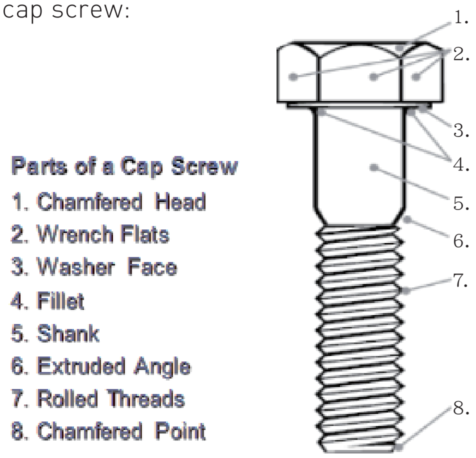
# Fastener

## Design and Terminology

by Guy Avellon

Many times we look at a bolt and do not think anything about its design characteristics and purpose, other than it looks nice and it fits. Yet the hex head cap screw is very purposeful and versatile, as it is available in many different strength levels and sizes. Even with inch and metric dimensions, many design features are standard.

First, let's start with the terms used on the common cap screw:




**Chamfered Head:** Though it is not critical to the function of the cap screw, it does lend to its appearance and helps to guide the socket onto the head for easier fit and positioning. This trait is found with cold headed products and usually not on hot formed or hot headed products.

**Wrench Flats:** The part of the hexagonal head that allows a socket or wrench to be applied so the cap screw may be tightened or held in place while being tightened by a nut.

Why this is significant: most dimensional prints for hex bolts will specify a dimension called 'WAF', which is an abbreviation for Width Across the Flats as well as "Width Across Corners". Tight tolerances and good quality control will provide for a proper fit that will not damage the wrenching socket or round the corners of the hex head.

**Washer Face:** Also known as the bearing surface, as it evenly distributes the load of the head onto the joint or flat washer. As a raised portion under the head of a cap screw, it will also elevate the head slightly to prevent the corners of the hex head from contacting the surface of the joint. In some cases, it will also protect the fillet from contact with the edge of a mounting hole.

**Fillet:** One of the most critical parts of the fastener; the fillet has definite dimensional radius tolerances that transition from the shank to the head. The fillet reduces the stresses at the head and shank junction. The fillet radius is more complex and compounded for socket head products as the heads have a smaller bearing surface and carry greater loads and stresses.

Why this matters: The head integrity of the fastener is so critical that when tensile testing to ASTM F606/606 M or SAE J429 for inch and J1216 for metric fasteners, these standards all specify that the fractures shall occur in the threads and not at the head to shank junction. If this occurs, the lot must be rejected.

**Shank:** The solid portion of a bolt or stud that is smooth and distinct from the threaded portion or the head and represents the major diameter (body) of the fastener.

**Extruded Angle:** This is a transitional portion of the body where, during the manufacturing process, a controlled dimensional portion of the shank is extruded to a smaller diameter. This smaller diameter becomes the pitch diameter for roll forming the threads.

Why this matters: Fasteners with cut threads will not have this angle and will have the threads end abruptly into the shank. Threads that are rolled will transition out at the beginning of the extruded angle and should never end into the angle or shank, as this will cause a point of high stress concentration. This thread run out is also known as an incomplete thread.

**Rolled Threads:** Rolled threads are formed from two reciprocating dies with progressive thread grooves. That is, as the bolt blank passes between these two dies, pressure from the thread grooves literally squeezes the metal from the pitch diameter upwards to form the thread crests and downwards to form the thread roots. The pitch diameter was roughly half the distance between the projected minor diameter and major diameter.

Why this matters: Rolled threads are 30% stronger in thread shear than cut threads. The grains of a steel bolt will run length wise. When threads are cut, the grain flow is interrupted, thereby decreasing its strength. This may be compared to stacking one brick on top of another brick: the stack is weak and not stable. With rolled threads, the grain patterns flow into the new shape of the thread and become more compact and stronger. This flow pattern may be compared with staggering the bricks as you would when building a wall. Never add threads to a roll threaded fastener with a thread die. Doing so will introduce severe stress points from the sharp thread cutting die which will promote metal fatigue.

**Chamfered Point:** This is a feature found on all fasteners manufactured in North America and on a few imports. This is an extra operation performed with a sharp tool forming the chamfer on the pitch diameter blank before it has its threads rolled on.

Why this matters: A fastener with a blunt end or sheared end may be prone to cross threading and is difficult to start threading a nut onto it. The chamfered point facilitates easier assembly, especially where speed and accuracy are important.

**USS:** Many years ago this stood for United States Standard. The current terminology uses 'Unified'. Therefore, when we specify UNC threads, it means Unified National Coarse. UNF would indicate Unified National Fine.

Why this matters: The larger diameter series of flat washers are still named USS. This does not reflect on the type of fastener it needs to be mated with, such as a USS washer and a UNC (USS) bolt. The better choice is the SAE (narrow) flat washer to be used with all SAE Grade 5 and 8 inch fasteners and/or 8.8 and 10.9 Property Class metric fasteners, because the inside diameter is smaller than the USS washer and will support the entire load under the fastener's head whereas the USS inside diameter is too large.

**UNRC, UNRF:** Many salespeople have mistakenly represented the 'R' as meaning rolled threads. Every fastener made today on an automatic bolt making machine has rolled threads. The R designates a mandatory root radius. The UNR thread root is defined as having a continuous rounded contour with a radius not less than 0.10825p.

Why this matters: Any time we have a radius, there is less stress build up. Any sharp angle, notch or scratch will develop stress risers that can and will develop into microcracks and metal fatigue failure. This dimensional specification for the radiused root is also carried out to the last thread run out before the extruded angle to be sure there are no sharp angles during this transition. Besides the fillet, this is the second most critical part of the fastener. Smooth, radiused parts increase the fatigue life of the fastener.

**Tensile Strength:** This is the point of ultimate axial loading that causes complete fracture: the maximum amount of load stress the fastener can withstand.

Why this matters: Some users still reference the strength of the fastener but may not take into consideration that this is not usable strength. The fastener will fail before it fractures. It fails when it reaches its yield strength.

**Yield Strength:** This is the point where the fastener becomes permanently elongated. When this occurs, the fastener is not as strong as it was before any load was applied and will continue to stretch and fail until it reaches its tensile strength for complete fracture.

**Proof Load:** This value is approximately 9% of the yield strength. Mathematically and experimentally, proof load is the maximum load that can be applied to a fastener and sustained without incurring any permanent elongation of only 0.0005" (0.013 mm).

Why this matters: Proof load is the value from which torque values are calculated. Design engineers can rely on this value to build in certain safety factors from 25 to 50%. This is the maximum usable strength of a fastener and will indicate the amount of expected clamping force it can safely generate. ■