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Bolts and Screws

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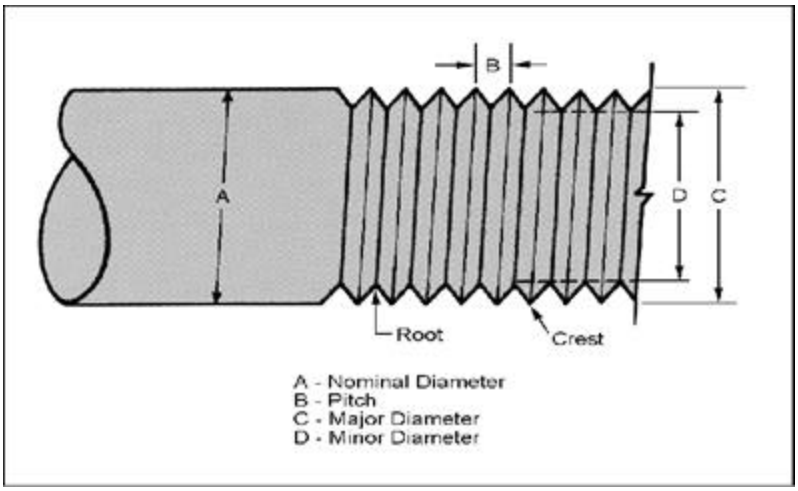
A mechanical joint must provide sufficient flange pressure to create and maintain a seal. Bolts or screws are the fasteners commonly used to give the clamping load that provides the pressure at the flanges.

Bolts and screws are among the many types of threaded devices referred to collectively as fasteners. There is some overlap between the definitions of bolts and screws. Generally, if the fastener is designed for use with a nut, and if it is tightened by applying a torque to the nut, then the fastener is a bolt. If it is designed for insertion into a hole with internal threads (as in an engine block), and if it is tightened by applying a torque to its head, then the fastener is a screw. Studs are headless fasteners or threaded rods. In the chemical industry, where standard pipe flanges are usual, through bolts are used almost exclusively. In other industries, most flat-faced flanges are clamped together with tap bolts or cap screws.



In the above figure, the arrows point to the root and the crest of the threads. The pitch of the thread is the distance from the crest of one thread to the crest of the next thread. This measurement is used to determine the number of threads per inch, or millimeters per thread, data that are usually supplied by the fastener manufacturer. The one most frequently used term in designating the size of a bolt or screw fastener is its nominal diameter.

Screw Thread and Material Strength Systems

Basically, screws and bolts are described according to their diameters, thread pattern, and material strength. There are English and metric systems for both sets of properties.

English unit designations for bolt sizes and screw threads follow the **unified** standard thread system in the United States. Unified standard threaded fasteners are available in three series of diameter-and-pitch combinations: unified coarse (UNC), unified fine (UNF), and unified extra fine (UNEF). The UNC coarse series finds the most common use with gaskets and is recommended for general assemblies where vibration is not a problem and where disassembly may be needed.

A shorthand notation that includes the nominal diameter, the number of threads per inch, and the thread-pitch series is used to identify unified thread bolts and screws on drawings or in parts lists. For example, 1/4" 20 UNC indicates a bolt or screw with a nominal diameter of 1/4", with twenty threads per inch and with unified coarse threads. Fastener sizes frequently encountered in gasketing applications include 1/4"-20 UNC, 5/16"-18 UNC, 3/8"-16 UNC, and 5/8"-11 UNC.

Currently proposed U.S. standards for metric-size fasteners call for only one series of diameter-pitch combinations. Metric threads are designated by a capital letter M, followed by the major diameter in millimeters, followed by the symbol "X," and then followed by the pitch distance in millimeters. For example, M6 x 1 indicates a metric thread with a major diameter of 6 mm and a pitch of 1 mm. The diameter is approximately 1/4 in., and the pitch is approximately 25 threads/inch similar to, but not the same as, 1/4"-28 UNF. Unified series and metric fasteners cannot be interchanged.

In addition to size and thread type, fastener specifications also include material tensile strength properties. As a screw or bolt is tightened, it first stretches elastically, then yields, and ultimately fails and breaks. Four load or stress levels describe this process. As the fastener is tightened, increasing tensile (stretch) load is created until a recommended **preload** is reached. This is the load that sufficiently stretches the bolt/screw to give a tight joint and overcome any forces tending to pull the joint apart. If the bolt were tightened further, the **proof** load would be reached, the maximum load that still allows a sufficient margin of safety before yield. Further tightening would stress the bolt/screw until the **yield load** was reached, the load at which the fastener begins to permanently stretch and not behave elastically. Finally, further tightening would take things to the ultimate load which is the greatest load the fastener can withstand. Still further tightening will cause significant plastic flow and failure. Typically, the preload is 75-85% of the proof load; the proof load is typically 90-95% of the yield strength and approximately 65% of the **ultimate load**.

These bolt/screw strength properties are quantified in terms of tensile stress in SAE grade designations and metric property classes. The SAE grades (2, 5,7, 8) specify proof load stress (psi), minimum tensile strength (psi), alloy composition, and treatment requirements for fastener steel. Within a grade, the requirements may depend on the fastener diameter. SAE grade 8 requirements are the most stringent. Metric requirements include proof stress measured in megapascals (MPa), minimum tensile strength (MPa), minimum yield strength (MPa), and maximum and minimum Rockwell hardness.