

What is Stainless Steel?

Stainless steel is the generic name for a number of different steels used primarily for their resistance to corrosion. The key element they all share is a certain minimum percentage (by mass) of chromium: 12%. Although other elements, particularly nickel and molybdenum, are added to improve corrosion resistance, chromium is always the deciding factor.

What causes corrosion?

Corrosion is a natural phenomenon as nature seeks to combine other elements which man has produced in a pure form for his own use. Iron occurs naturally as iron ore. Pure iron is therefore unstable and wants to “rust”; that is to combine with oxygen in the presence of water. For most of the Iron Age, which began about 1000 BC, cast and wrought iron was used; iron with a high carbon content and various unrefined impurities. The production of steel did not begin until the 19th century. At present the majority of steel produced in the world is carbon steel, which can be defined as an alloy of a small content of carbon combined with well-refined iron. Despite its various additions stainless steel still behaves as steel, it is not like the nickel alloys that are really alloys of a number of different metals, iron ore only being one. Even highly alloyed stainless steel grades, such as 316, have a minimum of 62% iron.

Carbon steels without any protection will form a coating of rust that will in a sense protect the rest of the steel. So constantly removing the rust exposes a new fresh layer of steel to be attacked. This is called general corrosion. Various coatings will impede the rusting process, in particular painting, coating with zinc (galvanised steel), and epoxy resins. Another lateral way of reducing corrosion is to put corrosion inhibitors into the solutions that would otherwise cause iron to corrode.

The unique advantage of stainless steel.

For a wide range of applications, stainless steel competes with carbon steels supplied with protective coatings, as well as other metals such as aluminium, brass and bronze. The success of stainless steel is based on the fact that it has one big advantage. The chromium in the stainless steel has a great affinity for oxygen, and will form on the surface of the steel at a molecular level a film of chromium oxide. This thin layer is described as passive, tenacious and self-renewing. Passive means that it does not react or influence other materials; tenacious means that it clings to the layer of steel and is not transferred elsewhere; self-renewing means that if damaged or forcibly removed more chromium from the steel will be exposed to the air and form more chromium oxide. This means that over a period of years a stainless steel knife can literally be worn away by daily use and by being re-sharpened on a sharpening stone and will still remain stainless. Manhole and access covers in the water treatment and chemical industry are widely made out of both galvanised steel and stainless steel. In normal use galvanised steel can last many years without corrosion occurring and in these cases there would be little advantage apart from aesthetic reasons to switch to stainless steel. Where stainless comes into its own is where the galvanised coating is constantly being worn away, for example by chains being dragged over it, or constantly being walked over, or where very corrosive chemicals are being randomly splashed onto it.

This leads to the fact that initial investment cost of fabrication in stainless steel will always be more expensive than using ordinary steel, not just because of the higher cost of stainless steel, but also because it is more difficult to machine. However it is the better life cycle costs of stainless steel that makes it attractive, both in terms of much longer service life, less maintenance costs, and high scrap value on de-commissioning.

Product characteristics.

Stainless steel can be selected for use compared to other materials for a number of reasons, not just its corrosion resistance. These include:

- Aesthetic qualities: it can be polished to a satin or mirror finish;
- “Dry corrosion” occurs to steel at higher temperatures where it oxidises or scales up. Stainless steel is far more resistant to this than ordinary carbon steel and grades such as 310 (25% chromium 20% nickel) were specifically developed for use at high temperatures;
- Non-contamination of the liquids stainless comes into contact with, because there is no coating to break down and dissolve;
- Weight savings: as thinner sections and more innovative design structures can be used, with cost savings on foundations and platform weights;
- Many anti-corrosion coatings are fire hazards or the materials themselves have a low melting point.

Applications.

The most everyday use of stainless steel is obviously in **cutlery**. Very cheap cutlery is made out of grades 409 and 430, with the finest quality cutlery using specially produced 410 and 420 for the knives and grade 304 (18/8 stainless, 18% chromium 8% nickel) for the spoons and forks. The different grades are used as 410/420 can be hardened and tempered so that the knife blades will take a sharp edge, whereas the more ductile 18/8 stainless is easier to work and therefore more suitable for objects that have to undergo numerous shaping, buffing and grinding processes.

Very large amounts of stainless steel are used in **food production and storage**. The most commonly used grades are 304 and 316. Typical uses would be dairy, milk storage and ham curing, frozen and salted fish storage. Whereas 304 is used for normal temperatures and acid concentrations, 316 is used for harsher environments. For example 304 is used in cheese production, but where salted ham is being prepared 316 is used. For low concentrations of phosphoric acid (one of the constituents of cola) 304 is used, but at higher temperatures and concentrations 316 is used. Food slicers are made out of 420 and 440. Very often in food production stainless is used not because the food itself is corrosive but the use of stainless allows for faster and more efficient cleaning. For example in ice cream production 316 is specified so that strong anti-bacteriological cleaning and rinsing systems can be used. One of the great advantage of stainless steel is that imparts no taste to the food that it comes into contact with.

The **pumping and containment of oils, gases and acids** has created a large market for stainless tanks, pipes, pumps and valves. The storage of dilute nitric acid was one of the first major success stories for 18/8 stainless steel as it could be used for thinner sections and was more robust than other materials. Special grades of stainless have been developed to have greater corrosion resistance. These are used in desalination plants, sewage plants, offshore oil rigs, harbour support and ships propellers.

Architecture is a growing market. Many modern building uses stainless for cladding. When reinforced concrete first started to be used it was considered that the carbon steel used would not rust, as cement, obviously derived from limestone, is alkaline. However, constantly using grit salt on bridges can change the pH to acidic thereby rusting the steel, which expands and cracks the concrete. Stainless steel reinforcing bar, although initially expensive, is proving to have good life cycle costing. The low maintenance cost and anti-vandal characteristics of stainless provides a growing market in public transport, ticket machines and street furniture.

The **nuclear power industry** uses large quantities of stainless, often specified with a low cobalt content, for both power and radiation containment. Special louvered ventilation shafts are made, which are used in case of emergencies to seal off plants for years if necessary. Steam and gas turbines use stainless because of its corrosion resisting and heat resisting qualities.

Especially clean melted stainless is used for **medical implants** and artificial hips. A great deal of **medical equipment** – such as orthopaedic beds, cabinets and examination machines – is made as standard from stainless because of its hygienic and easy-clean qualities. Pharmaceutical companies use stainless for pill funnels and hoppers and for piping creams and solutions.

Automobile industries are making increasing use of stainless steel, primarily for exhaust systems (grade 409) and catalytic converters, but also for structural purposes.