The Benefits of Stainless Steel

UNDERSTANDING AND IDENTIFYING THE IDEAL ENCLOSURE MATERIAL

Stainless steel is a steel alloy, consisting of at least 11 percent chromium. Chromium provides the shiny appearance it is known for, but also offers superior corrosion resistance. Unprotected carbon steel rusts quickly when exposed to air and moisture, degrading its mechanical properties and appearance. Stainless steel generally retains its properties in most conditions. However, there are some environments which can cause corrosion for stainless steel, such as low oxygen, high salinity (salt) and some extreme conditions (i.e. mines, strong acids). When stainless steel does experience corrosion, it is commonly by means of pitting, which appear as reddish spots on the surface.

The chromium present in the stainless alloy creates a thin, transparent passive oxide film when it comes in contact with oxygen. This film acts to protect the steel from corroding agents. While the film can be scratched away, the chromium present throughout the alloy allows the film to nearly self-heal instantly. If a zinc-plated, or painted, sample of mild steel is scratched, it will corrode and spread to areas beyond the scratch.

Stainless steel is available in many grades or formulations. The most common are in the 300 series, with 15-20 percent chromium. These are largely non-magnetic; however, forming and cold working can induce magnetic characteristics. The stainless steel in the 400 are typically magnetic due to higher levels of iron.

Stainless steel has become the standard material choice in many industries. For example, in the food and beverage industry, stainless steel allows for steam cleaning, while in pharmaceutical applications, stainless steel provides a clean, antibacterial surface. Stainless steel is also notable in various consumer products such as sinks and appliances.

GRADES OF STAINLESS

There are many different grades of stainless steel to accommodate diverse application requirements.

TYPE 304

Type 304 is the most common grade of stainless steel, also known as 18/8 for its composition of 18 percent chromium and eight percent nickel. The 300 series feature an austenitic crystal structure. Type 304 will resist corrosion in most environments; however, when exposed to salt and other chlorides, it will experience corrosion. In industrial environments, chlorides may be present in dust and flying ash, which if left unwashed on flat surfaces, will result in pitting.

TYPE 316

Type 316 is similar to Type 304, with increased corrosion resistance due to more nickel and the introduction of molybdenum. Type 316 shows stronger resistance to a range of environments, and is recommended in coastal regions where salt is present in the air, especially within one mile of the coast. Salt can also be deposited via rain, see figure 1.

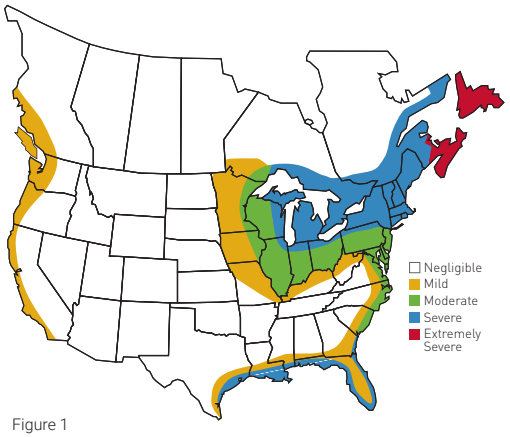


Figure 1

Chlorides can also be found in cold weather environments where salt is applied to roadways. Salt road spray can be carried surprisingly long distances both vertically and laterally away from the actual road surface. Type 316 also shows increased resistance to corrosion by strong acids, which may be found in paper mills and mines. An alternative version to Type 316 is Type 316L, which has lower carbon content. Lower carbon allows for better welding characteristics.

TYPE 321

Type 321 is a grade typically reserved for weldments subjected to severe corrosive environments and high service temperatures from 800 to 1,600 degrees Farenheit. The formulation of Type 321 is similar to Type 304, with the addition of titanium. When Type 304 is heated above 1,292 degrees Farenheit for an extended period of time it may suffer weld decay, which will initially display corrosion on the areas around the weld. Weld decay is lessened by the addition of titanium, making Type 321 stainless steel ideal for use inside aircraft exhaust manifolds, boiler shells and fire walls.

FERRITIC ALLOYS

Ferritic alloys feature a different crystal which affords better corrosion resistance than austenitic grades. However, they are less durable than Types 304 or 316 stainless steel grades. Ferritic alloys (Types 405 or 409) are usually less expensive, and are most often used on automobile exhaust components.

MARTENSITIC ALLOYS

Similarly to ferritic alloys, martensitic alloys also feature a distinct crystal structure. Martensitic alloys offer superior wear resistance but decreased corrosion resistance in comparison to austenitic alloys. Common martensitic alloy grades are Types 410, 420 and 440, of which Types 420 and 440 are commonly used in cutlery. Martensitic alloys are also highly machinable.

TYPE 500 SERIES ALLOYS

Type 500 series alloys are heat-resisting chromium alloys.

TYPE 600 SERIES ALLOYS

Type 600 series alloys are martensitic alloys, and are further strengthened through precipitation hardening, or age hardening.

TYPE 2205

Type 2205 is a grade known as duplex, for its ferritic and austenitic characteristics. Type 2205 offers superior corrosion resistance with high strength.

COST COMPARISON

Stainless steel is significantly more expensive than mild steel; Type 304 is roughly four times more expensive than mild steel while Type 316 is roughly five times more expensive than mild steel. Additionally, the manufacturing process is also more time consuming than mild steel, which increases production costs as well.

SURFACE FINISH

Stainless steel can be purchased in a variety of surface finishes, including:

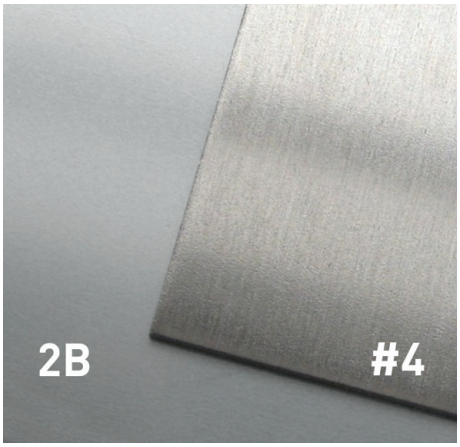
- #1 – Mill finish, a rough and dull finish
- #2D – Annealed, pickled, dull cold rolled
- #2B – Annealed, pickled, as rolled, cold rolled
- #3 – Intermediate polished, applications include consumer products such as sinks
- #4 – Standard polish, food and pharmaceutical grade

A stainless steel finish between a #3 and #4 finish has a protective masking applied to one side, which is left on the outside of an enclosure and will be removed as late in the manufacturing process as possible.

Surface finish does have an effect on corrosion resistance. Finer or more polished finishes have increased corrosion resistance, compared to coarser finishes such as 2B or mill finish.

MANUFACTURING

In general, manufacturing with stainless steel requires additional time and special care. Stainless steel products are usually left unpainted; therefore special care needs to be taken to avoid scratches and blemishes. For example, to protect enclosures, a masking can be used on the outside surface to protect against scratches through the production process. Stainless steel also has a grain direction that is visible on polished surfaces. Weldments should be laid out with the grain direction in the same orientation. The grain direction also affects corrosion resistance, as moisture moves parallel to the grain direction easier than across the grain. Enclosures should be designed to feature a vertical grain direction.



WELDING

The core welding process is essentially the same for stainless steel and mild steel, however, there are differences in the weld wire, gaps, additional blending and bluffing. The weld material needs to match the "host" material, thus stainless requires additional consumables (Types 304 and 316 wire for MIG welding). Other design considerations, such as weld gaps, should also be taken into account.

Stainless steel is more challenging to weld and requires a higher level of craftsmanship to create an aesthetic look. These welds also require grinding, blending and buffing to give the weld an acceptable appearance; typically only grinding is required on mild steel welds. Since stainless steel enclosures are largely unpainted, these additional steps are required to hide weld imperfections.

The welded joint is a common location to first notice corrosion. During welding, there may be iron particles present, which are embedded into the weld, especially if both mild steel and stainless are welded in the same facility. A process called passivation can be used to clean and re-establish the protective oxide film around the weld area. Passivation is generally done using an acid bath in which the material is dipped. There are also gels which can be applied locally to welds.

FORMING

Forming stainless steel uses the same process as mild steel. However, stainless steel can present additional forming challenges as it tends to spring back more than mild steel.

PAINTING

Some stainless steel enclosures are painted, especially in outdoor environments where solar radiation is a concern. A painted stainless steel enclosure (light color) remains up to ten degrees cooler than an unpainted enclosure in direct sunlight. Paint also offers an additional level of protection against corrosion in extreme environments. Stainless steel can be painted using standard processes and equipment.

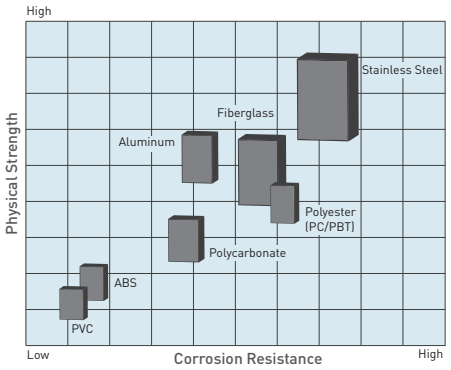
COMPARISON TO PLASTICS, COMPOSITES

Plastics and composites are ideal alternatives to stainless steel in specific applications. Composites offer advantages over stainless steel, including providing a lighter design and easy modification options. However, fiberglass composites can experience fiber bloom from UV rays, which is a common corrosion mode. A composite enclosure will likely have a lower cost than a stainless steel enclosure; however, in most situations, stainless steel offers better corrosion resistance and strength. Stainless steel is also better suited for extremely high or low operating temperatures.

Stainless steel is not recommended in environments which feature acids, such as Hydrochloric and Hydrofluoric, or in areas where ferrite chloride is present. In these applications, a Polyester enclosure may be the better selection.

While a stainless enclosure is relatively quick to design, build and test, a composite enclosure takes additional time to design. The tooling for a composite design also requires significant time and more costs to develop. If the final composite enclosure is unacceptable or does not pass an aspect of testing, the formulation of the material can be changed, but modifying the tooling may not be possible.

Plastic and composite enclosures are quality insulators, while mild steel and stainless steel absorb and conduct heat better. If an application requires the enclosure to dissipate heat, a mild steel or stainless steel enclosure should be considered.



SUMMARY

Stainless steel offers increased corrosion protection against environmental elements, while also providing a polished appearance and minimal maintenance. With a variety of grades and surface finishes, stainless steel can accommodate diverse application requirements while providing the necessary protection and performance. However, it is important to understand the enclosure environment before selecting stainless steel over other alternatives (painted or plated mild steel, plastics/composites) and also in choosing which grade of stainless steel should be used.