MOTORSPORTS CLINIC 1

Fasteners
The material in this power point is crucial to your success as an engineer if you do anything mechanical.

If you enter the mechanical engineering field and especially motorsports, fastener knowledge is something you need to have a thorough understanding of.

This is an introduction, make sure you further your study of materials and how they relate to fasteners on your own.
Fastener Topics

- Identification
- Head types
- Coatings
- Grades
- Stretching & Torque
- Nuts & Safety wire
- Heli-coil repairs
- Thread lockers & Anti seize
- Classifications, cut & rolled threads
- Studs
The identification process of fasteners starts with determining the standard, then the dimensions, finally the classification.

Fasteners come in 4 main types. SAE, metric, AN and British. (we only use SAE and metric standards)

Fasteners, nuts and washers are made from different materials. Most are steel, but aluminum, titanium, plastic, and others are out there.

Be very careful using anything other than steel!
You have to determine how many thread per inch (TPI), or how many mm per thread you have. (SAE is threads/inch. Metric is mm/thread)

A thread gauge tells you how many threads you have.

Next you measure the major diameter of the bolt. Note, almost every fastener will come about .003” to .005” under the stated size. For example a 3/8” bolt is .375”, but measures .371”
Thread Gauge
Diameter Measurement
Next you have to determine the bolt length and head type. The length is not usually measured from end to end, or overall length. This may be a specification, but the under head length (UHL) is how bolts are usually classified.

- Flat head bolts exception

To measure this use a tool, and measure from under the flange of the bolt to the end of the threads.
Identification cont.

Under head length
Now you have the standard, thread type, UHL. So far this bolt would be classified as: 3/8-16 UNC, 1.250” UHL.

Next you have the head type, coating, and grade.

The head type is easy to visually determine. The typical variations are: hex, torx, 12 pt, inverted torx, allen cap, flat head and Phillips.
Head Type cont.

Left to right: Torx, 12 pt., Hex, Allen, Flat & Philips.
After you have determined head type, you need to the coating and finally the class fit and grade.

Bolt coatings commonly are used to reduce friction, and prevent corrosion.

Coatings are usually zinc (either gold or clear), black oxide, and cadmium. Many others are available.
Stainless, blue zinc, yellow zinc, clear zinc, & black oxide
Besides length, grade is probably the most important factor when determining a fastener.

The grade refers to the strength that the fastener is rated to. The rating is usually done in pounds/inch squared. (PSI)

The common SAE grades are 3, 5, and 8. In metric designations they are 4.6, 8.8, 10.9, and 12.9. As the numbers go up in each standard, (SAE and metric) the carbon content goes up as well as the heat treatment, and the alloy content, all of which effect the strength.

These changes increase the strength of the fastener. For example a typical SAE grade 3 is rated to 60,000 lbs, where a grade 8 is rated to 150,000 to 180,000 lbs.
Always add (2) hash marks to what you see to get the grade of the bolt. (show is the SAE standard)

Grade 5

Grade 8

Metric 8.8 Bolt

8 x 100 = 800 MPa tensile strength
80% of 800 MPa = 640 N/mm² yield limit
Stretching and Torqueing a Fastener

- Torque and stretch are ways to determine a level of clamp force on a fastener. *(your always trying to reach a desired clamp force)*

- Ideally you want to stretch a fastener.

- Steel is like a spring, and you want the fastener to be clamping with adequate force. Too much stretch and you will lose clamping force, too little and you will have parts coming loose.

- The goal is to stretch the fastener to a greater point of stretch in assembly than the fastener will see in service. If you plan on reusing the fastener you will also need to be careful to not cause permanent deformation. -Over torque.

- Lubricants greatly influence stretch. This is because friction will consume the torque you apply and therefore will not stretch the fastener enough. This can be measured with a stretch gauge, or a mic.
Torque Wrench Adjustment
Stretch Gauge and Torque Wrench
Stretching a fastener into, but not beyond its yield point will provide multiple uses from the fastener. Stretching past the yield point will give you higher clamping force, but limit the fastener to one use because the bolt will not return to its original length.

Torque to yield bolts exist to provide clamping force measured past the yield point. In the deflection curve there is more resolution to gain a very accurate clamp force. The downside is the fastener is a one time use only.
Stress and Strain

- **Elastic Range**
- **Plastic Range**
- **Elongation Until Failure**
- **Ultimate Tensile Strength**
- **Yield Point** (Typically 85-95% of Yield)
- **Proof Load** (Typically 75% of Proof Load)
- **Failure** (Fracture Point or Tensile Point)

Tensile Stress-Strain Diagram

Bolted Joint Design, Fastenal.com
Lubricants on threads greatly effect the stretch of the fastener.

Lubricants are made of many different chemical compounds, commonly they are oil based and are viscous, or moly based and thicker.

The idea of the lubricant is to minimize the friction in the threads in order to stretch the fastener to its yield point for maximum clamp force the bolt can deliver.

The amount a lubricant can reduce friction is enormous. To this point most fastener company’s list the lubricant you use with a torque value to attain proper clamp force.
Nuts are typically made to be softer than their bolt counterpart. This is so the nut ID threads can deform around the bolts OD threads.

Nuts can come in all grades, classifications, coatings, and various drive configurations.

Common nut drives are usually limited to 6 and 12 point. These can come with retaining devices, flanges, and various provisions.
Nut Examples
Nuts can be retained, or an effort can be made to prevent them from loosening up and backing off.

Nylon pressed into the top of the nut is a very good way of retaining a nut. This is limited to two installations maximum before the nylon is no longer creating the proper friction to the bolt threads. This is a very common mistake made in industry.
Pinch nuts are another way to prevent loosening. This is done by having 3 sides of the top of the nut pressed into the path the bolt would travel. It is a mechanical means to create an interference. The military lock nuts are similar but they have 6 steps pressed in the bolts path. Both pinch and military can cause permanent damage to the bolt upon removal.

Castle nuts are an excellent way to prevent loosening. They have the top of the nut formed like a castle tower and a cotter pin fits through a shaft and mechanically prevents backing off.
Pinch Nuts and Castle Nut

Castle, military pinch, pinch, nylock
Safety wire is another form of retaining a bolt from coming loose. It uses a wire that passes through the head of a bolt. This wire is then put in tension, in the direction that tightens the bolt, then the wire is secured to another bolt or some other object.
Safety Wire cont.

Safety wire where and how to use it, ultralightnews.com

Safety Wire, yzfcentral.com
Heli-Coil repair kits are used when threads are pulled out of the base material, or you plan to use a component often and or attain high clamp loads with a soft base material.

A Heli-Coil is a coil made to specific ID and OD shapes from steel. The OD threads are designed to match a specific tap included with the kit. The ID coil female thread is designed to fit whatever you would like to use to thread into it. Coil kits can be purchased in SAE and metric standards to almost any desired pitch.
Coil Kit Examples
Coil Kit Examples cont.
Coil Examples

Note the tang on the bottom, this is install mechanism

Helicoil Video
Thread locker is an anaerobic sealer. This means it cures when not in the presence of oxygen. It is used to prevent the loosening of fasteners.

Deciding on which to use comes down to the following criteria: High or low strength. Removable or not. The temperature and chemicals it will be exposed to when curing, and the size of the fastener it will be thread locking.

In the shop we typically use Red for high strength. Blue for low strength removable, and very rarely we use Green for “never want to remove”.

When using this be cautious, you must consider the removability of the component. It can be a nightmare to remove a bolt with a Loctite that is too strong for the application.
Loctite
As the word implies, ant seize is to prevent the non-removal of a bolt or nut. Commonly stainless and similar nickel alloy materials will gaul and cause things like oxygen sensors to seize up in the header tube. There are two forms. The regular which is silver, and the high temp which is copper color. This is a good idea to put on any fastener which is exposed to harsh chemicals, high heat, and or removed frequently.
Anti-seize
All fasteners will fall into one of three categories when determining the precision of the fasteners dimensions.

- The classes are 1A, 2A and 3A.
- 1A is the loosest fit. This fit will permit debris in the threads and still work. This is not that common since the loose fit is actually designed in. (these come uncoated)
- 2A is the most common, typical fit between major diameter of bolt to minor diameter. (usually coated)
- 3A is the tightest fit. This is for high strength applications and of high quality call outs. The fit can be so close from the nut to the bolt threads that coatings will cause an interference. (the classification can only be measure with precision gauges)
Most threaded fasteners come manufactured at 75% thread engagement from the male to female. This is very common, however variations exist. Very hard materials are cut with less, usually around 50% to ease the machining process. Very high end fasteners can be made to have 100% engagement, however the additional 25% over normal does not translate to 25% more strength. It is extremely expensive to have fasteners made to this level, and gives you a lower return on investment.
For years threads were cut by machine tools. You can use a manual engine lathe, a die or a thread cutting machine for high volume. Cut threads have tremendous stresses in them left from the tool tip.

A major improvement to the manufacturing process is thread rolling. Threads are rolled by a machine with dies that compress the surface of the threads. This allows compressive strength and lowers surface stress risers while leaving a smooth surface finish.

Thread rolling also allows for a small radius in the thread root, where thread cutting leaves two distinct edges in the thread root on each side of the thread.

Bolt Video
Cut and Rolled Threads

Fasteners, ejsong.com

EDGE Thread Cutting Tools, swifts.com
Studs

- Studs are threaded on both ends and can have different sizes and thread pitches on both sides.
- Studs present some advantages for example, a cylinder head comes off and on many times in the life cycle of the head and block. If head studs are used the blocks deck threads are saved because the stud makes the sacrifice in wear.
- Studs also can deliver very accurate clamp forces because they see load in tension only, where bolts see tension and torsion loads.
Studs cont.
Washers

- Washers main purpose is to act like a bearing surface (prevent galling) between a nut or bolt and the part they’re being put in. They can also act as a sealant (crush washers).

- Make sure washer is hard enough to prevent the nut/bolt from squeezing them when torqued.

Do NOT use on racecars!
Quarter turn fasteners can be used to hold on body panels, windows and other components that need to be removed easily or quickly.
Where to order bolts

- www.McMaster.com
- www.Fastenal.com
- www.SRI-supplies.com