The nuts and bolts of things

The long-term reliability of bolted connections will often depend upon the correct combination of bolts, nuts and washers for an application. With a large selection of different sizes, strengths, thread types and head types, knowing what the markings mean and what the tightening torques are can be the difference between keeping a vehicle on the road and finding a vehicle at the repairers. This article is intended to inform you about the common types of fasteners that are used in our industry.

BOLTS

The most common type of bolt heads used on heavy vehicles are hexagon, 12-point (double hexagon) and hexagon recess (see the figure). Of these, the most common and most versatile is the hexagon head. The 12-point– and hexagon recess–type heads are generally used in high-strength, high-torque applications such as engine assemblies and specialist equipment. This article is mainly concerned with hexagon head fasteners because they are commonly used to make attachments to chassis rails.

FASTENER GRADES

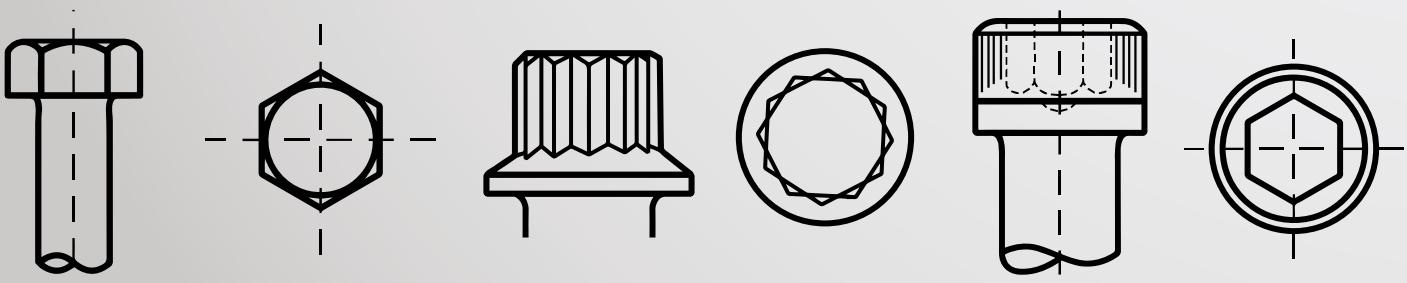
The faster strength grades are shown in the table. These grades apply to nuts, bolts and washers. All three should have the same grade.
UTS = ultimate tensile strength or breaking strength. Yield = permanent deformation limit. Proof load is the maximum acceptable stress under operating conditions, which is nominally 90% of yield.

TORQUE SETTINGS

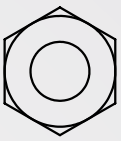
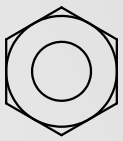
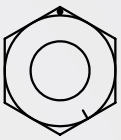
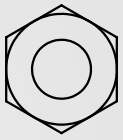
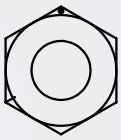
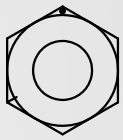
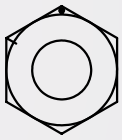
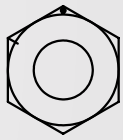
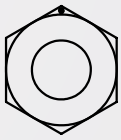
Adequate tightening of bolts is required to prevent loosening over time due to vibrations. Nuts become loose due to lateral movements that momentarily reduce the clamping force exerted on the threads. To overcome these lateral movements the clamping force must be adequate and the mating surfaces flat. Bolt tightening preload is recommended by the bolt manufacturer. It is usually about 60% of the yield strength. Bolt suppliers typically recommend bolt tensions about 60% of the yield strength but it is lower for fine threaded bolts. For a grade 8.8 M10 x 1.5mm bolt this would require a bolt torque setting of 50Nm when dry. Adding lubricant reduces the bolt torque setting required to achieve the same clamping force. In this case, the lubricated bolt would require a bolt torque setting of 38Nm
The addition of a locking solution such as Loctite is recommended for applications where vibrations are a concern. Loctite reduces the chance of lateral movement of the bolt head during vibration, thus allowing constant clamping force. Loctite also lubricates the thread so don't over tighten! Over-tightened bolts have a habit of breaking in service.

NUTS

The nuts must match the grade of the bolt selected. Otherwise, one of the threads can be easily damaged when the recommended tightening torque is applied. Bolts stay tight because the threads are pressing together so tightly that they can't slip with the side forces they experience.
According to VSB 6, structural attachments to the chassis rails must have a minimum hardware grade of Metric 8.8 or SAE grade 5 and use a suitable washer and a locking mechanism such as a Nyloc nut. For truck and trailer structural use, bolts and nuts used in structural applications must have a nut retention mechanism – either a lock nut



Hexagon head (left), 12-point (centre) and hexagon recess (right).

Metric grade	Bolt markings	Nut markings	SAE J429 grade	Bolt markings	Nut markings
4.6 ISO metric thread UTS = 400MPa yield = 60% of UTS proof load = 225 MPa			**Grade 1** UTS = 410 MPa yield = 250 MPa proof load = 227 MPa		
5.8 ISO metric thread UTS = 500MPa yield = 80% of UTS proof load = 380 MPa			**Grade 2** UTS = 510 MPa yield = 390 MPa proof load = 380 MPa		
8.8 ISO metric thread UTS = 800 MPa yield = 80 % of UTS proof load = 580 MPa			**Grade 5** UNC / UNF threads UTS = 827 MPa yield = 634 MPa proof load = 586 MPa		
10.9 ISO metric thread UTS = 1000 MPa yield = 90% of UTS proof load = 830 MPa			**Grade 8** UNC / UNF threads UTS = 1034 MPa yield = 896 MPa proof load = 827 MPa		
12.9 UTS = 1000 MPa yield = 90% of UTS proof load = 816 MPa			No equivalent. Specialist bolt domain.		
Preferred sizes: M6, M8, M10, M12, M16, M20, M24 Strength is proportional to shank area and hence to diameter squared. For example, an M20 has four times the strength of an M10. Note that nuts may have different markings that are also acceptable.			**Preferred sizes:** 1/4, 5/16, 3/8, 7/16, 1/2, 5/8, 3/4, 7/8, 1" Strength is proportional to shank area and hence to diameter squared. For example, an M20 has four times the strength of an M10. Note that nuts may have different markings that are also acceptable.		

or a polymer locking nut. When no nut retention mechanism is provided, as for wheel nuts, regular torque checking is mandatory.

WASHERS

Washers can be used to dissipate the clamping load over a larger surface area or be used in repairs where a hole has elongated. They are needed under the nut but not usually needed under the bolt head. Washers also protect the mating surface from possible damage caused by the bolt and nut.

Bolted fasteners come loose because of side slippage that causes the nut and bolt to move relative to one another. Sloppy holes and sloppy washers can facilitate side movement. Except for wheel nuts, washers should always be used under a nut to provide a uniform surface for the nut to tighten onto.

THREADS AND THREAD SIZES

Size for size, a fine thread is stronger than a coarse thread. This is true in tension and in shear. The fine thread bolt has a larger minor diameter and is inherently stronger. Fine threads are less likely to loosen because the thread incline is smaller than on a coarse thread.

Imperial threads are denoted as threads per inch, with the first measurement shown in inches being the major diameter. The second number is the number of threads per inch (TPI), for example: 7/16 – 14 UNC (Unified National Coarse) or 7/16 – 20 UNF (Unified National Fine). In comparison, a metric bolt identifies the major diameter in millimetres multiplied by the pitch distance, for example: M10 x 1.5 (Standard) or M10 x 1.25 (Fine).

Coarse thread bolts are more durable, and therefore easier to work with; and more common. Cross-threading is therefore less likely to occur with coarse threads. Fine thread bolts are often used where extreme vibrations occur, for example in engine assembly because they are less likely to loosen than a coarse threaded bolt.

Whilst coarse thread bolts are quicker to install, equivalent fine thread bolts are capable of offering the same clamping force with less tightening torque. Fine threads require less tightening torque than course threads to develop the same bolt preload.

On the negative side, fine threads are more vulnerable to galling, which is metal-metal tearing arising from surface welding. Don't over-tighten! Metric fine threads are more difficult to obtain commercially than imperial fine threads such as UNF. High quality chassis rail attachments will often have fine threaded hardware and reamed holes. The reaming ensures that the hole is uniform and without slop.

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