Stainless Steel Grades

In metallurgy, **stainless steel**, also known as **inox steel** or **inox**, is defined as a steel alloy with a minimum of 11% chromium content by mass.[1] Stainless steel does not stain, corrode, or rust as easily as ordinary steel (it *stains less*, but it is not stain-proof).[2] It is also called **corrosion-resistant steel** or **CRES** when the alloy type and grade are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment to which the material will be subjected in its lifetime. Common uses of stainless steel are cutlery and watch cases and bands.

Stainless steel differs from carbon steel by the amount of chromium present. Carbon steel rusts when exposed to air and moisture. This iron oxide film (the rust) is active and accelerates corrosion by forming more iron oxide. Stainless steels have sufficient amounts of chromium present so that a passive film of chromium oxide forms which prevents further surface corrosion and blocks corrosion from spreading into the metal's internal structure

When an alloy of steel contains more than approximately 10 ½% Chromium it can be classified as a stainless steel. This is because Chromium has a high affinity for Oxygen and forms a stable Oxide film on the surface of the steel. This film is resistant to further chemical or physical change.

Stainless steels can be divided into four major groups, namely Martens tic, Ferritic, Austenitic and Duplex.

The Martenstic Group

Martensitic stainless steels, the first stainless steels commercially developed (For cutlery) have a relatively high carbon content (0.1 - 1.2%) compared to other grades of Stainless steels. They are plain chromium steels containing between 12 and 18% chromium. The stainless steel is of moderate corrosion resistance which can be hardened by heat treatment resulting in high strength and hardness. Due to the high Carbon content of the steel it responds well to heat treatment to give various mechanical strengths, such as hardness. When heat treated this group of steels show a useful combination of corrosion resistance and mechanical properties that qualify them for a wide range of applications. It has poor weldability and is magnetic. It is commonly used for knife blades, surgical instruments, shafts, spindles and pins.

Type 410

A 13% Chrome, 0.15% Carbon alloy possessing good ductility and corrosion resistance. It can be easily forged and machined. Exhibits good cold working properties.

Grade 410 is the basic martensitic stainless steel; like most non-stainless steels it can be hardened by a "quench-and-temper" heat treatment. It contains a minimum of 11.5 per cent chromium, just sufficient to give corrosion resistance properties. It achieves maximum corrosion resistance when it has been hardened and tempered and then polished. Grade 410 is a general purpose grade often supplied in the hardened, but still machinable condition, for applications where high strength and moderate heat and corrosion resistance are required.

Martensitic stainless steels are optimised for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weldability and usually the need for a final heat treatment. Corrosion resistance of the martensitic grades is lower than that of the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures

Type 416

Similar to Type 410 but has added Sulphur giving improved machinability. Usually supplied in bar form.

Grade 416 has the highest machinability of any stainless steel, at about 85% of that of a free-machining carbon steel. As for most other free-machining stainless steels the improvement in machinability is achieved by addition of sulphur which forms manganese sulphide inclusions; this sulphur addition also lowers the corrosion resistance, weldability and formability to below that of its non-free machining equivalent Grade 410.

Grade 416 is sometimes used in the unhardened or hardened and highly tempered condition because of its low cost and ready machinability.

Martensitic stainless steels are optimised for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weldability and usually also allow for a final harden and temper heat treatment. Corrosion resistance is lower than the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures

Type 431

A 17% Chrome, 2½% Nickel, 0.15% max Carbon stainless alloy. Has superior corrosion resistance to types 410 & 416 due to the Nickel. Usually supplied in bar form.

The Ferritic Group

These are plain chromium stainless steels with varying chromium content between 11% and 18%, but with low carbon content. They have a moderate to good corrosion resistance, are not hardenable by heat treatment and always used in the unnealed conditions. They are magnetic. The formability is not as good as the austeinitics. These are commonly used in computer floppy disk hubs (430), automotive trim (430), automotive exhausts (409), material handling equipment (3CR12) and in hot water tanks (444).

.

Type 430

A 17% Chrome, low alloy Ferritic steel. It has good corrosion resistant properties up to about 800°C. Usually on used in strip and sheet form due to its poor machinability.

Grade 430 is a ferritic, straight chromium, non-hardenable grade, combining good corrosion resistance and formability characteristics with useful mechanical properties. Its ability to resist nitric acid attack permits its use in specific chemical applications but automotive trim and appliance components represents its largest fields of application.

Grade 430F is the free-machining version of this grade, available in bar form for use in automatic screw machines. Grade 434 is the molybdenum bearing version of Grade 430 and has the same useful combination of properties. Its molybdenum addition improves corrosion resistance.

The Austenitic Group

Most commonly used austenitic stainless steel contain 18% chromium and 8% nickel. They have an excellent corrosion resistance, weldability, formability fabricability, ductility, cleanability and hygiene characteristics. Along with good high and excellent low temperature properties, these are non magnetic (if annealed) and are hardenable by cold work only

This is the most widely used stainless steel. The common uses are in computer floppy disk shutters (304), computer keyboard key springs (301), kitchen sinks (304D), pharmaceuticals, petrochemical industry, food processing equipment, architectural applications and chemical plants.

Type 304

An economic balance of alloying materials. Excellent corrosion resistance in unpolluted and freshwater environments, though not recommended for seawater.

Stainless steel types 1.4301 and 1.4307 are also known as grades 304 and 304L respectively. Type 304 is the most versatile and widely used stainless steel. It is still sometimes referred to by its old name 18/8 which is derived from the nominal composition of type 304 being 18% chromium and 8% nickel.

304 L Stainless Steel

Type 304L is the low carbon version of Stainless steel 304. It is used in heavy gauge components for improved weldability. Some products such as plate and pipe may be available as “dual certified” material that meets the criteria for both 304 and 304L

304 H Stainless Steel

304H, a high carbon content variant, is also available for use at high temperatures.

Type 321

Grades 321 and 347 are the basic austenitic 18/8 steel (Grade 304) stabilized by Titanium (321) or Niobium (347) additions. These grades are used because they are not sensitive to intergranular corrosion after heating within the carbide precipitation range of 425-850°C. Grade 321 is the grade of choice for applications in the temperature range of up to about 900°C, combining high strength, resistance to scaling and phase stability with resistance to subsequent aqueous corrosion.

Grade 321H is a modification of 321 with a higher carbon content, to provide improved high temperature strength.

A limitation with 321 is that titanium does not transfer well across a high temperature arc, so is not recommended as a welding consumable. In this case grade 347 is preferred - the niobium performs the same carbide stabilisation task but can be transferred across a welding arc. Grade 347 is therefore the standard consumable for welding 321. Grade 347 is only occasionally used as parent plate material.

Like other austenitic grades, 321 and 347 have excellent forming and welding characteristics, are readily brake or roll formed and have outstanding welding characteristics. Post-weld annealing is not required. They also have excellent toughness, even down to cryogenic temperatures. Grade 321 does not polish well, so is not recommended for decorative applications.

Grade 304L is more readily available in most product forms, and so is generally used in preference to 321 if the requirement is simply for resistance to intergranular corrosion after welding. However 304L has lower hot strength than 321 and so is not the best choice if the requirement is resistance to an operating environment over about 500°C.

Type 347

Alloy 347 is a general purpose austenitic stainless steel with a face centered cubic structure. It is essentially non-magnetic in the annealed condition and can only be hardened by cold working. Niobium has been added to suppress grain boundary Chromium Carbide precipitation. Very similar to Type 321 but uses Niobium instead of Titanium.

Type 316

The addition of 2 - 3% Molybdenum in this grade gives increased corrosion resistance in offshore environments, however it does pit when immersed in seawater. A nickel content of 12% maintains the austenitic structure.

Grade 316 is the standard molybdenum-bearing grade, second in importance to 304 amongst the austenitic stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments. It has excellent forming and welding characteristics. It is readily brake or roll formed into a variety of parts for applications in the industrial, architectural, and transportation fields. Grade 316 also has outstanding welding characteristics. Post-weld annealing is not required when welding thin sections.

Grade 316L, the low carbon version of 316 and is immune from sensitization (grain boundary carbide precipitation). Thus it is extensively used in heavy gauge welded components (over about 6mm). Grade 316H, with its higher carbon content has application at elevated temperatures, as does stabilized grade 316Ti.

The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Type 317

Similar to 316 but the 3 - 4% Molybdenum gives increased pitting resistance when immersed in cold seawater.

6 Moly

Or as it is more properly known - UNS S31254 - gives high resistance to sea water attack due to high levels of Chromium and Molybdenum.

L Grades

Most austenitic grades can be provided as low carbon grades e.g. 316L where carbon is restricted to 0.03 to 0.035%. This reduces the tensile strength.

Duplex Stainless Steels

These stainless steels containing relatively high chromium (between 18 and 28%) and moderate amounts of nickel (between 4.5 and 8%), Molybdenum and Nitrogen to give a near equal mix of austenite and ferrite. The nickel content is insufficient to generate a fully austenitic structure and the resulting combination of ferritic and austenitic structures is called duplex. Most duplex steels contain molybdenum in a range of 2.5 - 4%. These have a high resistance to stress corrosion, cracking and chloride ion attacks. They have a higher tensile and yield strength than austenitic of ferritic steels as well as good weldability and formability. They are commonly used in marine applications, desalination plants, heat exchangers and petrochemical plants. Recommended extended use within temperature limits of -50 to +300 °C due to embrittlement.

UNS S31803

The most widely used grade of duplex and is typical of above description. Typical composition is 0.03% max Carbon, 22% Cr, 5.5% Ni, 3% Mo and 0.15% N.

UNS S32304

A low alloy duplex with similar corrosion properties to type 316, but with approximately double the tensile properties. Hence its primary use is in structures where mechanical strength is important. Typical composition is 0.03% max Carbon, 23% Cr, 4% Ni and 0.1%N.

UNS S32750

A super duplex exhibiting enhanced corrosion resistance and mechanical properties. Typical composition is 0.03% max Carbon, 25% Cr, 7% Ni, 4% Mo and 0.28% N.