Fasteners 101

Most people think a bolt is a bolt is a bolt. They see it as nothing but a piece of metal that holds things together. Fasteners (bolts or screws) are complex mechanically and metallurgically engineered hardware. They are made to metric, SAE and other standards, using different materials (identified by the grade, i.e. Grade 8), different thread types (coarse, fine, etc.), various lengths, with grip or no grip (shank), different head types, and different coatings (i.e. cadmium, dry film lube, etc.).

1. **Metric vs. SAE** bolts can be identified by their head markings. If the bolt head is marked with 8.8, 10.9 or 12.9, this is a metric bolt and the diameter, head, length and thread pitch is measured in mm. If the bolt has only 3 or 6 lines pointing toward the center of the head, this identifies the bolt as SAE (Society of Automotive Engineers). See **Table 1**. **Grade:** Bolts are also specified for strength, known as Grade for SAE or Class for Metric. In metric bolts there are 3 commonly used classes, 8.8, 10.9 and 12.9. There are also lower grade metric bolts which should be avoided. In SAE there are 2 commonly used grades, 5 and 8. Grade5 is identified by three bars on the head and Grade8 by 6 bars on the head. There are lower grades of SAE that too should be avoided. See **Table 1**.

2. **Strength:** The strength of a bolt corresponds to the grade or class of the bolt. Strength is described by **Tensile Yield Strength (Ys)**…The load at which the bolt starts to permanently deform and **Ultimate Tensile Strength (UTS)**…the load at which the bolt fails or fractures. **Table 1** shows the strength by Grade of Metric and SAE bolts. Note bolts are commonly subjected to shear loads as shown in **Table 1**. The shear strength of a bolt is approximately 60% of the tensile strength of the same bolt. Go to the following link to view minimum specifications for Grade 5 titanium;

   http://www.matweb.com/search/datasheet.aspx?MatGUID=a0655d261898456b958e5f825ae85390

Table 1. Strength and Markings for Various Grade Bolts (titanium on next page)

SAE Steel Bolts				
Head Marking	**Grade and Material**	**Applicable Bolt Diameter (inches)**	**Min. Yield Strength (Ksi)**	**Min. Tensile Strength (Ksi)**
No Markings	**Grade 2** Low or medium carbon steel	1/4 thru 3/4"	57Ksi	74Ksi
3 Radial Lines	**Grade 5** Medium Carbon Steel, Quenched and Tempered	1/4 thru 1"	92Ksi	120Ksi
6 Radial Lines	**Grade 8** Medium Carbon Alloy Steel, Quenched and Tempered	1/4 thru 1-1/2"	130Ksi	150Ksi
Stainless markings vary. Most stainless is non-magnetic	**18-8 StainlessSteel** (17-19% Chromium and 8-13% Nickel)	1/4 thru 5/8"	40 – 90Ksi	100 – 125Ksi Typical
Metric Steel Bolts				
8.8	**Class 8.8** Medium Carbon Steel, Quenched and Tempered	up to 72mm	640 MPa (93Ksi)	800 MPa (116Ksi)
10.9	**Class 10.9** Alloy Steel, Quenched and Tempered	5mm - 100mm	940 MPa (136Ksi)	1040 MPa (151Ksi)
12.9	**Grade 12.9** Alloy Steel, Quenched and Tempered	1.6mm - 100mm	1100 MPa (160Ksi)	1220 MPa (177Ksi)
Metric Stainless typically marked A-2	**A-2 StainlessSteel** (17-19% Chromium and 8-13% Nickel)	up to 20mm	450 MPa Typical (65Ksi)	700 MPa typical (102Ksi)

Tensile Strength: The maximum load in tension (pulling apart) which a material can withstand before breaking or fracturing.

Yield Strength: The maximum load at which a material exhibits 0.2% permanent deformation

1ksi = 1000psi, 1MPa = 1N/mm^2 = 145 pounds/inch^{2,}

Ti64 Titanium Alloy Bolts				
Ti64 Head Marking	**Grade and Material**	**Applicable Bolt Diameter (inches)**	**Min. Yield Strength (psi)**	**Min. Tensile Strength (psi)**
No Markings	**Commercially Pure Ti (AKA Grade 2 Ti)**	#10 thru 3/4" M4-M18	40Ksi 275MPa	50Ksi 344MPa
Shallow Dimple in hex bolts	**Ti-6Al-4V (AKA Grade 5 Ti)**	#10 thru 3/4" M4-M18	128Ksi 880MPa	140Ksi 950MPa
Deep dimple in hex flange bolts	**Ti-Micro64***	#10 thru 3/4" M4-M18	150Ksi 1030MPa	160Ksi 1100MPa

Tensile Strength: The maximum load in tension (pulling apart) which a material can withstand before breaking or fracturing.

Yield Strength: The maximum load at which a material exhibits 0.2% permanent deformation

1ksi = 1000psi, 1MPa = 1N/mm^2 = 145 pounds/inch^{2,}

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