AUTOMOTION® COMPONENTS

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STAINLESS STEEL

Stainless steel: types, properties, and relevant applications

Automotion Components Ltd. produce an **extensive range of stainless steel products.** Stainless steels are a popular choice for many reasons, but we know that choosing a stainless steel product for your application might not be straightforward due to the various different types of stainless steel that are available. The language used to describe different types of stainless steel can be confusing – so we've put together a primer that might help you choose the stainless steel that's right for your project.

The difference between steel and stainless steel is the addition of chromium (of which at least 10.5% is added), which forms an anti-corrosion film on the surface of the alloy. The anti-corrosion film slows the rate at which stainless steel rusts compared to non-stainless steel. The levels of chromium in stainless steel are generally capped at 18%, lest the material becomes too soft for general applications. In some types of stainless steel, nickel and/or molybdenum (and other elements) are also added to the alloy mixture to increase the rate of formation, and stabilise, the protective anti-corrosion layer.

Well-designed structures made of stainless steel require very little maintenance (protective coatings are often not required) and offer design lifetimes extending past a century – see Figure 1. For this reason, stainless steels are an environmentally friendly, economical choice for industrial applications.

There are many different types of stainless steel, named according to their chemical composition. In the 1930s, the various alloys were all given different American Iron and Steel Institute (AISI) numbers, such as "AISI 304", which is the most prevalent form of stainless steel in use today. However, nowadays there are many more types of stainless steel than there are AISI numbers, so a new classification – the European EN designation – is used to describe the precise composition of stainless steel. However, the EN numbers are a fairly new convention; in reality, the stainless steel numbered EN 1.4305 is usually still referred to as "AISI 304" or "A2" stainless steel (the latter designation is in accordance with ISO 3506). The difference here is that whilst the EN designation refers to the composition of the material, the AISI and ISO designations are based on the properties of the material, and can therefore encompass various different stainless steel compositions.
When browsing our extensive range of stainless steel products, the exact type of stainless steel is specified in the product's technical notes (AISI and EN numbers).

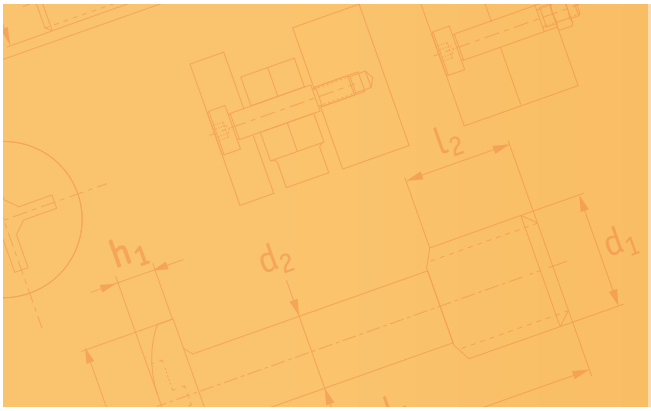


Figure 1:
The Chrysler building, completed in 1930, was the first industrial-scale application of stainless steel (1.4003) – at the time of completion, it was the tallest building in the world. Photo by Dan Smedley.

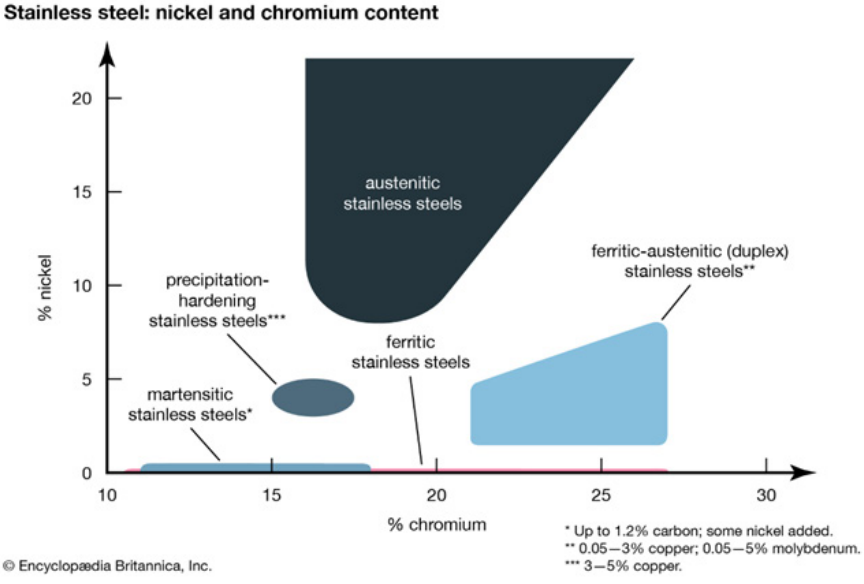
	AUSTENITIC			MARTENSITIC		PRECIPITATION-HARDENING
AISI ref.	303	304	316	416	440C	630
Our ref.	"A2"	A2	A4	A6	440C	17-4PH
Corrosion Resistance	***	****	*****	***	***	****
Classes	50	70	80	50	70	Dependent on treatment
Strength	*	**	***	**	***	***** (Depending on treatment)

Figure 2:
Overview of some of the stainless steels that we use in our products. Please continue reading for more details explaining the differences between the types and classes. ©Automotion Components Ltd.

AUSTENITIC STAINLESS STEELS

Austenitic stainless steels are generally non-magnetic and have good corrosion resistance (note: they can become magnetic depending on how the material is post-processed/ cold-worked). Austenitic stainless steels tend to have a higher corrosion resistance than other stainless steel phases shown in Figure 3. The most common type of stainless steel, "18/8" (A2/AISI 304/EN 1.4301), is austenitic. Applications of this popular stainless steel grade include: kitchen utensils,laboratory equipment, and construction.

Austenitic stainless steels (AISI 200 and 300 series) are not heat-hardenable, but their properties can be altered by cold working (e.g. pressing). Below is a comparison table (Table 1) delineating the differences between the most common austenitic stainless steel materials that we offer throughout our product ranges. This is not a comprehensive list.



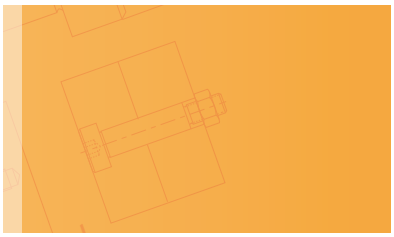
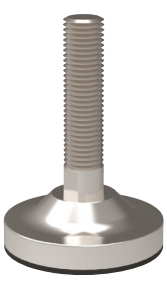


Figure 3:
Stainless steels are classified into phases based on their nickel and chromium content. In this section, we focus on austenitic stainless steels, which – in addition to iron and carbon – have added nickel (>8%) and chromium (>16,5%) chromium. Diagram© Encyclopaedia Britannica, 2020.

Table 1:
The most common types of austenitic stainless steel alloys, their chemical compositions and relevant properties. Please note that all grades shown here are types of austenitic stainless steel and contain ≤0.11 wt% N, ≤1,0 wt% Si, ≤2,0 wt% Mn, >0,045 wt% P. The alloy types listed here all have very similar densities, Young's moduli, electrical and thermal resistivities, so these data were not included. Reference: The European Stainless Steel Development Association, (2007). Stainless Steel: Tables of Technical Properties.

Stainless steel AISI type (ISO type)	303 (A1)	304 (A2)	316 (A4)
Stainless steel EN number	1.4305	1.4301	1.4401 and 1.4436
%Chromium	17,0-19,0	17,5-19,5	16,5-18,5
%Nickel	8,0-10,0	8,0-10,5	10,0-13,0
%Molybdenum	-	-	2,0-2,5
%Sulphur	0,15-0,35	≤0,015	≤0,015
%Carbon	≤0,1	≤0,07	≤0,07
%Copper	≤2,0	-	-
Tensile strength / MPa (at 25 °C)	600-720	590-680	590-680
Machinability	Excellent	Good	Good
Corrosion resistance	Good	Very good	Excellent
Application examples	Small, intricate items such as bearings and gears - machined because it is supplied in bar form.	Can be welded, therefore it has widespread use – e.g. in construction, automotive and aerospace engineering etc.	"Marine" or "medical" grade. Used for medical/ lab equipment, industrial chemical (or food) preparation, marine and nuclear applications.
Product examples in this grade	**Shoulder Screw** **P0130** 	**Levelling Foot** **P2200** 	**Wing Nut** **P0328** 

AISI 303/EN 1.4305 stainless steel is an A1 class stainless steel. Sulphur is added to it so that it can be easily machined from the round bar that it is supplied in. Some intricate parts can indeed only be made from AISI 303/EN 1.4305 stainless steel due to its excellent machinability. The added sulphur lowers its resistance to corrosion somewhat, but for the vast majority of our customers' needs (any applications that do not involve direct contact of your part with seawater or other corrosive chemicals), this slight lowering of corrosion resistance is not an issue. In fact, AISI 303/EN 1.4305 is often thought of as an A2 class stainless steel. In our internal references and part numbers, we refer to AISI 303 stainless steel as "A2" (e.g. the last part of this product code: P0130.060-006-A2), but the AISI and EN numbers are specified in the product subheading and the product materials information section.

However, if you think the slightly lower corrosion resistance of AISI 303/1.4305 stainless steel might be an issue for your application, please read on to find out about A4/AISI 316 stainless steel.

AISI 304/EN 1.4301 stainless steel is an A2 class stainless steel. Among other forms, it can be supplied in sheets, so when it is used to make intricate components, it must either be stamped or hot-forged and moulded into shape. Many of our products are the AISI 304/EN 1.4301-type stainless steel, as it is a popular choice of material – but please note that if you have a specific idea in mind, we may be able to make the part you need in other grades.

AISI 316/EN 1.4401 and 1.4436 stainless steel is a medical/marine grade A4 class stainless steel. It is the most corrosion-resistant stainless steel out of those introduced here and are used in environments where the material will be subjected to continual chemical attack – such as in marine applications, laboratories, and paper-making (in fact, this grade was developed for the cellulose industry because paper making involves the use of boiling concentrated sulphuric acid). AISI 316/EN 1.4401 and 1.4436 stainless steel is a little softer than AISI 304/EN 1.4301 but is excellent for chemical/food processing, and medical applications.

Class 50/70/80 - The above stainless steels can also come in strength classes. For example, you might occasionally see "A2 class 80" on our website – this distinguishes the more 'standard' A2 stainless steel, which has a minimum tensile strength of 700 N/mm^2 (A2 class 70), from a version with an 800 N/mm^2 tensile strength (A2 class 80 – high strength). There is also A2 class 50, which is softer than the above (500 N/mm^2 tensile strength). Note that the other austenitic stainless steels in Table 1 may also come in these strength classes (50, 70, 80).

What you need to know about austenitic stainless steels:

All stainless steels, and especially the austenitic grades, are renowned for their resistance to corrosion. To make things simpler for our customers, we divide our products into the classes "A2", which encompasses AISI 303 and 304 (EN 1.4305 and 1.4301, respectively), and "A4", which corresponds to AISI 316 (EN 1.4401; marine grade). You can find the accurate AISI/EN specification names in the technical notes for each product. Stainless steels can still rust over time, depending on the conditions they are exposed to. Although AISI 303 and 304 stainless steels are appropriate for the majority of applications, if you have an application environment that is highly corrosive, you may wish to consider selecting from our range of AISI 316 stainless steel products or getting in touch to discuss your needs.

MARTENSITIC / PRECIPITATION-HARDENING STAINLESS STEELS

Martensitic and precipitation-hardening stainless steels are often talked about together, as both types are heat-hardenable and have very similar compositions (11-18% chromium and low nickel content; please see Figure 2). Both classes of stainless steel are ferromagnetic. They are usually harder and have higher tensile strength than austenitic stainless steels. However, they tend to have lower corrosion resistance than austenitic stainless steels due to having higher carbon content and/or lower nickel/chromium content. Lower corrosion resistance can be ameliorated by, for example, nickel plating, which provides an additional layer of corrosion protection. Note that precipitation-hardening stainless steel has a small amount of added nickel (3-5%; see Figure 3), which gives precipitation-hardening stainless steels a corrosion resistance to rival that of the austenitic grades.

We offer a range of martensitic/precipitation-hardened stainless steel products, such as rails and rollers. Some of the common martensitic/precipitation-hardening steels that we offer are shown in Table 2.

Table 2:
Types of martensitic/precipitation-hardening stainless steel alloys that we also offer, their chemical compositions and relevant properties. The tensile strength and hardnesses of these stainless steels depend on how they are heat-hardened. (a) = annealed condition, (h) = hardened condition. The alloys listed here have additional differences in chemical composition, Young's moduli, electrical/thermal conductivity and hardness that are not listed here.

Stainless steel AISI type (ISO type)	416	440C	630 (17/4PH)
Stainless steel EN number	1.4005	1.4125	1.4542
%Chromium	12,0-14,0	16,0-18,0	15,0-17,0
%Nickel	-	-	3,0-5,0
%Molybdenum	≤1,50	≤0,75	≤0,60*
%Sulphur	0,15-0,35	≤0,015	≤0,03
%Carbon	0,09-0,15	0,80-1,20	≤0,07
%Copper	-	-	3,0-5,0
Tensile strength / MPa (at 25 °C)	530(a)-1200(h)	785(a)-2000(h)	900(a)-1200(h)
Machinability	Excellent. Similar to 303 series s/s	Not possible after hardening	Good
Corrosion resistance	Moderate. Lower resistance than austenitic s/s	Moderate. Lower resistance than austenitic s/s	Very good. Comparable to austenitic 304 series s/s
Application examples	Can be heat-hardened and tempered. Machined from bar form into bearings, nuts, gears (similar to 303 series s/s).	The hardest alloy of stainless steel; useful for ball bearings, and slabs subject to general wear and tear. Not suitable for use at <0 °C or at continuously elevated temperatures (>450 °C).	Blades, gears, high-strength surgical instruments. Not to be used continuously at >500 °C temperatures. *Also has an added 0,3% Niobium
Product examples in this grade	**Shoulder Screw** **P0133** 	**Crossed Roller Rails** **L1001** 	**Finger Clamp** **10164** 

AISI 416/EN 1.4005 stainless steel is a martensitic stainless steel with a relatively high carbon content. Due to the raised carbon content, it has excellent machinability, and is used to make intricate parts such as nuts, gears and bearings. AISI 416/EN 1.4005 stainless steel is magnetic and can be heat-hardened - these properties distinguish martensitic 416 series stainless steel from the austenitic 303 series grade. However, it also has a minimal nickel content, so corrosion resistance is limited.

AISI 440C/EN 1.4125 stainless steel is a high-carbon martensitic stainless steel. This grade can achieve the highest hardness of all stainless steels, achieving a maximum Brinell hardness of 269 (Rc 60) after heat-hardening. Although it has a lower corrosion resistance than austenitic stainless steels, coatings/platings may be applied to provide an extra layer of corrosion protection.

AISI 630/EN 1.4542 stainless steel is also sometimes referred to as "17/4 PH", where "17/4" refers to the chromium/nickel content and "PH" stands for 'precipitation-hardening'. This grade has a relatively high corrosion resistance – comparable to the popular austenitic series 304 stainless steel – and can reach higher strengths and hardnesses than the austenitic series.

What you need to know about martensitic/ precipitation-hardening stainless steels:

Martensitic and precipitation-hardening stainless steels exhibit superior hardness and strength profiles as compared to austenitic stainless steels. Due to lower corrosion resistances, they are best used in clean, dry environments, although a protective coating may be applied to overcome this limitation.

We hope that this information has helped you decide on the stainless steel for your application. If you need any additional information, please feel free to **contact us.**

The stainless steels that we use throughout our extensive range of products adhere to the relevant ISO standards, so you can be assured that our friendly team of experts will supply you with the part that will help your designs come to life!

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