Steel Material Properties

1. The word steel is understood to mean a deformable iron (Fe)-carbon (C) alloy with a maximum carbon content of 1.5%. The word "iron" should only be used to indicate the chemical element Fe, 100% pure iron and in the combination of the word malleable iron as distinct from malleable steel.

2. Unalloyed, low carbon steel with a C% ≤ 0.22% is used for the lower property classes of bolts, screws and nuts. This steel group is indicated with the letters St followed by a number corresponding with 1/10 of the minimum tensile strength in N/mm². For example, St38 has a minimum tensile strength of 10 x 38 = 380 N/mm².

3. Carbon steel can be divided into 3 types:
   - quality steel, indicated with the letter C followed by the C% multiplied by 100. E.g. C35 is a quality steel with 0.35% C and a P and S% of max 0.045.
   - high quality steel, indicated with the letters Ck with a lower P and S content. E.g. Ck 35 is a high quality steel with 0.35% C and P and S% of max 0.035.
   - cold heading steel, indicated with letters Cq having special cold forming characteristics. E.g. Cq 35 is a cold heading steel with 0.35% C and a P and S% of max 0.035.

4. In alloy steel group the percentage of elements – which normally only occur as traces or impurities – has been increased and/or other elements have been added to achieve or improve special characteristics, such as higher mechanical properties, better resistance against corrosion, low or high temperatures, etc.

   The designation starts with a number indicating 100 x the C-content, followed by the symbols of the relevant alloying elements in sequence of their quantity, starting with the largest, and finally another number (or series of numbers) indicating a certain ratio of the percentage of the alloying element(s).
   - 4 for the elements Cr-Co-Mn-Ni-Si-W
   - 10 for the elements Al-Cu-Mo-Ti-V
   - 100 for the elements C-P-S-N
   - 1000 for the elements B (boron)

   E.g. 36 Cr Ni Mo 4 is a steel alloyed with Cr, Ni and Mo with 36/100 = 0.36% C and 4/4 = 1% Cr.
   28 B 2 is a borium alloyed steel with 28/100 = 0.28% C and 2/1000 = 0.002% B.

   The most common elements used with fasteners have the following influence:
   - Carbon (C)
     is the most important element and influences the mechanical properties considerably. For fasteners the percentage varies up to 0.5% maximum. With increasing C content the strength increases, but the cold formability is reduced. From about 0.3% C the steel can be heat treated.
   - Nickel (Ni)
     improves the through-hardening, toughness at low temperatures and the non-magnetic properties. The combination of at least 8% Ni with about 18% Cr results in the important austenitic stainless steel quality A2.
   - Chromium (Cr)
     also increases hardenability and strength. A minimum content of about 12.5% is necessary for a steel to be qualified as stainless.
   - Molybdenum (Mo)
     increases hardenability and reduces temper brittleness. High temperature strength is improved. When 2 – 3% Mo is added to an alloy with about 18% Cr and about 12% Ni corrosion resistance increases considerably. This quality of austenitic stainless steel is used frequently for fasteners and is designated with A4.
   - Manganese (Mn)
     usually occurs like the elements silicon (Si), phosphorus (P) and sulphur (S) only as impurities. By adding Mn, strength, hardenability and wear resistance are increased. However the steel becomes more sensitive to overheating and temper brittleness.
   - Titanium (Ti)
     is used as carbide former for stabilization against intercrystalline corrosion in e.g. stainless steel. The elements Niobium (Nb) and Tantallum (Ta) cause the same effect.
   - Boron (B)
     is a relatively new alloying element in fasteners steel. Very small amounts of 0.002-0.003% already improves the through hardening considerably. Because of this, C% can be kept lower, improving the cold workability. The application of boron treated steels has become a very popular alternative in manufacturing cold formed, heat-treated fasteners.

5. Case hardening steel has a relatively low carbon content and is used to get a very hard, wear resistant surface by adding carbon during the heat treatment. This type of steel is used for tapping screws, thread cutting and self-drilling screws, chipboard screws, etc.

6. Free cutting steel is characterized by a good metal removal and short chip breaking. This is achieved by increasing the sulphur content to 0.34% max., sometimes with an extra addition of lead. A very popular type for fasteners is 9S20K with C% ≤ 0.13 and 0.18 – 0.25 S, which is machined in the cold-drawn condition. The manufacturing method of machining on automatic lathes is no longer used very much for commercial fasteners but it is still applied for small quantities or for a product configuration, which is difficult to cold form.

Chemical Composition of Steel Bolts, Screws and Studs

In the table below a specification is given of the steels for the standardized property classes of bolts, screws and studs in accordance with ISO898-1:1999.

Property Class	Material and treatment	Chemical composition limits (check analysis) % *(m/m)*					Tempering temperature
		C		P	S	B[a]	°C
		min.	max.	max.	max.	max.	min.
3.6[b]	Carbon Steel	-	0.20	0.05	0.06	0.003	-
4.6[b]		-	0.55	0.05	0.06	0.003	-
4.8[b]							
5.6		0.13	0.55	0.05	0.06	0.003	-
5.8[b]		-	0.55	0.05	0.06		
6.8[b]							
8.8[c]	Carbon steel with additives (e.g. B, Mn or Cr) quenched and tempered	0.15[d]	0.40	0.035	0.035	0.003	425
	Carbon steel quenched and tempered	0.25	0.55	0.035	0.035		
9.8	Carbon steel with additives (e.g. B, Mn or Cr) quenched and tempered	0.15[d]	0.35	0.035	0.035	0.003	425
	Carbon steel quenched and tempered	0.25	0.55	0.035	0.035		
10.9[e f]	Carbon steel with additives (e.g. B, Mn or Cr) quenched and tempered	0.15[d]	0.35	0.035	0.035	0.003	340
10.9[f]	Carbon steel quenched and tempered	0.25	0.55	0.035	0.035	0.003	425
	Carbon steel with additives (e.g. B, Mn or Cr) quenched and tempered	0.20[d]	0.55	0.035	0.035		
	Alloy steel quenched and tempered[g]	0.20	0.55	0.035	0.035		
12.9[f h i]	Alloy steel quenched and tempered[g]	0.28	0.50	0.035	0.035	0.003	380

a Boron content can reach 0.005% provided that non-effective boron is controlled by addition of titanium and/or aluminium.
b Free cutting steel is allowed for these property classes with the folllowing maximum sulfur, phosphorus and lead contents: sulfur 0.34%; phosphorus 0.11%, lead 0.35%.
c For nominal diameters above 20 mm the steels specified for property classes 10.9 may be necessary in order to achieve sufficient hardenability.
d In case of plain carbon boron steel with a carbon content below 0.25% (ladle analysis), the minimum manganese content shall be 0.6% for property class 8.8 and 0.7% for 9.8, 10.9 and 10.9.
e Products shall be additionally identified by underlining the symbol of the property class (see clause 9). All properties of 10.9 as specified in Table 3 shall be met by 10.9, however, its lower tempering temperature gives it different stress relaxation characteristics at elevated temperatures (see Annex A).
f For the materials of these property classes, it is intended that there should be a sufficient hardenability to ensure a structure consisting of approximately 90% martensite in the core of the threaded sections for the fasteners in the "as-hardened" condition before tempering.
g This alloy steel shall contain at least one of the following elements in the minimum quantity given: chromium 0.30%, nickel 0.30%, molybdenum 0.20%, vanadium 0.10%. Where elements are specified in combinations of two, three or four and have alloy contents less than those given above, the limit value to be applied for class determination is 70% of the sum of the individual limit values shown above for the two, three or four elements concerned.
h A metallographically detectable white phosphorus enriched layer is not permitted for property class 12.9 on surfaces subjected to tensile stress.
i The chemical composition and tempering temperature are under investigation.

Chemical Composition of Steel Nut

In the table below a specification of steel nuts is given in accordance with BS3692:2001.

Strength grade designation	Chemical composition limits (check analysis)			
	Carbon max. %	Manganese min. %	Phosphorus max. %	Sulfur max. %
4, 5 and 6 (See notes)	0.50	-	0.110	0.150
8	0.58	0.30	0.060	0.150
10 and 12 (See notes)	0.58	0.45	0.048	0.058

NOTE 1 Free cutting steel may be used only by special agreement between the purchaser and the supplier. In such cases, the following maximum phosphorus, sulfur and lead contents are permissible:
Phosphorus, 0.12 %; Sulfur, 0.34 %; Lead, 0.35 %

NOTE 2 Alloying elements may be added if necessary to develop the mechanical properties of the nuts stipulatd in clause 15.