It might be unusual to think of bolts and nuts as cutting-edge technology, but for at least 1,800 years these fasteners were nothing less. Until the Industrial Revolution, the six classical machines were responsible for every mechanical advantage. Of the original six machines, screws were likely the last to be invented, but also the most revolutionary.

They could be used to convey objects linearly or to pump fluids, as in Archimedes’ famous screw pump. Screws were effective as gear reductions in worm drives. Most importantly, they could assemble materials reliably and proficiently.

It’s easy to argue that bolts and nuts are just as high-tech today. After all, most compound machines are hybrids of simple machines. Now, after centuries of metal-working practice, threaded fasteners are manufactured to precision tolerances and must meet the robust demands of today’s high-efficiency, high-performance marketplace. As such, bolts are increasingly specialized and standardized, with no end in sight.

The differences between today’s bolts and nuts go far beyond dimensions. Do you know the difference between rolled threads and cut threads? What about thread fit classes? Metric thread vs. Unified Thread Standard? Or coarse versus fine thread?

More significantly, does your supplier know the difference, and can it develop hardware to meet your specific applications?

**Thread Manufacture**

Even in technical parlance there is often no distinction made between screws and bolts. The truth is that these terms were in use before the advent of machined threaded fasteners, so they are often used interchangeably. Standards bodies have concluded that it’s not specifications or manufacturing method that differentiate these fasteners; rather it’s how they are used. As outlined by Machinery’s Handbook and ASME B18, screws are externally threaded fasteners that mate with internal threads or can be driven through materials to assemble components. To install or remove a screw, torque is applied to the fastener head. Bolts are also externally threaded, but they are held in place while torque is applied to a nut. Compatible internal threads must have the same geometry as the threads on the bolt.

To the naked eye it might appear that all fastener threads are created equal. In fact there are two methods used to manufactured threads—rolling and cutting—that affect fastener functionality. Cutting requires a blank rod that is the exact diameter as the bolt specification, and excess material is cut away from the blank to create threads. This results in a thicker diameter before the threads start. All standard bolt sizes and thread types can be manufactured via cutting. Generally, bolts and screws with cut threads have better shear strength, but are also more complicated to manufacture and more expensive.

To fabricate rolled threads, a blank with a diameter slightly smaller than the designated end diameter is used. The blank is deformed by dies to create the helical peaks and valleys that wrap around the bolt shaft. This creates a fastener with smoother threads that also weighs less than same-sized cut bolts. These fasteners are cold-worked, which hardens...
the threads. Overall, rolling is a fast, efficient and less costly method of threading blanks. There are some constraints, such as limits on thread length and bolt diameters, and some materials are too hard to be cold worked by dies. Two types of structural bolts, A325 and A490, cannot be rolled because of these restrictions.

These conditions mean rolled threads are suitable for most applications, as they’re less expensive, and on average 7% stronger than cut threads. Whereas cold working hardens the minimum diameter, cutting abrades it and weakens the material surface. Typically the only instance where cut threads are explicitly sought are when specified materials are too hard to be rolled.

**Standardization**

In the 19th century, industrialization and machining advances led to mass-produced and distributed fasteners. Competing bolts of the same size with incompatible threads led to interoperability problems, especially with imported machinery. It took a global event of epic proportions (World War II) to foster international cooperation on bolt standardization. Canada, the United States and the United Kingdom were unable to fix each other’s tanks and vehicles during the war, so in 1949 they adopted the Unified Thread Standard (UTS) that outlined thread criterion using inch measurements. Meanwhile, the metric system was gaining popularity in Europe and Asia, leading to the United Kingdom dropping UTS and adopting the metric system instead. Today, Canada and the United States remain the only markets with high concentrations of UTS hardware. According to ISO, global hardware popularity is split 60% metric, 31% UTS and 9% other.

With the largest market share, metric bolts are the most easily identified. Denominations begin with the letter M and the number immediately after indicates the bolt diameter in millimeters. Metric fastener threads are also specified according to thread pitch, which is the distance between adjacent threads, again in millimeters. This is represented by the last number in a metric bolt’s designation. For example, a bolt labelled M10 x 1.5 is a metric bolt with a 10 mm diameter and 1.5 mm between threads.

Thread fit categorizes the tolerances between the peaks and valleys (crests and roots) of mating threaded hardware. In metric descriptions, thread fit is classified by a number and letter system; lower numbers indicate threads with higher precision and letters indicate tolerance position. In some instances hardware may actually be labelled with two sets of thread fit measurements. The first label represents the pitch diameter (the imaginary diameter that cuts the threads half way—the distance is equal from the major and minor diameters), while the latter represents the crest diameter, which is the minor diameter on internal threads and the major diameter on external threads. For example, a 4G5G bolt would have a grade 4 pitch internal thread and a grade 4 crest internal thread. When the pitch and crest grades are the same, the notation is simplified; a 4G4G bolt would be labelled 4G instead. Threads with higher tolerance install quicker and are better-suited to accommodate coatings such as a threadlocker.

<table>
<thead>
<tr>
<th>Thread class</th>
<th>Tolerance</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>1.50% pitch diameter</td>
<td>Only for fast and easy assembly and disassembly; rarely used.</td>
</tr>
<tr>
<td>1B</td>
<td>1.50% pitch diameter</td>
<td>Acceptable for the majority of applications; most common UTS bolt class.</td>
</tr>
<tr>
<td>2A</td>
<td>1.10% pitch diameter</td>
<td>High-accuracy, high-strength applications; safety.</td>
</tr>
<tr>
<td>2B</td>
<td>1.10% pitch diameter</td>
<td>Safety.</td>
</tr>
</tbody>
</table>

When compared to UTS, 6g metric threads will be very similar to a 2A UTS bolt in terms of thread fit.

UTS bolts that have diameters of less than 1/4 inch are provided gauge numbers, but inch measurements are used between 1/4 and 1 inch sizes. The second number of a UTS bolt designates the threads per inch (TPI). UTS bolts sizes between #0 and #10 have two possible TPI configurations (coarse and fine), while diameters of #12 and above can have two or three TPI configurations (coarse, fine and extra fine). For instance, a UTS bolt labelled #3-48 is a gauge 3 bolts or screw with 48 threads per inch, and a 1/4-20 screw has a 1/4 inch diameter and 20 threads per inch.

Thread fit is also a concern for UTS screws and bolts. Loose fitting hardware is better for applications that require quick assembly and disassembly, but precision fits (class 3) are best for high-accuracy, high-strength joints and harsh environments, such as socket head bolts in an engine. A-class threads are used for external threads and B-class threads are for internal threads.

<table>
<thead>
<tr>
<th>Thread type</th>
<th>Tolerance position grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>G, H</td>
</tr>
<tr>
<td>External</td>
<td>E, f, g, h</td>
</tr>
</tbody>
</table>

Source: Bayou City Bolt © 2015
Standards bodies have spent immense effort classifying thread pitch because it determines the thread tensile stress area, which can be discovered with this equation. The stress is correlated to the TPI of the bolt.

\[ A_s = \frac{\pi}{4} \times (D - (0.938194 \times p))^2 \]

Where:
- \( A_s \): tensile stress area
- \( D \): bolt diameter
- \( p \): 1/threads per inch (TPI)

For example, let’s compare the tensile stress area of two screws. The first is a 3/4-10 UNC screw.

\[ 0.3382 = \frac{\pi}{4} \times (0.75 - (0.938194 \times (1/10)))^2 \]

The second screw has the same diameter, but a different TPI; it is a 3/4-16 UNF screw.

\[ 0.3754 = \frac{\pi}{4} \times (0.75 - (0.938194 \times (1/16)))^2 \]

As demonstrated by the equation, it is the screw with the greater TPI that has the larger tensile stress area.

Lastly, threads on both metric and UTS fasteners are also categorized as coarse, fine or extra-fine. UTS thread types are typically labelled UNC (Unified Coarse), UNF (Unified Fine) or (Unified Extra Fine (UNEF). There is no difference in manufacturing quality between coarse, fine and extra-fine thread types, but there are differences in how they are employed.

Coarse threads are thicker and more durable than fine-threaded hardware. Coarse-threaded fasteners can also be installed more quickly. For instance, a 3/4-10 UNC requires 10 rotations to install 1 inch of the bolt shaft, while a 3/4-16 UNF would require 16 rotations. Coarse threads offer clearance for thread plating and are less likely to gall. These threads are also unlikely to strip if the bolt is made of a soft material.

Fine and extra-fine threads can be examined together. Their smaller pitches and greater TPI equate to better tensile strength, and a larger minor diameter provides better shear strength. Smaller thread helix angles also provide superior resistance to vibration in fine-threaded fasteners, a very important consideration. Thin materials are appropriate for fine and extra-fine threads. These are also more useful for precision applications.

Based on these detailed standards, 91% of threaded fasteners belong to one of these designations.
This document can be an invaluable reference point when selecting fasteners, but there is no need to commit it to memory. All of this information is based on the expertise of Bayou City Bolt’s knowledgeable engineers and representatives who can help your organization keep track of the exhausting variations of threaded screws, bolts and nuts.

For almost two millennia threaded hardware has supported some of the most important innovations in human history. Now your company has the chance to leverage the high-tech benefits of today’s novel hardware solutions.

Take advantage of the best fasteners modern machining has to offer by visiting www.bayoucitybolt.com or calling BCB at 866-670-4008.