels with austenitic structure used in construction technology are susceptible to stress corrosion cracking. However, damage with this type of corrosion is only known when used in indoor swimming pools and tunnels (which have a similar level of corrosion exposure as indoor swimming pools). The particular susceptibility of these materials can be explained primarily by the influence of the nickel content on the susceptibility of high-chromium steels to stress cor-

rosion cracking. A susceptibility exists with nickel contents between approximately 5 and 20 mass % and a minimum of the resistance exists with approximately 10 mass% nickel. The frequently used austenitic steels of the corrosion resistance classes CRC II and III (Table 1) with nickel contents around 10% by mass are therefore considered sensitive to stress corrosion cracking in critical media. The steels affected by stress corrosion cracking in Figs. 9 to 13 are to be assigned to this group of steels.

5. CORROSION RESISTANCE REQUIREMENTS FOR STAINLESS STEELS WHEN USED IN INDOOR SWIMMING POOLS

When used for mechanically stressed components, stainless steels are divided into corrosion resistance classes CRC I to V with regard to their corrosion resistance. The criteria are structural requirements, but not the decorative look, for example in the form of undesirable discoloration. However, the requirements for load-bearing structures can also be applied analogously if the appearance of the components plays a role, which can be assumed in a public swimming pool.

The regulations in the relevant building inspectorate approval [6] in conjunction with DIN EN 1993-1-4 [7] also apply to indoor swimming pools. The corrosion resistance increases in the order CRC I to V (CRC = Corrosion Resistance Class) (Section 4.2). With increasing Corrosion Resistance Class, the Pitting Resistance Equivalent PRE also increases, criterion for resistance to pitting corrosion. Nickel also improves the behaviour towards acidic environmental influences that are effective in indoor swimming pools (Section 3.3).



Figs. 16 to 18: Pitting induces stress corrosion cracking of stainless steel 1.4301 in an indoor swimming pool - examples

Table 1 divides stainless steels used in structural engineering into Corrosion Resistance Classes CRC I to V, names the chemical composition and the responsible material number with the short name and also the resulting Pitting Resistance Equivalent PRE as a criterion of resistance to pitting corrosion (see Section 4.2). The steels specified for corrosion resistance classes III to V are the steels suitable and therefore permitted for indoor swimming pools in these classes. The types of steel that are not permitted for corrosion resistance classes I and II are examples of these classes.

Table 1: Classification of stainless steels when used for mechanically stressed components and connections in an indoor swimming pool, which is operated with chlorinated tap water (this assessment can also be accepted if optical aspects play a role)

Structure	Material No.	Steel grade	PRE	CRC	Allowed in indoor swimming pool	
					Atmosphere	Water
F	1.4003	X2CrNi 12	11	I low		not allowed
F	1.4016	X6Cr 17	17			
F	1.4512	X2CrTi 12	17			
A	1.4301	X5CrNi 18-10	18	II moderate	not allowed	up to 200 mg Cl / liter allowed
A	1.4567	X3CrNiCu 18-9-4	18			
A	1.4311	X2CrNiN 18-10	20			
A	1.4307	X2CrNi 18-9	18			
A	1.4541	X6CrNiTi 18-10	18			
F-A	1.4482	X2CrMnNiMoN 21-5-3	21			
A	1.4401	X5CrNiMo 17-12-2	24	III medium	allowed for components with regular cleaning	
A	1.4404	X2CrNiMo 17-12-2	23			
A	1.4578	X3CrNiCuMo 17-11-3-2	24			
A	1.4571	X6CrNiMoTi 17-12-2	24			
A	1.4439	X2CrNiMoN 17-13-5	36	IV high		
A	1.4539	X1NiCrMoCu 25-20-5	37			
F-A	1.4462	X2CrNiMoN 22-5-3	34			
A	1.4565	X2CrNiMnMoN 25-18-6-5	43	V very high	allowed for components without regular cleaning	because of economic reasons not useful
A	1.4529	X1NiCrMoCuN 25-20-7	42			
A	1.4547	X1CrNiMoCuN 20-18-7	45			

PRE = Pitting Resistance Equivalent; CRC = Corrosion Resistance Class

F = ferritic; A = austenitic; F-A = ferritic-austenitic

Table 1 shows:

- For the use of stainless steels in the particularly corrosive indoor pool atmosphere apply, especially because of the high probability of stress corrosion cracking, special (high) requirements for the steel composition.
- Stainless steels with a Corrosion Resistance Class CRC II and III (e.g. steels of material no. 1.4301 and 1.4401) are particularly sensitive to chlorides and acids, since pitting and stress corrosion cracking are possible [1 to 3]. This is why such steels are problematic for use in an indoor pool atmosphere [11], especially if chlorine gas is generated during disinfection. For this reason, steels with CRC II and PRE of about 20 for load-bearing structures are generally not permitted for this atmospheric area. The following regulation applies to steels of CRCs III:

- In indoor swimming pools in the corrosion resistance classes CRC III to CRC V, only selected steels may be used if they are cleaned regularly.
- Only steel grades 1.4565, 1.4529 and 1.4547 of a CRC V with a PRE > 40 may be used for components and fasteners in an indoor pool atmosphere without regular cleaning of the components in accordance with the applicable regulations [6, 7].

If the stainless steels are in constant contact with water, stainless steels with a corrosion resistance class II to IV can be used [10, 12]. If tap water is chlorinated, its aggressiveness is increased because chlorine is a strong oxidizing agent. But even stainless steels with a CRC II and a PRE of approximately 20 are sufficiently resistant under these conditions.

If the indoor swimming pool is operated with salt-rich thermal or brine water and the water is disinfected using the chlorine gas process, the following requirements apply:

- In the atmospheric area, the regulations are identical to those listed in Table 1.
- In the case of components that are constantly flushed by the pool water, stainless steels with a PRE > 30 are required, that is, steels of corrosion resistance classes IV and V. For pools made of stainless steel, for example, material 1.4462 is often used [10, 12].

6. EVALUATION OF THE CORROSION DAMAGE MENTIONED IN SECTION 3

Section 2 shows that on the component surfaces in the atmosphere of indoor swimming pools, in the interaction of salts dissolved in water films and the disinfection of the pool water, a salt-rich electrolyte with strongly oxidizing properties is created. Based on the explanations in Section 3, this creates the prerequisites for increased corrosion of stainless steels in the indoor pool atmosphere. For this reason, there are certain requirements in the regulations for the composition of stainless steels in order to avoid corrosion damage (Section 5).

In particular, stainless steels of a so-called Corrosion Resistance Class II and III (which are only used for the damage mentioned in Section 2) have a high sensitivity to chlorides and acids, which is why they cause pitting and stress corrosion cracking and also noticeable rust formation occurred at an early stage. The corrosion damage mentioned is therefore caused by the facts that those responsible for the planning and / or execution of the indoor pools either did not know and/or did not observe existing regulations.

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