Product Training Manual

for

Fastener Products

$5.95

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INTRODUCTION

Fasteners have played a major role in the advancement of the human race since prehistoric days when the caveman used thongs to hold a rock into the split end of a stick to make the first axe. Since that day, the progress of fastening methods and devices includes: wooden pegs; wedges; the first iron nails; glue; rivets; welding; and today, a multitude of highly specialized fasteners that range from simple wooden clothespins to cap screws made from specialized materials for our space programs.

Few of us realize the importance that fasteners play in our way of life. Less than $100 worth of fasteners represents the difference between a useless pile of parts and a finished automobile. A $75,000 crawler tractor would be nothing but scrap iron without a few hundred dollars' worth of nuts and bolts.

Without the variety of fastening devices available to industry, we would have to do without electricity, city water, natural gas, telephone, radios, television, refrigeration, transportation, canned and frozen foods, clothing, shelter, and in fact, almost every necessity and convenience we take for granted.

Each year, the fastener industry uses over two million tons of steel to produce more than 200 billion fasteners in over two million different shapes and sizes. To keep pace with the rapidly expanding market and increasing demands for absolute reliability as well as availability, the fastener industry must continually develop new materials, improve its manufacturing and distribution techniques, invent ingenious new parts and gain prestige in the industrial world. All of these factors compile to make this one of the most complex industries that exist in the world today.

FASTENER FACTS

This handbook compiled by Imperial Supplies LLC is designed to give the maintenance technician an understanding of such important areas of fasteners as: fastener quality; the reasons for fastener failure; identification of fastener grades by headmarks; the importance of proper installation procedures; the importance of proper fastener selection for the job; effects of lubrication on torque and tension; thread types; vibration effects on fasteners; and why you should always use the shortest possible bolt. Your handbook also contains a glossary of fastener and metallurgical terminology.

FASTENER BASICS
SELF EVALUATION

Directions: Answer the following questions by circling True or False.

True False 1. Graded fasteners are required by law to meet certification standards for size, strength, chemical make up, and hardness.

True False 2. Every manufacturer and private label distributor is required to register the headmarking logo of their fasteners.

True False 3. A bolt having 6 dash - grademarkings, identifies it as a Grade 5 fastener.

True False 4. A bolt having NO headmarking or grademarking is a low carbon fastener.

True False 5. USS bolts have coarse threads.

True False 6. The most dangerous component of a fastener assembly is the re-use of nuts.

True False 7. Replacing the nut and bolt is NOT necessary in order to obtain the original clamp load.

True False 8. All-metal lock nuts are more reliable than nylon lock nuts.

Directions: Circle the best answer.

9. What is the difference between a USS washer and SAE washer?
   A. USS washers have a smaller outside diameter vs SAE washers.
   B. SAE washers have a larger inside diameter vs USS washers.
   C. USS washers have a larger inside and outside diameter vs SAE washers.
   D. USS washers should be used with USS threaded bolts and SAE washers should be used with SAE threaded bolts.

10. The number one cause for bolt failure is?
   A. Nuts and bolts that are re-used.
   B. Wrong grade of fastener is used.
   C. Over-torquing of fasteners.

11. Flat washers should be installed:
   A. With the flat side toward the head of the bolt.
   B. With the round side toward the head of the bolt.
   C. It doesn't matter which way it is installed.

Answers: 1.T, 2.T, 3.F, 4.T, 5.T, 6.T, 7.F, 8.T, 9.C, 10.C, 11.B

FASTENER TRAINING OUTLINE

Introduction to Fastener Training

Self Test Evaluation

The Fastener Quality Act (Public Law 101-592)

Product Certification
Lot Traceability
Headmarkings
Labels and Invoicing

The Fastener Manufacturing Process

The Seven Step Stamping Process
Headmarkings for cap screws
Grade identification for Grades 8 and 5, Metric 10.9 and 8.8, Stainless Steel 18/8 and 316, hex nuts, nylon lock nuts, and suspect fasteners

Thread and Pitch Identification

UNC/USS, UNF/SAE, threads per inch, and metric pitch
Use of cap screws that are too long

Washers

Coarse (USS) vs Fine (SAE)

Plating

Re-Use of Fasteners

Re-use of nuts
Re-use of cap screws

Why Fasteners Fail

Using the Skidmore

Demonstration
Torque
Use of impact tools

Head & Tip Styles

Fastener and Metallurgical Terminology

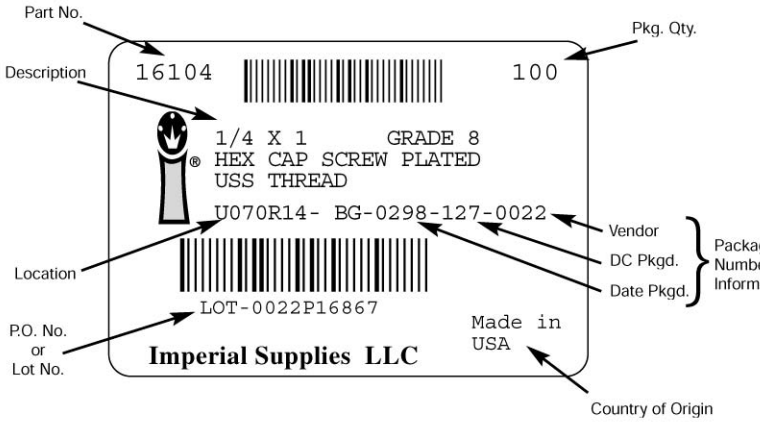
Public Law 101-592 (also referred to as HR3000)
WHAT DOES IT MEAN?

Public Law 101-592 -- The Fastener Quality Act is designed to monitor the quality and traceability of all graded fasteners including metrics and socket products. With the onslaught of substandard and counterfeit fasteners, such measures are necessary.

Public Law 101-592 has three primary requirements that affect both fastener manufacturers and distributors:

1. ***Product Certification:*** All products must be certified by an accredited laboratory to meet all chemical, dimensional, mechanical and physical requirements set by SAE and IFI. These certifications must also include lot numbers.

2. ***Lot Traceability:*** 100% lot traceability must be maintained through every stage of the manufacturing process -- from raw material through the heat-treating and plating processes. The lot numbers must be clearly marked on each manufacturer's box.



3. ***Headmarkings:*** Every manufacturer and private label distributor is required to register their unique headmarking logo.

Imperial Supplies LLC is committed to supplying only the highest quality products, and has taken steps to make Imperial a leader in quality products by including lot numbers on both the package and also the invoice, upgrading and modernizing our Quality Assurance department and purchasing from only quality conscious suppliers.

LOT TRACEABILITY

One of the key requirements of Public Law 101-592 (also known as HR3000 and the Fastener Quality Act) is to maintain 100% lot traceability through every stage of the manufacturing process by clearly marking the lot number on each packing label (See Figure 1).

Incoming lot number from manufacturer:

#0022P16867

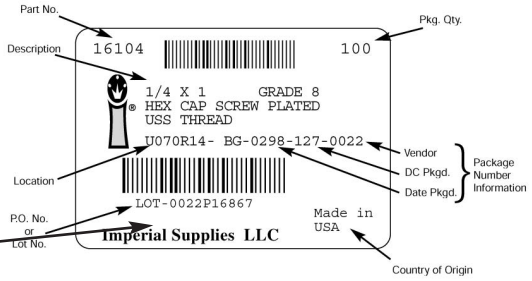


Figure 1

Imperial Supplies LLC has gone one step further by including lot numbers for all Public Law 101-592 governed products on every invoice (See Figure 2).

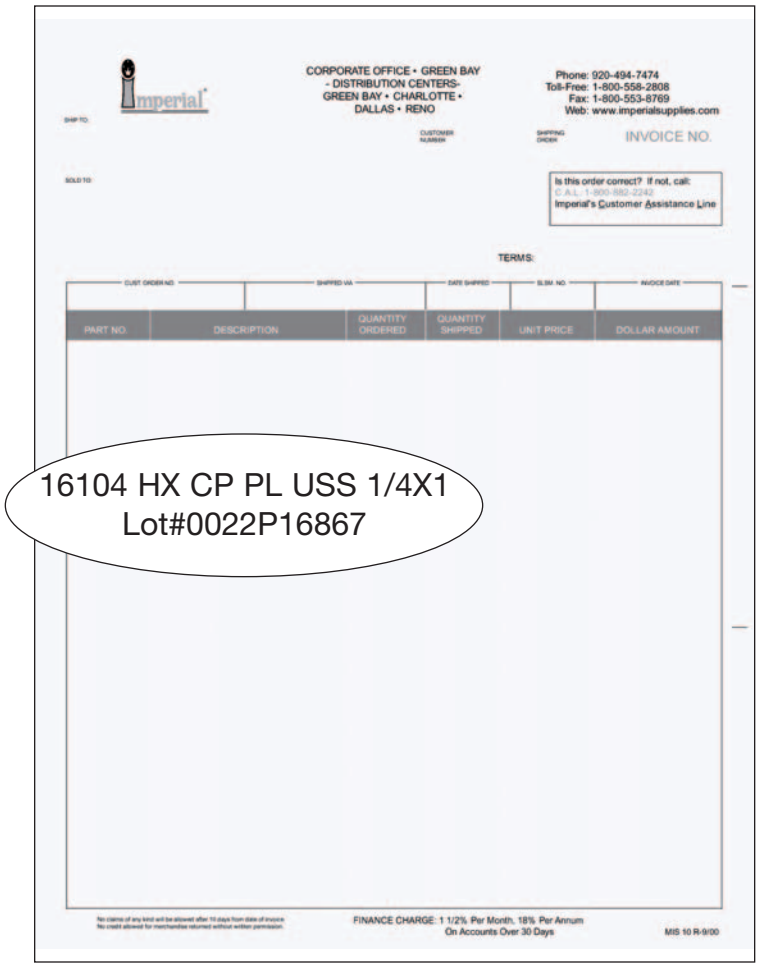


Figure 2

We maintain complete Lot Traceability. Now if you question a certain lot, simply check your invoices for the number, and give us a call at 1-800-558-2808.

FASTENER HEADMARKINGS

When manufacturers put their identification symbols on fasteners, purchasers can feel more confident about that product, for it means the fastener producers stand proudly behind what they sell.

Fastener headmarking becomes merely an extension of a producer's quality assurance program. The manufacturer's identification symbol traces a fastener back to its producer. Grade and material markings verify the capability of each fastener.

All reputable manufacturers willingly place their identifying mark on products, just as they mark these products with an industry-accepted performance capability symbol.

It certainly makes sense then, to purchase only such quality and performance-assured fasteners, fully identified with a headmarking, than to risk possible failure with unmarked fasteners.

Grade-marking identification assures a known quality-of-performance level to the buyer. These marks may take many forms: a design or symbol; a letter or letters; a letter combined with a numeral (or numerals) alone; or the use of dots/dashes along with a manufacturer's headmark.

In all cases, however, each marking is an accepted indication by one of several nationally recognized technical groups that a certain, specific set of criteria has been met. These marks indicate that every fastener so identified is manufactured in accordance with the applicable specification.

Technical societies and other bodies which develop fastener specifications include:
1. SAE (Society of Automotive Engineers) - whose specs generally cover chemical and mechanical requirements for threaded and non-threaded fasteners used broadly within the automotive and allied industries.

2. ASTM (American Society for Testing and Materials) - whose specs cover chemical and mechanical requirements for fasteners used in all types of engineering applications.

3. ANSI (American National Standards Institute)

4. ASME (American Society of Mechanical Engineers)

5. IFI (Industrial Fasteners Institute)

Basically, this widely copied system is for carbon and alloy steel commercial fasteners. Other standards are published by the Federal Government and some of its agencies, specifically for fasteners used within the military and aircraft and missiles.

Whatever the source of the standard, however, the manufacturer is given specific instruction and the ultimate responsibility for placing the performance capability at a specific location on a fastener. For it is only the manufacturer who knows the history of the raw material, the manufacturing process (cold, warm, or hot-heating), heat treating, plating, quality level, test acceptance, and packaging.

A FASTENER WITHOUT A STRENGTH MARKING MUST BE CONSIDERED TO BE AT THE LOWEST COMMON DENOMINATOR AND AT THE LOWEST POSSIBLE STRENGTH.

A manufacturer's identification symbol is the second type of headmarking used on fasteners. As noted, manufacturers of integrity are anxious to identify their product with a company mark.

How many of you drive in unmarked cars or unmarked tires, use unmarked tools, shoot unmarked shells through unmarked guns? Would you pay for 24 carat gold that was not marked? Can you think of any quality item you own or have every seen that is not marked to identify, with pride the manufacturer? Domestic manufacturers register their trademarks - a carry-over from the guilds - craftsmen of pride.

Not all imported fasteners are clearly marked. Does the lack of pride reflect in the quality - if only by implication? In case of failure, what recourse does a purchaser have? Is lot identification available, can the physical and chemical properties of the steel be certified by a domestic mill? Can the manufacturer certify that the product was produced and tested to meet all of the criteria of quality, the physical and chemical properties, and manufacturing processes?

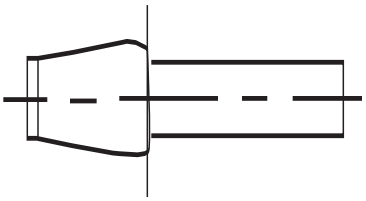
CURRENTLY, ALL EXTERNALLY THREADED PRODUCTS, 1/4" OR LARGER AND MANUFACTURED TO SAE, ASTM, IFI, OR GENERAL MOTORS STANDARDS, REQUIRE MANDATORY MARKINGS OF MANUFACTURING SOURCE. (See ASTM A449-9.1, ASTM A354-9.1, SAE J429H-6, IFI 501-6.1 specifications).

Imperial Supplies LLC provides both strength and source markings on all its cap screws. Thus, when it is time to replace a fastener, it is convenient for the purchaser to be able to identify and reorder a specific fastener and know that the replacement products will always be equal in strength. There is no danger of the product being downgraded, for the replacement fastener will always be equal to, or better than, the original. From these facts, it is evident that it is in your best interest, and those of your company, to insist that the fasteners you purchase be marked with both a manufacturer's logo and a strength marking. This applies to the assembly of the original equipment and to its overhaul maintenance.

BOLT MANUFACTURING PROCESS

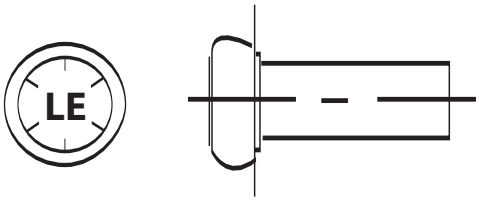
Cut-off

A blank is cut off from a coil. The diameter and length of the cut-off relates to the product diameter, finished bolt length and head size. The raw material is a domestically produced medium carbon alloy steel meeting the requirements of SAE and ASTM specifications. The raw material has been pickled, annealed and coated prior to the manufacturing process.



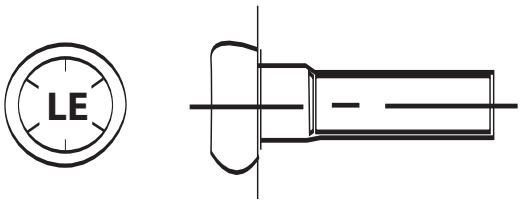
Upset

The end of the blank is deformed prior to forming the bolt head. Metal is moved in a controlled manner to assure head concentricity and integrity with the body of the bolt.



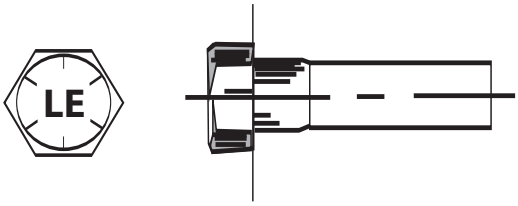
Head

A "BUTTON," whose diameter is slightly larger than the across corners dimension of the finished hex head, is formed. The "BUTTON" height is equal to the finished head height. The headmark is put on in this operation. The washer face, which provides good bearing contact, and the fillet radius, which contributes to bolt strength and head/body integrity, are formed during heading.



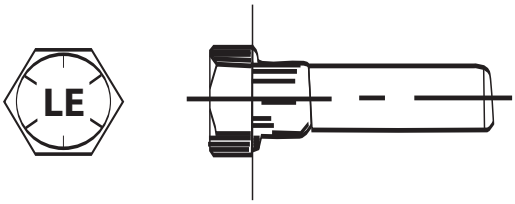
Extrude

The blank is pushed into a die where a portion of the body diameter is extruded down to the pitch diameter of the thread in preparation for thread rolling.



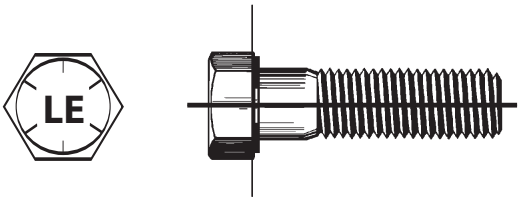
Trim

Excess material is sheared from the "BUTTON" forming the finished hex head. A trimmed hex provides sharp corners which enhance wrenchability.



Point

Material is machined from the end of the bolt blank forming a chamfer which contributes to better assembalibility with mating parts and reduces the possibility of thread damage to the starting threads.



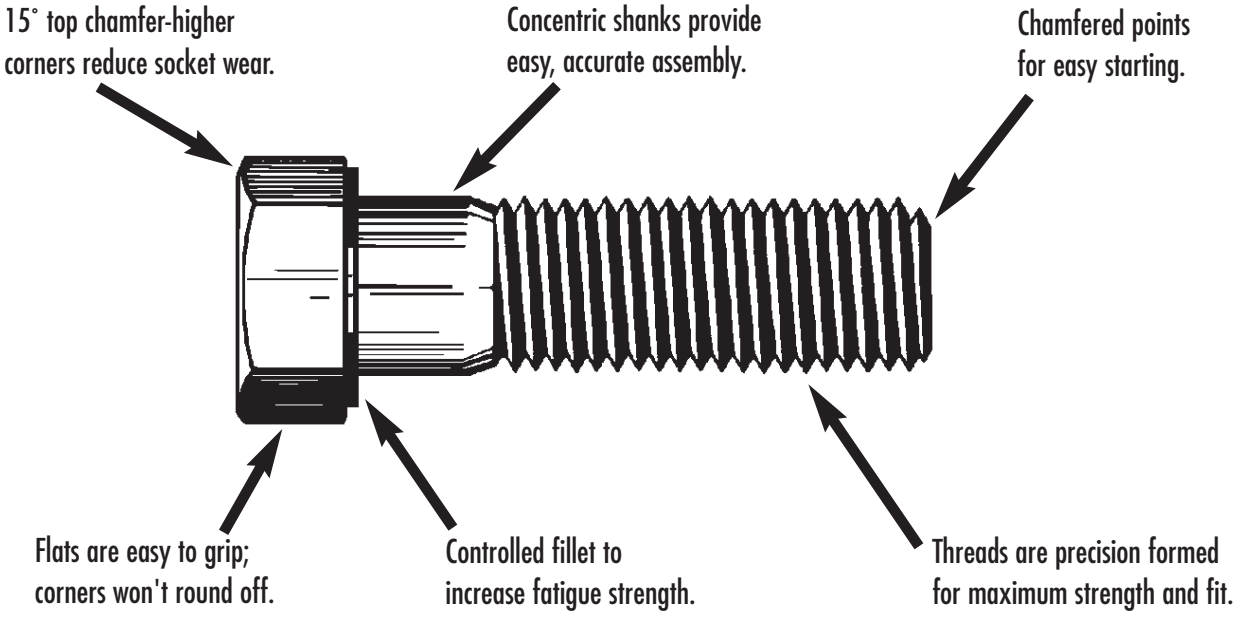
Roll Thread

Threads are formed as the blank passes thru a set of flat-faced reciprocating roll threading dies. The final thread form is smooth, accurate and consistent. The thread conforms to the ANSI B1.1 standard for UNRC or UNRF screw threads. Contributing to bolt strength and durability are features such as a controlled thread root radius and controlled transition between the thread runout and body of the bolt.

HOW QUALITY CAP SCREWS ARE MADE

After the cap screw has been manufactured, the first step in the heat-treatment process is placing these cap screws into a heat-treating furnace where the temperature is raised to about 1550˚ F. The atmosphere and temperature of the furnace must be rigidly controlled to prevent unwanted defects. The cap screws are kept in the heat-treatment furnace until the temperature of the core reaches the furnace temperature. This heat-treating temperature is higher than the annealing temperature of the wire. Once this temperature is reached, the cap screws are quenched in oil to produce extreme hardness in cap screws (050-058). This oil quenching is superior to quenching in water which produces a poor surface finish, scale, internal stresses, and brittleness.

After oil quenching, it is necessary to "temper" the cap screws to improve ductility and resilience. Tempering is accomplished by reheating the cap screws in controlled furnaces to between 800 to 1000˚ F. to the desired tensile strength and ductility, and then allowing them to "air quench" slowly in the air. As the tempering temperature is increased, the final hardness and tensile strength will decrease while the ductility will increase. With the addition of alloying metals such as: chromium, boron, nickel, and molybdenum the tempering temperature may be lowered without sacrificing ductility. After the cap screws are "air quenched," the cap screws are again placed in an oven and baked at a relatively low temperature for a long period of time.



FOR MAXIMUM HOLDING POWER,
ALWAYS USE A BALANCED ASSEMBLY

CAP SCREW - HEX NUT - FLAT WASHER - LOCK WASHER

INDUSTRY ACCEPTED FASTENER HEADMARKINGS

It has become very important for suppliers of graded cap screws to be able to identify the manufacturers of their product.

Figure A
Illustrates a
Gr. 8 bolt dash
headmarking.

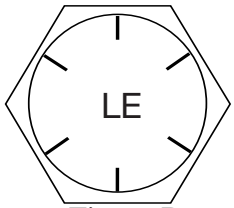


Figure B
Illustrates a
Gr. 8 bolt dash
headmarking.

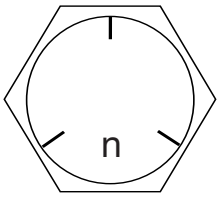


Figure C
Illustrates a
Gr. 5 bolt dash
headmarking.

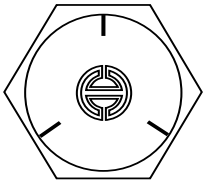


Figure D
Illustrates a
Gr. 5 bolt dash
headmarking.

The above headmarkings will include proper Grade identification:
Grade 5=3 dashes; Grade 8=6 dashes. The above markings are registered and recognized trademarks of the respective USA manufacturers. They are also recognized and approved for military use. Figure A is our own Imperial headmarking, manufactured by either Lake Erie Screw Corporation or Nucor Fastener. Figure B is Lake Erie Screw Corporation, Figure C is Nucor, and Figure D is Highland Bolt & Nut.

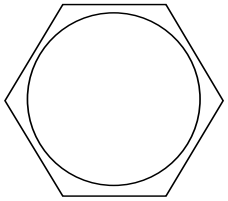


Figure E

Figure E
Illustrates a low
carbon Grade 2 bolt,
no headmarking or
grade markings makes
this bolt untraceable.

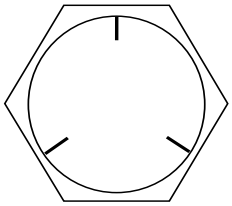
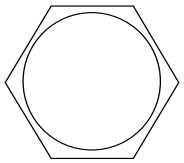
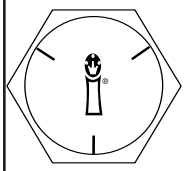
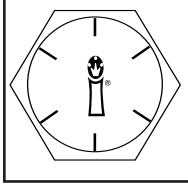


Figure F

Figure F
Illustrates a Grade 5
bolt with no manufacturer
headmarking which makes
this bolt untraceable.

Imperial Supplies LLC does not carry the Figure E or Figure F type bolts.

SAE Grade Markings for Steel Bolts and Screws

Grade Marking	Specification	Material	Bolt and Screw Size, in.	Proof Load, psi.	Tensile Strength Min., psi.	Rockwell Hardness Min.	Rockwell Hardness Max.
	SAE–Grade 0	Steel	1/4—1-1/2	—	—	—	—
	SAE-Grade 1	Low Carbon Steel	1/4—1-1/2	33,000	60,000	—	B 95
	SAE-Grade 2	Low Carbon Steel	1/4—3/4 Over 3/4—1-1/2	55,000 33,000	74,000 60,000	— —	B 100 B 95
	SAE-Grade 5	Medium Carbon Steel, Quenched and Tempered	1/4—3/4 Over 3/4—1" Over 1"—1-1/2	85,000 78,000 74,000	120,000 115,000 105,000	C 23 C 22 C 19	C 32 C 32 C 30
	SAE-Grade 8	Medium Carbon Alloy Steel, Quenched and Tempered	1/4—1-1/2	120,000	150,000	C 32	C 38

INDUSTRY ACCEPTED MARKINGS

More and more fastener manufacturers are becoming stricter with the specifications that govern their products. Such is the case with Imperial's Grade 5 and Grade 8 nut manufacturers. In the past, Imperial has requested that our parts be supplied with the customer-accepted markings of 3 radial dashes for Grade 5 (fig. A), and 6 radial dashes for Grade 8 (fig. B).

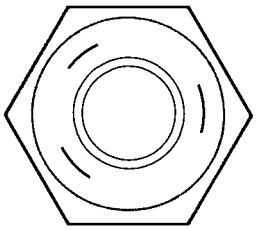


Figure A
Grade 5

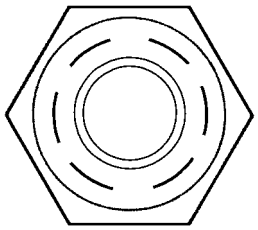


Figure B
Grade 8

Because of Public Law 101-592, Imperial and our manufacturers have agreed to follow only industry-accepted markings which fall under SAE J995. Under this specification, a Grade 5 will now have a dot, and a dash 120˚ counterclockwise from the dot (fig. C). A Grade 8 will have a dot and a dash 60˚ counterclockwise from the dot (fig. D), or a Grade 8 may also have a dot and a dash 60˚ clockwise from the dot (fig. E).

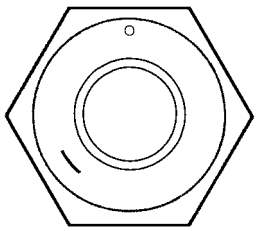


Figure C
Grade 5

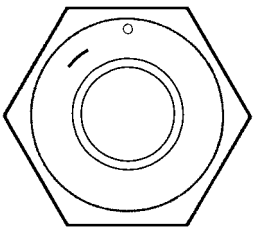


Figure D
Grade 8

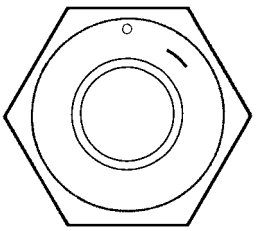
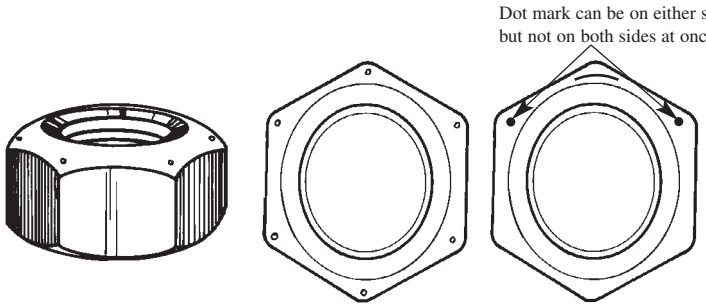


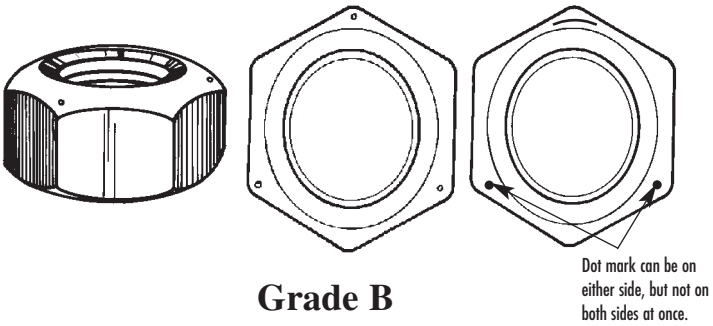
Figure E
Grade 8

As always, the Grade 8 nuts will have zinc yellow dichromate plating, and the Grade 5 nuts will have zinc plating, which makes it easier to determine which grade they are just by looking at them.

INDUSTRY ACCEPTED MARKINGS

PREVAILING TORQUE LOCK NUTS





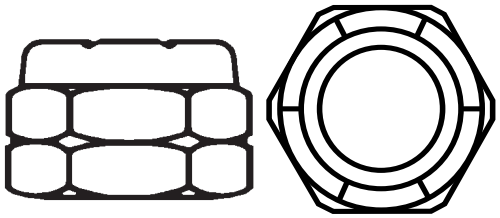
Grade C

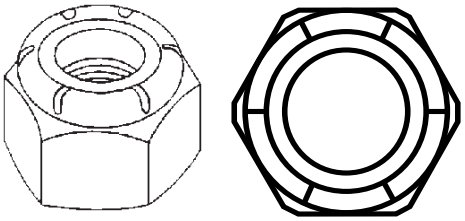
- Used with Grade 8 cap screws
- Have 6 dot grademarking
- Proof loads: 150,000 PSI
- All steel, one piece

Grade B

- Used with Grade 5 cap screws
- Have 3 dot grademarking
- Proof loads: 120,000 PSI
- All steel, one piece

NYLON INSERT LOCK NUT





Grade 8

- Notched corner designate Grade 8 markings, or dots, dashes, & manufacturer's headmark on the bottom or upper corners of the nut
- Vibration resistant
- Positive self-locking nylon collar
- Proof loads: 150,000 PSI

Grade 2

- No Grade markings
- Low carbon steel

FASTENER MEASUREMENT

Bolts and cap screws are measured by:

- Diameter of the bolt
- The length of the bolt measured under the head to the end
- Threads per inch, SAE or USS

FINE THREADS VERSUS COARSE THREADS

(USS/UNC versus SAE/UNF)

Many users of threaded fasteners do not understand the proper application of UNF and UNC threads and consequently carry an inventory of only one type or the other.

Where maximum holding power is required in an application that involves the use of a bolt with a nut, the use of UNF threads will provide greater ultimate strength. The reason for this strength differential is that the grooves of UNF threads are not as deep as those of UNC threads. This condition results in a greater cross-section of metal in the threaded section of the bolt. Since this cross-section or root diameter is larger, the stress area is greater.

When a bolt is to be threaded into a casting (used as a cap screw), the metal in the casting is usually weaker than the steel used in making that bolt. To reduce the possibility of stripping the threads out of the softer material in the casting, UNC threads should be used because the deeper grooves provide a greater cross-section of threads which will resist stripping.

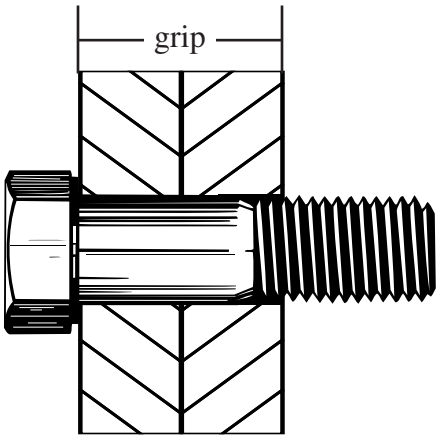
In this case we sacrifice bolt strength to improve thread strength. This is the reason that most studs will have UNC threads on the end that screws into a casting and UNF threads on the end on which a nut will be installed.

USE OF CAP SCREWS THAT ARE TOO LONG

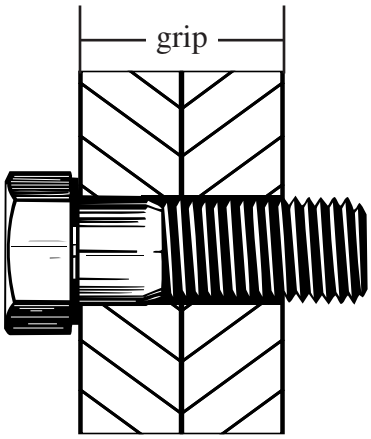
The threaded portion of a cap screw will stretch more easily than the full diameter of the shank. It is critical that as many unengaged threads as possible be kept within the grip of the fastener assembly.

Selecting the proper length cap screw ensure that there are a greater number of threads contained within the grip so that the amount of stretch would be divided among all the unengaged threads. Thus each individual thread would accommodate a much smaller amount of stretch. SAE requires that six unengaged threads be contained within the grip.

EXAMPLES:



TOO LONG



CORRECT

THREAD LENGTHS

THREAD LENGTH FORMULA:
- For bolts 6" and shorter – twice the diameter plus 1/4". (2D +1/4")
- Longer than 6" – twice the diameter plus 1/2". (2D + 1/2")

When bolts are short for formula thread length will extend as close to head or shoulder as practical. In actual production, thread lengths may be longer than the formula thread lengths. All standard except lag screws.

Diameter of Bolt (In.)	6" & Shorter (In.)	Longer Than 6" (In.)	Diameter of Bolt (In.)	6" & Shorter (In.)	Longer Than 6" (In.)
No. 10	5/8	7/8	1"	2-1/4	2-1/2
1/4	3/4	1"	1-1/8	2-1/2	2-3/4
5/16	7/8	1-1/8	1-1/4	2-3/4	3"
3/8	1"	1-1/4	1-3/8	3"	3-1/4
7/16	1-1/8	1-3/8	1-1/2	3-1/4	3-1/2
1/2	1-1/4	1-1/2	1-5/8	3-1/2	3-3/4
5/8	1-1/2	1-3/4	1-3/4	3-3/4	4"
3/4	1-3/4	2"	1-7/8	4"	4-1/4
7/8	2"	2-1/4	2"	4-1/4	4-1/2

SAE WASHERS VERSUS USS WASHERS

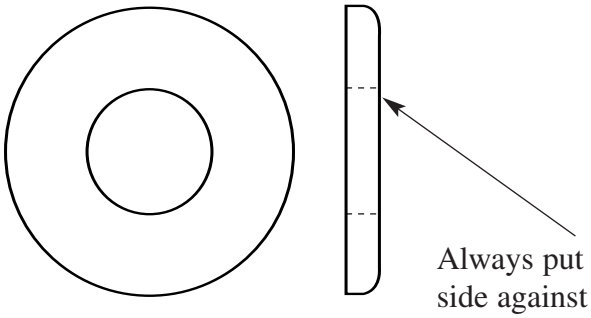
The main difference between SAE and USS washers are their dimensional sizes. USS washers have a larger outside and inside diameter than the same size SAE washer.

EXAMPLE

	Bolt Size	Inside Diameter	Outside Diameter
USS Washers	3/8	7/16	1"
SAE Washers	3/8	13/32	13/16

Reasons for using a USS vs SAE washer or the reverse:

- USS washers have a larger inside diameter which allows for more flexibility in using the washer for 2 sizes of bolts.
- SAE washers have a smaller outside diameter which allows it to be used in tight or hard to get to locations.



Always put the smooth (or rounded) side against the head of the bolt or nut. The rough side must be against the material which you are clamping.

PLATING - COATINGS & HEAT TREATMENT

Finish	Description
Electro-Zinc & Clear	Zinc is the most popular of all commercial platings because it is relatively economical and offers good corrosion resistance in environments not subject to excessive moisture. Commercial zinc plating has a standard minimum thickness of 0.00015 inches. However, Class 2A thread allowances in sizes No. 8 and smaller may not accomodate this thickness. To avoid any reduction in the strength properties of these screws, a thinner coating may be acceptable. A clear or blueish chromate finish is applied on top of the zinc to provide additional protection against white oxidation spots which can form due to moisture. Electroplating is the most common way of applying zinc coatings to fasteners. It is recommended by certain industry experts that case-hardened parts which are electro-plated should be baked after plating to minimize the risk of hydrogen embrittlement (see below).
Electro-Zinc & Yellow	Commercial zinc-yellow plating has a standard minimum thickness of 0.00020 inches. However, Class 2A thread allowances in sizes No. 8 and smaller may not accomodate this thickness. To avoid any reduction in the strength properties of these screws, a thinner coating may be acceptable. Yellow chromate offers a greater degree of protection from white corrosion than does clear chromate. Electroplating is the most common way of applying zinc coatings to fasteners.
Electro-Zinc & Wax	A wax lubricant is added to the zinc coatings of certain fasteners to improve the ease of assembly. This is the standard plating for thread rolling screws including the Plastite® and Taptite® II, as well as two-way reversible center-lock nuts. Case-hardened parts are still recommended to be baked after plating (see below).
Mechanical Zinc & Clear	Mechanically applying zinc to fasteners reduces the risk of hydrogen embrittlement forming within the parts. This minimizes the need for the precautionary practice of baking the parts soon after plating. A clear or blueish chromate finish is applied on top of the zinc to provide additional protection against white oxidation spots which can form due to moisture. It is common for lockwashers made from spring steel to be plated this way to avoid brittleness after baking.
Mechanical Zinc & Yellow	This finish is identical to mechanical zinc but with a yellow chromate finish. This is the standard plating for high-alloy split lockwashers and for tooth lockwashers used with zinc yellow machine screws.
Electro-Zinc & Clear for Sockets	Socket cap screws can receive a zinc plating of 0.0002 inches thickness. A clear chromate finish is applied on top of the zinc to provide additional protection against white corrosion. The manufacturer must be told prior to the thread rolling process that the parts are to be plated. The plated parts are then baked at 375°F for 24 hours within 1 hour of plating, then subjected to a 72-hour stress test.
Electro-Zinc & Green	Commercial zinc green is the finish applied to machine screws and thread-cutting screws that will be used as "grounding screws in electrical applications.
Nickel	Nickel has more of a silver color to it than zinc and has similar corrosion resistant characteristics. It is the standard finish of cap nuts and countersunk finishing washers.
Tin	Tin plating is sometimes used on parts in the food handling industry. because it resists organic acids. It improves the lubricity of steel and offers a high degree of corrosion resistance
Silver	Silver is an excellent conductor of electricity. Its benefits are both decorative and protective as it resists thread galling when mated parts are under extreme pressure or exposed to extreme heat.
Cadmium & Wax	Cadmium plating results in a smoother surface and greater resistance to white oxidation spots than zinc plating. However, cadmium is a much more toxic metal than zinc, which makes the plating process more difficult and costly. The standard most commercial platers use when applying cadmium is a minimum thickness of .0002 inches. A supplemental wax coating is often added as a lubricant when cadmium is used on prevailing torque lock nuts.
Hot-Dip Galvanized	Hot dip galvanizing is generally the most effective way to apply a sufficient thickness of zinc to threaded fasteners for the zinc to serve as a corrosion protectant in harsh environments. During the galvanizing process, steel reacts with molten zinc, forming layers of zinc-iron alloy layers which are metallurgically bonded to the steel surface. This hard barrier has a low corrosion rate and resists mechanical damage. Bolts and nuts 3/8 inch diameter and smaller shall have a zinc coating with an average thickness of 0.0017 in. with no individual bolt having a coating of less than 0.0014 in.. Bolts and nuts over 3/8 inches diameter, and all sizes if washers shall have a zinc coating with an average thickness of 0.0021 in. with no individual bolt having a coating of less than 0.0017 in..
Baking of Case Hardened Parts	Electroplated screws which are case hardened should be baked for a minimum of 4 hours within the temperature range of 375-450°F no later than 4 hours after the plating operation. However, this process does not guarantee that hydrogen embrittlement will not still be present after baking or that it will not occur at a later date while in service. Specialized testing or a substitute part may be required, depending on the application. This heat treatment practice is recommended for tapping screws, drywall screws, SEMS screws, clinch nuts and clinch studs.
Passivation of Stainless Fasteners	This process enhances stainless steel's corrosion resistance.The fasteners are dipped in a solution which removes "free iron" from the surface and produces a passive film on the surface of the parts. NOTE: Passivation does not noticeably improve a stainless fastener's physical appearance. To achieve a more polished look, a burnishing process can be done.
Black Phosphate	This is the standard finish for most drywall screws, particle board screws and retaining rings. It can have either a dull or bright appearance. No additional oil treatment is added. NOTE: A part with a black phosphate coating actually gains its color from that of the substrate (the plain metal) prior to the phosphate finish. This is why a hardened part, such as a drywall screw, will be darker than a machine screw would be if both received the same "black phosphate" coating.
Black Phosphate & Oil	The most common standard coating of black phosphate and oil is 1100 mg per sq/ft, minimum. The oil serves as a rust inhibitor and a lubricant. Some fasteners with this plating are required to pass a salt-spray test, the duration and cost of whch must be agreed upon between buyer and seller prior to the sale. Floorboard screws, frame bolts, Grade-GT locknuts and spring nuts are usually supplied with a black phosphate and oil finish.
Black Oxide	This is a "conversion coating" which means it is formed by a chemical reaction with the metal to form an integral surface, as opposed to an "applied coating" like zinc which bonds to the metal. An oil finish is applied as a rust inhibitor. For more information about black oxide, see below.
Chrome	Chrome plating can be done two ways: 1) A "hard chrome" finish deposits a thick layer of chrome on the part. This gives the fastener a very hard finish and superior wear resistance but does not offer much protection to corrosion; 2) A "nickel-chrome" finish is achieved by applying a flash of chrome on top of the nickel plating. This offers resistance to tarnishing and corrosion.
Dacrotized	Dacrotizing is a pollution-free ceramic coating for fasteners used with treated lumber. The coating offers corrosion protection comparable to hot-dip galvanizing without discoloring the wood. Screws with a proper dacrotized coating can typically withstand a 500-hour salt-spray test. Dacrotizing minimizes greatly the risk of hydrogen embrittlement so baking the parts is not required after the finish is applied.
Blue Polymer	Polymer is a barrier coating because it creates a seal around the part which resists corrosion and abrasion. A phosphate-zinc base is initially applied to the fastener, followed by the polymer which bonds to the sub-coating. This finish gives excellent rust protection and is commonly used to coat concrete screws.
Green Ceramic	Ceramic finish is also a barrier coating used to offer corrosion resistance. It is used, though not exclusively, on certain types of construction fasteners and typically provides over 500 salt spray hours of protection.

Black Oxide Finish

Black Oxide is a conversion coating (as opposed to an applied coating) because it results from a chemical reaction with the iron present in the metal fastener and forms an integral protective surface. It is a coloring of the base metal which neither removes nor deposits meta; therefore it adds, at the most, 5 to 10 millionths of an inch to the fastener's dimensions. Likewise, it cannot chip, peel or rub off. Also, the item maintains 99% of its conductivity making black oxide a popular finish for electrical parts.

When a black oxide finish is specified, it is interpreted as "Black Oxide and Oil". Other supplementary coatings such as wax or lacquer may be ordered, but fasteners with those finishes are usually not available from a distributor's stock. A waxed coating over the black oxide is often preferred for parts used in the furniture industry and for fasteners bagged in kits.

Typically, a water-displacing oil is used which gives the part a lustrous appearance and improved lubricity without excessive residue. The color is a deep black rather than the grayish-black appearance of a black phosphate, and remains consistent at temperatures as high as 600° F. Black oxide also resists abrasions better than phosphate.

One of the most important advantages of black oxide is that there is almost no risk of hydrogen embrittlement because the process does not involve electroplating nor does it require an acid-activation. Case hardened parts need not be baked after receiving a black oxide finish.

Black oxide neither enhances nor detracts from a fastener's resistance to corrosion. The post-treatment oil application offers good indoor corrosion protection, but a zinc-plated part is more resistant to rust. However, parts with a black oxide finish will not suffer from white corrosion which can occur over time with electro-plated parts. To avoid the risk of white corrosive particles (which can cause electrical shorts) many in the electronics industry opt for black oxide instead of zinc-plated fasteners.

Steel black oxide parts are not recommended for outdoor uses, but the popularity of black oxide stainless fasteners is growing. In addition to being used for decorative purposes, the finish reduces light glare and reflection, and makes the surface of the fastener smoother. The automotive aftermarket utilize them in tail-light assemblies, luggage racks, grills and windshield wiper assemblies, to name a few.

Notes on Heat Treating Fasteners

Steel fasteners are heat treated to develop the fastening strengths their material structure is capable of reaching. The iron, carbon, manganese and other elements which form the grains of steel are transformed during heat treating to a structure capable of greater load carrying. The as-heat treated hardness, and tensile strength, are two of several metallurgical measures of the finished heat treated fastener.

Heat treating is a "three box" process: *Harden-Quench-Temper.* The raw fasteners travel into the hardening furnace where a high temperature and an atmosphere with a metered amount of carbon molecules alter the fasteners' microstructure. Once "soaked" in and transformed in this environment, the fasteners are rapidly cooled, or "quenched" to shift the fastener metal into the martensitic microstructure right for fastening. To relieve the stresses from the rapid temperature changes needed to quench properly, the final step, tempering, draws the fastener back to their final hardness and tensile strength using a temperature lower than used in hardening. By hardening, quenching and tempering a steel fastener, the finished product develops the mechanical properties to provide fastening ability.

RE-USE OF FASTENERS

The Industrial Fastener Institute (IFI) completes many studies on the strength-loss of re-used fasteners. Their basic findings: **The component which causes the most danger to a fastener assembly when re-used is the nut.**

- The first thread of a USS nut supports 38% of the total load on a bolt.
- The second thread supports 25% of the total load.
- The third thread supports 18% of the total load.
- **81% of the total load is placed on the first three threads of the nut!**

To allow the nut to absorb the load of the bolt, the nut must be slightly softer than the bolt in order to form to the contour of the bolts' threads. This causes distortion of the threads to occur on the nut during installation. Only by installing a new nut can you restore the original clamp load.

In critical applications, we strongly recommend replacing both the cap screw and nut.

WHY FASTENERS FAIL

Fastener problems will arise if the user fails to realize the importance of proper selection for the application, torque, re-use of fasteners, and installation.

Common causes of fastener failure:

- Fasteners are over torqued
- Re-use of fasteners
- Wrong application of graded fastener
- Compression of material, loss of clamping force
- Mis-matched fasteners of different grades
- Use of cap screws that are too long
- Improperly installed washers

TORQUE

Torque is one of the most misused words when installing bolts. Mechanics tighten bolts using a wrench or an air impact gun. **These tools create torque that cannot be controlled.** If the tightness specification is given in ft./lbs., **a torque wrench must be used to indicate when the specified torque is reached.** The indicator on the wrench is measuring the resistance to turning as the two threaded surfaces mate.

Key Points

- **Over torqued fasteners are the #1 cause of fastener failure.**
- Selecting the proper fastener will ensure reliability.
- Properly tightened (torqued) fasteners apply a clamping force equal to or greater than the maximum operating load.

NOTE: If these two conditions exist, the bolt cannot fail by fatigue because it experiences no stress since the clamping force is equal to or greater than the maximum operating load.

- Too little clamping force can lead to fatigue failure caused by dynamic loads:
  - Vibration
  - Impact
  - Shock

- Stress cracks caused by too little clamping force occur at the weakest points:
  - At the root of threads
  - At the fillet where the bolt head and shank meet
  - At a cut or scratch on the surface

- Steel, regardless of its grade or hardness, will stretch. As long as the amount of stretch does not exceed the yield point it will maintain its reliability.

- Torque each bolt as close to the yield point without exceeding it will maximize the service life of fastener assemblies.

SOLUTION

1. Buy certified fasteners.
2. Purchase bolts from reputable distributors.
3. Analyze failed bolt and solve the problem.
4. Use a matched system.

Stronger fasteners are less expensive in the long run.

TORQUE CHART GUIDE

BOLTS Identification • Strength • Clamp • Torque • Materials

GRADE 2

Diameter	Proof Load	Yield Strength	Tensile Strength
1/4" – 3/4"	55,000	57,000	74,000
3/4" – 1-1/2"	33,000	36,000	60,000

Low or Medium Carbon Steel

Size	Clamp Load (lb)	Assembly Torque Dry (ft lb)	Assembly Torque Lub (ft lb)	Min. Tensile (lb)
1/4 – 20	1320	6	5	2700
1/4 – 28	1500	7	6	2900
5/16 – 18	2160	11	11	4400
5/16 – 24	2400	12	12	4700
3/8 – 16	3200	20	15	6400
3/8 – 24	3620	23	17	8800
1/2 – 13	5850	50	35	11500
1/2 – 20	6600	55	40	12500
5/8 – 11	9350	100	75	18500
5/8 – 18	10550	110	85	20000
3/4 – 10	13800	175	130	27000
3/4 – 16	15400	200	150	29000
7/8 – 9	11450	170	125	30000
1 – 8	15000	250	190	39500
1-1/8 – 7	18900	350	270	50000
1-1/4 – 7	24000	500	380	63000
1-3/8 – 6	28600	670	490	75500
1-1/2 – 6	34800	870	650	91000

A325 GRADE 5

Diameter	Proof Load	Yield Strength	Tensile Strength
1/4" – 1"	85,000	92,000	120,000
3/4" – 1-1/2"	74,000	81,000	105,000

Medium Carbon Steel, Quenched and Tempered

Size	Clamp Load (lb)	Assembly Torque Dry (ft lb)	Assembly Torque Lub (ft lb)	Min. Tensile (lb)
1/4 – 20	2000	8	7	4450
1/4 – 28	2300	10	8	4840
5/16 – 18	3350	17	13	7190
5/16 – 24	3700	19	14	7670
3/8 – 16	4950	30	23	10530
3/8 – 24	5600	35	25	14400
1/2 – 13	9000	75	55	19000
1/2 – 20	10500	90	65	20500
5/8 – 11	14400	150	110	30100
5/8 – 18	16370	180	130	32600
3/4 – 10	21300	260	200	44200
3/4 – 16	23800	300	220	47400
7/8 – 9	29450	320	320	53100
1 – 8	38600	640	480	69500
1-1/8 – 7	42300	800	600	87800
1-1/4 – 7	53800	1120	840	110300
1-3/8 – 6	64100	1460	1100	132200
1-1/2 – 6	7800	1910	1460	159600

GRADE 8

Proof Load	Yield Strength	Tensile Strength
120,000	130,000	150,000

Carbon Alloy Steel, Quenched and Tempered

Size	Clamp Load (lb)	Assembly Torque Dry (ft lb)	Assembly Torque Lub (ft lb)	Min. Tensile (lb)
1/4 – 20	2850	12	9	6600
1/4 – 28	3250	14	10	7200
5/16 – 18	4700	25	18	10700
5/16 – 24	5200	25	20	11500
3/8 – 16	7000	45	35	15800
3/8 – 24	7900	50	35	21600
1/2 – 13	12750	110	80	28600
1/2 – 20	14370	120	90	30800
5/8 – 11	20350	220	170	45200
5/8 – 18	23000	240	180	49000
3/4 – 10	30100	380	280	66300
3/4 – 16	33500	420	320	71100
7/8 – 9	41600	600	460	91000
1 – 8	54500	900	680	119200
1-1/8 – 7	68900	1280	960	150500
1-1/4 – 7	87200	1820	1360	189200
1-3/8 – 6	104000	2380	1780	226700
1-1/2 – 6	126500	3160	2360	273600

Yield Strength is the load at which the fastener exhibits a specified elongation at a specific load.

Tensile Strength is the minimum total load that will fail the fastener.

Clamp Load – 75% x Proof x Stress Area. Also called the fastener preload or initial load. The "Clamp" Load is the true maximum load of any fastener.

Proof Load is the load which the fastener must withstand without a permanent set.

Torque Dry assumes a coefficient of friction of 0.20.

Torque Lubricated assumes a coefficient of friction of 0.15.

Minimum Tensile – minimum load at which the fastener will fail. Minimum safe working load is 4:1.

A325 is the designation for "structural" Grade 5 bolts which have larger head dimensions.

METRIC TORQUE CHART GUIDE

TORQUE FIGURES FOR METRIC COARSE THREAD BOLTS AND SCREWS

Torque figures for bolts and screws with metric thread and head dimension, as in DIN 912, 931, 933 etc.

The figures MA in this table include:

a) coefficient of friction microns total + 0.14

b) 90% of minimum elongation

c) torque figures when assembling fasteners

The coefficient of friction of microns total = 0.14 applies for fasteners without coating (self-colour) when slightly lubricated. Additional lubrication of the thread will substantially alter the coefficient of friction, leading to uncontrollable pre-load situations. Pre-load situations will also be influenced by the fastening methods and tools used. The following figures are guidelines only. Figures in Nm (Newton meters).

Thread Diameter	Property Classes				
	4.6	5.6	8.8	10.9	12.9
M4	1.02	1.37	3.0	4.4	5
M5	2.00	2.70	5.9	8.7	10
M6	3.50	4.60	10	15	18
M8	8.40	11	25	36	43
M10	17	22	49	72	84
M12	29	39	85	125	145
M14	46	62	135	200	235
M16	71	95	210	310	365
M18	97	130	300	430	500
M20	138	184	425	610	710
M22	186	250	580	820	960
M24	235	315	730	1,050	1,220
M27	350	470	1,100	1,550	1,800
M30	475	635	1,450	2,100	2,450
M33	645	865	1,970	2,770	3,330
M36	830	1,111	2,530	3,560	4,280

TORQUE FIGURES FOR METRIC FINE THREAD BOLTS AND SCREWS

Thread Diameter	Tightening Torque MA max (NM) Property Classes		
	8.8	10.9	12.9
M8 x 1.00	22	30	36
M10 x 1.25	42	59	71
M12 x 1.25	76	105	130
M14 x 1.50	120	165	200
M16 x 1.50	180	250	300
M18 x 1.50	260	365	435
M20 x 1.50	360	510	610
M22 x 1.50	480	680	810
M24 x 2.00	610	860	1050

Conversion Figures	
To get Ncm fromNm	Nm x 100
To get inch pounds from Ncm	Ncm x 0.08851
To get foot pounds from Ncm	Ncm x 0.00737
To get foot pounds from Nm	Nm x 0.7376

All information is strictly informative.

FASTENING - TORQUE TABLE

Suggested Torque Values (in. lb.)

The following suggested tightening torques provide an excellent starting point for determining torque requirements. Remember, you may need to vary these numbers somewhat based on the individual joint or the amount of fastener lubrication.

Bolt Size	18-8 Stainless Steel	Brass	Silicon Brass	Aluminum 2024-T4	316 Stainless Steel	Monel	Nylon
2 – 56	2.5	2.0	2.3	1.4	2.6	2.5	0.44
2 – 64	3.0	2.5	2.8	1.7	3.2	3.1	
3 – 48	3.9	3.2	3.6	2.1	4.0	4.0	
3 – 56	4.4	3.6	4.1	2.4	4.6	4.5	
4 – 40	5.2	4.3	4.8	2.9	5.5	5.3	1.19
4 – 48	6.6	5.4	6.1	3.6	6.9	6.7	
5 – 40	7.7	6.3	7.1	4.2	8.1	7.8	
5 – 44	9.4	7.7	8.7	5.1	9.8	9.6	
6 – 32	9.6	7.9	8.9	5.3	10.1	9.8	2.14
6 – 40	12.1	9.9	11.2	6.6	12.7	12.3	
8 – 32	19.8	16.2	18.4	10.8	20.7	20.2	4.30
8 – 36	22.0	18.0	20.4	12.0	23.0	22.4	
10 – 24	22.8	18.6	21.2	13.8	23.8	25.9	6.61
10 – 32	31.7	25.9	29.3	19.2	33.1	34.9	8.20
1/4″ – 20	75.2	61.5	68.8	45.6	78.8	85.3	16.00
1/4″ – 28	94.0	77.0	87.0	57.0	99.0	106.0	20.80
5/16″ – 18	132.0	107.0	123.0	80.0	138.0	149.0	34.90
5/16″ – 24	142.0	116.0	131.0	86.0	147.0	160.0	
3/8″ – 16	236.0	192.0	219.0	143.0	247.0	266.0	
3/8″ – 24	259.0	212.0	240.0	157.0	271.0	294.0	
7/16″ – 14	376.0	317.0	349.0	228.0	393.0	427.0	
7/16″ – 20	400.0	357.0	371.0	242.0	418.0	451.0	
1/2″ – 13	517.0	422.0	480.0	313.0	542.0	584.0	
1/2″ – 20	541.0	443.0	502.0	328.0	565.0	613.0	
9/6″ – 12	682.0	558.0	632.0	413.0	713.0	774.0	
9/6″ – 18	752.0	615.0	697.0	456.0	787.0	855.0	
5/8″ – 11	1110.0	907.0	1030.0	715.0	1160.0	1330.0	
5/8″ – 18	1244.0	1016.0	1154.0	798.0	1301.0	1482.0	
3/4″ – 10	1530.0	1249.0	1416.0	980.0	1582.0	1832.0	
3/4″ – 16	1490.0	1220.0	1382.0	958.0	1558.0	1790.0	
7/8″ – 9	2328.0	1905.0	2140.0	1495.0	2430.0	2775.0	
7/8″ – 14	2318.0	1895.0	2130.0	1490.0	2420.0	2755.0	
1″ – 8	3440.0	2815.0	3185.0	2205.0	3595.0	4130.0	
1″ – 14	3110.0	2545.0	2885.0	1995.0	3250.0	3730.0	
1-1/8″ – 7	413.0	337.0	383.0	265.0	432.0	499.0	
1-1/8″ – 12	390.0	318.0	361.0	251.0	408.0	470.0	
1-1/4″ – 7	523.0	428.0	485.0	336.0	546.0	627.0	
1-1/4″ – 12	480.0	349.0	447.0	308.0	504.0	575.0	
1-1/2″ – 6	888.0	727.0	822.0	570.0	930.0	1064.0	
1-1/2″ – 12	703.0	575.0	651.0	450.0	732.0	840.0	

This table is offered as the suggested maximum torquing values for threaded products and is only a guide. All values shown on the chart, except for nylon, represent a safe working torque; in the case of nylon only, the figures represent breaking torque.

THREADED ROD DATA

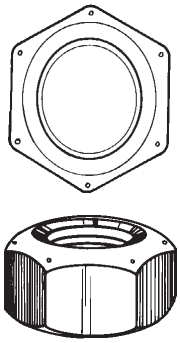
		Steel Strength (lb)					
		ASTM A 307 Rod (Grade 2)			Stainless Steel (Grade 304 or 316)		
Rod Diameter (inch)	Stressed Cross Section (sq inch)	Yield Strength	Tensile Strength	Shear Strength	Yield Strength	Tensile Strength	Shear Strength
1/4	0.0318	1,145	1,908	1,259	954	2,385	1,590
3/8	0.0775	2,790	4,650	3,069	2,325	5,813	3,875
1/2	0.1419	5,108	8,514	5,619	4,257	10,653	7,095
5/8	0.226	8,136	13,560	8,950	6,780	16,950	11,330
3/4	0.334	12,024	20,040	13,226	10,020	25,050	16,700
7/8	0.462	16,632	27,720	18,295	13,860	34,650	23,100
1	0.606	21,816	36,360	23,998	18,180	45,450	30,300
1-1/14	0.969	34,884	58,140	38,372	29,070	72,675	48,450
1-1/2	1.045	37,620	62,700	41,382	31,350	78,375	52,250

GUIDE FOR PREVAILING-TORQUE LOCK NUT ASSEMBLY TORQUES (CAD AND WAX, GRADE B, C, AND GRADE G FLANGE NUTS) LOCK NUT STANDARDS FROM IFI-100 REQUIREMENTS

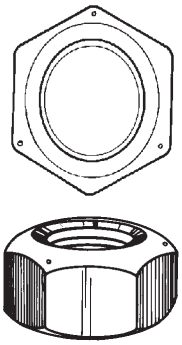
Torque-Tension Requirements

Size Threads Per Inch	Grade B Clamp Load (lb)	Grade B Assembly Torque Max.	Grade B Assembly Torque Min.	Grade C Clamp Load (lb)	Grade C Assembly Torque Max.	Grade C Assembly Torque Min.	Grade G Clamp Load (lb)	Grade G Assembly Torque Max.	Grade G Assembly Torque Min.
1/4–20	2,000	85**	60**	2,850	125**	85**	2,850	150**	100**
1/4–28	2,300	90**	65**	3,250	125**	85**	3,250	160**	105**
5/16–18	3,350	150**	110**	4,700	190**	130**	4,700	240**	155**
5/16–24	3,700	160**	120**	5,200	200**	140**	5,200	230**	155**
3/8–16	4,950	20	14.5	6,950	28	20	6,950	32	21
3/8–24	5,600	22	16	7,900	29	21	7,900	33	22
7/16–14	6,800	32	23	9,600	43	31	9,600	51	34
7/16–20	7,550	34	24	10,700	43	31	10,700	60	40
1/2–13	9,050	50	37	12,800	62.5	45	12,800	85	55
1/2–20	10,200	52.5	37.5	14,440	70	50	14,440	89	59
9/16–12	11,600	70	50	16,400	95	70	16,400	120	80
9/16–18	13,000	77.5	57.5	18,300	95	70	18,300	132	88
5/8–11	14,500	95	70	20,300	122.5	90	20,300	143	95
5/8–18	16,300	97.5	72.5	23,000	125	90	23,000	175	115
3/4–10	21,300	165	125	30,100	210	155	30,100	240	160
3/4–16	23,800	165	120	33,600	210	155	33,600	270	170
7/8–9	29,500	250	185	41,600	312.5	225	41,600	360	260
7/8–14	32,400	270	200	45,800	312.5	225	45,800	402	247
1–8	38,700	375	275	54,600	462.5	360	54,600	530	410
1–12	42,300	395	290	59,750	490	360	59,750	—	—
1–14	43,000	400	300	61,100	500	362.5	61,100	645	398
1-1/8–7	42,100	404	294	69,000	585	454	69,000	—	—
1-1/8–12	47,500	437	327	76,800	622	453	76,800	—	—
1-1/4–7	53,500	513	375	87,000	736	573	87,000	—	—
1-1/4–12	59,700	549	412	96,600	782	570	96,600	—	—
1-3/8–6	63,800	612	445	104,000	880	685	104,000	—	—
1-3/8–12	72,900	670	503	118,000	955	696	118,000	—	—
1-1/2–6	77,600	745	545	127,000	1,075	837	127,000	—	—
1-1/2–12	87,700	807	605	142,000	1,150	837	142,000	—	—

Grade C



Grade B



Grade G

- Clamp Loads for the Grade B lock nuts equal 75% of the bolt proof loads specified for SAE J-429 Grade 5, and ASTM A-449 bolts.
  Clamp Loads for Grade C lock nuts equal 75% of the bolt proof loads specified for SAE J-429 Grade 8, and ASTM A-354 Grade BD bolts.
- IFI-100 does not govern lock nuts above 1". The values shown in the chart are to be used as a mid-range guideline.

** **Torque values for 1/4" and 5/16" sizes are in inch lbs. All other torque values are in foot lbs.**

METRIC TORQUE CHART FOR HEX HEAD CAP SCREWS

Size	Class	Newton Meters Zinc Plated	Newton Meters Unplated	Foot Pounds (approx.) Zinc Plated	Foot Pounds (approx.) Unplated	Class
M4 x .70 Pitch	8.8	3.1	2.2	2.30	1.65	8.8
M5 x .80 Pitch	8.8	6.1	5.5	4.58	4.13	
M6 x 1.00 Pitch	8.8	10.4	9.5	7.80	7.13	
M7 x 1.00 Pitch	8.8	17.0	15.5	12.75	11.63	
M8 x 1.25 Pitch	8.8	25.0	23.0	18.75	17.25	
M8 x 1.00 Pitch	8.8	27.0	24.5	20.25	18.38	
M10 x 1.50 Pitch	8.8	51.0	46.0	38.25	34.50	
M10 x 1.00 Pitch	8.8	57.0	52.0	42.75	39.00	
M10 x 1.25 Pitch	8.8	54.0	49.0	40.50	36.75	
M12 x 1.75 Pitch	8.8	87.0	79.0	65.25	59.25	
M12 x 1.25 Pitch	8.8	96.0	87.0	72.00	65.25	
M12 x 1.50 Pitch	8.8	92.0	83.0	69.00	62.25	
M14 x 2.00 Pitch	8.8	140.0	125.0	105.00	93.75	
M14 x 1.50 Pitch	8.8	150.0	135.0	112.50	101.25	
M16 x 2.00 Pitch	8.8	215.0	195.0	161.25	146.25	
M18 x 2.50 Pitch	8.8	300.0	280.0	225.00	210.00	
M20 x 2.50 Pitch	8.8	430.0	390.0	322.50	292.50	
M22 x 2.50 Pitch	8.8	580.0	530.0	435.00	397.50	
M24 x 3.00 Pitch	8.8	740.0	670.0	555.00	502.50	
M6 x 1.00 Pitch	10.9	15.5	14.0	11.63	10.50	10.9
M8 x 1.25 Pitch	10.9	37.0	34.0	27.75	25.50	
M10 x 1.50 Pitch	10.9	75.0	68.0	56.25	51.00	
M12 x 1.75 Pitch	10.9	160.0	117.0	97.50	87.75	
M14 x 2.00 Pitch	10.9	205.0	185.0	153.75	138.75	
M16 x 2.00 Pitch	10.9	310.0	280.0	232.50	210.00	

DIAMETER/DECIMAL/METRIC CHART FOR SMALL DIAMETERS

Gauge or Dia.	Decimal (in)	(mm)
No. 0000	0.021	.53
No. 000	0.034	.86
No. 00	0.047	1.19
No. 0	0.060	1.524
No. 1	0.073	1.854
No. 2	0.086	2.184
No. 3	0.099	2.515
No. 4	0.112	2.845
No. 5	0.125	3.175
No. 6	0.138	3.505
No. 8	0.164	4.166
No. 10	0.190	4.826
No. 12	0.216	5.484

FASTENER CONVERSION CHART INCH TO METRIC

Inch Equivalent UNC	UNF	Metric Size-Pitch ISO and IFI Recommended
1 – 64	1 – 72	M2 x 0.4
3 – 48	3 – 56	M2.5 x 0.45
4 – 40	4 – 48	M3 x .05
6 – 32	6 – 40	M3.5 x 0.6
8 – 32	8 – 36	M4 x .07
10 – 24	10 – 32	M5 x .08
1/4 – 20	1/4 – 28	M6 x 1
5/16 – 18	5/16 – 24	M8 x 1.25
3/8 – 16	3/8 – 24	M10 x 1.5
7/16 – 14	7/16 – 20	M12 x 1.75
1/2 – 13	1/2 – 20	M14 x 2
5/8 – 11	5/8 – 18	M18 x 2
3/4 – 10	3/4 – 16	M20 x 2.5
1 – 8	1 – 12	M24 x 3
1-1/4 – 7	1-1/8 – 12	M30 x 3.5
1-1/2 – 6	1-1/4 – 12	M36 x 4

APPROXIMATE EQUIVALENCY CHART METRIC/U.S.

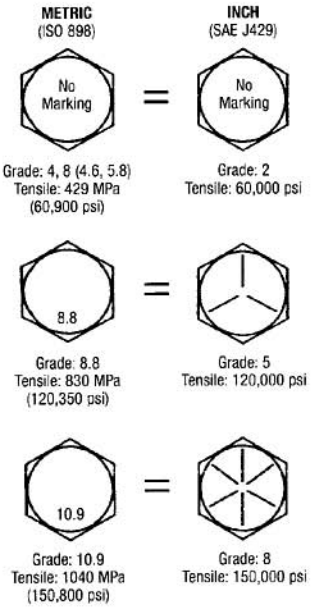
ROUGHLY EQUIVALENT U.S. BOLT MATERIALS

Metric Nut Class Metric Bolt Class	SAE J429 Normally Used	Grades	ASTM Grades
4.6	4 or 5	1	A307, Grade A
4.f8	4 or 5	2	
5.8	5	2	
8.8	8	5	A325, A449
9.9	9	5+	A193, B7 and B16
10.9	10 or 12	8	A490; A354, Grade 8D
12.9	10 or 12		A540; B21 through B24

COMMON DIN NUMBERS FOR METRIC FASTENERS

DIN	Hex Capscrews
931	Coarse thread pitch partially threaded (specify grade)
933	Coarse thread pitch fully threaded (specify grade)
930	Fine thread pitch partially threaded (specify grade)
961	Fine thread pitch fully threaded (specify grade)
DIN	**Nuts**
934	Hex nuts (specify pitch and class)
985	Nylon insert locknuts (specify pitch and class)
980V	All metal locknuts (specify pitch and class)
DIN	**Washers**
125	Flatwashers
127	Lockwashers
DIN	**Socket Products**
912	Socket head capscrews (normally GR 12.9 and coarse thread)
7991	Flat head socket capscrews (normally GR 12.9 and coarse thread)
916	Socket setscrews (normally GR 12.9 and coarse thread)
DIN	**Machine Screws**
7985	Pan head Phillips drive zinc plated
965	Flat head Phillips drive zinc plated
DIN	**Threaded Rod**
975	All threaded rod (normally 1 meter lengths, specify grade and pitch)

STRENGTHS



NOTE: Metric hex socket cap screws are available in lower strength grades (8.8, 10.9) and marked accordingly.

METRIC THREADS

Metric threads evolved similarly to the inch thread series. The current ISO metric screw thread system includes a coarse series, fine series and a number of constant pitch thread series.

The ISO metric coarse thread series is uniquely positioned, in terms of its thread pitches. It is located approximately half way between Unified coarse and Unified fine. For a given diameter, metric coarse threads are finer than Unified coarse but coarser than Unified fine. The metric coarse thread has certain technical advantages over either of the two Unified inch thread series.

ISO metric fine thread series has much fine thread pitches than those of the Unified fine series. Use of the metric fine series for commercial metric fastener applications is not recommended.

Metric External Fastener Strength Grades

The metric fastener strength grades are called "property classes." This term originated in ISO standards and was continued into ASTM and SAE specifications. The ISO "property class" system for externally threaded metric fasteners is specified in ISO 898/1.

Property class designations, as found on the head of a metric bolt, are numerals indicating the following information:

- The numeral or numerals preceding the first decimal point approximate 1/100th of the specified minimum tensile strength in megapascals (MPa).

Metric Grades

The numeral following the first decimal point approximates 1/10th of the ratio (expressed as a percentage), between the minimum yield strength and the minimum tensile strength. The yield strength is always a percentage of the tensile strength. Yield strength is where thread deformation begins, and this value is always less than the bolt's tensile strength.

Metric Strength Grade System Examples

A class 4.6 steel metric bolt has a specified minimum tensile strength of 400 MPa (4 x 100) and a specified minimum yield strength of 240 MPa (0.6 x 400). The numbers 4 and .6 make up the designation, with the .6 being the ratio of 240 MPa minimum yield strength to 400 MPa minimum tensile strength.

Not all metric designations give exact tensile and yield values as earlier discussed. Each gives reasonable approximates.

Note: *It is a mandatory regulation in SAE and ASTM standards that inch series fasteners of the medium-carbon and alloy steel strength grades and metric fasteners of all property classes be marked for grade identification. The only exceptions are slotted and recessed head screws and bolts smaller than 5mm. Also of major importance is that these same standards require that all steel fasteners be marked to identify the manufacturer.*

METRIC/INCH COMPARATIVE CHART FOR DIAMETERS 1 inch = 25.4 mm 1 mm = 0.04"

Metric Diameter	Decimal (in)	Nearest Diameter (in)	Decimal (in)
M2	(0.079)	#2	(0.086)
M2.5	(0.098)	#3	(0.999)
M3	(0.118)	#5	(0.125)
M3.5	(0.138)	#6	(0.138)
M4	(0.157)	#8	(0.164)
M5	(0.197)	3/16	(0.187)
M6	(0.236)	1/4	(0.250)
M8	(0.315)	5/16	(0.312)
M10	(0.394)	3/8	(0.375)
M12	(0.472)	7/16	(0.437)
		1/2	(0.500)
M14	(0.551)	9/16	(0.562)
M16	(0.630)	5/8	(0.625)
M20	(0.787)	3/4	(0.750)
M24	(0.945)	1	(1.000)
M30	(1.181)	1-1/8	(1.125)
M36	(1.417)	1-1/4	(1.250)
		1-3/8	(1.375)
M42	(1.653)	1-1/2	(1.500)
M48	(1.890)	1-3/4	(1.750)
		2	(2.000)
M56	(2.205)	2-1/4	(2.250)
M64	(2.520)	2-1/2	(2.500)
M72	(2.835)	2-3/4	(2.750)
M80	(3.150)	3	(3.000)
M90	(3.543)	3-1/2	(3.500)
M100	(3.937)	4	(4.000)

METRIC/INCH COMPARATIVE CHART FOR LENGTHS

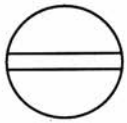
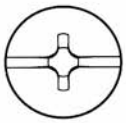
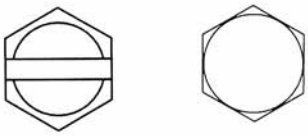
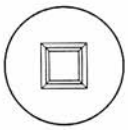
Metric Length	Decimal (in)	Nearest Length (in)	Decimal (in)
10mm	(0.394)	3/8	(0.375)
12mm	(0.472)	1/2	(0.500)
16mm	(0.630)	5/8	(0.625)
20mm	(0.787)	3/4	(0.750)
25mm	(0.984)	1	(1.000)
30mm	(1.181)	1-1/4	(1.250)
35mm	(1.387)	1-3/8	(1.375)
40mm	(1.575)	1-1/2	(1.500)
45mm	(1.772)	1-3/4	(1.750)
50mm	(1.968)	2	(2.000)
55mm	(2.165)	2-1/4	(2.250)
60mm	(2.362)	2-3/8	(2.275)
65mm	(2.559)	2-1/2	(2.500)
70mm	(2.756)	2-3/4	(2.750)
75mm	(2.953)	3	(3.000)
80mm	(3.150)	3-1/4	(3.250)
90mm	(3.543)	3-1/2	(3.500)
100mm	(3.937)	4	(4.000)
120mm	(4.724)	4-3/4	(4.750)
130mm	(5.118)	5	(5.000)
140mm	(5.512)	5-1/2	(5.500)
150mm	(5.905)	6	(6.000)
160mm	(6.299)	6-1/4	(6.250)
170mm	(6.693)	6-1/2	(6.500)
180mm	(7.087)	7	(7.000)
190mm	(7.480)	7-1/2	(7.500)
200mm	(7.874)	8	(8.000)

FRACTIONS • DECIMALS • MILLIMETERS

Inches	Decimals	MM
1/64	.015625	.39688
1/32	.03125	.79375
3/64	.046875	1.19063
1/16	.0625	1.58750
5/64	.078125	1.98438
3/32	.09375	2.38125
7/64	.109375	2.77813
1/8	.125	3.17500
9/64	.140625	3.57188
5/32	.15625	3.96875
11/64	.171875	4.36563
3/16	.1875	4.76250
13/64	.203125	5.15938
7/32	.21875	5.55625
15/64	.234375	5.95313
1/4	.25	6.35000
17/64	.265625	6.74688
9/32	.28125	7.14375
19/64	.296875	7.54063
5/16	.3125	7.93750
21/64	.328125	8.33438
11/32	.34375	8.73125
23/64	.359375	9.12813
3/8	.375	9.52500
25/64	.390625	9.92188
13/32	.40625	10.31875
27/64	.421875	10.71563
7/16	.4375	11.11250
29/64	.453125	11.50938
15/32	.46875	11.90625
31/64	.484375	12.30313
1/2	.5	12.70000
33/64	.51562	13.09688
17/32	.53125	13.49375
35/64	.546875	13.89063
9/16	.5625	14.28750
37/64	.578125	14.68438
19/32	.59375	15.08125
39/64	.609375	15.47813
5/8	.625	15.87500
41/64	.640625	16.27188
21/32	.65625	16.66875
43/64	.671875	17.06563
11/16	.6875	17.46250
45/64	.703125	17.85938
23/32	.71875	18.25625
47/64	.734375	18.65313
3/4	.75	19.05000
49/64	.765625	19.44688
25/32	.78125	19.84375
51/64	.796875	20.24063
13/16	.8125	20.63750
53/64	.828125	21.03438
27/32	.84375	21.43125
55/64	.859375	21.82813
7/8	.875	22.22500
57/64	.890625	22.62188
29/32	.90625	23.01875
59/64	.921875	23.41563
15/16	.9375	23.81250
61/64	.953125	24.20938
31/32	.96875	24.60625
63/64	.984375	25.00313
1"	1.000	25.40000

MM	Inches	MM	Inches
.1	.0039	46	1.8110
.2	.0079	47	1.8504
.3	.0118	48	1.8898
.4	.0157	49	1.9291
.5	.0197	50	1.9685
.6	.0236	51	2.0079
.7	.0276	52	2.0472
.8	.0315	53	2.0866
.9	.0354	54	2.1260
1	.0394	55	2.1654
2	.0787	56	2.2047
3	.1181	57	2.2441
4	.1575	58	2.2835
5	.1969	59	2.3228
6	.2362	60	2.3622
7	.2756	61	2.4061
8	.3150	62	2.4409
9	.3543	63	2.4803
10	.3937	64	2.5197
11	.4331	65	2.5591
12	.4724	66	2.5984
13	.5118	67	2.6378
14	.5512	68	2.6772
15	.5906	69	2.7165
16	.6299	70	2.7559
17	.6693	71	2.7953
18	.7087	72	2.8346
19	.7480	73	2.8740
20	.7874	74	2.9134
21	.8268	75	2.9528
22	.8661	76	2.9921
23	.9055	77	3.0315
24	.9449	78	3.0709
25	.9843	79	3.1102
26	1.0236	80	3.1496
27	1.0630	81	3.1890
28	1.1024	82	3.2283
29	1.1417	83	3.2677
30	1.1811	84	3.3071
31	1.2205	85	3.3465
32	1.2598	86	3.3858
33	1.2992	87	3.4252
34	1.3386	88	3.4646
35	1.3780	89	3.5039
36	1.4173	90	3.5433
37	1.4567	91	3.5827
38	1.4961	92	3.6220
39	1.5354	93	3.6614
40	1.5748	94	3.7008
41	1.6142	95	3.7402
42	1.6535	96	3.7795
43	1.6929	97	3.8189
44	1.7323	98	3.8583
45	1.7717	99	3.8976
		100	3.9370

SELF-TAPPING SCREW DRIVE TYPES

DRIVE TYPES FOR SELF-TAPPING SCREWS		
Schematic	**Drive Type**	**Uses**
	Phillips	Most recommended drive type. Provides good control in driving. Always use a driver bit of the proper size which is in good condition.
	Slotted	Accepts standard blade screwdriver. Requires less downward pressure to drive parts than those with recessed openings. Use proper fitting blade to minimize slippage.
	Combination: Phillips/Slotted	Accepts phillips and standard blade screwdrivers. Often used when fastener is expected to be driven and backed-out several times.
	Hex / Slotted-Hex	Accepts hex wrench. Slotted drive is added to make it easier to remove the fastener.
	Torx®	Positive-engaging, fast-locating method which transmits drive torque with less required downward pressure. Good fastening appearance.
	Square	Increases productivity with excellent torque transmission and resists cam-out. Distinctive appearance which discourages tinkering.
	Pozidriv®-Alternative (Type 1A)	Design offers even greater control in driving than Phillips drive. Used in automotive and appliance manufacturing.

SELF-TAPPING SCREW HEAD STYLES

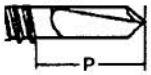
Schematic	Head Style	Description	Applications/ Advantages
	Bugle	A countersunk head with a flat top surface and a concave underhead bearing surface.	Designed specifically for use in drywall. Distributes bearing stress over a wider area than flat heads.
	Pan	Slotted pan heads have a flat or gently rounded top surface, cylindrical sides and a flat bearing surface. Phillips, Torx® and square pan heads have a rounded top surface, cylindrical sides and a flat bearing surface.	For general applications. Can be substituted in most applications for round, truss or binding heads.
	Flat 82°	A countersunk head with a flat top surface and a cone-shaped bearing surface with a head angle of approximately 82°.	Used in applications where protrusion of the fastener above the mating surface is unacceptable. Use a protrusion gage when measuring head height.
	Flat Undercut	Similar to an 82° flat head except that the head is undercut to 70% of its normal side height.	Standard for short lengths because it allows greater length of threads. Also avoids transition fillet and assembly interference.
	Indented Hex	Has an indented top surface, six flat sides, and a flat bearing surface.	Preferred in high volume assembly where pneumatic equipment is used to drive the screw. Can transmit significantly higher tightening torque levels than other head styles.
	Indented Hex Washer	Has an indented top surface, six flat sides with a flat washer which projects beyond the sides and provides a flat bearing surface. The washer and hex head are formed together as one piece. An undercut area where the bearing surface meets the shank is an optional design feature.	Increased bearing area reduces likelihood of crushing mating surfaces.
	Serrated Hex Washer	Same as an Indented Hex Washer head but with serrations formed into the bearing surface on the underside of the washer.	Serration geometry is oriented to resist loosening. Also slows the screw at the point of engagement with the mating piece of sheet metal so as to minimize stripping.
	Truss	Has a low rounded top with a flat bearing surface greater in area than a round-head screw of the same nominal size.	Weaker than pan or round heads but preferred in applications where minimal clearance exists above the head. Truss profile provides a trim, finished appearance.
	Wafer	A countersunk head with a flat top surface and a cone-shaped bearing surface. The wafer's 70° conical underhead area does not extend to the outer edge of the head, providing a bearing surface of 16° around the circumference of the underhead.	Preferred head style for Type-CSD self-drilling screws. Provides the necessary bearing surface and flush fit in wood and softer materials. The head/shank fillet contoured to strengthen the underhead area.
	Oval	A countersunk head with a rounded top surface and a cone-shaped bearing surface of approximately 82°.	Preferred over a flat head in conical applications, or when a more decorative finished look is desired. The countersunk surface nests into mating countersunk application sites.
	Oval Undercut	Similar to an 82° oval head except that the head is undercut to 70% of its normal side height.	Standard for short lengths because it allows greater length of threads.
	Round (U-drive)	Has a semi-elliptical top surface and a flat bearing surface.	Standard head style for drive screws. Provides efficient non-torque fastening for high-speed assembly.

SELF DRILLING FASTENER SELECTION GUIDE

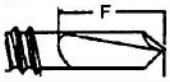
Head Style: Determine if the head style chosen will ensure stability during driving, and give the desired finished appearance and corrosion resistance.

Thread Diameter & Type: Make sure that the choice of threads will provide good connection strength. Use "Recommended Material Thickness" column in chart.

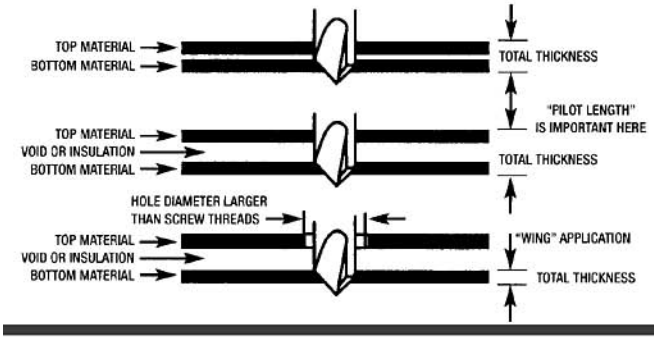
Pilot Length: Make sure that the drilling operation will be completed before the threading operation begins.

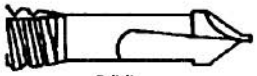


Flute Length: Use the "Point Length" column in the chart to determine if the point length is long enough.



Use the Right Tool: A 1900 to 2500 RPM screwgun rated at 4 amps or more, with a properly adjusted depth-locating nosepiece must be used for the best fastening results.



To use	Diameter	Recommended Material Thickness	Point Length
Type 2	No. 4	.035 to .080	.140
	No. 6	.035 to .090	.140
	No. 8	.035 to .100	.156
	No. 10	.035 to .110	.203
	No. 12	.035 to .187	.234
	1/4"	.035 to .175	.296
Type 3	No. 6	.090 to .110	.171
	No. 8	.100 to .140	.203
	No. 10	.110 to .175	.250
	No. 12	.110 to .210	.281
	1/4"	.110 to .220	.312
Type 4	No. 11	.175 to .312	.387
	No. 12	.175 to .250	.281
	1/4"	.175 to .250	.312
Special Type 3 or 4	No. 10	.175 to .315	.406
	No. 12	.210 to .375	.437
	1/4"	.250 to .375	.468
 Dril-it	No. 12	.250 to .500	.625
Type 5			

SELECTING THE CORRECT PHILLIPS POINT SIZE

Point Size	Wood Screws: Body Dia.	Wood Screws: Flat, Oval	Wood Screws: Round	Machine Screws: Flat, Oval, Binding	Machine Screws: Round, Fillister	Machine Screws: Truss, Brazier, Button	Sheet Metal Screws: Flat, Round, Oval, Stove, Binding
0	0	0	0	0	0	0	
1	3/16	2	2	2	2	2	2
	3	3	3	3	3	3	
	4	4	4	4	4	4	
2	1/4	5	5	5	5	5	5
	6	6	6	6	8	6	
	7	7	8	8	10	7	
	8	8	10	10	8		
	9	9	10				
	10						
3	5/16	10	12	12	12	12	12
	12	14	1/4	1/4	1/4	14	
	14	16	5/16				
	16						
4	3/8	18	18	5/16	3/8	5/16	
	20	20	3/8	7/16	3/8		
	24	24	7/16	1/2	7/16		
	1/2	1/2					

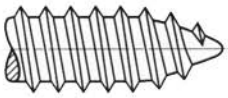
Phillips Insert

IMPORTANT The table above will enable you to determine the Phillips point size required for any Phillips screws or bolts. The No. 2 and No. 3 point sizes cover the range of Phillips screws most commonly used. The Apex Phillips bits on the following pages are available in point sizes to drive any Phillips screw.

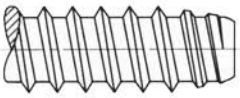
SELF-TAPPING SCREW HOLE SIZE DATA

TYPES A, AB, B, AND 25

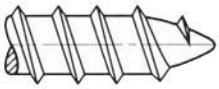
AB



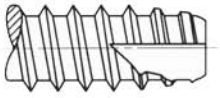
B



A



25



Suggested Test Plate Thicknesses & Hole Sizes for Types AB - B - 25					
Nominal Screw Size & No. of Threads per Inch	Thickness			Hole Size	
	Gage	Max	Min	Drill Size	Hole Diam.
2-32	18	.0500	.0460	48	.0760
3-28	18	.0500	.0460	46	.0810
4-24	18	.0500	.0460	44	.0860
5-20	18	.0500	.0460	36	.1065
6-20	14	.0770	.0730	32	.1160
7-19	14	.0770	.0730	30	.1285
8-18	14	.1270	.1230	29	.1360
10-16	1/8	.1270	.1230	21	.1590
12-14	1/8	.1270	.1230	3/16	.1875
1/4-14	3/16	.1905	.1845	5.5 mm	.2165
5/16-12	3/16	.1905	.1845	I	.2720
3/8-12	3/16	.1905	.1845	21/64	.3281

Suggested Hole Sizes for Type A		
Nominal Screw Size	Closest Drill Size to Mean Hole Diameter	
	Drill Size	Hole Diam.
6-18	#32	0.1160
7-16	#30	0.1285
8-15	#29	0.1360
10-12	#21	0.1590
12-11	3/16	0.1875
14-10	5.5mm	0.2165
20-9	L	0.2900
24-9	11/32	0.3438

Notes Regarding Hole Preparation:

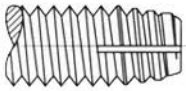
- Preformed holes can be drilled, cored, punched, pierced, or extruded. If edge burrs can cause assembly difficulty, they should be removed. Wall ovality and/or taper can affect load carrying ability.

- "Minimum torsional strength" is the torque that free standing screws must accept without evidence of damage or failure.

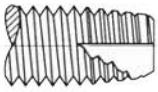
SELF-TAPPING SCREW HOLE SIZE DATA

TYPES 1, 23, F, U, AND HIGH-LOW

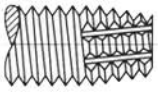
Type 1



Type 23

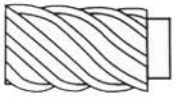


Type F



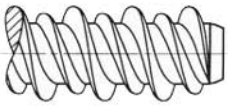
Suggested Test Plate Thicknesses & Hole Sizes for Types 1, 23 & F Thread Cutting Screws					
Nominal Screw Size & Thread Pitch	Thickness			Hole Size	
	Gage	Max	Min	Drill Size	Hole Diam.
2-56	18	.0800	.0760	49	0.0730
4-40	18	.1110	.1070	41	0.0960
5-40	18	.1110	.1070	37	0.1010
6-32	14	.1425	.1385	31	0.1200
8-32	14	.1905	.1845	26	0.1470
10-24	1/8	.1905	.1845	17	0.1730
10-32	1/8	.1905	.1845	16	0.1770
12-24	1/8	.1905	.1845	8	0.1990
1/4-20	3/16	.2530	.2470	1	0.2280
5/16-18	3/16	.3155	.3095	L	0.2900
3/8-16	3/16	.3780	.3720	T	0.3580

Type U
Drive Screw



Recommended Hole Sizes--Type-U Drive Screws		
Screw Size	Drill Size No.	Hole Diameter
00	55	.052
0	51	.067
2	44	.086
4	37	.104
6	31	.120
7	29	.136
8	27	.144
10	20	.161
12	11	.191
14	2	.221

High-
Low



Suggested Hole Sizes -- High-Low Screws		
Nominal Screw Size & Number of Threads per Inch	Pilot Hole Diameter Flexural Modulus of Plastic	
	Up to 200,000 P.S.I.	200,000-400,000 P.S.I.
2-32	.0670	.0700
4-24	.0810	.0860
5-20	.0935	.0995
6-19	.1015	.1100
8-18	.1200	.1285
10-16	.1360	.1440
12-16	.1570	.1660
1/4-15	.1890	.2010

FASTENER AND METALLURGICAL TERMINOLOGY

AISI: American Iron and Steel Institute

ALLOY STEELS: Steels with carbon from 0.1% to 1.1% and containing alloying elements such as nickel, chromium, vanadium, and molybdenum. The total of all such alloying elements in these types of steels is usually less than 5%.

ANNEALED: A heat treatment of an alloy above its critical or recrystallization temperature, usually followed by furnace cooling. The treatment results in low hardness, high ductility, and usually improves service life.

ANSI: American National Standards Institute

ASME: American Society of Mechanical Engineers

ASTM: American Society for Testing Materials

AUSTENTIZING: Heating above a material's critical temperature and quenching in a liquid medium to obtain a relatively uniform hardness throughout the part.

BEND: Force that tends to change the center line from anything other than a straight line.

BRINELL HARDNESS: A test for determining the hardness of a material by forcing a hard steel or carbide ball of specified diameter into it under a specified load. The result is expressed as the Brinell hardness number, which is the value obtained by dividing the applied load in kilograms by the surface area of the resulting impression in square millimeters.

CARBIDES: Usually refers to the general class of pressed and sintered tungsten carbide cutting tools which contain tungsten carbide plus smaller amounts of titanium and tantalum carbides along with cobalt which acts as a binder. It is also used to describe hard compounds in steel and cast irons.

CARBON STEELS: Steels with carbon plus small amounts of manganese silicon, sulfur, phosphorus, or other elements.

CASE HARDENING: A heat treatment operation in which carbon and/or nitrogen are absorbed by the outer layer of steel, producing a "case" or surface which has a substantially higher hardness than the "core" or interior.

CARBURIZED: A condition attained by using carburizing heat treatments to increase the carbon content at the surface of steels. This is done by placing the parts in contact with carbonaceous solids, liquids, or gases at approximately 1600˚ F. to 1700˚ F. The depth of penetration and amount of carbon pickup are a function of the time, temperature, and carburizing medium. Hardening treatments of carburized surfaces develop hardnesses of up to 65R.

CAST: A state of the alloy after solidification of the molten alloy.

CAST STEELS: Steels which are cast to shape and used without having been hot-rolled or forged, but which are usually heat-treated to produce appropriate material properties.

COLD DRAWN: A condition produced by reducing hot-rolled rod to size by pulling the rod through a die of the desired diameter. This is frequently done at room temperature, but in any event, must be carried out below the recrystallization temperature of the material. This process often improves machinability by providing better surface finish and chip control.

COLD ROLLED: A condition developed by reducing hot-rolled flat stock by passing it between rolls to the desired thickness. Temperature limitations are the same as for cold drawing.

CORROSION RESISTANT STEELS: A term often used to describe the cast stainless steels and to differentiate those cast steels used primarily for corrosion applications.

DIE CAST: Condition resulting from casting in metallic dies.

DOUBLE SHEAR STRENGTH: The maximum load required to fail the shank of a fastener when loaded in a transverse direction. The double shear strength is equal to approximately 60% of the ultimate tensile strength.

DRAWING: A term often used to mean the same as tempering, which is the preferred designation. Drawing should be reserved for hot and cold mechanical working operations.

ELONGATION: The increase in length, expressed as a percent, of a piece of steel that has been stretched to its breaking point. Elongation and Reduction of Area are means of determining the ductility of steel.

EXTRUDED: Wrought material produced by forcing an alloy or other material through a die.

FATIGUE: The result of varying stresses or workloads. The simplest form of fatigue occurs when metal is bent back and forth until it is broken. Such failures can occur considerably below the ultimate tensile strength and are normally the result of not preloading (tightening) the screw beyond its working load, thus permitting the screw to bend back and forth until it is broken.

FATIGUE STRENGTH: The ability of a fastener to withstand cyclic loading without failure.

FILLET: The small radius of the curve between the side of the shank and the washer face, under the head, of a cap screw. This fillet reduces the concentration of stresses where the head and the shank of the bolt meet. It reduces the possibility of “popping” the head off the bolt shank. Extreme care should be taken not to damage the fillet during installation.

FLAME HARDENED: Surfaces hardened by controlled torch heating followed by quenching with water or air.

FORGED: A cold or hot mechanical working process performed by presses or hammers to shape metals. Treatments such as annealing or normalization should generally be applied after forging to improve machinability and uniformity thereof.

HARDENED: Designates condition produced by various heat treatments such as quench hardening, age hardening, and precipitation hardening.

HEAT RESISTANT STEELS: Cast Steels which are highly alloyed and used for high temperature applications such as furnace conveyor parts, etc. . .

HEAT TREATED PRODUCT: Product that is austentized, quenched, and tempered (quenched and tempered).

The heat treatment consists of:

1. Austentizing: heating above the material's critical temperature and quenching in a liquid medium to obtain relatively uniform hardness throughout the part.
2. Tempering: re-heating the as-quenched part at a lower temperature to increase the toughness and ductility.

HIGH SPEED STEELS: Steels which contain tungsten, molybdenum, vanadium, cobalt carbon, and other elements.

HIGH TEMPERATURE ALLOYS: Generally alloys of nickel, cobalt, or iron which are used at temperatures in excess of 1200˚ F. in applications such as rockets, jet engine blades, and compressor and turbine discs, etc. . .

HOT ROLLED: A term used to describe alloys which are rolled at temperatures above the recrystallization temperature. Many alloys are hot-rolled, and machinability of such alloys may vary because of differences in cooling conditions from lot to lot.

IFI: Industrial Fasteners Institute

INDUCTION HARDENED: Surface or through-hardened using induction heating followed by quenching with water or air.

MAJOR DIAMETER: The distance across the crest or top of the threads on a bolt. This would be the same as the inside diameter of a tube that would slip snugly over the threads.

MALLEABLIZING: Process of annealing brittle white cast iron in such a way that the combined carbon is wholly or partly transformed to graphite or temper carbon nodules in a ferritic or pearlitic microstructure, thus providing a ductile and machinable material.

MARTENSITE: An acicular or needle-like microstructure that is formed in quenched steels. It is very hard and brittle in the as-quenched form and therefore, is usually tempered before being placed into service. The harder forms of tempered martensite have poorer machinability.

MINOR DIAMETER: The distance across the base or root of the threads of a bolt. If the threads were carefully removed on a lather, the remaining diameter would be the Minor Diameter.

NITRIDED: Surface hardened by absorption of nitrogen from a gaseous or salt bath medium.

NORMALIZED: Heat treatment of iron-base alloys above the critical temperature, followed by cooling in still air. This is often done to refine or homogenize the grain structure of castings, forgings, and wrought steel products.

NITRIDING: A heat treating method in which nitrogen is diffused into the surface of iron-based alloys. This is done by heating the metal at a temperature of about 950˚ F. in contact with ammonia gas or other suitable nitrogenous materials. The surface, because of formation of nitrides, becomes much harder than the interior (case hardened). Depth of the nitrided surface is a function of the length of time of exposure and can vary from .0005" to .032" thick. Hardness is generally in the 65-70R range.

PITCH: The number of threads in one inch of the threaded length of a cap screw, expressed as threads per inch (TPI). The pitch of one thread is the distance that a nut would advance on a bolt when turned one full turn.

POINT: The chamfer on the thread end of a bolt that permits easier starting of the nut.

PROOF LOAD: The load, just under the yield strength, which a bolt can withstand without obtaining a permanent set or extension (permanent set .0005" increase in length of bolt). This is the maximum safe load that the bolt can support.

QUENCHED: Rapid cooling of alloys by immersion in liquids or gases after heating.

REDUCTION OF AREA: The loss of cross-sectional area, expressed as a percent, that occurs when steel has been stretched to its breaking point. In cap screws this stretching is sometimes referred to as “necking-out.”

ROCKWELL HARDNESS TEST: A method of determining the hardness of metal by measuring the depth of penetration that a point or penetrator makes into the metal after an accurately controlled blow has been struck on the penetrator. For heat-treated steel, a cone shaped diamond point is used and the Rockwell Hardness value is expressed as C-scale. For soft metals a 1/16" diameter steel ball is used as a penetrator and the hardness value is expressed as B-scale.

ROOT: The deepest point of the V-notch that forms the groove of a thread. A well-designed fastener should incorporate a radiused or rounded root.

SAE: Society of Automotive Engineers

SHEAR: Force exerted 90˚ to the center line or length of the bolt that tends to cut the bolt into two or more pieces.

SHEAR STRENGTH: The amount of force, usually expressed in PSI, required to shear the bolt into two pieces. This is referred to as single shear and usually has a value of about 65% of the tensile strength. Double shear, where shearing forces are applied at two points along the shank of the bolt, would cut the bolt into three pieces. Double shear strength is usually about 175% of the tensile strength.

STAINLESS STEELS: Steels which have good or excellent corrosion resistance. One of the most popular contains 18% chromium and 8% nickel. There are three broad classes of stainless steels, ferritic, austentic, and martensitic. These various classes are produced through the use of various alloying elements in differing quantities.

STRESS AREA: The cross-sectional area of metal that would be exposed if a piece of the threaded end of the bolt was cut off 90˚ to the center line. The threaded portion of a cap screw is not as strong as the full size shank because of the spiral notch that forms the threads. Since the threads provide a small amount of strength, the diameter that is used to compute the stress area is slightly greater than the minor diameter (root diameter) of the threaded section.

STRESS RELIEVED: The heat treatment used to relieve the internal stresses induced by forming or heat-treating operations. It consists of heating a part uniformly, followed by cooling slowly enough so as not to reintroduce stresses. To obtain low stress levels in steels and cast irons, temperatures as high as 1250˚ F. may be required.

STRUCTURAL STEELS: Steels covering a wide range of strengths and used for structural purposes. These steels are sometimes called high-strength steels or constructional steels.

TEMPERED: Reheating of hardened steels or hardened cast irons to reduce hardness and to lower internal stress.

WROUGHT: Condition of a material which has been worked mechanically as in forging, rolling, drawing, etc. . .

TENSILE STRENGTH (also call ULTIMATE TENSILE STRENGTH):
The load, usually expressed in pounds per square inch (PSI), required to cause failure in tension (stretch). The tensile strength, in pounds, of a given size bolt is obtained by multiplying the PSI tensile strength by the stress area. For example: a 3/4-10 cap screw contains .3340 sq. in. of stress area. Made from 120,000 PSI material would have a strength of 120,000 x .3340 or 40,080 lbs. of actual strength.

TENSION: Load that is applied in line with the center line of a bolt that stretches it. When a bolt is tightened by torquing, it develops a “cohesion” force on the assembly. The greater the tension, the greater the cohesion effect. When the cohesion force (tension or preload) is greater than the pushing apart force (workload) the bolt will not fatigue or fail since it cannot feel the effect of the workload.

THREAD LENGTH: The standard formula for determining the length of thread on a cap screw is twice the diameter of the cap screw plus 1/4" for cap screws up to and including 6" in length. For cap screws longer than 6", the thread length is twice the diameter of the cap screw plus 1/2". In shorter sizes, where the standard formula for thread length is longer than the length of the shank, the cap screws will be threaded to the head.

TOOL STEELS: Steels used to make cutting tools and dies. Many of these steels have considerable quantities of alloying elements such as chromium, carbon, tungsten, molybdenum, and other elements. Tool steels in the trade are classified, for the most part, by their applications, such as high speed, shock-resisting mold, and special-purpose steels.

TORQUE: The amount of twisting force required to apply tension to fastener assembly. It is normally expressed in inch pounds (in. lbs.) or foot pounds (ft. lbs.) of torque. Torquing then is the act of tightening a fastener assembly to some specific value.

TORSION: Radial force that is applied to the head of a bolt or to the threads of a bolt when a nut is being tightened that applies a twisting force to the bolt.

UNC: Unified National Coarse Thread series previously known as USS.

UNF: Unified National Fine Thread series previously known as SAE.

WEDGE TENSILE STRENGTH: The maximum load in pounds that a cap screw will carry before breaking when it is pulled with a 10˚ angle wedge placed under the head of the cap screw. This test determines the relative ductility of the cap screw when subjected to bending forces.

YIELD POINT: The point at which a screw product begins to stretch without increasing the load on the assembly (may reach 90% of tensile strength in alloy fasteners).

YIELD STRENGTH: The load, usually expressed in PSI, that is necessary to stretch the cap screw to the point where, after the load is removed, the cap screw will not return to its previous length. When steel is stretched two-tenths of one percent (.2%) of its original length, permanent set will occur.