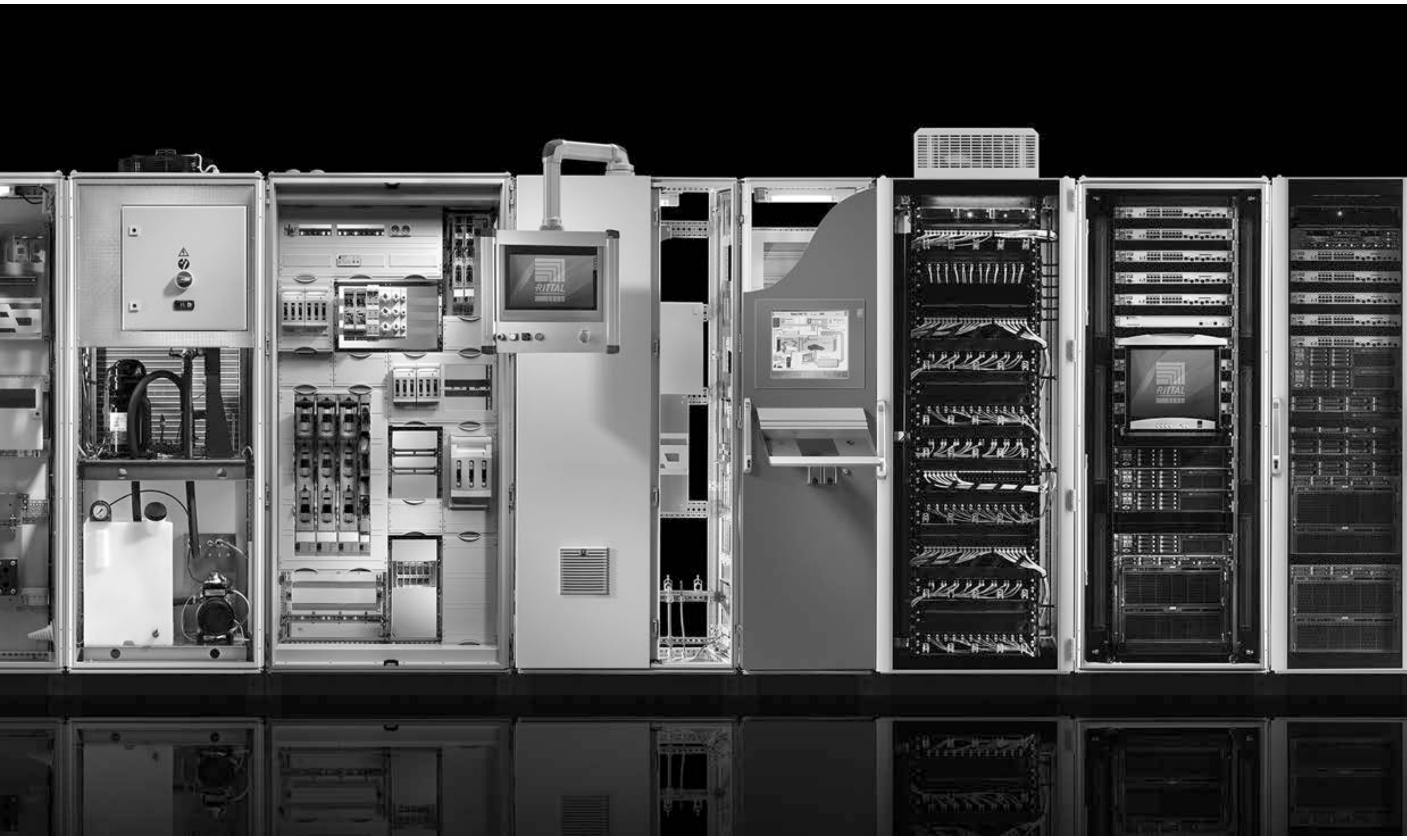
Rittal – The System.

Faster – better – everywhere.



Whitepaper:
Stainless steel for enclosures

Hans-Joachim Becker
Andreas Fabrizius

Table of contents

Authors:

Hans-Joachim Becker holds a degree in mechanical engineering. He is Director for Quality Management Technology at Rittal and in responsible for the accredited Rittal quality laboratory in Herborn.

Andreas Fabrizius holds Master's Degree (Master of Science) in corrosion protection technology. He is a laboratory engineer for materials and corrosion protection technology in Rittal's Quality Management Department in Herborn.

Introduction

Stainless steel is used in many applications, for instance in the food and pharmaceuticals industries, to prevent steel parts weakening due to corrosion. Housings and enclosures are a case in point here as they ensure permanent protection for the components installed in them under adverse environmental conditions, even without paint.

This Whitepaper discusses the function of stainless steels and their use in enclosures and housings. First, the paper examines just what "stainless" exactly means, as well as which chemical processes promote this property. Another issue dealt with is why stainless steels can still exhibit traces of rust under certain conditions, and how this can be effectively prevented. The aim is to give the user a comprehensible guideline to help him/her select the correct enclosure for the on-site ambient conditions.

Figure 1: Rittal stainless steel enclosures deployed at Friesland-Campina.

Steel as a material

Steel is easily the most widely used metallic material. It is an essential basis of production in automotive and mechanical engineering. Each year, approx. 43 million tonnes of steel are currently being produced in Germany, the largest steel-producing country in the European Union [STA1]. Iron alloys are called “steel” when they have a carbon content of less than 2.06%. This low carbon content (iron alloys with a higher carbon content are referred to as “cast iron”) ensures that steel can be processed by metal forming methods. The exact properties of the steel can be specifically changed by adding other chemical elements. The constituents most commonly used in steel alloys (besides iron) are molybdenum, chromium, nickel, vanadium, titanium and manganese. Currently, the European Steel Register lists over 2,500 types of steel with a variety of properties [STA2] that are suitable for different applications. The most important criteria that need to be taken into account when selecting steels include strength (toughness), ductility, weldability and corrosion resistance.

Water and oxygen – the enemies of steel

One major disadvantage of steel as a material is the susceptibility of the iron to corrode. Iron oxidises when subjected to water and oxygen. Ferrous and ferric oxides are formed; when combined with water of crystallization they comprise what is commonly referred to as “rust”. Rust is porous and mechanically unstable, and so reduces the load bearing capacity of the original steel component. As its volume increases through oxidation, rust often starts to flake off. As a result, the steel below then starts to rust in turn.

A large number of possibilities exist to prevent steel from corroding. The most common method is painting, where a protective layer is applied that prevents the steel from coming into contact with oxygen, water or humidity. The disadvantage of this method is that damage to the paint layer eliminates the corrosion protection. Typical examples are scratches in car paint, which can cause corrosion to the bodywork. A drilled hole made in a painted steel part removes the corrosion protection at that position. Generally, steel can be protected from rusting by preventing the surface coming into contact with water and oxygen at the same time.

Stainless steel

One particularly elegant solution is the use of stainless steel to prevent corrosion. While it often referred to as “stainless steel”, this description is not entirely correct. Special alloy additions to steel ensure that any surface corrosion is effectively prevented. The first patent application for stainless steel made was by Friedrich Krupp AG [DEU] in 1912. Today, several hundred types of stainless steel are used in various fields of application. Stainless steel’s working principle is based on having a high percentage of chromium (at least 10.5%) in the alloy [DIN]. This high chromium content causes a protective layer of chromium oxide to form on the surface of the steel. Besides guarding against oxygen and water, this layer has another special feature: Although it is only extremely thin, it repairs itself almost automatically. If it does suffer damage, the chromium at the damage site oxidises very quickly, so restoring the previous level of protection. This is referred to a “self-healing surface”.

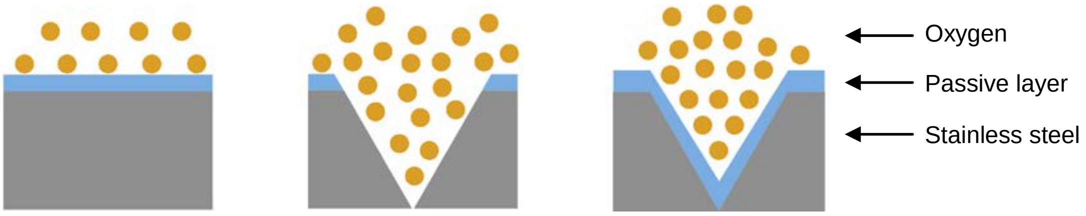


Figure 2: Self-healing passive layer

Mechanical properties

In stainless steels, resistance to corrosion is also associated with a high level of toughness. This means that such steels can be machined much less easily than other types of steel using mechanical cutting procedures. Shorter tool service lives and a higher machining time lead to significantly higher costs if the same component is to be produced from stainless steel by metal-cutting methods. On the other hand, stainless steel can be easily formed without cutting. Enclosures made of sheet steel can therefore be produced relatively easily. Today, the use of stainless steel is common in many areas where corrosion resistance is important. Typical examples are the manufacture of housings or enclosures for the chemical and food industries or for medical technology.

Figure 3: The Rittal TS 8 stainless steel bayed enclosure system is used in the food industry in numerous applications.

Can stainless steel rust?

The term “stainless steel” suggests that components manufactured from this steel do not corrode. However, there is no guarantee that stainless steel will not rust under any circumstances. For example, the 1912 patent application refers to the process simply as the “production of articles ... that require a high resistance to corrosion ...” [DEU] In this respect, the term “stainless steel” is somewhat misleading, although actually, stainless steel does not rust under most conditions.

Figure 4: Example of red rust on stainless steel

Mechanical damage and contact with other metals

The corrosion-inhibiting effect of the chromium oxide layer may be lost in the event of mechanical damage to the steel surface. Certainly, a new protective layer is formed together with the oxygen in the air. But if small particles of another metal remain adhering to the surface, corrosion can be triggered as a result. This occurs especially when these particles are of conventional steel or other metals. Thus, an electrochemical system may form that promotes the corrosion of the actually non-rusting steel. Typical cases are, for example, damage to a component made of stainless steel that is lifted with the fork of a forklift truck. The use of non-stainless steel screws with stainless steel can also cause corrosion.

In some cases the phenomenon of “flash rust” may occur. Here, small metal particles are deposited on the surface of the stainless steel, where they start to rust if oxygen and moisture are present. Such metal particles may actually be transmitted via the air. Typical cases where such metal particles find their way onto the surface include nearby metalworking on non-stainless steels. When machining a steel part with a disc grinder, sparks are often produced that consist of small, glowing metal particles. Abrasion from steel parts can also generate such particles, which can then lead to the phenomenon.

Chemical factors

The corrosion protection provided by the chromium oxide layer on stainless steel only functions if the layer remains intact. Acids may attack or damage the layer to the extent that corrosion protection is no longer present. Depending on the type of stainless steel, concentrated hydrochloric acid may dissolve the material completely. Besides this, an atmosphere containing chlorine, in a swimming pool for example, can attack some stainless steels.

Stainless steel faces special challenges in marine applications or near the coast. Saline aerosols, which are transported onto the surfaces by the wind, contain a relatively high concentration of chloride ions. This concentration increases further if some of the water evaporates during transport or on the metal surface. Thus, the corrosive effect can be greater than that of normal salt water.

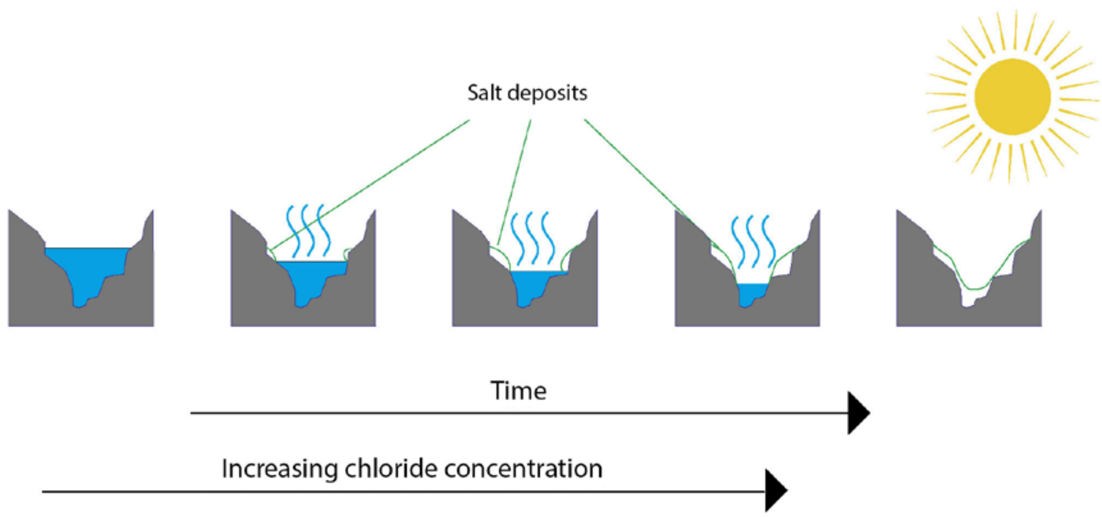


Figure 5: Accumulation of salt

Influence on surface quality

Both the mechanical and the chemical influence on a component made of stainless steel greatly depend on the surface structure. Very rough surfaces and surface depressions mean that saltwater aerosols can accumulate in surface indentations, for example. The effect described above, where the chloride ion concentration increases through evaporation, may also occur. Even particles originating from metalworking, as described above, are deposited more easily on the surface the rougher that the surface is.

Stainless steel enclosures

Enclosures and other stainless steel housings are commonly used in harsh environments. Rittal [RIT] offers enclosures and various other housings of type 1.4301 stainless steel (also known as Grade 304, V2A-steel or “18/8”) for the food and pharmaceutical industries, where hygiene is especially important. This type of steel was one of the first grades of stainless steel to be commercially available and now makes up around a third of all the stainless steel produced [STA1]. This alloy contains 18% chromium and 10% nickel, so that enclosures made from this steel are resistant to water vapour, humidity and weak acids. In addition, Rittal offers (as a standard feature) enclosures and housings made from Type 1.4404 stainless steel, which is often referred to as V4A-steel or Grade 316L. This material is even more resistant to attack by salt and acid than Type 1.4301 is, making it suitable for even more demanding applications. The products range from terminal boxes (KL), compact enclosures (AE), Hygienic Design enclosures (HD) to free-standing enclosures (SE 8) and bayed enclosure suites (TS 8), up to console systems (TP) and PC enclosures. The company also offers almost its entire range of enclosures and housings in stainless steel.

Figure 6: Production of Hygienic Design enclosures at the Rittal plant in Wissenbach

The outer surfaces of the housings and enclosures are brushed (grain size 240 to 400) and are thus relatively smooth. Nevertheless, depending on the environmental conditions, superficial rust may form. However, this does not normally impair the enclosure’s function. Under normal circumstances, any rusting through or damage that could impair function isvirtually ruled out during the normal service life of such an enclosure.

Regular cleaning can prevent flash rust

The quality of a steel surface plays an important role in relation to corrosion resistance. The smoother a surface is, the more difficult it is for particles to adhere to it. Chloride ions can hardly accumulate on flat surfaces. However, the polishing of surfaces is a complex business and therefore often too expensive. One simple and practical alternative is to clean the surfaces regularly. Particles that trigger flash rust and residues of aerosols can be removed. so effectively preventing any corrosion. Existing flash rust can also be removed, if necessary with the help of suitable cleaning agents.

Should corrosion still occur, perhaps because the environmental conditions are too unfavourable, the use of painted enclosures still remains an option. Here, Rittal offers two alternatives: The stainless steel enclosures are coated with clear varnish, ensuring that the stainless steel appearance is maintained. However, it is also possible to cover the stainless steel enclosure with a high quality powder coating. This means that a variety of different colours are possible.

Consistent quality philosophy

The consistent Rittal quality philosophy has resulted in internationally recognised certification. In addition to comprehensive product certification in accordance with global standards, the Rittal in-house quality laboratory has been accredited by the Deutschen Akkreditierungsrat (German Accreditation Council; DAR), CSA and Underwriters Laboratories (UL). Rittal operates an end-to-end quality policy that ensures high quality standards in products and processes; control loops within that system help to minimise errors in the course of manufacturing. This process results in a high-quality and sophisticated product and a boost in customer loyalty.

Summary

Stainless steel is a material with over 100 years of history. The properties of the steel can be altered very specifically by making appropriate additions to the alloy. A chromium content of at least 10.5% is responsible for the “stainless” characteristic. This chromium forms a thin layer of chromium oxide, which prevents the steel below from coming into contact with oxygen or water and so rusting on the surface. The chromium oxide layer can regenerate again automatically following damage.

Stainless steel enclosures are very robust and have a long service life. There are a number of different reasons why rust may still form on the surface. For one thing, there is the phenomenon of flash rust. The actual steel enclosure itself does not rust but instead the particles that accumulate on the surface do. This can always happen when the ambient air contains metal particles or dust.

Another cause may be a high content of salt water in the air. The chloride ions from the salt water greatly increase oxidation. When the salt water on the surface dries, the concentration of chloride ions on the surface may increase, so accelerating oxidation even further.

The surface finish also plays an important role in ensuring freedom from rust. As a rule, very smooth surfaces are less susceptible to corrosion than uneven or rough surfaces are.

Absolute freedom from rust is practically impossible to achieve with steel. Rust on the surface, so-called “flash rust”, cannot impair the function of an enclosure made of stainless steel. Regular cleaning of the surface helps here. In particularly difficult environmental conditions, it is advisable to treat the surface further, for example with paint.

Sources

[STA1] www.stahl-online.de
[STA2] www.stahldaten.de
[DEU] German Reich Patent No. 304126:1912
[DIN] DIN EN 10088-1-3:2005: Stainless steels
[RIT] www.rittal.de

Rittal – The System.

Faster – better – everywhere.

- Enclosures
- Power Distribution
- Climate Control
- IT Infrastructure
- Software & Services

RITTAL GmbH & Co. KG
Auf dem Stützelberg · 35726 Herborn · Germany
Phone + 49(0)2772 505-0 · Fax + 49(0)2772 505-2319
E-mail: info@rittal.de · www.rittal.com · www.rimatrix5.de