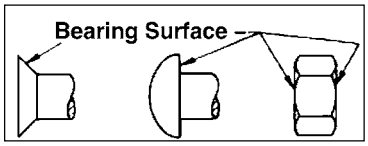
ALLOWANCE
The prescribed difference between the design size (maximum material) and the basic size.

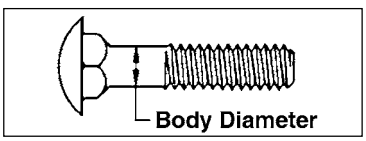
BASIC PROFILE
The cyclical outline, in an axial plane, of the permanently established boundary between the provinces of the external and internal threads. All deviations are with respect to this boundary.

BASIC SIZE
That size from which the limits of size are derived by the application of allowances and tolerances.

BEARING SURFACE
The bearing surface is the supporting or locating surface of a fastener with respect to the part which it fastens (mates). The loading of a fastener is usually through the bearing surface.

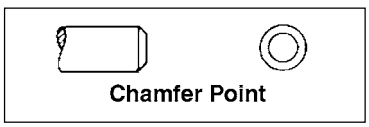


BODY DIAMETER
The body diameter is the diameter of the body of a threaded fastener.



CHAMFER
The conical surface at the starting end of a thread.

CHAMFER POINT
A chamfer point is a truncated cone point, the end of which is approximately flat and perpendicular to the fastener axis. These points on threaded fasteners generally have point included angles of 45 to 90 degrees and a point diameter equal to or slightly less than the minor diameter of the thread. This point is intended to facilitate entry of fasteners into holes at assembly.



CLASS OF THREAD
An alphanumerical designation to indicate the standard grade of tolerance and allowance specified for a thread.

Class 1A and 1B
Classes 1A and 1B are very loosely toleranced, therefore, this class produces the loosest fit; that is, the greatest amount of play in assembly. An allowance is applied to the external thread in class 1A and 1B. This class is ideally suited where quick and easy assembly is of prime design concern.
Class 1A and 1B is standard for only coarse and fine threads with sizes of 1/4 inch and larger. Very few fasteners produced in Canada and the United States have this class of fit.

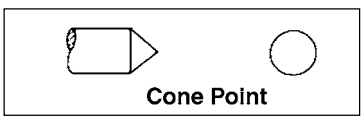
Class 2A and 2B
Class 2A and 2B is the most common thread class specified for inch series fasteners. Class 2A for external threads has an allowance while class 2B for internal threads does not. Class 2A and 2B threads offer excellent value of fit when considering manufacturing conveniences and economy, against fastener performance. This class offers a good grade of commercial products such as machine screws, bolts, nuts, and studs for most interchangeable equipment parts and structural applications. It is estimated that over 90 percent of inch fastener series in Canada and the United States have class 2A and 2B threads.

Class 3A and 3B
Class 3A and 3B threads have no specific allowance and are manufactured to restrictive tolerances. These classes of threads are intended for exceptionally high-grade commercial products such as socket cap screws, set screws, aerospace bolts and nuts, and connecting rod bolts where close or snug fit for precision is essential, as well as in applications where safety is a critical design feature.

CLEARANCE FIT
The maximum material condition clearance between mating assembled parts.

COLD WORKING
Cold working is the plastic deformation of metals at temperatures below that which will cause recrystallization. This cold working is accompanied by an increase in strength and hardness, called work hardening, and a decrease in ductility. The cold working effects of forming bolt and screw heads, of extruding bolt shanks, and of roll threading increase strength values, often considerably.

CONE POINT
A cone point is a sharp conical point designed to perform perforating or aligning functions at assembly.



COUNTERSINK
Flare or bevel at the hole end.

CUT THREAD
Threads are cut or chased so that the unthreaded portion of shank is equal to major diameter of the thread.

ELEMENT
Elements of a thread are flank angle, root, crest, pitch, lead angle, surface finish, major, minor, and pitch diameters.

EXTERNAL THREAD
A screw thread formed on the outside of a cylindrical surface.

FASTENER
A fastener is a mechanical device for holding two or more bodies in definite positions with respect to each other.

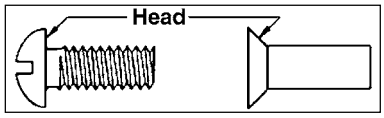
FULL OR NOMINAL DIAMETER BODY
A full or nominal diameter body is a body the diameter of which is generally within the dimensional limits of the major diameter of the thread. Sometimes referred to as 'full size body'.

GIMLET POINT
A gimlet point is a threaded cone point usually having a point angle of 45 to 50 degrees. It is used on thread forming screws such as Type 'AB' tapping screws, wood screws, lag screws, etc.

GRADES OF FASTENERS

In the SAE system, grades are designated by numbers from 1 through 8. These numbers have no quantitative relationship to strength properties, except that increasing numbers represent increasing tensile strengths. Decimals after whole numbers indicate the same basic properties, with variations in either material or processing treatment. The ASTM grades are designated by their document number. Some of the ASTM standards describe two or more types or grades with the difference being either a variation of material – for example, ASTM A325 Types 1, 2 and 3 – or modified properties of the same material – ASTM A307 Grades A and B.

HEAD



The head of a fastener is the enlarged shape preformed on one end of a headed fastener to provide a bearing surface.

HIGH STRENGTH FASTENER

A high strength fastener is a fastener having high tensile and shear strengths attained through combinations of materials, work-hardening and heat treatment.

HEAT TREATMENT

The strength and ductility of metals can be significantly altered by various types of heating operations. Heat treatment refers to any of a number of operations involving the heating of the parts in appropriate furnaces, gas fired or electric, often with controlled atmosphere, and the subsequent cooling at controlled rates. In the manufacture of fasteners the strength and ductility of the parts can in this way be adjusted, within limits, to fit the particular application.

INCOMPLETE THREAD

Threads having crests or roots not fully formed. Incomplete threads occur at the end of pointed externally threaded products, at countersinks in the faces of threaded holes or nuts, and at thread runouts where the threaded section blends into the unthreaded shank.

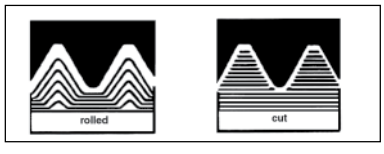
THREAD

A thread is a portion of a screw thread encompassed by one pitch. On a single-start thread it is equal to one turn.

MAJOR CYLINDER

An imaginary cylinder that would bound the crests of an external straight thread or the roots of an internal straight thread.

METHODS OF MANUFACTURE



Threads are either rolled or cut – the former increases the major diameter of the thread over the diameter of the unthreaded shank; the latter, the unthreaded portion of the shank is equal to the major diameter of the thread. Cold rolled threading produces a stronger part and is less apt to shear or rupture under stress than cut threading. The metal flow indicating the strength is shown by the above diagram.

MAJOR DIAMETER

On an internal thread, the diameter at the root and on an external thread the major diameter is the diameter at the thread crest.

MINOR DIAMETER

On an internal thread, the diameter at the crests and on an external thread, the diameter at the root.

NOMINAL SIZE

The designation which is used for the purpose of general identification. The basic major diameter of a threaded fastener is often referred to as 'nominal size'.

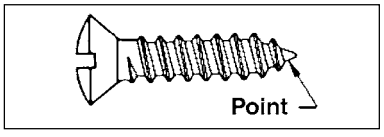
PHYSICAL PROPERTIES

Physical properties are the properties defining the basic characteristics of the material or fastener.

PITCH

The pitch of a thread having uniform spacing is the distance, measured parallel to its axis, between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis. Pitch is equal to the lead divided by the number of thread starts.

POINT



The point of a fastener is the configuration of the end of the shank of a headed fastener or of each end of a headless fastener.

PROOF LOAD

Proof load represents the maximum useable load limit of the fastener for many design-service applications. Proof load is commonly defined as the tension applied load which the fastener must support without evidence of any deformation. Often, proof load and yield strength are interpreted as being the same.

Note: *Proof load is a force measurement. The units are pounds or newton. Yield strength is a stress measurement. The units are PSI or MPa. The stress at the proof load is 90-93% of the yield strength.*

REFERENCE DIMENSION

A dimension usually without tolerance, used for information purposes only. It does not govern production or inspection operations. A reference dimension is derived from other values shown on the drawing or on related drawings.

RIGHT-HAND THREAD

A thread is right-hand if, when viewed end-on, it winds in a clockwise and receding direction. A thread is considered to be right-hand unless specifically indicated.

ROLLED THREAD

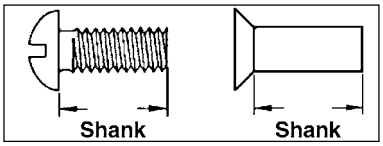
Threads are cold formed by squeezing the blank between reciprocating serrated dies. This acts to increase the major diameter of the thread over and above the diameter of unthreaded shank (if any).

ROOT

That surface of the thread that joins the flanks of adjacent thread forms and is immediately adjacent to the cylinder from which the thread projects.

SHANK

The shank is that portion of a headed fastener which lies between the head and the extreme point.

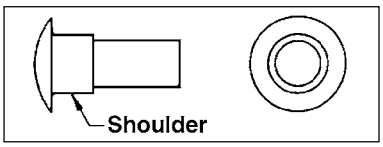


SHEAR STRENGTH

Shear is transverse rupture. It is caused by a pushing or pulling force at 90° from the axis of a part. Thus, a rivet used as a pulley axle will shear if the load on the pulley exceeds the shear value of the rivet. Shear strengths generally are 60% of the specified minimum tensile strength.

SHOULDER

A shoulder is an enlarged portion of the body of a threaded fastener or shank of an unthreaded fastener.



TENSILE STRENGTH

Tensile strength, or ultimate strength, is that property of a material which determines how much load it can withstand without breaking. It is calculated by determining the tensile stress corresponding to the maximum load observed in a tension test. Cold working raises the tensile strength of most metals and alloys. Heat treatment can often be used to increase or reduce the tensile strength.

THREADED FASTENER

A threaded fastener is a fastener – a portion of which has some form of screw thread.

THREAD PITCH

The distance measured parallel to the thread axis between corresponding points on adjacent threads. Pitch is equal to the lead divided by the number of thread starts. Unified threads are designated in threads per inch and their thread pitch is reciprocal of the number of threads per inch (tpi). Metric threads are designated by their actual pitch.

THREAD SERIES

Thread series are groups of diameter-pitch combinations distinguished from each other by the number of threads per inch applied to a series of specific diameters. There are two general series classifications: standard and special.

Coarse Thread Series Applications

The coarse thread series (UNC/UNRC) is generally used for the bulk production of screws, bolts, and nuts. It is commonly used in relatively low strength materials such as cast iron, aluminum, magnesium, brass, bronze, and plastic because the coarse series threads provide more resistance to internal thread stripping than the fine or extra-fine series. Coarse series threads are advantageous where rapid assembly or disassembly is required, or if corrosion or damage from nicks due to handling or use is likely.

Fine Thread Series Applications.

The fine thread series (UNF/UNRF) is commonly used for bolts and nuts in high strength applications. This series has less thread depth and a larger minor diameter than coarse series threads. Consequently, thinner walls are permitted for internal threads and more strength is available to external threads than for coarse series threads of the same nominal size.

8-Thread Series.

The 8-thread series (8UN) is a uniform-pitch series for large diameters or as a compromise between coarse and fine thread series. Although originally intended for high-pressure-joint bolts and nuts, it is now widely used as a substitute for the coarse thread series for diameters larger than 1 inch.

12-Thread Series

The 12-thread series (12UN) is a uniform-pitch series for large diameters requiring threads of medium-fine pitch. Although originally intended for boiler practice, it is now used as a continuation of the fine thread series for diameters larger than 1-1/2 inch.

THREADS PER INCH

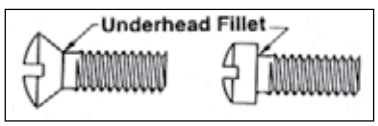
The number of thread pitches per inch. It is the reciprocal of the axial pitch value in inches.

TOLERANCE

The total amount of variation permitted for the size of a dimension. It is the difference between the maximum limit of size and the minimum limit of size.

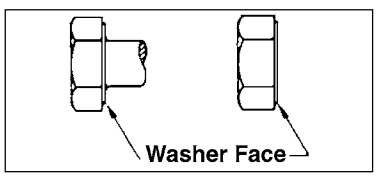
UNDERHEAD FILLET

An underhead fillet is the fillet at the junction of the head and shank of a headed fastener.



WASHER FACE

A washer face is a circular boss on the bearing surface of a bolt or nut.



YIELD STRENGTH

Yield strength is defined as the tension applied stress at which the fastener experiences a specified amount of permanent deformation. The fastener material simply has been stressed beyond its elastic limit and has entered its plastic zone. Yield strengths of machined test specimens are easily determined because of their uniform cross-sectional area throughout the stressed length. It has been noted that the yield strength characteristics of test specimens do not always parallel those of the full size fastener from which they are taken. This is because the beneficial effects of cold working may be completely lost when the test piece is machined from the parent product. It is difficult to test full size fasteners for yield strength because of the different strain rates in areas such as: the fully threaded portion; the thread runout; and the unthreaded shank which comprises the stressed length. Because of this, the 'proof load' system was introduced as an approved technique for testing a fastener's deformation characteristics.

What is a screw? What is a bolt?

One of the questions most frequently asked about fasteners during the past decades has been: *"What's the difference between a screw and bolt?"* A seemingly innocent question, it is nevertheless one that until 1965 did not lend itself to a positive clear-cut answer. Every "expert" had an answer, usually different from others, and no matter how logical or persuasive it was, it seemed that the criteria employed to differentiate screws from bolts permitted far more exceptions to the rule than compliance with it.

While many engineers looked upon this question as an interesting exercising in semantics, it created for the fastener manufacturer and his customer an increasingly troublesome variety of problems. By the early 60's, it became quite clear that the need to establish a pattern of consistency in the nomenclature of threaded fasteners could no longer be ignored.

It just so happened that Subcommittee 2 of Standards Committee B18 of the American Society of Mechanical Engineers was studying the possibility of simplifying the standards for square and hexagon bolts, screws and nuts. Recognizing that conflicts in product terminology existed just within the few products under its own technical responsibility, the Subcommittee volunteered to prepare definitions, together with an identification procedure, which would permit the positive classification of any externally headed and threaded fastener as a bolt or a screw.

In accepting the assignment, the Subcommittee was aware that certain basic factors of fastener life were inviolable. They realized that most of the product names being currently used had long histories of acceptance commercially, and that massive changes, regardless upon what logic they might be based, would not be welcomed. They also appreciated that any new definition for a bolt and a screw should reflect to the maximum degree possible generic understandings of what these products really are. Further, they knew that any procedure designed to differentiate screws from bolts must be simple, quickly performed, primarily visual, and independent of an intimate knowledge of product design and manufacturing methods. Moreover, the conclusion yielded by the investigation should be reproducible.

Finding the Solution

The first step, of course, was a study of encyclopedia and dictionary definitions. Previous efforts within this country to identify such products were reviewed, and also the basis of differentiation recognized in other countries of the world were considered. The one common thread that seemed to wind its way through the many principles examined was that **screws are used in tapped holes; bolts are used with nuts.**

This one generally accepted generic difference set the stage of solution of the riddle. By introducing a small, yet novel, twist in this concept, suddenly, for the first time, black and white definitions materialized, and the gray area of overlap disappeared.

Once the Subcommittee had accepted this new concept, it was a logical continuation to analyze the principal engineering features of a threaded fastener which give it the capability of being used in a tapped hole. As soon as this work was completed, a specification was drafted, presenting the new definitions and outlining a step-by-step procedure for determining whether a headed and threaded product should be properly identified as a bolt or as a screw. The specification was circulated and following further refinement, was given final endorsement by the Subcommittee and approval by ASME Standards Committee B18. "Specifications for Identification of Bolts and Screws" was published for the first time as an Appendix of the newly issued American National Standard "Square and Hex Bolts and Screws", ANSI B18.2.1-1965.

The new subtlety involved simply modifying the intent of the criterion, "screws are used in tapped holes," to be: "screws have the capability of being used in tapped hole." This change led to an extremely simple and yet surprisingly pure set of criteria for distinguishing a bolt from a screw. **The basic premise is that if a fastener is so designed as to permit it to be properly assembled into a tapped hole, it is a screw.** If, on the other hand, the design of the fastener indicates that it is not suited for use in a tapped hole and should be assembled with a nut, it is a bolt. Thus, the difference is based on the design capability of the fastener, and not on actual service application. This new approach effectively removes the doubt from those fasteners which are used sometimes in tapped holes and sometimes with nuts.

How It Works

To see how the system works, consider some of the more familiar types of threaded fasteners and how they fit the definitions and identification procedure. Many are immediately obvious by the application of the primary criteria of ASME B18.12.1 Appendix B. Wood screws, lag screws, and most types of tapping screws do not have thread forms which can accommodate standard nuts; therefore, these products are automatically classified as screws. Plow, carriage, track, elevator, and step bolts have head configurations which prevent their being tightened by turning the head during assembly. Consequently, this makes their use in a tapped hole impractical, and automatically classifies these products as bolt.

This screening out still leaves a number of externally threaded fasteners, such as square bolts, hex cap screws, hex bolts, machine screws, and socket head cap screws, which have an indicated dual ability to be turned into a tapped hole, or to be assembled with a nut. However, in accordance with the ASME B18.2.1 Appendix, if the majority of the design characteristics assist the proper use in a tapped or other preformed hole, the product is a screw regardless of its installed service application. The supplementary criteria are then applied to determine if its primary characteristics contribute to its function as a screw. These supplementary criteria include the following elements:

— Bearing Surface
— Head Angularity
— Body Control
— Shank Straightness
— Thread Concentricity
— Point
— Length Tolerance

Applying these criteria, the majority being present would define the product in question as a screw.

The criteria established are nondimensional and apply equally to either inch or metric fasteners. The complete information may be found in Appendix B or ASME B18.2.1: Specifications for Identification of Bolts and Screws, page N-52.

Interestingly, of all of the many standard types of fasteners now covered by American National Standards, only in one or two isolated instances was a change in nomenclature from screw to bolt, or bolt to screw, necessary to provide a complete pattern of consistency. These changes were completed in the late 1960's. Importantly, as new products are designed and introduced into American National Standards, they can be assigned correct nomenclature at the outset.

SQUARE AND HEX BOLTS AND SCREWS (INCH SERIES)

Appendix B
Specifications for Identification of Bolts and Screws

(This Appendix is not part of ASME B18.2.1-1996 and is included for information only.)

B1. Scope

This specification establishes a recommended procedure for determining the identity of an externally threaded fastener as a bolt or as a screw.

B2. Definitions

B2.1 Bolt

A bolt is an externally threaded fastener designed for insertion through holes in assembled parts, and is normally intended to be tightened or released by torquing a nut.

B2.2 Screw

A screw is an externally threaded fastener capable of being inserted into holes in assembled parts, of mating with a preformed internal thread or forming its own thread, and of being tightened or released by torquing the head.

B3. Explanatory Data

A bolt is designed for assembly with a nut. A screw has features in its design which make it capable of being used in a tapped or other preformed hole in the work. Because of basic design, it is possible to use certain types of screws in combination with a nut. Any externally threaded fastener which has a majority of the design characteristics which assist its proper use in a tapped or other preformed hole is a screw, regardless of how it is used in its service application.

B4. Procedure

To identify an externally threaded fastener as a bolt or as a screw, two sets of criteria — Primary and Supplementary — shall be applied. The Primary Critera (Paras. B5.1 through B5.4) shall be applied first. Any faster which satisfies one of the Primary Criteria shall be identified accordingly, and no further examination need be made. The Supplementary Criteria (Paras. B6.1 through B6.9, and not listed in order of importance or priority of application) shall be applied to a fastener which does not satisfy complete any one of the Primary Criteria. The Supplementary Criteria detail the principal features in the design of an externally threaded fastener which contribute to its proper use as a screw. A fastener having a majority of these characteristics shall be identified as a screw.

B5. Primary Criteria

B5.1 An externally threaded fastener which, because of head design or other feature, is prevented from being turned during assembly, and which can be tightened or released only by torquing a nut, is a bolt. (Example: round head bolts, track bolts, plow bolts.)

B5.2 An externally threaded fastener which has a thread form which prohibits assembly with a nut having a straight thread of multiple pitch length, is a screw. (Example: wood screws, tapping screws.)

B5.3 An externally threaded fastener, which must be assembled with a nut to perform its intended service, is a bolt. (Example: heavy hex structural bolt.)

B5.4 An externally threaded fastener, which must be torqued by its head into a tapped or other preformed hole to perform its intended service is a screw. (Example: square head set screw.)

TECHNICAL

BOLT THREADS AND THREAD LENGTHS

THREADS – MACHINE SCREW AND BOLT SIZES

Number of Threads per Inch – Unified Standard

Coarse Thread Series, Class 2A Fit, recommended for general use.

Diameter of Bolt (in)	UNC Coarse Thread Series	UNF Fine Thread Series	Diameter of Bolt (in)	UNC Coarse Thread Series	UNF Fine Thread Series
No. 0	–	80	9/16	12	18
No. 1	64	72	5/8	11	18
No. 2	56	64	3/4	10	16
No. 3	48	56	7/8	9	14
No. 4	40	48	1	8	14 (12)*
No. 5	40	44	1-1/8	7	12
No. 6	32	40	1-1/4	7	12
No. 8	32	36	1-3/8	6	12
No. 10	24	32	1-1/2	6	12
No. 12	24	28	1-3/4	5	–
1/4	20	28	2	4-1/2	–
5/16	18	24	2-1/4	4-1/2	–
3/8	16	24	2-1/2	4	–
7/16	14	20	2-3/4	4	–
1/2	13	20	3	4	–

***Indicates number of threads per inch for Unified Fine (1"-12 thread is U.N.F. standard. However 1"-14 thread is popular demand and generally stocked in place of 1"-12.)**

Diameter in Inches	Stud UN Threads per Inch	Bolts UNC Threads per Inch	Bolts UNF Threads per Inch	Bolts UNS Threads per Inch
1/4	20	20	28	
5/16	18	18	24	
3/8	16	16	24	
7/16	14	14	20	
1/2	13	13	20	
9/16	12	12	18	
5/8	11	11	18	
3/4	10	10	16	
7/8	9	9	14	
1	8	8	12	14
1-1/8	8	7	12	
1-1/4	8	7	12	
1-3/8	8	6	12	
1-1/2	8	6	12	
1-5/8	8			
1-3/4	8	5		
1-78	8			
2	8	4-1/2		
2-1/4	8	4-1/2		
2-1/2	8	4		
2-3/4	8	4		
3	8	4		
3-1/4	8	4		
3-1/2	8	4		
3-3/4	8	4		
4	8	4		

THREAD LENGTHS

All Standard Except Lag Screws

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, thread will extend as close to head or shoulder as practical. In actual production, thread lengths may be longer than the formula thread lengths.

Diameter of Bolt (in)	6" and Shorter (in)	Longer Than 6" (in)	Diameter of Bolt (in)	6" and 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

QUOTE

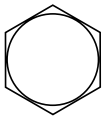
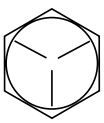
"A prudent person profits from personal experience, a wise one from the experience of others."

JOSEPH COLLINS

IDENTIFICATION MARKINGS

It is a mandatory requirement in SAE and ASTM standards that fasteners of the medium carbon and alloy steel strength grades be marked for grade identification. The only exceptions are slotted and recessed head screws and very small size fasteners – generally, smaller than 1/4" where head size doesn't permit marking. Additionally, and of major importance, these same standards require **all** carbon steel externally threaded fasteners be further marked to identify the manufacturer. Identification markings are the purchaser's best guarantee of product quality. By indicating the strength properties the fastener should have and the producing company, markings provide traceability and accountability. With the ever present threat of a liability action in case of a service failure, traceability is ample incentive to any reputable producer to exercise all of the care necessary to manufacture fully conforming parts. Carbon steel bolts and screws without markings should be viewed with a high degree of suspicion. The only prudent assumption is that the fastener has the lowest strength properties permitted in any steel grade, and if not manufacturer marked, then it was produced either by a non-North American company or by one using questionable practices.

Grade Identification Markings for Popular Grades of Carbon Steel Externally Threaded Fasteners

Grade Identification Marking	Specification	Nominal Size (in)	Proof Load Stress ksi	Tensile Strength Min ksi	Hardness Rockwell Min	Hardness Rockwell Max	See Note
Material: Low or Medium Carbon Steel							
 NO MARK	SAE J429 – Grade 1	1/4 thru 1-1/2	33	60	B70	B100	
	SAE J429 – Grade 2	1/4 thru 3/4	55	74	B80	B100	
		over 3/4 thru 1-1/2	33	60	B70	B100	
	ASTM A307 – Grade A	1/4 thru 4	–	60	B69	B100	
	ASTM A307 – Grade B	1/4 thru 4	–	60 min	B69	B95	
			–	100 max			
Material: Medium Carbon Steel, Quenched and Tempered							
	SAE J429 – Grade 5	1/4 thru 1	85	120	C25	C34	
	ASTM A449 – Type 1	over 1 thru 1-1/2	74	105	C19	C30	
	ASTM A449 – Type 1	over 1-1/2 thru 3	55	90	183	235	3
Material: Medium Carbon Steel, Quenched and Tempered							
	ASTM A325 – Type 1	1/2 thru 1	85	120	C24	C35	5
		over 1 to 1-1/2	74	105	C19	C31	
Material: Low Carbon Martensite Steel, Quenched and Tempered							
	ASTM A325 – Type 2	1/2 thru 1	85	120	C24	C35	
		over 1 to 1-1/2	74	105	C19	C31	
Material: Atmospheric Corrosion Resistant Steel, Quenched and Tempered							
	ASTM A325 – Type 3	1/2 thru 1	85	120	C24	C35	6
		over 1 to 1-1/2	74	105	C19	C31	
Material: Medium Carbon Alloy Steel, Quenched and Tempered							
	SAE J429 – Grade 8	1/4 thru 1-1/2	120	150	C33	C39	
	ASTM A354 – Grade BD	1/4 thru 2-1/2	120	150	C33	C39	7
		over 2-1/2 thru 4	105	140	C31	C39	7
Material: Medium Carbon Alloy Steel, Quenched and Tempered							
	ASTM A490 – Type 1	1/2 thru 1-1/2	120	150 min 170 max	C33	C38	

NOTES:

1. In addition to the indicated grade marking, all grades included in this Table must be marked for manufacturer identification.
2. While hex heads are shown, grade markings apply equally to products with other head configurations.
3. Hardnesses are Brinell Hardness Numbers.
4. Grade 5.1 is a popular grade for sems.
5. A325 Type 1 bolts may also be marked with 3 radial lines 120° apart in addition to the A325 marking.
6. The bolt manufacturer, at his option, may add other markings to indicate the use of atmospheric corrosion resistant steel.
7. A354 Grade BD products, in sizes 1-1/2" and smaller, are identified as shown and, at the manufacturer's option, may have the letters BD added. Larger sizes are marked only BD.

TECHNICAL

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

GRADE 5 A325

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

GRADE 8

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

Carbon Alloy Steel, Quenched and Tempered

TIGHTENING TORQUE GUIDE

SAE Grade 2—Coarse Thread

SIZE	CLAMP LOAD	PLAIN	PLATED
¼-20 (.250)	1,313	66 in. lbs	49 in. lbs.
5/16-18 (.3125)	2,175	11 ft. lbs	8 ft. lbs.
3/8-16 (.375)	3,188	20 ft. lbs	15 ft.lbs.
7/16-14 (.4375)	4,388	32 ft.lbs.	24 ft. lbs.
½-13 (.500)	5,850	49 ft.lbs.	37 ft. lbs.
5/8-11 (.625)	9,300	97 ft.lbs.	73 ft. lbs.
¾-10 (.750)	11,400	166 ft.lbs.	125 ft. lbs.
7/8-9 (.875)	13,800	173 ft.lbs.	129 ft. lbs.
1-8 (1.000)	15,000	250 ft.lbs.	188 ft. lbs.
1⅛-7 (1.125)	18,900	354 ft.lbs.	286 ft. lbs.
1¼-7 (1.250)	24,000	500 ft.lbs.	375 ft. lbs.
1⅜-6 (1.375)	28,575	655 ft.lbs.	491 ft. lbs.
1½-6 (1.500)	34,800	870 ft.lbs.	952 ft. lbs.

TIGHTENING TORQUE GUIDE

SAE Grade 5—Coarse Thread

SIZE	CLAMP LOAD	PLAIN	PLATED
¼-20 (.250)	2,025	8 ft. lbs	76 in. lbs.
5/16-18 (.3125)	3,338	17 ft. lbs	13 ft. lbs.
3/8-16 (.375)	4,950	31 ft. lbs	23 ft.lbs.
7/16-14 (.4375)	6,788	50 ft.lbs.	37 ft. lbs.
½-13 (.500)	9,075	76 ft.lbs.	57 ft. lbs.
9/16-12 (.5625)	11,625	109 ft.lbs.	82 ft. lbs.
5/8-11 (.625)	14,400	150 ft.lbs.	112 ft. lbs.
¾-10 (.750)	21,300	266 ft.lbs.	200 ft. lbs.
7/8-9 (.875)	29,475	430 ft.lbs.	322 ft. lbs.
1-8 (1.000)	38,625	644 ft.lbs.	483 ft. lbs.
1⅛-7 (1.125)	42,375	794 ft.lbs.	596 ft. lbs.
1¼-7 (1.250)	53,775	1120 ft.lbs.	840 ft. lbs.
1⅜-6 (1.375)	64,125	1470 ft.lbs.	1102 ft. lbs.
1½-6 (1.500)	78,000	1950 ft.lbs.	1462 ft. lbs.

TIGHTENING TORQUE GUIDE

SAE Grade 8—Coarse Thread

SIZE	CLAMP LOAD	PLAIN	PLATED
¼-20 (.250)	2,850	12 ft. lbs	9 ft. lbs.
5/16-18 (.3125)	4,725	25 ft. lbs	18 ft. lbs.
3/8-16 (.375)	6,975	44 ft. lbs	33 ft.lbs.
7/16-14 (.4375)	9,600	70 ft.lbs.	52 ft. lbs.
½-13 (.500)	12,750	106 ft.lbs.	80 ft. lbs.
9/16-12 (.5625)	16,350	153 ft.lbs.	115 ft. lbs.
5/8-11 (.625)	20,325	212 ft.lbs.	159 ft. lbs.
¾-10 (.750)	30,075	376 ft.lbs.	282 ft. lbs.
7/8-9 (.875)	41,550	606 ft.lbs.	454 ft. lbs.
1-8 (1.000)	54,525	909 ft.lbs.	682 ft. lbs.
1⅛-7 (1.125)	68,700	1288 ft.lbs.	966 ft. lbs.
1¼-7 (1.250)	87,225	1817 ft.lbs.	1363 ft. lbs.
1⅜-6 (1.375)	103,950	2682 ft.lbs.	1787 ft. lbs.
1½-6 (1.500)	126,450	3161 ft.lbs.	2371 ft. lbs.

SAE Grade 8—Fine Thread

SIZE	CLAMP LOAD	PLAIN	PLATED
¼-28 (.250)	3,263	14 ft. lbs	10 ft. lbs.
5/16-24 (.3125)	5,113	27 ft. lbs	20 ft. lbs.
3/8-24 (.375)	7,875	49 ft. lbs	37 ft. lbs.
7/16-20 (.4375)	10,650	78 ft.lbs.	58 ft. lbs.
½-20 (.500)	14,400	120 ft.lbs.	90 ft. lbs.
9/16-18 (.5625)	18,300	172 ft.lbs.	129 ft. lbs.
5/8-18 (.625)	23,025	240 ft.lbs.	180 ft. lbs.
¾-16 (.750)	33,600	420 ft.lbs.	315 ft. lbs.
7/8-14 (.875)	45,825	668 ft.lbs.	501 ft. lbs.
1-12 (1.000)	59,700	995 ft.lbs.	746 ft. lbs.
1-14 (1.000)	61,125	1019 ft.lbs.	764 ft. lbs.
1⅛-12 (1.125)	77,025	1444 ft.lbs.	1083 ft. lbs.
1¼-12 (1.250)	96,600	2012 ft.lbs.	1509 ft. lbs.
1⅜-12 (1.375)	118,350	2712 ft.lbs.	2034 ft. lbs.
1½-12 (1.500)	142,275	3557 ft.lbs.	2668 ft. lbs.

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.

THREADED ROD DATA

Rod Diameter (inch)	Stressed Cross Section (sq inch)	Steel Strength (lb)					
		ASTM A 307 Rod (Grade 2)			Stainless Steel (Grade 304 or 316)		
		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
1-1/4	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

STEEL FASTENERS

CARBON STEEL FASTENERS

Approximately 90 percent of all fasteners are manufactured from carbon steel. Steel has excellent workability, a broad range of strength properties, and the raw material is quite inexpensive. There are over 100 different standard strength grades for steel fasteners, each with its own set of properties and designations.

In general, carbon steel fastener strength grades can be placed into three broad groupings involving low carbon, medium carbon, and alloy steel, The most widely referenced strength grade for carbon steel external threaded fasteners is detailed in the SAE J429 standard. The system is comprised of bolt grades made from low carbon steel through to alloy steels.

The common grades of the SAE system are repeated and expanded upon in separate ASTM standards, notably A307, A449, A325 and A490.

LOW CARBON STEELS (Used for GR2 bolts)

Low carbon steels, as used for fasteners, are defined as those with insufficient carbon content to permit a predictable response to a strengthening heat treatment process. The most commonly used analysis are AISI 1006, 1008, 1016, 1018, 1021 and 1022. These steels have good workability, they can be case hardened, and are weldable.

Note: *(Piping Bolt) The low carbon steel fastener ASTM A307 is a special bolt used in piping and flange work. It has properties similar to other low carbon steel bolts except that it has the added requirement of a specified maximum tensile strength. The reason for this is to ensure that the bolt will fracture, before breaking a cast iron flange on a pump or valve, if the bolt is inadvertently over-tightened.*

MEDIUM CARBON STEELS (Used for GR5 bolts)

Medium carbon steels are heat treatable, which means that through metallurgical treatments the tensile strength of the fastener after processing can be significantly higher than that of its original raw material. Popular analysis are AISI 1030, 1035, 1038 and 1541. On a strength-to-cost basis, medium carbon heat treated steel fasteners provide more load carrying capability per unit of cost than any other known metal. Their yield-to-tensile ratio is the lowest of all heat treated steels which gives them superior ductility. In fact, they are frequently referred to as 'forgiving' which means they have a punching bag ability to absorb punishment and service abuse.

ALLOY STEELS (Used for GR8 bolts)

Carbon steel is classed as an alloy steel when the maximum of the range of content specified for manganese is greater than 1.65 percent, or for silicon 0.60 percent, or for copper 0.60 percent, or when the chromium content is less than 4.0 percent (if greater it approaches being a stainless steel), or when the steel contains a specified minimum content of aluminum, boron, cobalt, columbium, molybdenum, nickel, titanium, vanadium, zirconium, or any other element added to achieve a specific effect.

ALLOY STEEL STUD BOLTING MATERIALS

The following grades of heat treated alloy steel studs are commonly used for high-pressure or extreme service in diameters of 1/4 inch to 4 inches, inclusive. Other grades and other diameters are available on special order.

ASTM A193, Grade B7
A heat treated chromium-molybdenum steel widely used for medium high temperature service. (Liquid quench -50° to 900°F, Air quench -40° to 900°F)

ASTM A193, Grade B7M
Similar to B7 studs except that the minimum yield and tensile strength requirements are reduced and the hardness controlled to 235 Brinell maximum. Designed for use in corrosive environments. (-50° to 900°F.)

ASTM A193, Grade B16
A heat treated chromium-molybdenum, vanadium steel for high pressure, high temperature service. (-50° to 1100°F.)

ASTM A320, Grade L7
This grade is intended for low temperature service down to minus 150°F and has a minimum Charpy impact value of 20 ft lb at this temperature. (-150° to 1100°F.)

ASTM A320, Grade L7M
Similar to L7 studs except that the minimum yield and tensile strength requirements are reduced and the hardness controlled to 235 Brinell maximum. This stud is designed for use in low temperature corrosive environments. (-150° to 1100°F.)

ASTM A193, Grade B8
These Chromium-Nickel (AISI 304) austenitic steel studs are used in corrosive environments. (-325° to 1500°F.)

ASTM A193, Grade B8M
These Chromium-Nickel Molybdenum (AISI 316) austenitic steel studs are used in corrosive environments. (-325° to 1500°F.)

CARBON AND ALLOY STEEL NUTS

ASTM A194, Latest Revision, Grade 2H
Suitable for use in high temperatures and high pressure conditions.

ASTM A194, Grade 2HM
Similar to 2H nuts except this grade is designed for use in corrosive environments.

ASTM A194, Latest Revision, Grade 4
Heat treated molybdenum steel nuts suitable for severe temperature and pressure conditions.

ASTM A194, Latest Revision, Grade L7
New stamping as per ASTM is **7L**. Heat treated chrome-molybdenum steel nuts suitable for extreme temperature and pressure conditions. Suitable for sub-zero service conditions and have minimum Charpy impact values of ASTM spec. A320. Grade 7 down to -150°F.

ASTM A194, Grade L7M
New stamping as per ASTM is **7ML**. Similar to grade L7 nuts except this grade is designed for use in corrosive environments.

ASTM A194, Grade 8/8M
Stainless steel nuts designed for use in corrosive environments.

TABLE OF MECHANICAL PROPERTIES OF VARIOUS MATERIALS

	Common Uses					Mechanical Properties					
Grade	Flat Washers	Shims	Shaft Keys	Pins	Structural	Tensile Strength	Yield Strength	Brinnell	Rockwell 'B'	Rockwell 'C'	Machinability
1008	✔					49,000	41,500	95			55
1010	✔	✔				53,000	44,000	95			55
A36	✔					55,000	30,000	111	B72		50
1018	✔		✔	✔		64,000	54,000	126	B85		70
1026	✔					87,000	72,000	179			70
1035			✔			72,000	39,500	143	B90		65
1045	✔		✔	✔	✔	91,000	77,000	179		C15	65
1144				✔		108,000	90,000	217		C19	80
12L14	✔			✔		78,000	60,000	163	B86		180
1215	✔			✔		78,000	60,000	163	B83		136
Ledloy 300				✔		78,000	60,000	163	B83		180
1075		✔			✔						
1095		✔	✔		✔	140,000	83,000	293			
W-1 Drill Rod				✔	✔	100-164ksi		207-341			100
O-1 Drill Rod				✔	✔	100-164 ksi		207-341			95
A-2 Drill Rod				✔	✔	100-164 ksi		207-341			65
4037				✔		97,000	94,000	192			70
4130	✔			✔	✔	98,000	87,000	201	894		70
4140	✔		✔		✔	102,000	90,000	223		C19	66
8630			✔			100,000	95,000	194			
303			✔	✔		35,000	90,000	160	B80		
304	✔	✔	✔			35,000	85,000	180	B90		
316	✔		✔			35,000	85,000	200	B95		
Alloy 20			✔			80,000	35,000				
416			✔			40,000	75,000	180	B90		
Monel 400	✔		✔			70,000	28,000				
2024		✔		✔		26,000	18,000				
6061	✔		✔			18,000	12,000	30			
C110	✔	✔				32-48 ksi	8-45 ksi		40F-47B		
C360		✔	✔			49-68 ksi	18-52 ksi		68F-80B		
SAE 660	✔					35,000	20,000		41B		
Olite	✔										
52100	✔			✔	✔	107,000	87,500	229			41
Nylon	✔										

QUOTE

"Forget yourself in your work. If your employer sees that you are more concerned about your own interests than about his, that you are fussy about getting credit of every little or big thing you do, then you are apt to be passed by when a responsible job has to be filled…Don't worry about how big an increase in your salary you can contrive to get. Don't let your mind dwell on money at all, if you can help it. Throw yourself, body, soul, and spirit, into whatever you are doing…The truth is that in every organization, no matter how large or how small, someone is taking notice of any employee who shows special ability."

HARRY B. THAYER

ASTM STANDARDS

ASTM (The American Society for Testing and Materials), founded in 1898, is a scientific and technical organization formed for 'the development of standards on characteristics and performance of materials, products, systems, and services; and the promotion of related knowledge.' ASTM is the world's largest source of voluntary consensus standards.

STANDARDS AND SPECIFICATIONS

A29/ A29M	Steel bars, carbon and alloy, hot-wrought and cold-finished
A31	Steel rivets and bars for rivets, pressure vessels
A36	Structural steel
A90	Test method for weight of coating on zinc-coated (galvanized) iron and steel articles
A31	Structural steel for ships
A143	Safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement
A153	Zinc coating (hot-dip) on iron and steel hardware
A183	Carbon steel track bolts and nuts
A193/ A193M	Alloy steel and stainless steel bolting materials for high-temperature service
A194/ A194M	Carbon and alloy steel nuts for bolts for high-pressure and high-temperature service
A239	Test method for locating the thinnest spot in a zinc (galvanized) coating on iron or steel articles by the Preece test (copper sulfate dip)
A242	High-strength low-alloy structural steel
A262	Detecting susceptibility to intergranular attack in austenitic stainless steels
A276	Stainless and heat-resisting steel bars and shapes
A307	Carbon steel externally threaded standard fasteners
A320/ A320M	Alloy steel bolting materials for low-temperature service
A325	High strength bolts for structural steel joints
A342	Test methods for permeability of feebly magnetic materials
A353/ A353M	Pressure vessel plates, alloy steel, 9 percent **n**ickel, double-normalized and tempered
A354	Quenched and tempered alloy steel bolts, studs, and other externally threaded fasteners
A370	Methods and definitions for mechanical testing of steel products
A380	Cleaning and descaling stainless steel parts, equipment, and systems
A385	Providing high-quality zinc coatings (hot-dip)
A394	Zinc-coated steel transmission tower bolts
A437/ A437M	Alloy steel turbine-type bolting material specially heat treated for high-temperature service
A449	Quenched and tempered steel bolts and studs
A453/ A453M	Bolting materials, high-temperature, 50 to 120 ksi yield strength, with expansion coefficients comparable to austenitic steels
A484/ A484M	Stainless and heat-resisting wrought steel products (except wire)
A489	Carbon steel eyebolts
A490	Heat-treated steel structural bolts, 150 ksi tensile strength
A493F	Stainless and heat-resisting steel for cold heading and cold forging
A502	Steel structural rivets
A540/ A540M	Alloy steel bolting materials for special applications
A555/ A555M	Stainless and heat-resisting steel wire
A563	Carbon and alloy steel nuts
A564	Hot-rolled and cold-finished age-hardening stainless and heat-resisting steel bars, wire, and shapes
A568	Steel, carbon and high-strength low-alloy hot-rolled and cold-rolled sheets
A574	Alloy steel socket-head cap screws
A582	Free-machining stainless and heat-resisting steel bars,hot-rolled or cold-finished
A588/ A588M	High-strength low-alloy structural steel with 50 ksi minimum yield point to 4 inches thick
A591	Steel sheet, cold-rolled, electrolytic zinc-coated
A676	Hot-dipped aluminum coatings on ferrous articles
A687	High-strength non-headed steel bolts and studs
A706	Low-alloy steel deformed bars for concrete reinforcement
A709	Structural steel for bridges
A751	Methods, practices, and definitions for chemical analysis of steel products
A788	Steel forgings
B6	Zinc (slab zinc)
B16	Free-cutting brass rod, bar, and shapes for use in screw machines

B99	Copper-silicon alloy wire for general purposes
B117	Method of salt spray (fog) testing
B134	Brass wire
B151	Copper-nickel-zinc alloy (nickel silver) and copper-nickel rod and bar
B154	Method of mercurous nitrate test for copper and copper alloys
B159	Phosphor bronze wire
B183	Preparation of low carbon steel for electroplating
B193	Test method for resistivity of electrical conductor materials
B201	Test chromate coatings on zinc and cadmium surfaces
B211	Aluminum alloy bars, rods, and wire
B242/ B242M	Preparation of high-carbon steel for electroplating
B244	Measurement of thickness of anodic coatings on aluminum and other non-conductive coatings on non-magnetic basis metals with eddy-current instruments
B254	Preparation of and electroplating on stainless steel
B320	Preparation of iron castings for electroplating
B322	Cleaning metals prior to electroplating
B342	Test method for electrical conductivity by use of eddy current
B374	Definitions of terms relating to electroplating
B487	Measurement of metal and oxide coating thicknesses by microscopical examination of a cross section
B499	Measurement of coating thicknesses by the magnetic method: non-magnetic coatings on magnetic basis metals
B504	Measurement of thickness of metallic coatings by the coulometric method
B565	Shear testing of aluminum-alloy rivets and cold-heading wire and rods
B567	Measurement of coating thickness by the beta backscatter method
B568	Measurement of coating thickness by x-ray spectrometry
B571	Test methods for adhesion of metallic coatings
B602	Attribute sampling of electrodeposited metallic coatings and related finishes
B633	Electrodeposited coatings of zinc on iron and steel
B695	Coatings of zinc mechanically deposited on iron and steel
B696	Coatings of cadmium mechanically deposited on iron and steel
B697	Guidelines for selection of sampling plans for inspection of electrodeposited metallic coatings and related finishes on products
F432	Roof and rock bolts and accessories
F436	Hardened steel washers
F467	Non-ferrous nuts for general use
F468	Non-ferrous bolts, hex cap screws, and studs for general use
F541	Alloy steel eyebolts
F593	Stainless steel bolts, hex cap screws and studs
F594	Stainless steel nuts
F606	Conducting tests to determine the mechanical properties of externally and internally threaded fasteners, washers, and rivets
F788	Surface discontinuities of bolts, screws and studs, inch and metric
F812	Surface discontinuities of nuts, inch and metric
F835	Alloy steel socket button and flat countersunk head cap screws
F837	Stainless steel socket head cap screws
F844	Washers, plain (flat), unhardened for general use
F879	Stainless steel socket button and flat countersunk head cap screws
F880	Stainless steel socket set screws
F901	Aluminum transmission tower bolts and nuts
F912	Alloy steel socket set screws
F959	Compressible-washer-type direct tension indicators for use with structural fasteners

QUOTE

"A bank is a place where they lend you an umbrella in fair weather and ask for it back again when it begins to rain."

ROBERT FROST

Stainless Steel Fasteners — Frequently Asked Questions

What makes stainless steel stainless?

Stainless steel must contain at least 10.5% chromium. It is the element that reacts with the oxygen in the air to form a complex chrome-oxide surface layer that is invisible but strong enough to prevent further oxygen from staining or rusting the surface. Higher levels of chromium and the addition of other alloying elements such as nickel and molybdenum enhance the surface layer and improve the corrosion resistance of the stainless material.

Can stainless steel rust?

Stainless does not "rust" as you think of regular steel rusting with a red oxide on the surface that flakes off. If you see red rust it is probably due to some iron particles that have contaminated the surface of the stainless steel and it is these iron particles that are rusting.

Is stainless steel magnetic?

There are several types of stainless steel. Martensitic (400 series) stainless steels are strongly magnetic. Austenic (300 series) stainless steels which contain nickel have very low magnetic permeability when annealed. The situation is far less clear when these steels have been cold worked by wire drawing, rolling, heading or even heavy polishing, all of which (except the last) are common aspects of fastener manufacturing. After substantial cold working a Grade 304 stainless fastener may exhibit quite a strong response to a magnet. In general, higher the nickel to chromium ratio the more stable the austenic structure and the less magnetic response that will be induced by cold work. This means Grade 316 will be in most instances almost totally non-responsive because of its higher nickel content.

What is passivation?

When the amount of chromium (in an iron matrix) exceeds 10-1/2%, a complex chrome oxide forms instantaneously that prevents the further diffusion of oxygen into the surface and results in the "passive" nature of stainless steel and its resistance to oxidation (rusting) or corrosion. A chemical "dip" into 10% nitric acid plus 2% hydrofluoric acid bath enhances the development of this "Passive" oxide.

Can stainless steel be welded?

Yes. Stainless steel is easily welded but the welding procedure is different than that used with carbon steel. The "filler" rod or electrode must be stainless steel.

Can stainless steel be hardened?

Yes. The Austentic 300 Series stainless steel can be hardened but only through work hardening. That is by cold working the material, either by cold rolling down to lighter and lighter gauges or by drawing the wire through a die or size altering operation. Ferritic 400 Series (409, 430, 434, 439) cannot be hardened by heat treatment. Martenistic 400 Series (403, 410, 416, 420, 440) can be hardened by heat treatment.

What does the designation "L" mean?

The use of the letter "L" after the grade number, i.e. 304L means the carbon content is restricted to a maximum of 0.03% (normal is 0.08% maximum). This lower level of carbon is usually used where welding will be performed. The lower level of carbon helps to prevent the chromium from being depleted.

I ordered 18-8 stainless bolts and got a bolt with F593C marked on the head. Did I get the right bolt?

Yes. 18-8 is a generic specification which includes 304 stainless steel. F593C is the ASTM spec for 304 stainless steel bolts and is part of the new marking system.

Is there is difference in stainless steel bought in North America compared to overseas?

Generally no. In fact many North American manufacturers use stainless steel wire and rod that has been imported. The specifications are quite clear on what constitutes stainless steel no matter where it is made.

Is a Grade 304 stainless bolt as strong as a Grade 5 Bolt?

No. While steel bolts are graded for strength such as Grade 2-5-8, stainless steel bolts are not. Stainless steel bolts are defined by their chemical content.

Are stainless steel bolts EC ROHS compliant?

In stainless steel, chromium is in the metallic state which is not hazardous. The chromium in the oxide layer on passivated stainless steel is dichromium trioxide which is a trivalent compound. The chromium banned by ROHS is hexavalent chromium.

WHY IS STAINLESS STAINLESS?

Stainless steels achieve 'stainless' characteristics by virtue of their ability to form a tight adherent film of iron-chromium oxide which strongly resists attack by the atmosphere and a wide variety of industrial gases and chemicals. This effect, plus the superior high temperature strength characteristics exhibited by many of these alloys, accounts for their wide use at ordinary and elevated temperatures with a wide choice of mechanical properties and several distinct levels of corrosion resistance.

These steels may be subdivided into the following groups:

1. Martensitic stainless steels are iron-chromium alloys which are hardenable by heat treatment. Representative of this group are Types 410, 420, 431 and 440C.
2. Ferritic stainless steels are iron-chromium alloys which cannot be hardened significantly by heat treatment. Representative of this group are Types 405 and 430.
3. Austenitic stainless steels are iron-chromium-nickel and iron-chromium-manganese-nickel alloys which are hardenable by cold working. Representative of this group are Types 201, 304, and 316.
4. Precipitation hardening stainless steels are iron-chromium-nickel alloys with additional elements which are hardenable by solution treating and aging.

Alloys in the first two groups are magnetic in all conditions; those in the third group are slightly magnetic in the cold worked condition, but non-magnetic in the annealed condition in which they are most often used. Alloys in the fourth group are magnetic in the precipitation hardened condition.

NOTE: The Fastener Industry is now involved in the process of changing the head markings on stainless steel bolts to correspond to the ASTM specification. Please refer to the chart at the bottom of the page.

QUOTE

"There are few, if any, jobs in which ability alone is sufficient. Needed, also, are loyalty, sincerity, enthusiasm and team play."

WILLIAM B. GIVEN, JR.

MATERIALS AVAILABLE

18.8 Stainless Steel
This is the most popular type of stainless used in the production of fasteners. Its composition is approximately 18% Chromium and 8% Nickel, thus the name 18.8. Several grades of stainless are included in this classification including 302, 303, 304 and 305. These all have good strength and corrosion resistance.

316 Stainless Steel
This is more corrosion resistant than 18.8, but also more expensive. It is composed of approximately 18% Chromium and 12% Nickel with the addition of 2% to 4% Molybdenum. It also maintains its strength at higher temperatures than 18.8.

410 Stainless Steel
It has approximately 12% Chromium with no Nickel. It is not very corrosion resistant and is magnetic, but it can be heat treated to become harder.

Alloy 20
This alloy has approximately 20% Chromium and 34% Nickel plus 3% to 4% Molybdenum. It is very corrosion resistant and is especially popular when in contact with sulfuric acid.

Brass
This metal is approximately 65% Copper and 35% Zinc. It offers a good combination of strength, corrosion resistance and workability.

Nickel Copper 400
This alloy is approximately 70% Nickel and 30% Copper. It has excellent strength and corrosion resistance and is used in salt water marine and other chemical environments.

Titanium
This has a very high strength to weight ratio, as well as good corrosion resistance.

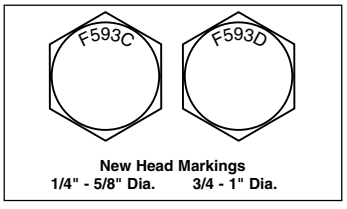
Inconel
Registered Trademark of Inco Ltd. Composed of approximately 77% Nickel and 15% Chromium. It offers superior strength and good corrosion at high temperatures.

Silicon Bronze
It is composed of approximately 96% Copper, 3% Silicon and 1% Manganese. It is more corrosion resistant and tougher than brass. It is widely used in the electrical industry.

EXAMPLES OF HEAD MARKING CHANGES

18.8 STAINLESS STEEL
HEX HEAD CAP SCREWS
UNC – Unified National Coarse Thread

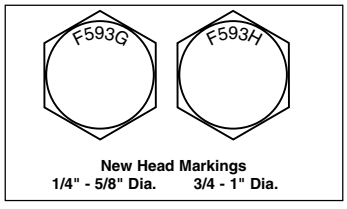
Present Head Markings
All Diameters



New Head Markings
1/4" - 5/8" Dia. 3/4 - 1" Dia.

316 STAINLESS STEEL
HEX HEAD CAP SCREWS
UNC – Unified National Coarse Thread

Present Head Markings
All Diameters



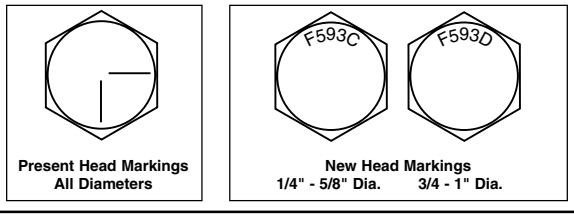
New Head Markings
1/4" - 5/8" Dia. 3/4 - 1" Dia.

Chromium	Nickel	Max. Carbon	Max. Mangan.	Max. Phosph.	Max. Sulphur	Molybd.	Max. Silicon	Copper	Other Elements	Tensile	Yield	Approx. Hardness
300 SERIES AUSTENITIC STAINLESS: Accounts for 86%-90% of stainless fasteners; best corrosion resistance of stainless alloys; non-magnetic before cold working; low heat conductivity; good strength at higher temperatures; not hardenable by heat treatment. Tensile and yield will increase sharply in austenitic fasteners made by cold forming but may decrease in fasteners made by machining. Consequently, the range for tensile and yield is broad and depends largely on how fasteners are made. Grades commonly used for cold forming such as 302HQ, 304, and 316 may have much higher strength than other grades.												
18/8	Most common designation for non-magnetic stainless fasteners; encompasses 30 to 40 various mixtures of 301, 302, 303, 304, 305 and XM7.											
17-20% Usually 17-19%	8-13% Usually 8-10.5%	.08% Usually .03-05%	2%	.2% Usually .045%	.03-15% Usually .03%		1%	0-4% Usually 2%-3%		80,000-150,000 usual range. After cold work: 100,000-125,000 typical for 1/4-5/8 dia.; 100,000 typical for 3/4-1" dia.; 80,000-90,000 typical over 1" dia.	40,000 min. After cold work: 80,000-90,000 typical 1/4-5/8 dia.; 45,000-70,000 typical 3/4 and over dia.	B85-95
304	Most popular stainless for hex head cap screws; also frequently used for flat washers.											
18-20%	8-10.5%	.08%	2%	.45%	.03%		1%			85,000-150,000 range. After cold work: 125,000 typical for 1/4-5/8 dia.; 100,000 typical for 3/4-1" dia.; 90,000 typical above 1" dia.	40,000 min. After cold work: 90,000 typical for 1/4-5/8 dia.; 50,000-70,000 typical for 3/4 and over dia.	B85-95
304L	Low carbon increases corrosion resistance and welding capacity.											
18-20%	8-12%	.03%	2%	.045%	.03%		1%			Slightly lower than 304 due to lower carbon content		
305	High nickel content lowers work hardening during severe cold forming and keeps parts non-magnetic.											
17-19%	10.5-13%	.12%	2%	.045%	.03%		1%			90,000-125,000 Typical: 100,000	40,000 min. Typical: 50,000-70,000	
316	Addition of molybdenum increases corrosion resistance to chloride and sulfides.											
16-18%	10-14%	.08%	2%	.045%	.03%	2-3%	1%			85,000-140,000 usual range. After cold work: 120,000 typical for 1/4-5/8 dia.; 95,000 typical for 3/4-1" dia.; 80,000 typical above 1" dia.	40,000 min. After cold work: 80,000-90,000 typical for 1/4-5/8 dia.; 50,000-70,000 typical for 3/4 and over dia.	B85-95
309	Higher chromium and nickel give better corrosion resistance at high temperatures (1900°F.)											
22-24%	12-15%	.2%	2%	.045%	.03%		1%		100,000-120,000	60,000-80,000	B85-95	
400 SERIES MARTENSITIC STAINLESS: About 5% of stainless fasteners; magnetic; no nickel and high carbon content mean the lowest corrosion resistance among the different types of stainless. Tensile and yield will increase sharply in martensitic stainless by heat treating.												
400 Mixture Martensitic Often a mixture of different 400 materials, usually with carbon content towards high end of max. giving greater strength but lowering corrosion resistance.												
11.5-14%		.30% Usually .15-.30%	1.25% Usually 1%	.06% Usually .04%	.15% Usually .03%		1%			180,000-250,000 if heat treated	150,000-200,000 if heat treated	C34-C45
410	Higher carbon content gives strength; most popular of the grades with 12% chrome; used in highly stressed conditions.											
11.5-13.5%		.15%	1%	.04%	.03%		1%			180,000 heat treated	150,000 heat treated	C34
416	Higher sulfur content helps machinability but lowers corrosion resistance.											
12-14%		.15%	1.25%	.06%	.15%		1%			180,000 heat treated	150,000 heat treated	C34
420	Higher carbon gives greater strength but lowers corrosion resistance.											
12-14%		.30% Nom. 15% min	1%	.04%	.03%		1%			250,000 heat treated	200,000 heat treated	C45
PRECIPITATION HARDENED STAINLESS, MONEL, AND ALUMINUM												
630	Infrequently used; high corrosion resistance; strength and ductility in high and low temperatures due to solution annealing and hardening.											
15.5-175%	3.5%	.07%	1%	.04%	.03%	1%		3-5%	Columbian and Tantalum - 15.4 5%	135,000	105,000	C28
Monel 400	Most commonly used nickel-copper alloy for cold forming; excellent corrosion resistance in heat and salt water.											
	63-70%	.3%	2%		.5%				2.5%-Iron, .5%-Alum., .15% Sulf., remainder Copper	80,000-125,000	400,000-70,000	B70
Aluminum 2024 Most popular of aluminum alloys; needs heat treatment for strength.												
.1%			.3-.9%		.5%			3.8-4.9%	.25% Zinc. 1.2-1.8% Magnesium, remainder Alum.	60,000 heat treated	50,000 heat treated	B60 heat treated

Chromium	Nickel	Max Carbon	Max Mangan.	Max Phosph.	Max Sulphur	Molybd.	Max Silicon	Copper	Other Elements	Tensile	Yield	Approx. Hardness
BRASS and BRONZE												
Brass Alloy 270		Good cold forming due to high copper content; also used for milled from bar nuts.										
								65%	35% Zinc	70,000	45,000	B65
Brass Alloy 360		Good machinability due to added lead; good for screw machine parts.										
								61.5%	3% Lead remainder Zinc	50,000	30,000	B55
Commercial Brass		Easier to cold form as copper content increases; as copper content decreases, the metal becomes stronger and harder.										
								60-65%	35-40% Zinc. .05-.15 Lead	55,000	35,000	B60
Bronze Alloy 651		Generally used for hex head cap screws.										
			.07%				2.0%	96.0% min	.05% Lead max. 1.5% Zinc max.	70,000-80,000	35,000-45,000	B70-B75
Bronze Alloy 655		Used for hot forged fasteners.										
	.06%		1.5%				3.8%	94.8% min	.05% Lead max. 1.5% Zinc max.	70,000-80,000	35,000-45,000	B70-B75
Commercial Bronze		Addition of lead helps machinability.										
							2-4%	94-96%	.05-.8% Lead, .05-1.5% Zinc.	70,000-80,000	35,000-45,000	B70-B75
Phosphorus Bronze		Tin increases strength; phosphorus helps against stress corrosion; excellent cold forming properties.										
				.3%				95%	5% Tin	60,000	35,000	B60
Naval Bronze		Addition of tin gives better corrosion resistance against salt water.										
								59-62%	.5-1% Tin, 2% Lead remainder Zinc	70,000	30,000	B65

TORQUE GUIDE CHART – STAINLESS STEEL

18.8 STAINLESS STEEL HEX HEAD CAP SCREWS UNC – Unified National Coarse Thread

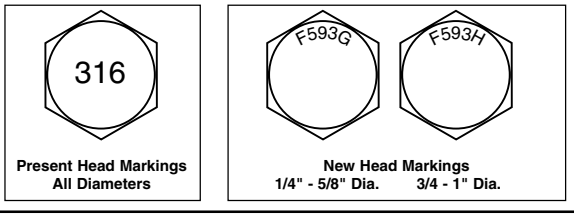


Present Head Markings All Diameters

New Head Markings 1/4" - 5/8" Dia. 3/4 - 1" Dia.

Size	Clamp Load (lb)	Assembly Torque Dry (ft lb)	Min. Lub (ft lb)	Tensile (lb)
1/4 - 20	1350	6	5	2780
1/4 - 28	1500	7	5	3020
5/16 - 18	2200	12	9	4400
5/16 - 24	2400	13	10	4700
3/8 - 16	3200	20	15	6500
3/8 - 24	3700	23	17	9000
1/2 - 13	5900	50	37	11900
1/2 - 20	6700	56	42	12800
5/8 - 11	9500	100	75	18800
5/8 - 18	10800	113	84	20400
3/4 - 10	14100	177	132	27600
3/4 - 16	15700	197	148	29600
7/8 - 9	11700	232	174	37900
1 - 8	15300	256	192	49700
1-1/8 - 7	19300	363	272	62700
1-1/4 - 7	24500	512	384	78800
1-3/8 - 6	29200	671	503	94400
1-1/2 - 6	35600	891	668	114000

316 STAINLESS STEEL HEX HEAD CAP SCREWS UNC – Unified National Coarse Thread



Present Head Markings All Diameters

New Head Markings 1/4" - 5/8" Dia. 3/4 - 1" Dia.

Size	Clamp Load (lb)	Assembly Torque Dry (ft lb)	Min. Lub (ft lb)	Tensile (lb)
1/4 - 20	2100	9	7	4600
1/4 - 28	2400	10	7	5000
5/16 - 18	3400	18	13	7400
5/16 - 24	3800	20	15	7900
3/8 - 16	5100	32	24	10900
3/8 - 24	5700	36	27	15000
1/2 - 13	9350	78	58	19800
1/2 - 20	10550	88	66	21400
5/8 - 11	14950	116	75	31400
5/8 - 18	16850	136	80	34000
3/4 - 10	20300	178	132	42300
3/4 - 16	22670	208	152	45400
7/8 - 9	16850	246	213	58100
1 - 8	22900	368	290	69500
1-1/8 - 7	25400	386	411	87800
1-1/4 - 7	32200	548	480	110300
1-3/8 - 6	38400	629	629	125900
1-1/2 - 6	46700	835	835	152000

CORROSION GUIDE

This guide details the effects of various corrosive environments on popularly used fastener materials.

	Stainless Steel								
Corrosive Medium	18/8, 302 303, 304 305	316	410, 416 430	Brass and Naval Bronze	Silicon Bronze	Copper	Copper (Monel)	Aluminum	Nylon
Acetate Solvents, Crude	Excel	Excel	Good	Fair	Good	Good	Good	Excel	Good
Acetate Solvents, Pure	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Acetate Acid, Crude	Good	Excel	Poor[2]	Fair[1]	Good	Good	Good	Good	Poor
Acetate Acid (Pure)	Good	Excel	Poor[2]	Fair[1]	Good	Good	Good	Excel	Poor
Acetic Acid Vapors	Good	Excel	Poor	Poor	Good	Good	Fair	Good	Poor
Acetic Anhydride	Good	Excel	Poor	Poor	Good	Good	Good	Excel	Poor
Acetone	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Acetylene	Excel	Excel	Excel	3	Poor	Poor	Good	Excel	
Alcohols	Excel	Excel	Excel	Good	Excel	Excel	Excel	Good	Good
Aluminum Sulfate	Fair	Good	Poor	Fair[1]	Good	Good	Good	Fair	Poor
Alums	Fair	Good	Poor	Fair[1]	Good	Good	Good	Excel	Fair
Ammonia Gas[4]	Excel	Excel	Excel	Poor[56]	6	6	6	Excel	Good[36]
Ammonium Chloride	Fair	Excel	Fair	Fair[1]	Good	Good	Excel	Poor	Fair
Ammonium Hydroxide	Excel	Excel	Excel	Poor	Poor	Poor	Fair Good	Good[36]	
Ammonium Nitrate	Excel	Excel	Excel	Poor	Fair	Fair	Fair	Excel	Fair
Ammonium Phosphate (Ammoniacal)	Excel	Excel	Excel	Poor	Poor	Poor	Good	Poor	Good
Ammonium Phosphate (Neutral)	Excel	Excel	Good	Fair	Fair	Fair	Good	Fair	Excel
Ammonium Phosphate (Acid)	Good	Excel	Fair	Fair[1]	Fair	Fair	Good	Fair	Fair
Ammonium Sulfate	Excel	Excel	Good	Fair[1]	Fair	Fair	Good	Good[35]	Fair
Asphalt	Excel	Excel	Good	Good	Excel	Excel	Excel	Excel	Excel
Beer	Excel	Excel	7	Good	Good	Good	Excel	Excel	Excel
Beet Sugar Liquors	Excel	Excel	Good	Good	Excel	Excel	Excel	Excel	Good
Benzene or Benzol[8]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Benzine[8]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Borax	Excel	Excel	Excel	Good	Good	Good	Excel	Good	Good
Boric Acid	Good	Excel	Fair	Fair[1]	Good	Good	Excel	Excel	Good
Butane, Butylene, Butadiene[9]	Excel[10]	Excel[10]	Excel[10]	Excel[34]	Excel[34]	Excel[34]	Excel	Excel	Excel
Calcium Bisulfite	Good	Excel	Poor	Poor	Good	Good	Poor	Poor	Good
Calcium Hypochlorite	Fair	Good	Poor	Fair	Fair	Fair	Fair	Poor	Fair
Cane Sugar Liquors	Excel	Excel	Good	Good	Excel	Excel	Excel	Excel	Good
Carbon Dioxide (Dry)	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Carbon Dioxide (Wet and Aqueous)	Excel	Excel	Excel[11]	Fair[11]	Good[11]	Good[11]	Good[11]	Excel	Excel
Carbon Disulfide	Excel	Excel	Good	Fair	Poor	Poor	Fair	Excel	Excel
Carbon Tetrachloride[12]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Good	Excel
Chlorine (Dry)	Good	Good	Good	Good	Good	Good	Excel	Poor	Poor
Chlorine (Wet)	Poor	Fair	Poor	Poor	Fair	Fair	Fair	Poor	Poor
Chromic Acid	Good	Excel	Fair	Poor	Poor	Poor	Fair	Poor	Poor
Citric Acid	Good	Excel	Fair	Fair[1]	Good	Good	Good	Good	Good
Coke Oven Gas	Excel	Excel	Excel	Fair	Fair	Fair	Good	Good	Fair
Copper Sulfate	Excel	Excel	Excel	Poor	Fair	Fair	Fair	Poor	Fair
Core Oils	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Cottonseed Oil	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Creosote	Excel	Excel	Excel	Fair	Good	Good	Excel	Good	
Ethers	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Ethylene Glycol	Excel	Excel	Excel	Good	Excel	Excel	Excel	Good	Good
Ferric Chloride	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Ferric Sulfate	Excel	Excel	Excel	Poor	Fair	Fair	Fair	Good	Poor
Formaldehyde	Excel	Excel	Excel	Good	Good	Good	Excel	Good	Good
Formic Acid	Good	Excel	Poor	Fair[1]	Good	Good	Good	Poor	Poor
Freon	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Good	Excel
Furfural	Excel	Excel	Excel	Good	Good	Good	Excel	Excel	Excel
Gasoline (Sour)	Excel	Excel	Fair	Fair	Poor	Poor	Poor	Poor	Excel
Gasoline (Refined)	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Gelatin	Excel	Excel	Fair[13]	Fair[13]	Excel[13]	Excel[13]	Excel	Excel	Excel
Glucose	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Glue	Excel	Excel	Excel	Fair	Excel	Excel	Excel	Fair	Excel
Glycerine or Glycerol	Excel	Excel	Excel	Good	Excel	Excel	Excel	Excel	Good

Corrosive Medium	Stainless Steel 18/8, 302 303, 304 305	Stainless Steel 316	Stainless Steel 410, 416 430	Brass and Naval Bronze	Silicon Bronze	Copper	Copper (Monel)	Aluminum	Nylon
Hydrochloric Acid	Poor	Poor	Poor	Poor	Fair[14]	Fair[14]	Fair[14]	Poor	Poor
Hydrocyanic Acid (Hydrogen Cyanide)	Excel	Excel	Fair	Poor	Poor	Poor	Good	Excel	Excel
Hydrofluoric Acid	Poor	Poor	Poor	Poor	Fair	Fair	Excel	Poor	Poor
Hydrogen Fluoride	Good	Good	Fair	Fair	Good	Good	Excel	Poor	Poor
Hydrogen[9]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Hydrogen Peroxide	Excel	Excel	Excel	Poor	Fair	Fair	Good	Good	Fair
Hydrogen Sulfide (Dry)	Excel	Excel	Good	Fair[6]	Poor[6]	Poor[6]	Fair[6]	Excel	Good[37]
Hydrogen Sulfide (Wet and Aqueous)	Good	Excel	Fair[15]	Fair	Poor	Poor	Fair	Excel	Good[37]
Lacquers and Lacquer Solvents	Excel	Excel	Excel	Fair	Excel	Excel	Excel	Excel	Excel
Lime-Sulfur	Excel	Excel	Good	Poor	Fair	Fair	Good	Poor	Good
Magnesium Chloride	Good	Excel	Fair	Fair	Good	Good	Excel	Poor	Excel
Magnesium Hydroxide	Excel	Excel	Excel	Good	Excel	Excel	Excel	Fair	Good
Magnesium Sulfate	Excel	Excel	Excel	Good	Excel	Excel	Excel	Good	Excel
Mercuric Chloride	Poor	Fair[16]	Poor	Poor	Poor	Poor	Poor	Poor	
Mercury	Excel	Excel	Excel	Poor	Poor	Poor	Good	Poor	Excel
Milk	Excel	Excel	Good	Fair	Fair	Fair	Fair	Excel	Excel
Molasses	Excel	Excel	Good	Good	Excel	Excel	Excel	Excel	Excel
Natural Gas	Excel	Excel	Excel	Good	Excel	Excel	Excel	Excel	Excel
Nickel Chloride[17]	Fair	Good	Poor	Poor	Fair	Fair	Good	Poor	Poor
Nickel Sulfate[17]	Good	Excel	Fair	Fair	Good	Good	Excel	Poor	Poor
Nitric Acid	Good	Good	Good[18]	Poor	Poor	Poor	Poor	Fair	Poor
Oleic Acid	Good[20]	Excel	Good[20]	Fair[19]	Good[24]	Good[24]	Excel	Excel	Excel
Oxalic Acid	Good	Excel	Fair	Fair	Fair	Fair	Excel	Poor	Poor
Oxygen[9]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Good
Palmitic Acid	Good[20]	Excel	Good[20]	Fair[19]	Good[24]	Good[24]	Excel	Excel	Excel
Petroleum Oils (Sour)	Excel	Excel	Fair	Fair	Poor	Poor	Poor	Poor	Excel
Petroleum Oils (Refined)	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Phosphoric Acid 25%	Fair[23]	Excel	Poor	Poor	Good[21]	Good[21]	Good[22]	Poor	Poor
Phosphoric Acid 25%, 50%	Poor	Good	Poor	Poor	Good[21]	Good[21]	Good[22]	Poor	Poor
Phosphoric Acid 50%, 85%	Poor	Good	Poor	Poor	Good[21]	Good[21]	Good[22]	Excel	Excel
Picric Acid	Excel	Excel	Good	Poor	Poor	Poor	Poor	Fair	Poor
Potassium Chloride	Good	Excel	Fair	Fair	Good	Good	Excel	Poor	Excel
Potassium Hydroxide	Excel	Excel	Excel	Poor	Fair	Fair	Excel	Poor	Good[38]
Potassium Sulfate	Excel	Excel	Excel	Good	Excel	Excel	Excel	Excel	Excel
Propane[9]	Excel[10]	Excel[10]	Excel[10]	Excel	Excel	Excel	Excel	Excel	Excel
Rosin (Dark)	Excel	Excel	Excel	Good	Good	Good	Excel	Excel	Excel
Rosin (Light)	Excel	Excel	Excel	Poor	Poor	Poor	Good	Good	Excel
Shellac	Excel	Excel	Excel	Good	Excel	Excel	Excel	Excel	Excel
Soda Ash (Sodium Carbonate)	Excel	Excel	Excel	Good	Good	Excel	Excel	Poor	Excel
Sodium Bicarbonate	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Good	Excel
Sodium Bisulfate	Poor	Excel	Poor	Fair[1]	Good	Good	Excel	Fair	Fair
Sodium Chloride	Good	Excel	Fair	Fair	Good	Good	Excel	Good	Excel
Sodium Cyanide	Excel	Excel	Excel	Poor	Poor	Poor	Good	Poor	Good
Sodium Hydroxide	Excel	Excel	Excel	Poor	Fair	Fair	Excel	Poor	Good[38]
Sodium Hypochlorite	Fair	Excel	Poor	Excel	Fair	Fair	Fair	Poor	Fair
Sodium Metaphosphate	Excel	Excel	Good	Fair	Good	Good	Excel	Fair	Excel
Sodium Nitrate	Excel	Excel	Excel	Fair	Good	Good	Excel	Excel	Excel
Sodium Perborate	Excel	Excel	Excel	Fair	Good	Good	Excel	Fair	
Sodium Peroxide	Excel	Excel	Excel	Fair	Good	Good	Excel	Fair	Fair
Sodium Phosphate (Alkaline)	Excel	Excel	Excel	Fair	Good	Good	Excel	Poor	Good
Sodium Phosphate (Neutral)	Excel	Excel	Excel	Good	Excel	Excel	Excel	Poor	Excel
Sodium Phosphate (Acid)	Good	Excel	Poor	Fair[1]	Good	Good	Excel	Poor	Fair
Sodium Silicate	Excel	Excel	Excel	Fair	Good	Good	Excel	Good	Good
Sodium Sulfate	Excel	Excel	Excel	Good	Excel	Excel	Excel	Excel	Excel
Sodium Sulfide	Excel	Excel	Excel	Poor	Poor	Poor	Good	Poor	Good
Sodium Thiosulfate (Hypo)	Excel	Excel	Excel	Poor	Poor	Poor	Good	Excel	Good[39]
Sludge Acid	Poor	Fair	Poor	Poor	Good	Good	Good	Poor	
Stearic Acid	Good[20]	Excel	Good[20]	Fair[19]	Good[24]	Good[24]	Excel	Excel	Excel
Sulfur	Excel	Excel	Excel	Fair	Fair	Fair	Fair	Excel	Good
Sulfur Chloride	Fair	Good	Poor	Poor	Poor	Poor	Good	Poor	Poor
Sulfur Dioxide (Dry)[9]	Excel	Excel	Excel	Fair	Excel	Excel	Excel	Good	Good
Sulfur Dioxide (Wet)	Good	Excel	Poor	Poor	Good	Good	Poor	Fair	Fair

Corrosive Medium	Stainless Steel 18/8, 302 303, 304 305	Stainless Steel 316	Stainless Steel 410, 416 430	Brass and Naval Bronze	Silicon Bronze	Copper	Copper (Monel)	Aluminum	Nylon
Sulfuric Acid 10%	Poor	Good[25]	Poor	Poor	Good[25]	Good	Good[25]	Poor	Poor
Sulfuric Acid 10%, 75%	Poor	Poor	Poor	Poor	Fair	Fair	Good	Poor	Poor
Sulfuric Acid 75%, 95%	Fair[27]	Good[27]	Fair[27]	Poor	Fair[26]	Fair[26]	Fair[26]	Poor	Poor
Sulfuric Acid 95%	Good	Good	Good	Poor	Fair	Poor	Poor	Fair	Poor
Sulfurous Acid	Fair	Good	Poor	Poor	Good	Good	Poor	Poor	Fair
Tar	Excel	Excel	Good	Good	Excel	Excel	Excel	Excel	Excel
Tartaric Acid	Good	Excel	Fair	Fair[1]	Good	Good	Good	Good	Fair
Toluene or Toluol[8]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Trichloroethylene[12]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Good
Turpentine	Excel	Excel	Good[28]	Fair[28]	Excel	Excel	Excel	Excel	Excel
Varnish[29]	Excel	Excel	Excel	Good	Good	Good	Excel	Excel	Excel
Vegetable Oils[29]	Excel	Excel	Excel	Good	Good	Good	Excel	Excel	Excel
Vinegar[25]	Good	Excel	Fair	Poor	Good	Good	Good	Excel	Fair
Water (Acid Mine Water)	[31]	[31]	[31]	Poor	[30]	[30]	[30]	Fair	Good
Water (Fresh)	Excel	Excel	Excel	Fair[32]	Good	Good	Excel	Excel	Excel
Water (Salt)	Good[33]	Fair[33]	Fair[32]	Good	Good	Excel	Good	Excel	
Whiskey	Excel	Excel	Fair	Good	Good	Good	Good	Fair	Excel
Wines	Excel	Excel	Fair	Good	Good	Good	Good	Fair	Excel
Xylene or Xylol[8]	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
Zinc Chloride	Poor	Good	Poor	Poor	Good	Good	Excel	Poor	Good
Zinc Sulfate	Good	Excel	Fair	Fair	Good	Good	Excel	Good	Good[39]

Notes:

1. Subject to dezincification and/or stress corrosion; especially at elevated temperatures and with concentrated solutions.
2. May be useful with cold dilute acid.
3. Alloys containing up to 60 percent copper acceptable; high copper alloys not acceptable.
4. Temperature assumed to be below that at which gas cracks and liberates nascent nitrogen.
5. Subject to stress corrosion with low concentrations.
6. Apparently resistant to dry gas at ordinary temperatures; attacked rapidly by moist gas and by hot gas.
7. Not recommended for use with beverage grade.
8. Chemicals used for treating in manufacture assumed to be absent.
9. Temperature assumed to be no higher than that normally encountered in compression, storage, and distribution.
10. Useful at elevated temperatures.
11. Not recommended for use with carbonated beverages.
12. Water assumed to be absent.
13. Not recommended for use with edible grades.
14. Only with dilute or unaerated solutions.
15. Subject to stress corrosion by moist gas; and to severe general corrosion by saturated acqueous solution.
16. Subject to stress corrosion.
17. None of these materials recommended for use with nickel plating solutions.
18. Higher chromium alloys (over 18 percent) preferred.
19. Not recommended for temperatures over 212°F (100°C).
20. Alloys with less than 18 percent Cr. not recommended for temperatures over 212°F (100°C). Others not recommended for temperatures over 392°F (200°C).
21. Up to 140°F (60°C).
22. Up to 194°F (90°C).
23. At room temperature.
24. Not recommended for temperatures over 392°F (200°C).
25. Non-ferrous alloys preferred when unaerated and at temperatures above normal. Stainless Steel best when aerated and at normal to moderate temperatures.
26. With cold acid only.
27. In the absence of exposure to moist air.
28. Crude produce may contain acids which corrode these materials.
29. Some of these ratings may not apply when handling light colored products at elevated temperatures of 392°F (200°C).
30. Good with water containing no oxidizing salts; fair with water containing oxidizing salts.
31. Excellent with water containing oxidizing salts; not good with water containing no oxidizing salts.
32. Subject to dezincification with hot and/or aerated waters.
33. Subject to pitting attack.
34. Copper may act as a catalyst for undesirable reactions.
35. Free sulphuric acid absent.
36. Good at concentrations under 10 percent and below 100°F (38°C).
37. Suitable for limited service at concentrations under 50 percent and below 100°F (38°C).
38. Good only at concentrations under 10 percent and below 100°F (38°C).
39. Good only at concentrations under 20 percent and below 100°F (38°C).

QUOTE

"Anyone can hold the helm when the sea is calm."

PUBLILIUS SYRUS

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 finer 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 were 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/IMPERIAL 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/IMPERIAL 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	(3.375)
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)

QUOTE

"The three great essentials to achieve anything worth while are, first, hard work; second, stick-to-itiveness; third, common sense."

THOMAS EDISON

IMPERIAL/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

QUOTE

"It is the direct man who strikes sledgehammer blows, who penetrates the very marrow of a subject at every stroke and gets the meat out of a proposition, who does things."

ORISON S. MARDEN

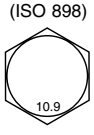
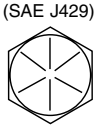
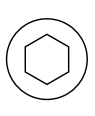
FASTENER CONVERSION CHART

INCH TO METRIC		
Inch Equivalent		Metric Size-Pitch
UNC	UNF	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/IMPERIAL

ROUGHLY EQUIVALENT US BOLT MATERIALS			
Metric Bolt Class	Metric Nut Class Normally Used	SAE J429 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

STRENGTHS

METRIC (ISO 898)		INCH (SAE J429)	METRIC (ISO 898)		INCH (SAE J429)
	=			=	
Grade: 4.8 (4.6, 5.8) Tensile: 429 MPa (60,900 psi)		Grade: 2 Tensile: 60,000 psi	Grade: 10.9 Tensile: 1040 MPa (150,800 psi)		Grade: 8 Tensile: 150,000 psi
	=			=	
Grade 8.8 Tensile: 830 MPa (120,350 psi)		Grade: 5 Tensile: 120,000 psi	Grade: 12.9 Tensile: 1220 MPa (176,900 psi) *		Grade: ASTM A574 Tensile: 170,000 psi **Note**: Generally not marked

***Note:** Metric Hex Socket Cap Screws are available in lower strength grades (8.8, 10.9) and marked accordingly.

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)

QUOTE

"The great achievements have always been individualistic. Indeed, any original achievement implies separation from the majority. Though society may honour achievement, it can never produce it."

GEORGE CHARLES ROCHE

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

QUOTE

"The only thing to do with good advice is to pass it on; it is never of any use to oneself."

OSCAR WILDE

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 from Nm	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

QUOTE

"We pay for the mistakes of our ancestors, and it seems only fair that they should leave us the money to pay with."

DONALD MARQUIS

CONVERSION CHART

Fractions (in)	Decimals (in)	Metric (mm)	Fractions (in)	Decimals (in)	Metric (mm)	Fractions (in)	Decimals (in)	Metric (mm)	Fractions (in)	Decimals (in)	Metric (mm)
–	.0004	.01	25/32	.781	19.844	–	2.165	55.	3-11/16	3.6875	93.663
–	.004	.10	–	.7874	20.	2-3/16	2.1875	55.563	–	3.7008	94.
–	.01	.25	51/64	.797	20.241	–	2.2047	56.	3-23/32	3.719	94.456
1/64	.0156	.397	13/16	.8125	20.638	2-7/32	2.219	56.356	–	3.7401	95.
–	.0197	.50	–	.8268	21.	–	2.244	57.	3-3/4	3.750	95.
–	.0295	.75	53/64	.828	21.034	2-1/4	2.250	57.150	–	3.7795	96.
1/32	.03125	.794	27/32	.844	21.431	2-9/32	2.281	57.944	3-25/32	3.781	96.044
–	.0394	1.	55/64	.859	21.828	–	2.2835	58.	3-13/16	3.8125	96.838
3/64	.0469	1.191	–	.8661	22.	2-5/16	2-312	58.738	–	3.8189	97.
–	.059	1.5	**7/8**	.875	22.225	–	2.3228	59.	3-27/32	3.844	97.631
1/16	.062	1.588	57/64	.8906	22.622	2-11/32	2.344	59.531	–	3.8583	98.
5/64	.0781	1.984	–	.9055	23.	–	2.3622	60.	3-7/8	3.875	98.425
–	.0787	2.	29/32	.9062	23.019	2-3/8	2.375	60.325	–	3.8976	99.
3/32	.094	2.381	59/64	.922	23.416	–	2.4016	61.	3-29/32	3.9062	99.219
–	.0984	2.5	**15/16**	.9375	23.813	2-13/32	2.406	61.119	–	3.9370	100.
7/64	.109	2.778	–	.9449	24.	2-7/16	2.438	61.913	3-15/16	3.9375	100.013
–	.1181	3.	61/64	.953	24.209	–	2.4409	62.	3-31/32	3.969	100.806
1/8	.125	3.175	31.32	.969	24.606	2-15/32	2.469	62.706	–	3.9764	101.
–	.1378	3.5	–	.9843	25.	–	2.4803	63.	**4**	4.000	101.600
9/64	.141	3.572	63/64	.9844	25.003	**2-1/2**	2.500	63.500	4-1/16	4.062	103.188
5/32	.156	3.969	**1**	1.000	25.400	–	2.5197	64.	4-1/8	4.125	104.775
–	.1575	4.	–	1.0236	26.	2-17/32	2.531	64.294	–	4.1338	105.
11/64	.172	4.366	1-1/32	1.0312	26.194	–	2.559	65.	4-3/16	4.1875	106.363
–	.177	4.5	1-1/16	1.062	26.988	2-9/16	2.562	65.088	4-1/4	4.250	107.950
3/16	.1875	4.763	–	1.063	27.	2-19/32	2.594	65.881	4-5/16	4.312	109.538
–	.1969	5.	1-3/32	1.094	27.781	–	2.5984	66.	–	4.3307	110.
13/64	.203	5.159	–	1.1024	28.	2-5/8	2.625	66.675	4-3/8	4.375	111.125
–	.2165	5.5	1-1/8	1.125	28.575	–	2.638	67.	4-7/16	4.438	112.713
7/32	.219	5.556	–	1.1417	29.	2-21/32	2.656	67.469	**4-1/2**	4.500	114.300
15/64	.234	5.953	1-5/32	1.156	29.369	–	2.6772	68.	–	4.5275	115.
–	.2362	6.	–	1.1811	30.	2-11/16	2.6875	68.263	4-9/16	4.562	115.888
1/4	.250	6.350	1-3/16	1.1875	30.163	–	2.7165	69.	4-5/8	4.625	117.475
–	.2559	6.5	1-7/32	1.219	30.956	2-23/32	2.719	69.056	4-11/16	4.6875	119.063
17/64	.2656	6.747	–	1.2205	31.	2-3/4	2.750	69.850	–	4.7244	120.
–	.2756	7.	**1-1/4**	1.250	31.750	–	2.7559	70.	4-3/4	4.750	120.650
9/32	.281	7.144	_	1.2598	32.	2-25/32	2.781	70.6439	4-13/16	4.8125	122.238
–	.2953	7l5	1-9/32	1.281	32.544	–	2.7953	71.	4-7/8	4.875	123.825
19/64	.297	7.541	–	1.2992	33.	2-13/16	2.8125	71.4376	–	4.9212	125.
5/16	.312	7.938	1-5/16	1.312	33.338	–	2.8346	72.	4-15/16	4.9375	125.413
–	.315	8.	–	1.3386	34.	2-27/32	2.844	72.2314	**5**	5.000	127.000
21/64	.328	8.334	1-11/32	1.344	34.131	–	2.8740	73.	–	5.1181	130.
–	.335	8.5	1-3/8	1.375	34.925	2-7/8	2.875	73.025	5-1/4	5.250	133.350
11/32	.344	8.731	–	1.3779	35.	2-29/32	2.9062	73.819	**5-1/2**	5.500	139.700
–	.3543	9.	1-13/32	1.406	35.719	–	2.9134	74.	–	5.5118	140.
23/64	.359	9.128	–	1.4173	36.	2-15/16	2.9375	74.613	5-3/4	5.750	146.050
–	.374	9.5	1-7/16	1.438	36.513	–	2.9527	75.	–	5.9055	150.
3/8	.375	9.525	–	1.4567	37.	2-31/32	2.969	75.406	**6**	6.000	152.400
25/64	.391	9.922	1-15/32	1.469	37.306	–	2.9921	76.	6-1/4	6.250	158.750
–	.3937	10.	–	1.4961	38.	**3**	3.000	76.200	–	6.2992	160.
13/32	.406	10.319	**1-1/2**	1.500	38.100	3-1/32	3.0312	76.994	**6-1/2**	6.500	165.100
–	.413	10.5	1-17/32	1.531	38.894	–	3.0315	77.	–	6.6929	170.
27/64	.422	10.716	–	1.5354	39.	3-1/16	3.062	77.788	6-3/4	6.750	171.450
–	.4331	11.	1-9/16	1.562	39.688	–	3.0709	78.	**7**	7.000	177.800
7/16	.438	11.113	–	1.5748	40.	3-3/32	3.094	78.581	–	7.0866	180.
29/64	.453	11.509	1-19/32	1.594	40.481	–	3.1102	79.	–	7.4803	190.
15/32	.469	11.906	–	1.6142	41.	3-1/8	3.125	79.375	7-1/2	7.500	190.500
–	.4724	12.	1-5/8	1.625	41.275	–	3.1496	80.	–	7.8740	200.
31/64	.484	12.303	–	1.6535	42.	3-5/32	3.156	80.169	**8**	8.000	203.200
–	.492	12.5	1-21/32	1.6562	42.069	3-3/16	3.1875	80.963	–	8.2677	210.
1/2	.500	12.700	1-11/16	1.6875	42.863	–	3.1890	81.	8-1/2	8.500	215.900
–	.5118	13.	–	1.6929	43.	3-7/32	3.219	81.756	–	8.6614	220.
33/64	.5156	13.097	1-23/32	1.719	43.656	–	3.2283	82	**9**	9.000	228.600
17/32	.531	13.494	–	1.7323	44.	3-1/4	3.250	82.550	–	9.0551	230.
35/64	.547	13.891	**1-3/4**	1.750	44.450	–	3.2677	83.	–	9.4488	240.
–	.5512	14.	–	1.7717	45.	3-9/32	3.281	83.344	9-1/2	9.500	241.300
9/16	.563	14.288	1-25/32	1.781	45.244	–	3.3071	84.	–	9.8425	250.
–	.571	14.5	–	1.8110	46.	3-5/16	3.312	84.1377	**10**	10.000	254.001
37/64	.578	14.684	1-13/16	1.8125	46.038	3-11/32	3.344	84.9314	–	10.2362	260.
–	.5906	15.	1-27/32	1.844	46.831	–	3.3464	85.	–	10.6299	270.
19/32	.594	15.081	–	1.8504	47.	3-3/8	3.375	85.725	**11**	11.000	279.401
39/64	.609	15.478	1-7/8	1.875	47.625	–	3.3858	86.	–	11.0236	280.
5/8	.625	15.875	–	1.8898	48.	3-13/32	3.406	86.519	–	11.4173	290.
–	.6299	16.	1-29/32	1.9062	48.419	–	3.4252	87.	–	11.8110	300.
41/64	.6406	16.272	–	1.9291	49.	3-7/16	3.438	87.313	**12**	12.000	304.801
–	.6496	16.5	1-15/16	1.9375	49.213	–	3.4646	88.	13	13.000	330.201
21/32	.656	16.669	–	1.9685	50.	3-15/32	3.469	88.106	–	13.7795	350.
–	.6693	17.	1-31/32	1.969	50.006	**3-1/2**	3.500	88.900	14	14.000	355.601
43/64	.672	17.066	**2**	2.000	50.800	–	3.5039	89.	15	15.000	381.001
11/16	.6875	17.463	–	2.0079	51.	3-17/32	3.531	89.694	–	15.7480	400.
45/64	.703	17.859	2-1/32	2.03125	51.594	–	3.5433	90.	16	16.000	406.401
–	.7087	18.	–	2.0472	52.	3-9/16	3.562	90.4877	17	17.000	431.801
23/32	.719	18.256	2-1/16	2.062	52.388	–	3.5827	91.	–	17.7165	450.
–	.7283	18.5	–	2.0866	53.	3-19/32	3.594	91.281	18	18.000	457.201
47/64	.734	18.653	2-3/32	2.094	53.181	–	3.622	92.	19	19.000	482.601
–	.7480	19.	2-1/8	2.125	53.975	3-5/8	3.625	92.075	–	19.6850	500.
3/4	.750	19.050	–	2.126	54	3-21/32	3.656	92.869	**20**	20.000	508.001
49/64	.7656	19.447	2-5/32	2.156	54.769	–	3.6614	93.			

METRIC TABLES

LINEAR	One METER (m) = 10 decimeter (dm) = 100 centimeter (cm) = 1000 millimeters (mm) 1000 meters = One kilometer (km)
SQUARE	One SQUARE METER (m2) = 100 sq decimeters (dm2) = 1000 sq centimeters (cm2) = 1,000,000 sq millimeters (mm2)
CUBIC	One CUBIC METER (m3) = 1000 cu decimeter (dm3) = 1,000,000 cu centimeters (cm3)
CAPACITY	One LITRE (L) = 10 decilitres (dL) = 1000 millilitres (mL) 100 litres = One Hectolitre (hL)
WEIGHT	One DILOGRAM (kg) = 100 decagrams (dkg) = 1000 grams (g) 100 kilos = One metric cent (q) 1000 kilos = One ton (t)
PRESSURE	KILO PER SQUARE CENTIMETER (kg/cm2) One kilo per sq centimeter = One ATMOSPHERE (atm)
TEMPERATURE	CENTIGRADE degree (°C) = CELCIUS degree (°C)

METRIC CONVERSION EQUIVALENTS

LINEAR

INCH to METRIC
1 inch = 25,400 millimeters
1 inch = 2.540 centimeters
1 foot = 304.800 millimeters
1 foot = 30.480 centimeters
1 foot = 0.3048 meters
1 yard = 91.4400 centimeters
1 yard = 0.9144 meters
1 mile = 1.609.35 meters
1 mile = 1.609 kilometers

METRIC to INCH
1 millimeter = .0393700 inches
1 centimeter = .393700 inches
1 meter = 39.3700 inches
1 meter = 3,2808 feet
1 meter = 1.0936 yards
1 kilometer = .62137 miles

AREA

SQ. INCH to METRIC
1 sq inch = 645.16 sq millimeters
1 sq inch = 6.4516 sq centimeters
1 sq foot = 929.00 sq centimeters
1 sq foot = .0929 sq meters
1 sq yard = .836 sq meters
1 sq mile = 2.5889 sq kilometers

METRIC to SQ. INCH
1 sq millimeter = .00155 sq inches
1 sq centimeter = .1550 sq inches
1 sq meter = 10.7640 sq feet
1 sq meter = 1.196 sq yard
1 sq kilometer = .38614 sq miles

CUBIC

CU. INCH to METRIC
1 cu inch = 16.387 sq centimeters
1 cu foot = .02832 cu meters
1 cu yard = .765 cu meters

METRIC to CU. INCH
1 cu centimeter = .0610 cu inches
1 cu meter = 35.314 cu feet
1 cu meter = 1.308 cu yards

CAPACITY

IMPERIAL to METRIC
1 fluid oz = 28.413 millilitres
1 fluid oz = 0.02841 litres
1 pint = 0.56826 litres
1 quart = 1.13652 litres
1 gallon = 4.546 litres

METRIC to IMPERIAL
1 millilitre = 0.035195 fluid oz
1 centilitre = 0.35195 fluid oz
1 decilitre = 3.5195 fluid oz
1 litre = 0.88 quarts
1 hectolitre = 21.9969 gallons

WEIGHT

AVOIR DUPOIS to METRIC
1 grain = 64.7989 milligrams
1 ounce = 28.35 grams
1 lb = .4536 kilograms
1 short ton (2000 lb) = 907.200 kilograms
1 short ton (2000 lb) = 9.072 metric cents
1 short ton (2000 lb) = 9.072 ton

METRIC to AVOIR DUPOIS
1 gram = 15.432 grains
1 dekogram = .353 oz
1 kilogram = 2.2046 pounds
1 metric cent = 220.46 pounds
1 ton = 2204.6 lb
1 ton = 1.102 short tons

PRESSURE

POUNDS/INCHES to METRIC
1 pound/sq inch = .0703 kilogram per square centimeter
1 pound/sq inch = .0703 atmosphere (metric)

METRIC to POUNDS/INCHES
1 kilogram/sq centimeter = 14.223 pounds/sq inch
1 kilogram/sq centimeter = 1 atmosphere

TEMPERATURE

FAHRENHEIT to CELSIUS
1 Fahrenheit degree (°F) = 1.8 x (°C) plus 32

CELSIUS to FAHRENHEIT
1 Centigrade (Celsius) degree (°) = .556 x (°F minus 32)

RECOMMENDED TAPPING DRILL SIZE

M (ISO METRIC COARSE)

Size mm	Pitch mm	Drill mm
M1	.25	.75
M1.1	.25	.85
M1.2	.25	.95
M1.4	.3	1.1
M1.6	.35	1.25
M1.8	.35	1.45
M2	.4	1.6
M2.2	.45	1.75
M2.5	.45	2.05
M3	.5	2.5
M3.5	6	2.9
M4	.7	3.3
M4.5	.75	3.75
M5	.8	4.2
M6	1	5
M7	1	6
M8	1.25	6.75
M9	1.25	7.75
M10	1.5	8.5
M11	1.5	9.5
M12	1.75	10.2
M14	2	12
M16	2	14
M18	2.5	15.5
M20	2.5	17.5
M22	2.5	19.5
M24	3	21
M27	3	24
M30	3.5	26.5
M33	3.5	29.5
M36	4	32
M39	4	35
M42	4.5	37.5
M45	4.5	40.5
M48	5	43
M52	5	47
M56	5.5	50.5
M60	5.5	54.5
M64	6	58
M68	6	62
M72	6	66
M76	6	70

MF (ISO METRIC FINE)

Size mm	Pitch mm	Drill mm
M2	.25	1.75
M2.2	.25	1.95
M2.3	.25	2.05
M2.5	.35	2.15
M2.6	.35	2.25
M3	.35	2.65
M3.5	.35	3.15
M4	.35	3.65
M4	.5	3.5
M5	.35	4.65
M5	.5	4.5
M5	.75	4.25
M5.5	.5	5
M6	.5	5.5
M6	.75	5.25
M7	.75	6.25
M8	.5	7.5
M8	.75	7.25
M8	1	7
M9	.75	8.25
M9	.1	8
M10	.5	9.5
M10	.75	9.25
M10	1	9
M10	1.25	8.75
M11	.75	10.25
M11	1	10
M11	1.25	9.75
M12	.5	11.5
M12	.75	11.25
M12	1	11
M12	1.25	10.75
M12	1.5	10.5
M14	1	13
M14	1.25	12.75
M14	1.5	12.5
M15	.75	14.25
M15	1	14
M15	1.5	13.5
M16	.5	15.5
M16	.75	15.25
M16	1	15
M16	1.25	14.75
M16	1.5	14.5
M17	1	16
M17	1.5	15.5
M18	.75	17.25
M18	1.25	16.75
M18	1.5	16.5
M18	2	16
M19	1	18
M20	1	19
M20	1.5	18.5
M20	2	18
M22	1	21
M22	1.5	20.5
M22	2	20
M24	1	23

MF (ISO METRIC FINE)

Size mm	Pitch mm	Drill mm
M24	1.5	22.5
M24	2	22
M25	1	24
M25	1.5	23.5
M25	2	23
M27	1	26
M27	1.5	25.5
M27	2	25
M28	1	27
M28	1.5	26.5
M28	2	26
M30	1	29
M30	1.5	28.5
M30	2	28
M30	3	27
M32	1	31
M32	1.5	30.5
M32	2	30
M33	1.5	31.5
M33	2	31
M33	3	30
M35	1.5	33.5
M35	2	33
M35	3	32
M36	1	35
M36	1.5	34.4
M36	2	34
M36	3	33
M38	1	37
M38	1.5	36.5
M38	2	36
M39	1.5	37.5
M39	2	37
M39	3	36
M40	1	39
M40	1.5	38.5
M40	3	37
M42	1.5	40.5
M42	2	40
M42	3	39
M42	4	38
M45	1.5	43.5
M45	2	43
M45	3	42
M48	1.5	46.5
M48	2	46
M48	3	45
M48	4	44
M50	1.5	48.5
M50	2	48
M50	3	47
M52	1.5	50.5
M52	2	50
M52	3	49
M52	4	48
M56	2	54
M56	4	52

All information is strictly informative

QUOTE

"I know of no more disagreeable situation than to be left feeling generally angry without anybody in particular to be angry at."

FRANK MOORE COLBY

TAP DRILL SIZES
(Bolt Threads)

Thread	Drill
0-80	3/64
1-64	53
1-72	53
2-56	51
2-64	50
3-48	5/64
3-56	46
4-40	43
4-48	42
5-40	39
5-44	37
6-32	36
6-40	33
8-32	29
8-36	29
10-24	25
10-32	21
12-24	17
12-28	15
1/4-20	7
1/4-28	3
5/16-18	F
5/16-24	I
3/8-16	5/16
3/8-24	Q
7/16-14	U
7/16-20	W
1/2-13	27/64
1/2-20	29/64
9/16-12	31/64
9/16-18	33/64
5/8-11	17/32
5/8-18	37/64
3/4-10	21/32
3/4-16	11/16
7/8-9	49/64
7/8-14	13/16
1-8	7/8
1-12	59/64
1-14	15/16

TAP DRILL SIZES
NPT (Pipe) Thread

Thread	Drill
1/16 (27)	D
1/8 (27)	R
1/4 (18)	7/16
3/8 (18)	37/64
1/2 (14)	23/32
3/4 (14)	59/64
1" (11-1/2)	1-5/32
1-1/4 (11-1/2)	1-1/2
1-1/2 (11-1/2)	1-47/64
2" (11-1/2)	2-7/32

DECIMAL EQUIVALENTS
Fractional • Wire • Metric • Letter Sizes

Drill Size	Decimal
0.10	.0039
97	.0059
96	.0063
95	.0067
94	.0071
93	.0075
92	.0079
0.20	.0079
91	.0083
90	.0087
89	.0091
88	.0095
87	.0100
86	.0105
85	.0010
84	.0015
0.30	.0018
83	.0120
82	.0125
81	.0130
80	.0135
0.35	.0138
79	.0145
1/64	**.0156**
0.40	.0157
78	.0160
0.45	.0177
77	.0180
0.50	.0197
76	.0200
75	.0210
0.55	.0217
74	.0225
0.60	.0236
73	.0240
72	.0250
0.65	.0256
71	.0260
0.70	.0276
70	.0280
69	.0292
0.75	.0295
68	.0310
1/32	**.0312**
0.80	.0315
67	.0320
66	.0330
0.85	.0335
65	.0350
0.90	.0354
64	.0360
63	.0370
0.95	.0374
62	.0380
61	.0390
1.00	.0394
60	.0400
59	.0410
1.05	.0413
58	.0420
57	.0430
1.10	.0433
1.15	.0453
56	.0465
3/64	**.0469**
1.20	.0472
1.25	.0492
1.30	.0512
55	.0520

Drill Size	Decimal
1.35	.0531
54	.0550
1.40	.0551
1.45	.0571
1.50	.0591
53	.0595
1.55	.0610
1/16	**.0625**
1.60	.0630
52	.0635
1.65	.0650
1.70	.0669
51	.0570
1.75	.0689
50	.0700
1.80	.0709
1.85	.0728
49	.0730
1.90	.0748
48	.0760
1.95	.0768
5/64	**.0781**
47	.0785
2.00	.0787
2.05	.0807
46	.0810
45	.0820
2.10	.0827
2.15	.0846
44	.0860
2.20	.0866
2.25	.0886
43	.0890
2.30	.0906
2.35	.0925
42	.0935
3/32	**.0938**
2.40	.0945
41	.0960
2.45	.0965
40	.0980
2.50	.0984
39	.0995
38	.1015
2.60	.1024
37	.1040
2.70	.1063
36	.1065
7/64	**.1094**
35	.1100
2.80	.1102
34	.1110
33	.1130
2.90	.1142
32	.1160
3.00	.1181
31	.1200
3.10	.1220
1/8	**.1250**
3.20	.1260
30	.1285
3.30	.1299
3.40	.1339
29	.1360
3.50	.1378
28	.1405
9/64	**.1406**
3.60	.1417
27	.1440

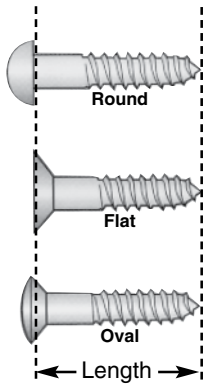
Drill Size	Decimal
3.70	.1457
26	.1470
25	.1495
3.80	.1496
24	.1520
3.90	.1535
23	.1540
5/32	**.1562**
22	.1570
4.00	.1575
21	.1590
20	.1610
4.10	.1614
4.20	.1654
19	.1660
4.30	.1693
18	.1695
11/64	**.1719**
17	.1730
4.40	.1732
16	.1770
4.50	.1772
15	.1800
4.60	.1811
14	.1820
13	.1850
4.70	.1850
3/16	**.1875**
12	.1890
4.80	.1890
11	.1910
4.90	.1929
10	.1935
9	.1960
5.00	.1969
8	.1990
5.10	.2008
7	.2010
13/64	**.2031**
6	.2040
5.20	.2047
5	.2055
5.30	.2087
4	.2090
5.40	.2126
3	.2130
5.50	.2165
7/32	**.2188**
5.60	.2205
2	.2210
5.70	.2244
1	.2280
5.80	.2283
5.90	.2323
A	.2340
15/64	**.2344**
6.00	.2362
B	.2380
6.10	.2402
C	.2420
6.20	.2441
D	.2460
6.30	.2480
1/4	**.2500**
E	.2500
6.40	.2520
6.50	.2559
F	.2570
6.60	.2598

Drill Size	Decimal
G	.2610
6.70	.2638
17/64	**.2656**
H	.2660
6.80	.2677
6.90	.2717
I	.2720
7.00	.2756
J	.2770
7.10	.2795
K	.2810
9/32	**.2812**
7.20	.2835
7.30	.2874
L	.2900
7.40	.2913
M	.2950
7.50	.2953
19/64	**.2969**
7.60	.2992
N	.3020
7.70	.3031
7.80	.3071
7.90	.3110
5/16	**.3125**
8.00	.3150
O	.3160
8.10	.3189
8.20	.3228
P	.3230
8.30	.3268
21/64	**.3281**
8.40	.3307
Q	.3320
8.50	.3346
8.60	.3386
R	.3390
8.70	.3425
11/32	**.3438**
8.80	.3465
S	.3480
8.90	.3504
9.00	.3543
T	.3580
9.10	.3583
23/64	**.3594**
9.20	.3622
9.30	.3661
U	.3680
9.40	.3701
9.50	.3740
3/8	**.3750**
V	.3770
9.60	.3780
9.70	.3819
9.80	.3858
W	.3860
9.90	.3998
25/64	**.3906**
10.00	.3937
X	.3970
10.20	.4016
Y	.4040
10.30	.4055
13/32	**.4062**
Z	.4130
10.50	.4134
27/64	**.4219**
10.80	.4252

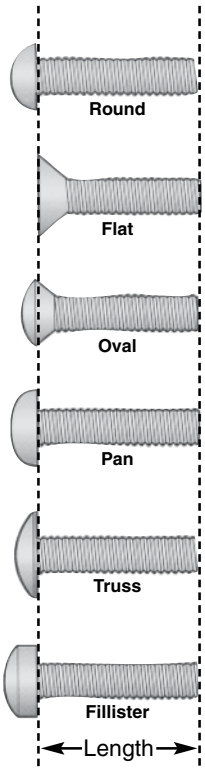
Drill Size	Decimal
11.00	.4331
7/16	**.4375**
11.20	.4409
11.50	.4528
29/64	**.4531**
11.80	.4646
15/32	**.4688**
12.00	.4724
12.20	.4803
31/64	**.4844**
12.50	.4921
1/2	**.5000**
13.00	.5118
33/64	.5156
17/32	.5312
13.50	.5315
35/64	.5469
14.00	.5512
9/16	**.5625**
14.50	.5709
37/64	.5781
15.00	.5906
19/32	.5938
39/64	.6094
15.50	.6102
5/8	**.6250**
16.00	.6299
41/64	.6406
16.50	.6495
21/32	.5452
17.00	.6693
43/64	.6719
11/16	**.6875**
17.50	.6890
45/64	.7031
18.00	.7087
23/32	.7188
18.50	.7283
47/64	.7344
19.00	.7480
3/4	**.7500**
49/64	.7656
19.50	.7677
25/32	.7812
20.00	.7874
51/64	.7969
20.50	.8071
13/16	**.8125**
21.00	.8268
53/64	.8281
27/32	.8438
21.50	.8465
55/64	.8594
22.00	.8661
7/8	**.8750**
22.50	.8858
57/64	.8906
23.00	.9055
29/32	.9062
59/64	.9219
23.50	.9252
15/16	**.9375**
24.00	.9449
61/64	.9531
24.50	.9646
31/32	.9688
25.00	.9843
63/64	.9844
1	1.000

FASTENER MEASUREMENT CHART

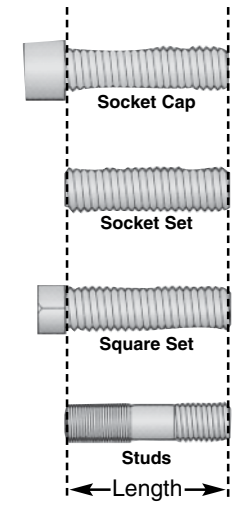
WOOD SCREWS



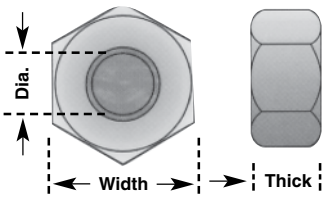
MACHINE SCREWS



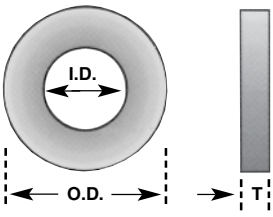
SET SCREWS and STUDS



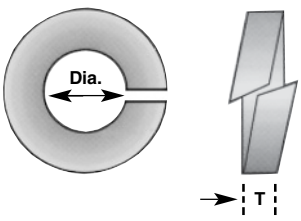
HEXAGON NUTS



WASHERS

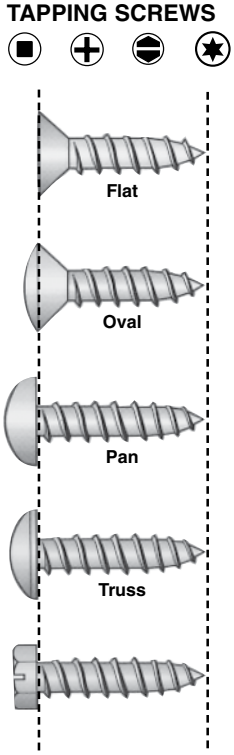


Plain Steel Washers

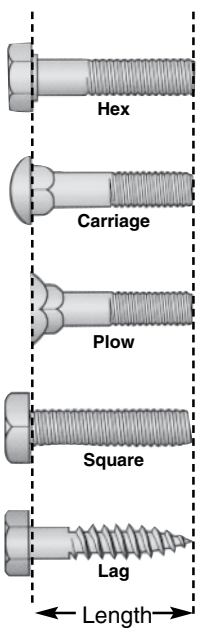


Lock Washers

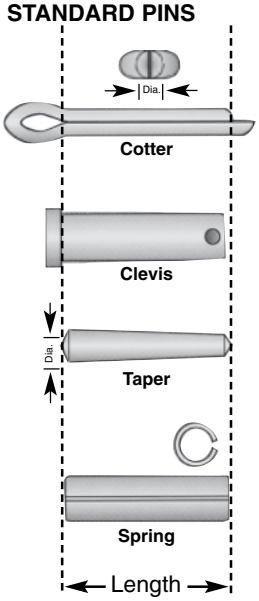
TAPPING SCREWS



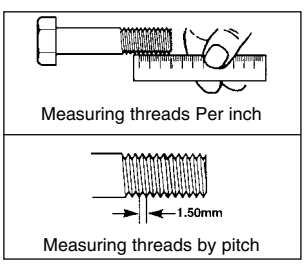
CAP SCREWS and BOLTS



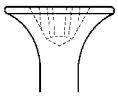
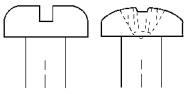
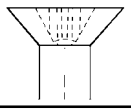
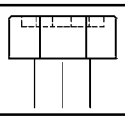
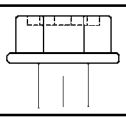
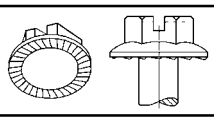
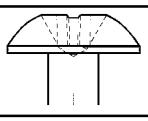
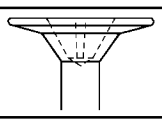
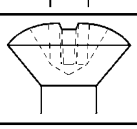
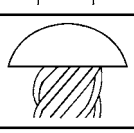
STANDARD PINS



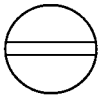
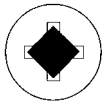
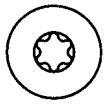
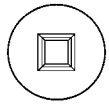
Measuring Threads



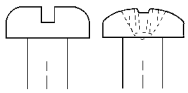
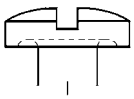
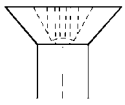
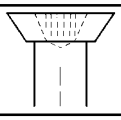
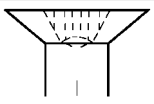
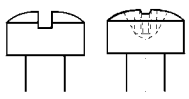
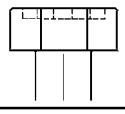
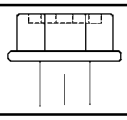
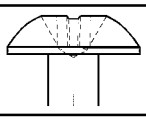
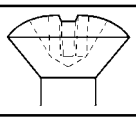
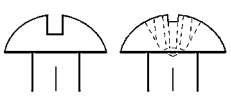
SELF-TAPPING SCREWS – HEAD STYLES

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 bearing heads.
	Flat 82˚	A countersunk head with a flat top surface and a coneshaped 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 gauge 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	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 same nominal size	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.
	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.

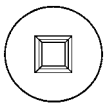
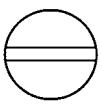
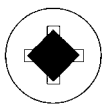
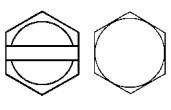
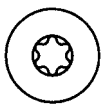
DRIVE TYPES

Schematic						
Drive Type	**Phillips**	**Slotted**	**Phillips/Sq. Drive Combination**	**Hex / Slotted-hex**	**Torx**	**Square**
Uses	Increases productivity with excellent torque transmission and resists cam-out.	Accepts standard blade screwdriver. Requires less downward pressure to drive parts than those with recessed openings.	Accepts Phillips and square drive screwdrivers. Used when fastener is expected to be backed out several times.	Accepts hex wrench. Slotted drive is added to make it easier to remove the fastener.	Positive-engaging, fast-locating method which transmits drive torque with less required downward pressure.	Provides good control in driving. Always use a driver bit of proper size in good condition.

MACHINE SCREWS – HEAD STYLES

Schematic	Head Style	Description	Applications / Advantages
	Pan	Slotted pan heads have a flat or gently rounded top surface, cylindrical sides and a flat bearing surface. Phillips and torx pan heads have a rounded top, cylindrical sides and a flat bearing surface.	Has a general purpose bearing area. Can be substituted in most applications for round, truss or binding heads.
	Binding Undercut	Has a rounded top surface and slightly tapered sides. the bearing surface is flat with an annular undercut adjacent to the shank.	Preferred design for making a firm electrical connection.
	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 gauge 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.
	Flat 100˚	A countersunk head with a flat top surface and a cone-shaped bearing surface with a head angle of approximately 100˚.	Preferred over an 82˚ flat head when fastening in soft materials – the 100˚ countersunk head distributes pressure over a larger surface area.
	Fillister	Has a rounded top surface, cylindrical sides, and a flat bearing surface. The greater side height is what distinguishes a fillister head from a pan head.	Preferred style for use in counterbored holes.
	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 and 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.	Offers greater protection to the mating surface than a standard indented hex head. Increases bearing area reduces likelihood of crushing mating surfaces.
	Truss	Has a low rounded top surface 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 assembly appearance.
	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.
	Round	Has a semi-elliptical top surface and a flat bearing surface	Sometimes preferred over pan head for its smooth surface and appearance.

DRIVE TYPES

Schematic						
Drive Type	**Square**	**Phillips**	**Slotted**	**Phillips/Sq. Drive Combination**	**Hex / Slotted-hex**	**Torx**
Uses	Most recommended drive type. Provides good control in driving. Always use a driver bit of proper size in good condition.	Provides good control in driving. Always use a driver bit in good condition.	Accepts standard blade screwdrivers. Requires less downward pressure to drive slotted parts than it does those with cross-dressed openings.	Accepts Phillips and square drive screwdrivers. Often used when fastener is expected to be driven and backed-out several times.	Accepts hex wrench. Slotted drive is added to make it easier to remove the fastener.	Positive-engaging, fast-locating method of transmitting drive torque and optimizing worker efficiency.

Point Styles

Die Point: Minimum reduction of point is approximately 10% below maximum minor diameter.

Dog Point: Straight pointed section reduced in diameter slightly below root diameter of thread for ease in starting.

Pinch Point (Rounded): Point has rounded contour with pinch-off marks for aligning or assembling parts requiring pilot action.

Nail Point (Pinched): Has sharp point and slightly squared surface to lock against wood or other soft material.

Cupped Point: Depression in end reduces area in contact with surface to increase its holding power under pressure.

Cone Point: Offers smooth surface, accurate length, and sharp point.

Type A Point: Thread-forming screw for use in thin metal .015 to .050 thick.

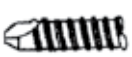
Type AB Point: Thread-forming screw combining location-type point of Type A with thread size and pitch of Type B.

Type F Point: Thread-cutting machine screw with blunt tapered point, and multi-cutting edges. For heavy-gauge metals, die castings, and plastic.

Type FZ Point: Thread cutting. Blunt tapered point and multi-cutting edges. For plastics, die castings, metal-clad and resin-impregnated plywoods.

Type 1 Point: Thread-cutting screw with single flute. Produces standard machine screw thread for field replacement.

Type 25 Point: Thread-cutting. Type B thread with large chip clearing and cutting edges for plastics and other soft materials.



Self-Drilling: Eliminates all hole preparation – no punching, drilling, or tapping needed.

Drill Point: Cutting edge drills through sheet metal at peak speed. Mated threads increase strip and back-out pressures.

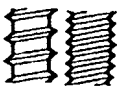
Gimlet Point: A cone-shaped threaded point that quickly penetrates and threads into softer materials.

Self-Tapping Screw Usage Guide

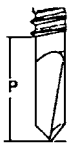
Note: Point A/AB = Sharp B = Blunt

SCREW SIZE (in)	METAL (ga)	(in)	POINT Type	DRILL No.
No. 4	28	.016	A/AB/B	44
(.112)	26	.019	A/AB/B	44
24	.025	B	43	
	24	.025	A/AB	42
	22	.031	A/AB/B	42
	20	.038	A/AB/B	40
No. 6	28	.016	B	37
(.137)	26	.019	B	37
	24	.025	B	43
	22	.031	B	42
	20	.038	B	35
No. 6	28	.016	A/AB	39
(.138)	26	.019	A/AB	39
	24	.025	A/AB	39
	22	.031	A/AB	38
	20	.038	A/AB	36
No. 7	26	.019	B	32
(.151)	24	.025	B	32
	22	.031	B	32
	20	.038	B	32
	18	.050	B	31
	16	.063	B	30
No. 7	28	.016	A/AB	39
(.155)	24	.025	B	32
	22	.031	B	32
	20	.038	B	32
	18	.050	B	31
	16	.063	B	30
No. 7	28	.016	A/AB	39
(.155)	26	.019	A/AB	39
	24	.025	A/AB	39
	22	.031	A/AB	38
	20	.038	A/AB	36
No. 8	26	.019	B	32
(.163)	24	.025	B	32
	22	.031	B	32
	20	.038	B	32
	18	.050	B	30
No. 8	26	.019	A/AB	33
(.165)	24	.025	A/AB	39
	22	.031	A/AB	38
	20	.038	A/AB	36
No. 10	26	.019	B	27
(.186)	24	.025	B	27
	22	.031	B	27
	20	.038	B	27
	18	.050	B	27
No. 10	26	.019	A/AB	30
(.191)	24	.025	A/AB	30
	22	.031	A/AB	30
	20	.038	A/AB	29
	18	.050	A/AB	25
No. 12	24	.025	B	19
(.212)	22	.031	B	19
	20	.038	B	19
	18	.050	B	19
No. 12	24	.025	A/AB	26
(.218)	22	.031	A/AB	25
	20	.038	A/AB	24
	18	.050	A/AB	22
No. 14	24	.025	A/AB	14
(.251)	22	.031	A/AB	12
	20	.038	A/AB	11
	18	.050	A/AB	9
No. 14	22	.031	B	13
(.243)	20	.038	B	13
	18	.050	B	11
	16	.063	B	8

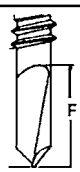
HEAD STYLE: Determine if the head style chosen will ensure stability during driving, and give the desired finished appearance and corrosion resistance.



THREAD DIAMETER & TYPE: Make sure that the choice of threads will provide good connection strength. Use "Recommended Material Thickness" column in chart below.

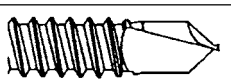
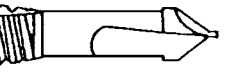
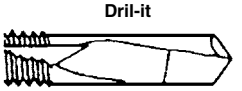


PILOT LENGTH: Make sure that the drilling operation will be completed before the threading operation begins.

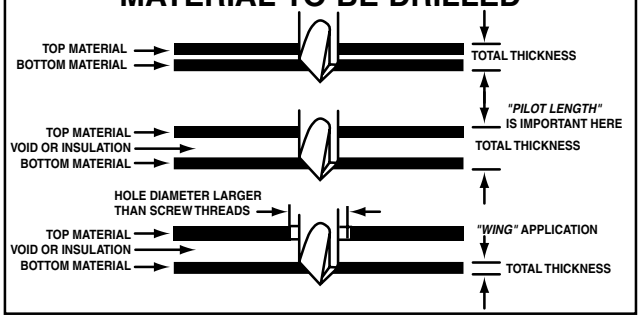


FLUTE LENGTH: Use the "Point Length" column in the chart below to determine if the point length is long enough.

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  Type 5	No. 12	.250 to .500	.625

MATERIAL TO BE DRILLED



DECIMAL EQUIVALENTS OF STANDARD GAUGES OF SHEET STEEL & ALUMINUM

Number of Gauge	Aluminum	Sheet Steel
000000	.580	–
00000	.5165	–
0000	.4600	.4062
000	.4096	.375
00	.3658	.3437
0	.3249	.3125
1	.2893	.2812
2	.2576	.2656
3	.2294	.2391
4	.2043	.2242
5	.1819	.2092
6	.1620	.1943
7	.1443	.1793
8	.1285	.1644
9	.1144	.1495
10	.1019	.1345
11	.0907	.1196
12	.0808	.1046
13	.0720	.0897
14	.0641	.0747
15	.0571	.0673
16	.0506	.0598
17	.0453	.0538
18	.0403	.0478
19	.0359	.0418
20	.0320	.0359
21	.0285	.0329
22	.0253	.0299
23	.0226	.0269
24	.0201	.0239
25	.0179	.0209
26	.0159	.0179
27	.0142	.0164
28	.0126	.0149
29	.0113	.0135
30	.0100	.0120
31	.0089	.0105
32	.0080	.0097
33	.0071	.0090
34	.0063	.0082
35	.0056	.0075
36	.0050	.0067
37	.0045	.0064
38	.0040	.0060

PLATING – COATINGS – FINISH

ZINC – Most common form of corrosion protection. "Commercial" zinc is electrically applied to a thickness of .00015 to .0002".
CADMIUM – A significantly better coating than zinc in salt environments with excellent lubricity. Applied electrically to a thickness of .0003 to .0005". Cadmium has become very expensive in recent years because of EPA regulations concerning disposal of its plating by-products.
MECHANICAL or PEEN plating – Utilizes glass balls or beads to mechanically pound a coating of zinc on to the fastener to an approximate thickness of .0065". Equal to "Hot Dip" Galvanizing.
COATINGS – Newest and most significant improvement in corrosion protection. IE Stalgard – Climaseal. These coatings are applied like paint over a zinc plated fastener and offer a superior form of protection.

BULK GRADE 5 AND 8 CAPSCREWS

	Diameter												
Length (in)	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"	1-1/2"
1/2	3300	1950	1300										
5/8	3000	1800	1200										
3/4	2700	1650	1100	750	475								
1	2200	1400	900	650	400	350	250	150					
1-1/4	1900	1100	800	550	375	300	225	140					
1-1/2	1600	1000	675	500	300	275	200	125	85	55			
1-3/4	1400	850	600	450	275	250	175	120	80	55			
2	1200	800	550	400	250	225	175	100	75	50	40	30	
2-1/4	1000	700	450	350	225	200	150	100	70	50			
2-1/2	900	600	400	300	225	175	125	90	65	45	35	25	
2-3/4	750	550	400	300	200	150	125	85	60	40			
3	750	500	325	275	200	150	100	80	55	40	30	25	15
3-1/4	600	450	325	250	175	125	100	75	50	40			
3-1/2	550	450	300	225	150	125	100	70	50	35	30	20	15
3-3/4	500	400	250	225	150	125	100	65	45	35			
4	450	400	250	200	150	100	90	60	45	35	25	20	12
4-1/2	450	300	225	175	125	100	80	55	40	30	20	15	12
5	400	250	225	150	125	100	75	45	35	25	20	15	11
5-1/2	400	250	175	150	100	75	70	45	35	25	20	15	10
6	350	250	175	125	100	75	65	40	30	25	15	15	10
6-1/2			175		100		60	40	30	20	15	14	9
7			150		90		55	35	25	20	15	12	9
7-1/2			150		80		55	35	25	20	15	12	8
8			150		80		50	35	25	18	15	10	8
9			130		75		45	30	23	15	13	10	7
10			120		65		40	30	20	15	12	10	6
12			100		55		35	25	17	13	10	8	5

WASHERS AND HEX NUTS

Length	HEX NUTS			USS WASHERS		SAE WASHERS		USS WASHERS Qty/100 lb	SAE WASHERS Qty/100 lb	LOCKWASHERS	
(in)	Pkg	Case	Bulk	Pkg	Bulk (lb)	Pkg	Bulk (lb)	(approx)	(approx)	Pkg	Case
#6	100	2000	15000	100	50					100	7500
#8	100	2000	15000	100	50					100	7500
#10	100	2000	15000	100	50			29400		100	7500
1/4	100	2000	5500	100	50	100	50	16200	24400	100	7500
5/16	100	2000	3600	100	50	100	50	9600	21200	100	7500
3/8	100	1500	2500	100	50	100	50	7460	15140	100	7500
7/16	50	800	1400	50	50	50	50	3800	11360	50	3750
1/2	50	800	1000	50	50	50	50	2740	5900	50	2500
9/16	25	300	650	25	50	25	50	2300	5740	25	1250
5/8	25	300	540	25	50	25	50	1290	3880	25	1250
3/4	20		325	20	50	20	50	1000	2360	20	1000
7/8	20		200	20	50	20	50	720	1720	20	780
1	20		135	20	50	20	50	580	1310	20	40
1-1/8	15		95	15	50			490		15	300
1-1/4	15		65	15	50			520		15	300
1-3/8	10		50	10	50			360		10	150
1-1/2	10		40	10	50			340		10	150
1-5/8			30	10	50			250			
1-3/4			23	10	50			230			
2			15	10	50			180			
2-1/4			10								
2-1/2			8								
2-3/4			6								
3			5								

QUOTE

"When I am working on a problem, I never think about beauty. I think only about how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong."

BUCKMINSTER FULLER