FASTENERS MADE OF STAINLESS STEELS

Stainless steels

The great variety of stainless steels makes them the most important materials in the industrial world. As early as the beginning of the 20th century it was observed that certain steel alloys did not show any signs of corrosion, or corrode only very slowly. Back then, different steel mills did research with steel types that were assumed to be corrosion-resistant. For example, research done by the German Krupp company and the Austrian Max Mauermann led to the development of an austenitic variant with a chromium content of 18% and a nickel content of approx. 10%. Today, this alloy is known as A2 (formerly know as V2A) or, with added molybdenum, as A4 (formerly V4A).

But what exactly does the term "stainless steel" mean? It applies to steels, which under "normal" climactic conditions do not corrode. Corrosion in this context is red rust, i.e. the product of the reaction between iron and oxygen. Stainless steels have a corrosion self-protection property generated by a natural resistance coating. The chromium in the steel alloy reacts on the exposed surface with the atmospheric oxygen to form chromium oxide, and this creates a very thin, but hard and airtight, passive layer which protects the steel from corrosion. If this passive layer is damaged, i.e. while the steels are being processed or in use, the surface protection will regenerate itself within a few hours, depending on the environmental conditions. In order to form the chromium oxide layer, the chromium content must be sufficiently high along the entire surface, and the surrounding air must contain oxygen. Foil-protected stainless steel sheets, for example, do not have such a passive layer yet, as there is no oxygen available under the foil. But, also, the material itself may sometimes not provide sufficient chromium locally under certain conditions. Stainless steels with large carbon content show this behaviour. Carbon will then react with the chromium to form chromium carbides and thus leave no way for the material to form a sufficiently thick passive layer. Where there is not enough unbonded chromium the steel surface becomes susceptible to salts and chlorides. This may be avoided by using grades with low carbon content such as material 1.4404 or titanium alloy such as material 1.4571. Also, increasing the chromium content improves the formation and resistance of the passive layer. This is beneficial in the so-called duplex steels with chromium content partly up to 26%.

In addition to the purely ferritic, austenitic and martensitic grades, duplex grades, which have a mixed structure of austenite and ferrite, were also produced in the 1930s. However, duplex steels back then were not stable enough to be used for technical purposes. This has changed very recently by adding nitrogen. Today we compare four material groups of stainless steels: austenites (A), ferrites (F), martensites (C) and duplex steels (D).

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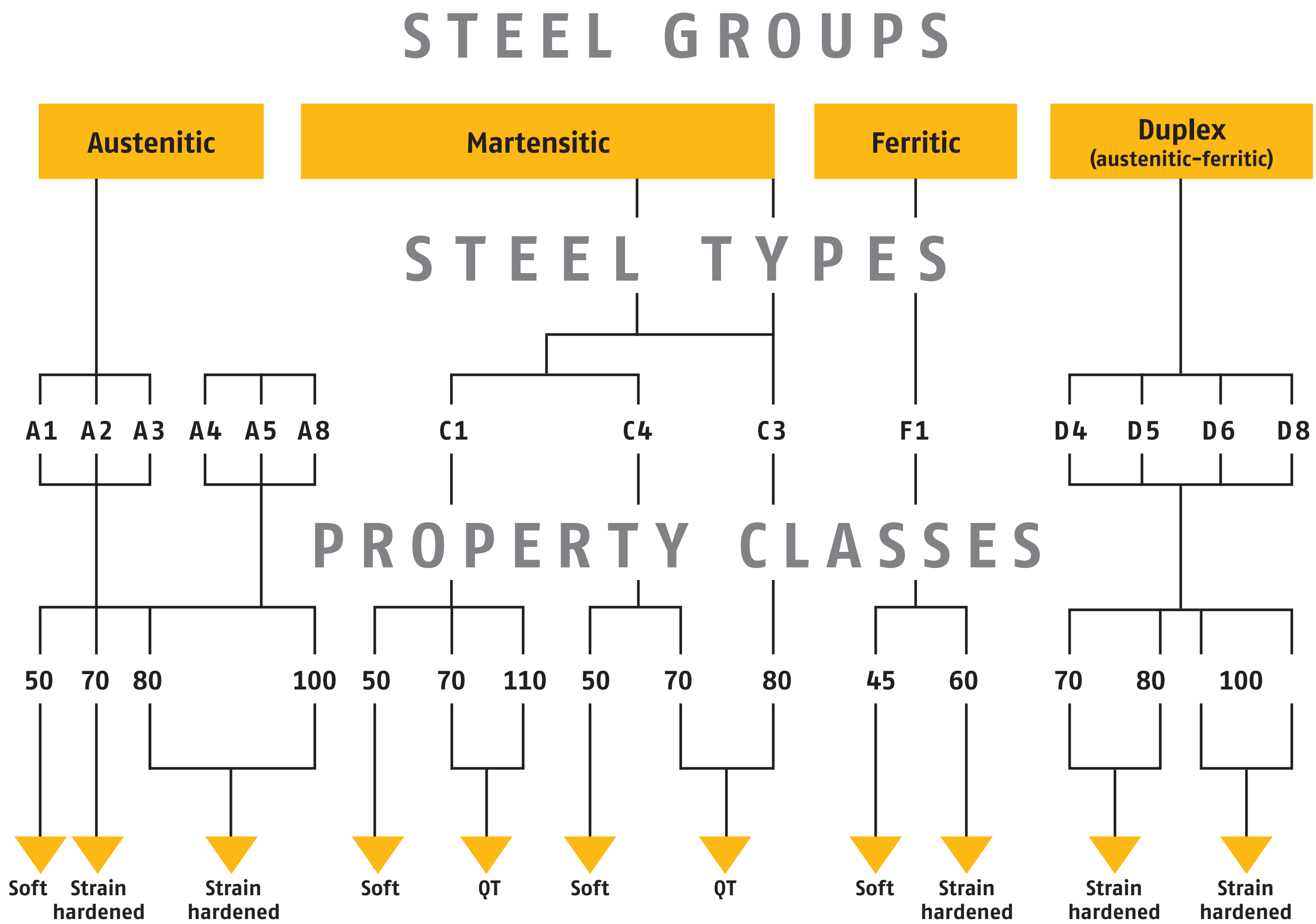
Material groups: austenites (A), ferrites (F), martensites (C) and duplex steels (D)



In the field of fasteners, martensites and ferrites are not significant. Due to their properties, austenitic and duplex steels are mainly used. REYHER has a wide range of stainless steel products in stock. These articles are ready for delivery. These products comprise of austenitic steels made of A2, A4 and A5 with nominal diameters from M2 up to M48. Newly added to the range are duplex products made of D6 and with a property class of 100.

In addition, we can procure and stock materials to your individual requirements. See the "Overview of materials" (page 4). We will gladly assist you in selecting the right materials for your particular application.

Overview of materials – extract from ISO 3506-6

Steel type	Material code	Properties
A1	1.4305 (X8CrNiS18-9)	for machining production partially corrosion-resistant partially acid-resistant partially weldable
A2	1.4301 (X5CrNi18-10)	for cold/hot forging corrosion-resistant partially acid-resistant good weldability
A3	1.4541 (X6CrNiTi18-10) 1.4550 (X6CrNiNb18-10) 1.4590 (X2CrNbZr17)	
A4	1.4401 (X5CrNiMo17-12-2) 1.4435 (X2CrNiMo18-14-3) 1.4436 (X3CrNiMo17-13-3) 1.4439 (X2CrNiMoN17-13-5)	for cold/hot forging highest corrosion resistance partially acid-resistant good weldability
A5	1.4571 (X6CrNiMoTi17-12-2) 1.4580 (X6CrNiMoNb17-12-2)	
C1	1.4006 (X12Cr13) 1.4021 (X20Cr13)	partially corrosion-resistant
C3	1.4057 (X17CrNi16-2)	
C4	1.4005 (X12CrS13) 1.4104 (X14CrMoS17)	partially corrosion-resistant for machining
F1	1.4016 (X6Cr17)	corrosion-resistant partially acid-resistant very suitable for environments with high chloride content
A8	1.4529 (X1NiCrMoCuN25-20-7)	good mechanical properties extremely high resistance to pitting corrosion, stress corrosion and crevice corrosion
D2	1.4482 (X2CrMnNiMoN21-5-3)	outstanding mechanical properties low nickel content
D4	1.4362 (X2CrNiN23-4)	outstanding mechanical properties good resistance to stress corrosion and intergranular corrosion
D6	1.4462 (X2CrNiMoN22-5-3) 1.4481 (X2CrNiMoN25-7-3)	outstanding mechanical properties high resistance to stress corrosion in media containing chloride, and to pitting corrosion
D8	1.4410 (X2CrNiMoN25-7-4) 1.4501 (X2CrNiMoCuWN25-7-4) 1.4507 (X2CrNiMoCuN25-6-3)	outstanding mechanical properties excellent corrosion resistance in case of corrosive chemicals such as sulphuric acid, phosphoric acid and nitric acid

Austenitic steels

Austenites, named after Sir William Chandler Roberts-Austen, are a γ-solid solution of iron. Austenitic steels A1 to A8 are highly corrosion-resistant, depending on the environmental conditions. In order to reduce the tendency for strain hardening and to achieve better workability, copper can be added to these materials. These materials cannot be hardened by heat treatment and are not magnetisable (permeability).

Steel types A3 and A5 have elements of titanium, niobium or tantalum added in order to achieve higher resistance to intercrystalline corrosion in high temperatures or after welding, for example. These elements combine with the additional carbon and thus prevent the formation of detrimental chromium carbides. Alternatively, it is also possible to use alloys with a very low carbon content, such as material 1.4404, where the carbon content of which is less than 0.03%.

Typical uses for austenitic steels are applications where the environments are highly corrosive, such as in the chemical industry.

Martensitic steels

Martensite, or martensitic, after the German materials scientist Adolf Martens, is a microstructure within the steel structure.

This structure is created when the material is cooled down quickly after hardening. In the field of technical heat treatment of steels, martensitic transformation is probably the most important, as – apart from practical exceptions – all hardening and quenching treatments include the formation of martensite. In contrast to austenitic materials, martensitic materials can be hardened. With martensites, higher mechanical properties (e.g. higher tensile strength) can be achieved compared to austenitic steels. However, compared to austenites, the corrosion resistance is reduced.

Ferritic steels

Ferrite, or ferritic, is a microstructure within the steel structure. The name is a deviation of ferrum, the Latin name for iron.

The ferritic microstructure is magnetic. These grades normally show very low ductility in low temperature application. They are intended for use in medium corrosive environments.

Note:

Normally, because of their superior cold forging properties, austenitic steels or duplex steels are used for the manufacture of fasteners.

Components of duplex steels

The name "duplex" describes a material which is composed of equal amounts of ferrites and austenites. The combination of these two components brings out their particular advantages. For example, the 0.2% yield strength with equal ductility is higher in duplex than in austenitic materials. Moreover, the fatigue strength under corrosive conditions is also higher for duplex steels.

The mixed austenite and ferrite structure is set by reducing the nickel content. Correspondingly, the chromium content must be increased. The common material 1.4462 contains 22% chromium, but only 5% nickel. Due to the increased chromium content, duplex steels are more resistant to corrosion than austenitic materials under various conditions of use. Nitrogen is another very important alloying element for this steel type. It helps form austenite, so that a homogeneous distribution of ferrite and austenite is assured. Also, the resistance of the austenitic phase to stress crack corrosion is improved largely by adding nitrogen. The ferritic phase shows superior resistance due to the combined chromium and molybdenum content.

Properties of duplex steels

Although the principle of duplex steels has been known for decades, this steel type was not accepted for a long time because of difficulties during welding. In this respect, the modern alloys have been developed and improved, so that now duplex steels have become easier to use and therefore more commercially important in recent years. In the field of fasteners, these materials are becoming more commonly used, which is proven by incorporating these materials into ISO 3506-1 and -2.

In this standard, material groups D 2, D 4, D 6 and D 8 have now been defined specifically for fasteners. Just like for all other material groups, only a rough analysis is defined. However, if this is compared to the common materials, it shows that Lean-Duplex 1.4362 for group D 4 and standard duplex materials 1.4462 and 1.4410 for group D 6 will probably dominate.

This is because they have a higher basic strength compared to austenites, therefore it is easier to achieve higher final strength values with duplex steels. The property class 100 is thus a very interesting supplement and with its tensile strength of 1,000 MPa and a yield strength of 800 MPa it achieves strength values, which are only slightly below those of a carbon steel screw of property class 10.9.

Fields of application for duplex steels

Due to the above-mentioned properties duplex steels may be used in all fields of application in which the corrosion resistance or yield strength of austenitic steels is not sufficient. As they are more resistant to chloride-induced stress corrosion compared to the austenitic materials, it is also possible to improve the resistance against saltwater or thawing salt.

Moreover, they can be used for steel construction work, for example for slender bridge designs or for areas with a high degree of humidity or pollution. In the general technical approval Z-30.3-6, material 1.4462 is allocated to corrosion resistance class IV (strong). Duplex steels are of great interest for the chemical industry due to their resistance to chlorine and chlorides as well as sulphur dioxide. Within this range, the number of possible applications is reduced due to the lower operating temperature (300 °C). Above this temperature, embrittlement may occur in the material due to the high chromium content.

Standard materials and special materials in the REYHER product range

Standard materials

We offer you a wide range of stainless steel products made of standard materials that we keep in stock. Therefore, we are able to supply you with all the articles you desire.

Please find below our product groups and standard materials:

- Austenitic steels made of A 2
  with nominal diameters from M 2 to M 48
- Austenitic steels made of A 4
  with nominal diameters from M 2 to M 48
- Austenitic steels made of A 5
  with nominal diameters from M 6 to M 30
- Duplex steels made of D 6
  with nominal diameters from M 6 to M 16
- BUMAX® – high-strength stainless steel fasteners of the product group BUMAX 88 (corresponds to the steel property class 8.8)
- BUMAX® – high-strength stainless steel fasteners of the product group BUMAX 109 (corresponds to the steel property class 10.9)

Special materials

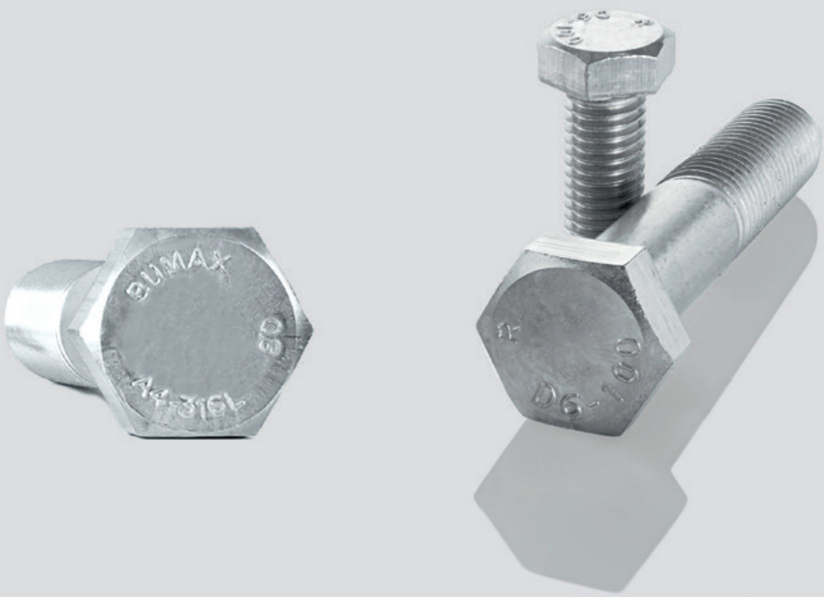
In addition to standard materials from the range of stainless steels we also offer a variety of special materials.

Here is an extract:

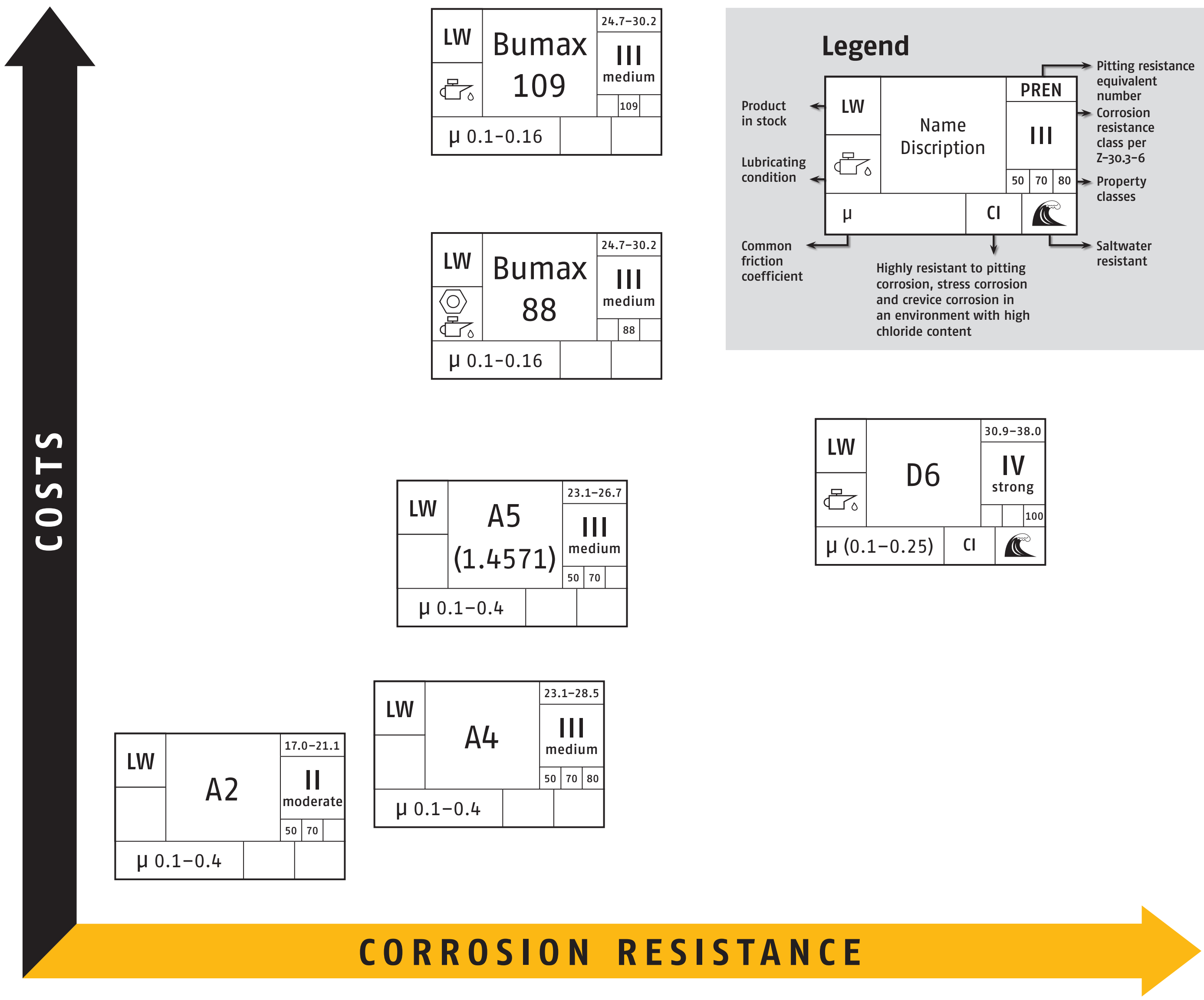
- Precipitation hardenable grades, material 1.4568 (17-7 PH), material 1.4548 (17-4 PH)
- 6-Mo-grades, e.g. materials 1.4547 (254 SMO) or 1.4529
- Heat-resistant and high-temperature-resistant grades, e. g. materials 1.4980, 1.4913 and 1.4923

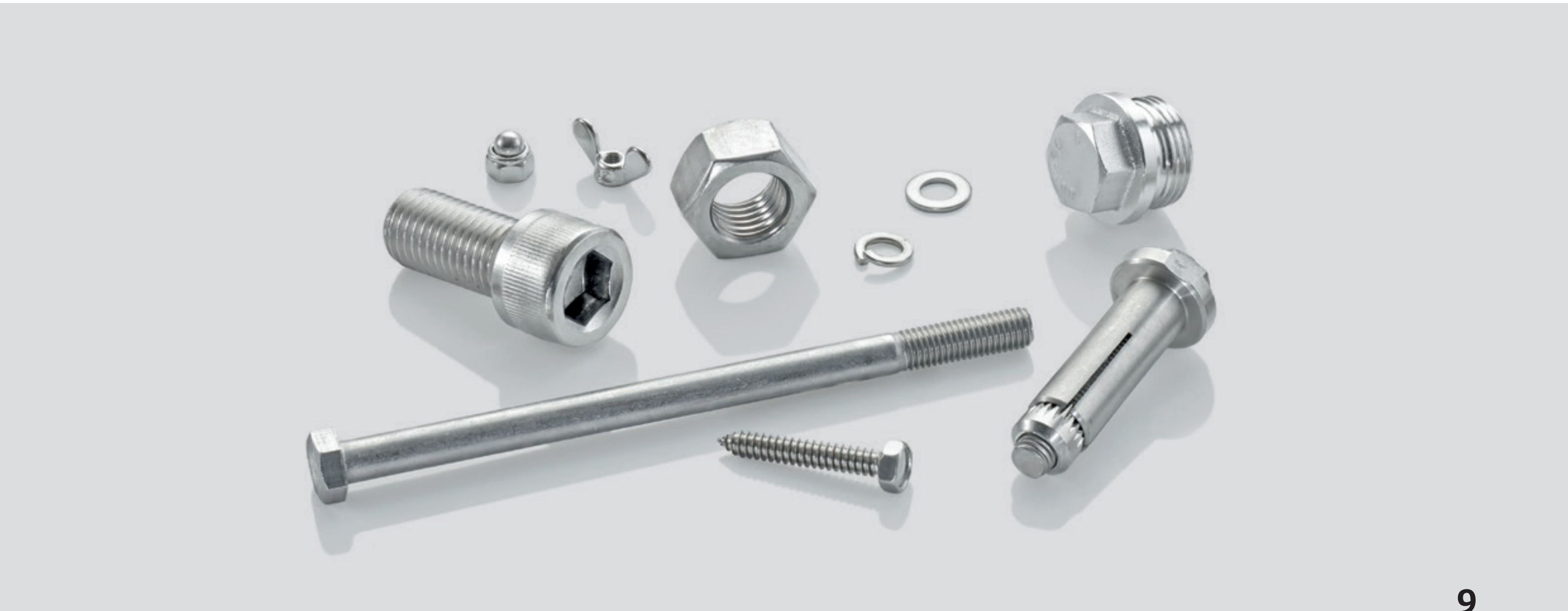
We offer products for all fields of application.

We gladly offer advice and support regarding your individual material requirements. We do the sourcing for you and can also add all the articles you need to our stock.



Overview of corrosion protection and costs





Technical expertise with REM – REYHER Engineering Management

Our REM team takes care of all technical matters and details regarding fasteners and fixing technology. With continuous training our comprehensive expertise is kept up to date. This is your advantage as our client.

For fasteners made of stainless steel we gladly support you in selecting the right materials for your particular application. In order to choose the right material, a multiplicity of application parameters has to be considered, such as temperature or exposure to corrosive substances, for example. Our expert engineers and technicians will gladly give advice. We are happy to hear from you and to support you in case of technical questions.

Technical hotline:
Phone +49 40 85363-999

REM®
REYHER ENGINEERING MANAGEMENT

Permeability

The magnetic permeability μ_r determines the permeability of matter for magnetic fields. Permeability is the ratio of magnetic flux density B to magnetic field strength H.

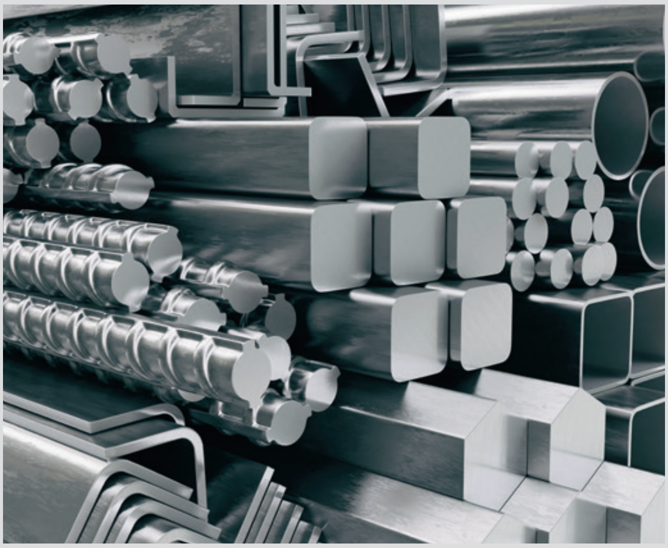
The magnetic permeability of this material is very low, if the value for μ_r is near 1. For fasteners made of stainless steel this property is described in ISO 3506-6. Fasteners made of austenitic steels cannot be magnetised in general. After cold forming, the material may be slightly magnetisable. Magnetism may also occur after machining the material by turning or punching. So the permeability μ_r of A 2 is ~1.8, μ_r of A4 is ~1.015. In certain applications, values that are too high may be reduced with special heat treatment by experienced companies.

Hardening austenitic materials (Kolsterising®)

Austenitic materials cannot be hardened with heat treatment. However, by Kolsterising® it is possible to increase the surface hardness, such as for wear protection. In this diffusion process, large amounts of carbon are diffused into the material at low temperatures (<300 °C). The carbon is dissolved to interstitial sites and does not form carbides.

Due to the large amounts of carbon, compression stress is caused in the surface, which leads to a very high surface hardness of >1,000 HV 0.05.

This standard treatment for wear protection results in a hardening depth of ~22 µm in austenitic stainless steels.



Spring properties of certain washers made of stainless steels

As austenitic materials cannot be quenched, they do not have the same mechanical properties as spring steel (great hardness). Spring washers made of A 2 (1.4301) for example are "flattened" during assembly. After loosening, these spring washers remain in this flat condition, which leads to the conclusion that there is no spring effect.

In standardisation this is taken into account by not standardising fastened spring elements made of austenitic materials (respective standards have been withdrawn). However, these products are still requested for practical applications. As an alternative for such applications, austenitic materials such as 1.4310 (X10CrNi18-8), or more optimally, 1.4568 (X7CrNiAl17-7), can be used.

Alternatively, martensitic materials may also be used, although with reduced corrosion resistance. These materials do not have the same properties as spring steel; however, they have – reduced – measurable spring forces. Tightened spring washers, which have only A 2 or A4 in their names and are often offered at low prices, should not be used in modern constructions, as they have no spring forces.


Quality testing in our internal testing laboratory: determining friction coefficients

High friction coefficients in bolted joints and in galling

Besides other property classes, fasteners made of stainless steels also show different friction behaviour than screws made of carbon steel, which must be considered for assembly.

If two stainless steel elements are fastened, the friction coefficients in the thread and on the contact surfaces are higher than with quenched and tempered screws. In addition, the spread is also much higher. Targeted preloading without lubricating the fasteners is nearly impossible.

Friction may be so high that it leads to galling, depending on the assembly conditions. It is assumed that during assembly the temperatures get so high locally that this leads to "weld" in a microscopic range. By tightening the fastener more, the "weld" is torn. This leads to increased surface roughness, which makes it even harder to turn the screw or nut. This step is repeated until the fastener can not be turned any further.

By using lubricants, the friction coefficients can be modified in a targeted manner. This way, not only can galling be avoided, but it is also possible to calculate the preload and the corresponding tightening torque. Copper paste is a suitable lubricant, but also ceramic lubricants or dry film lubricants, which are applied in advance.

Our product range in the field of stainless steels also comprises lubricated products. For example, all products made of duplex steel are generally lubricated. We also offer lubricated Bumax products, where only the class 88 bolts are lubricated by default. In the case of our bolts per ISO 4032 made of A2-70 and A4-70 you may choose with or without lubrication, as we offer both.

For applications for which a defined preload must be set, we recommend determining the tightening torques by testing in environments which reflect the actual conditions. This is possible with a torque-preload test. We gladly support you with this.

Typical values

Ø	Fkl.	Preload in kN for μ_{ges} =				Tightening torques in Nm for μ_{ges} =			
		0.10	0.14	0.20	0.30	0.10	0.14	0.20	0.30
M4	50	1.47	1.39	1.26	1.07	0.8	1	1.3	1.6
	70	3.14	2.97	2.71	2.3	1.8	2.2	2.8	3.4
	80	4.19	3.96	3.61	3.06	2.4	3	3.7	4.6
M5	50	2.39	2.27	2.07	1.76	1.7	2.1	2.6	3.2
	70	5.13	4.86	4.44	3.77	3.5	4.5	5.6	6.8
	80	6.84	6.48	5.91	5.02	4.7	5.9	7.4	9.1
M6	50	3.39	3.21	2.93	2.48	2.9	3.6	4.5	5.5
	70	7.26	6.87	6.27	5.32	6.2	7.7	9.7	11.9
	80	9.68	9.13	8.36	7.09	8.2	10.3	12.9	15.8
	100	12.9	12.22	11.14	9.46	11	13.8	17.2	21.1
M8	50	6.21	5.88	5.37	4.57	7	8.8	11	13.6
	70	13.3	12.61	11.51	9.79	15	18.8	23.6	29.1
	80	17.74	16.81	15.35	13.05	19.9	25.1	31.5	38.8
	100	23.65	22.42	20.47	17.4	26.6	33.5	42	51.8
M10	50	9.87	9.37	8.56	7.28	13.8	17.4	21.8	27
	70	21.16	18.4	18.34	15.6	29.5	37.3	46.8	57.8
	80	28.21	26.76	24.45	20.79	39.4	49.7	62.4	77.1
	100	37.61	35.67	32.6	27.73	52.5	66.3	83.2	102.8
M12	50	14.38	13.65	12.48	10.62	23.8	30.1	37.8	46.8
	70	30.83	29.26	26.75	22.76	51	64.5	81	100.2
	80	41.1	39.01	35.66	30.35	68	85.9	108	133.6
	100	54.81	52.01	47.55	40.46	90.6	114.6	144	178.2
M14	50	19.74	18.74	17.14	14.59	37.8	47.9	60.2	74.6
	70	42.31	40.16	36.73	31.27	81.1	103	129	160
	80	56.41	53.54	48.97	41.69	108	137	172	212
	100	75.21	71.39	65.29	55.58	144.1	182.4	229.5	284.2
M16	50	27.04	25.71	23.56	20.1	58.2	74.2	94	117
	70	57.94	55.09	50.49	43.08	125	159	201	251
	80	77.25	73.46	67.33	57.44	166	212	269	334
	100	103	97.94	89.77	76.58	221.7	282.8	358	445.9
M18	50	33.01	31.35	28.68	24.43	81.3	103	130	161
	70	70.73	67.17	61.46	52.34	174	221	278	345
	80	94.31	89.56	81.95	69.79	232	295	371	460
M20	50	42.27	40.2	36.84	31.34	114	146	184	230
	70	90.58	86.14	78.95	67.35	245	312	395	492
	80	120.8	114.9	105.3	89.8	326	416	527	656
M22	50	52.67	50.15	46.02	39.32	156	200	254	318
	70	112.87	107.46	98.61	84.25	334	428	544	680
M24	50	60.88	57.9	53.01	45.27	197	251	318	396
	70	130.5	124.1	113.7	97	421	537	680	848
M27	50	79.86	76.05	69.82	59.67	289	371	473	591
	70	171	163	150	128	620	795	1,013	1,267
M30	50	97.23	92.54	84.9	72.5	394	504	640	800
	70	208	198	182	155	844	1,080	1,373	1,715
M33	50	121	115	106	90	531	683	871	1,092
M36	50	142	135	124	106	684	876	1,117	1,398
M39	50	170	162	149	128	883	1,137	1,452	1,822

Property classes

As austenitic materials cannot be hardened with heat treatment, they have the property class 50 in unprocessed delivery condition, which corresponds to a tensile strength of 500 MPa. In non-machining production, they are strain hardened; in this process, the tensile strength values of austenitic materials may rise up to 1,000 MPa (property classes 70 + 80 + 100). As the hardening pressure such as in the case of thread rolling is limited, the property class 70, which is common in practice, may be achieved in screws with a maximum size of up to M 24.

In solution heat treated condition, duplex steels reach higher strength values already, and may thus also be hardened to a higher property class by strain hardening. For these grades, the property classes 70, 80 and 100 are standardised. We have property class 100 in stock, which corresponds to a tensile strength of 1,000 MPa and a yield strength of 800 MPa.

Unlike with steel screws, there is no linear connection between the tensile strength and the 0.2% yield strength. The yield strength corresponding to the tensile strength 50, 70, 80, and 100 is listed in the table below.

The mechanical and chemical properties for corrosion-resistant fasteners are defined in DIN EN ISO 3506-1, -2 and -3.

Steel group	Steel type	Property class	Tensile strength	0.2% yield strength	Elongation after fracture
Austenitic	A 1, A 2, A 3	50	500	210	0.6d
		70	700	450	0.4d
		80	800	600	0.3d
	A 4, A 5	50	500	210	0.6d
		70	700	450	0.4d
		80	800	600	0.3d
		100	1,000	800	0.2d
	A 8	70	700	450	0.4d
		80	800	600	0.3d
		100	1,000	800	0.2d
Martensitic	C 1	50	500	250	0.2d
		70	700	410	0.2d
		110	1,100	820	0.2d
	C 3	80	800	640	0.2d
	C 4	50	500	250	0.2d
		70	700	410	0.2d
Duplex	D 2, D 4, D 6, D 8	70	700	450	0.4d
		80	800	600	0.3d
		100	1,000	800	0.2d

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REYHER informs: Stainless steels

- ✔ Overview of material groups austenites (A), ferrites (F), martensites (C) and duplex steels (D)
- ✔ REYHER offers fasteners made of stainless steels for all fields of application
- ✔ New in the REYHER product range: duplex steels
- ✔ Technical consulting
- ✔ Stock products available immediately

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