Fasteners

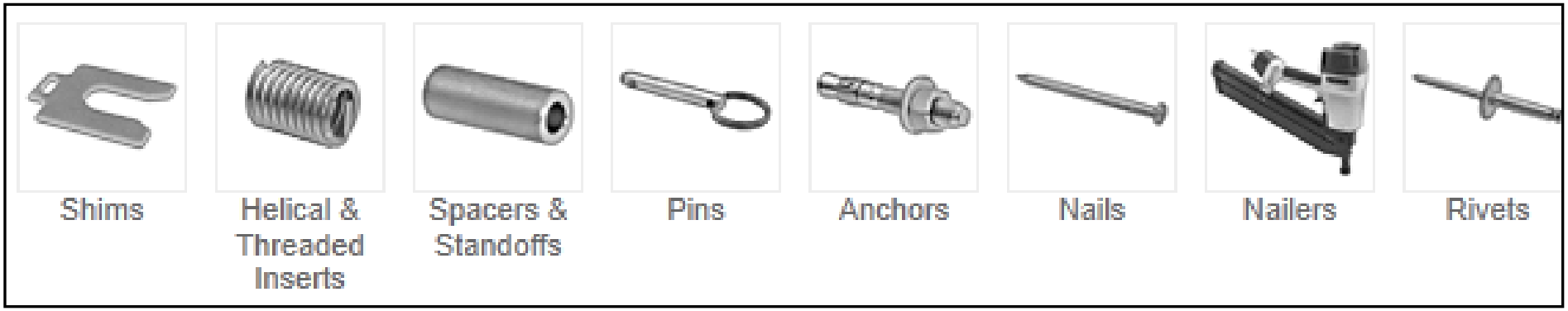
Fasteners connect parts

- **Bolts and nuts (threaded)**
- **Screws (threaded)**
- **Washers**
- **Keys**
- **Pins**
- **more**

Fasteners are not a permanent means of assembly like welding or adhesives.

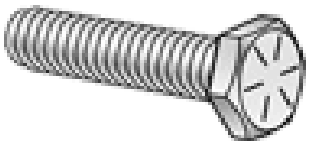
Purchasing information must be specified in a note to allow the fastener to be ordered correctly.

Commonly Used Fasteners

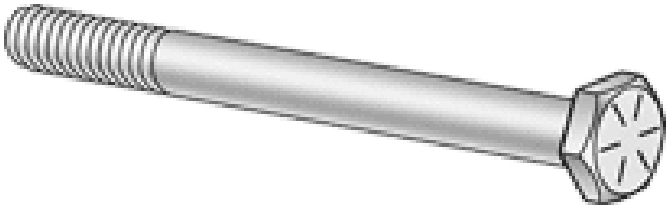


Commonly Used Fasteners

A **Bolt** has a head on one end and a thread on the other end. It is inserted through a hole and secured with a nut.



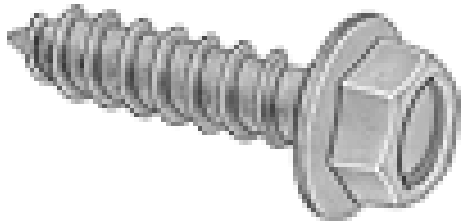
Fully Threaded



Partially Threaded

A chamfer on the end of the screw thread makes it easier to engage the nut.

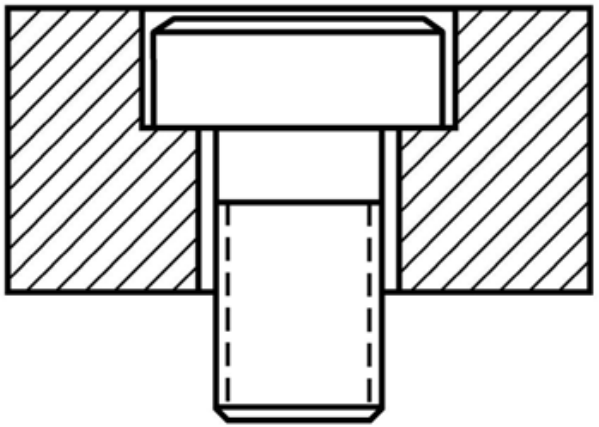
A **Screw** is designed to be used in a threaded hole - sometimes with a nut.

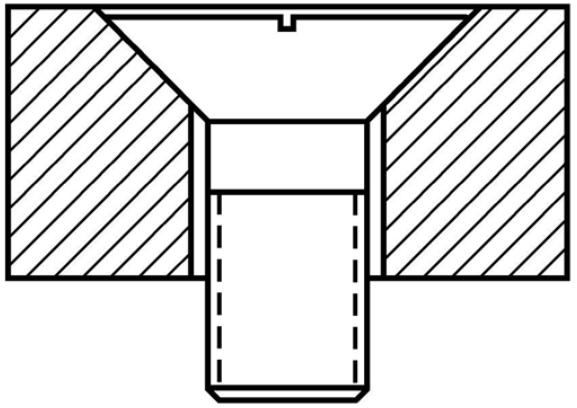


Bolt and Screw Clearances

Sometimes bolt or screw heads need to be flush with the surface.

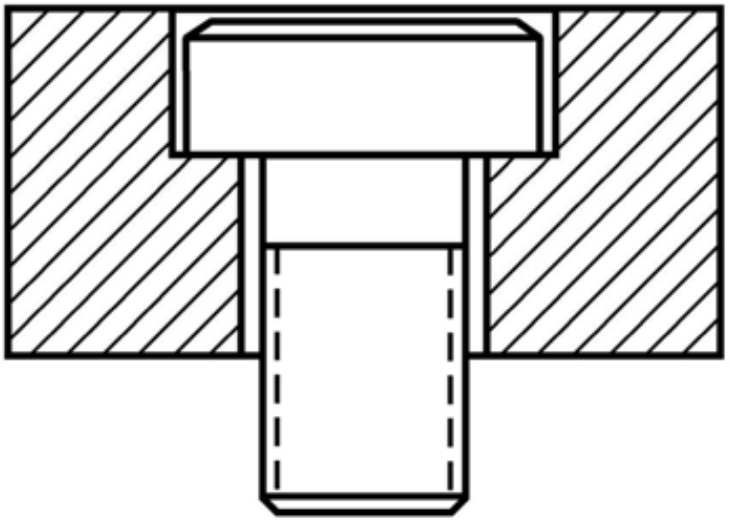
This can be achieved by using either a Counterbore or Countersink hole depending on the fasteners head shape.

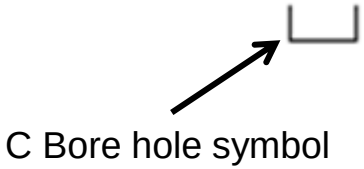




Bolt and Screw Clearances

A counterbore hole is designed to recess a bolt or screw head below the surface of a part.

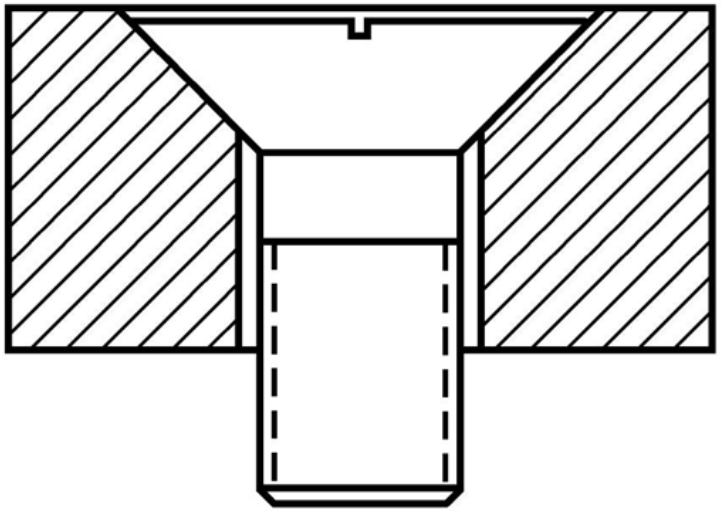




C Bore hole symbol

Bolt and Screw Clearances

A countersink hole is an angled hole designed to recess screws with angled heads.

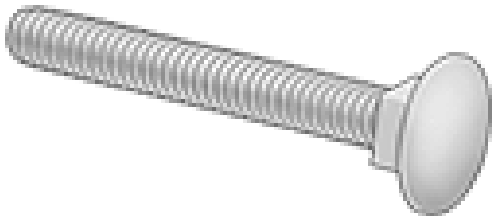


C Sink hole symbol

Commonly Used Fasteners

Carriage Bolt

A carriage bolt is mostly used in wood with a domed shape top and a square under the head, which is pulled into the wood as the nut is tightened.



Hex Bolt

A hex bolt has a hexagonal shaped top.

Stud

A stud is a rod with threaded ends.

Commonly Used Fasteners

Nut

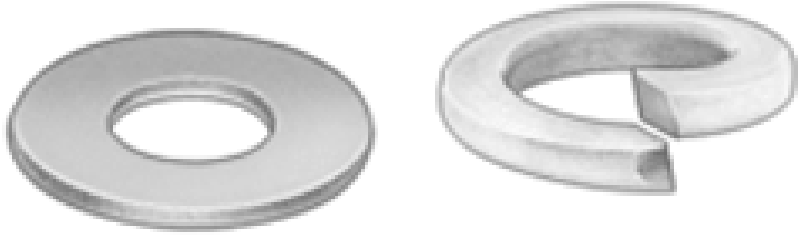
A nut is used to attach machine thread fasteners.

From left to right: **Hex** nut, **Wing** nut, and **Lock** nut.

Washer

A washer provides a greater contact surface under the fastener. This helps prevent a nut, bolt or screw from breaking through the material.

Flat vs. **Split Lock**.



Commonly Used Fasteners

Machine screw

A machine screw is similar to the slot-head cap screw but smaller, available in many styles and materials.
A machine screw is also commonly referred to as a stove bolt.

From top to bottom: **Slotted**, **Square** and **Phillips**.

Wood screw

A wood screw has a tapered shank and is for use exclusively in wood.
Available in a variety of head styles and materials.

From left to right: **Slotted**, **Phillips** and **Hex**.

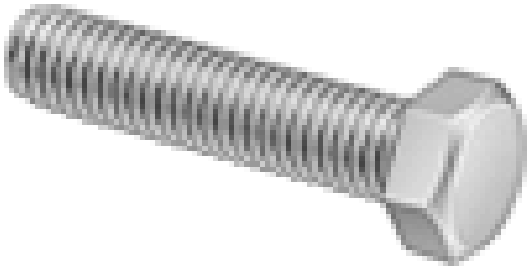
Commonly Used Fasteners

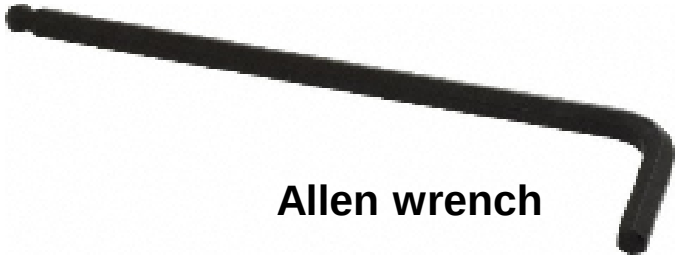
Cap Screw

A hexagon cap screw is similar to a bolt except it is used without a nut, and generally has a longer thread.

Cap screws are available in a variety of head styles and materials.

From left to right: **Hex** and **Allen**.





Allen wrench

Commonly Used Fasteners

Socket screw

A socket screw, also known as Allen head are fastened with a hexagon Allen wrench.

Available in several head styles and materials.

Allen wrench

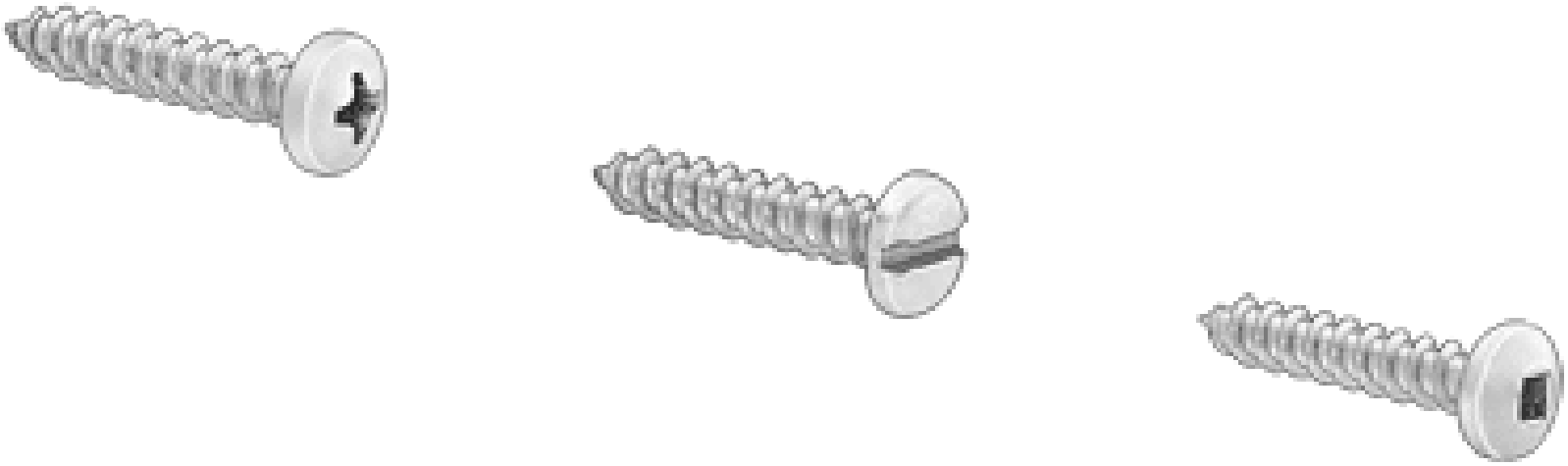
Commonly Used Fasteners

Sheet metal screw

A sheet metal screw is a highly versatile fastener designed for thin materials.

- can be used in wood, fiberglass and metal.
- available in steel and stainless steel.
- also called self-tapping screws.

From left to right: **Phillips**, **Slotted** and **Square**.



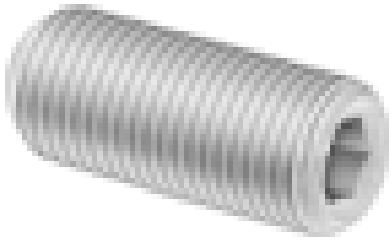
Commonly Used Fasteners

Set Screw

A set screw is used to prevent relative motion between two parts.

It is screwed into one part so that its point is pushed firmly against the other part.

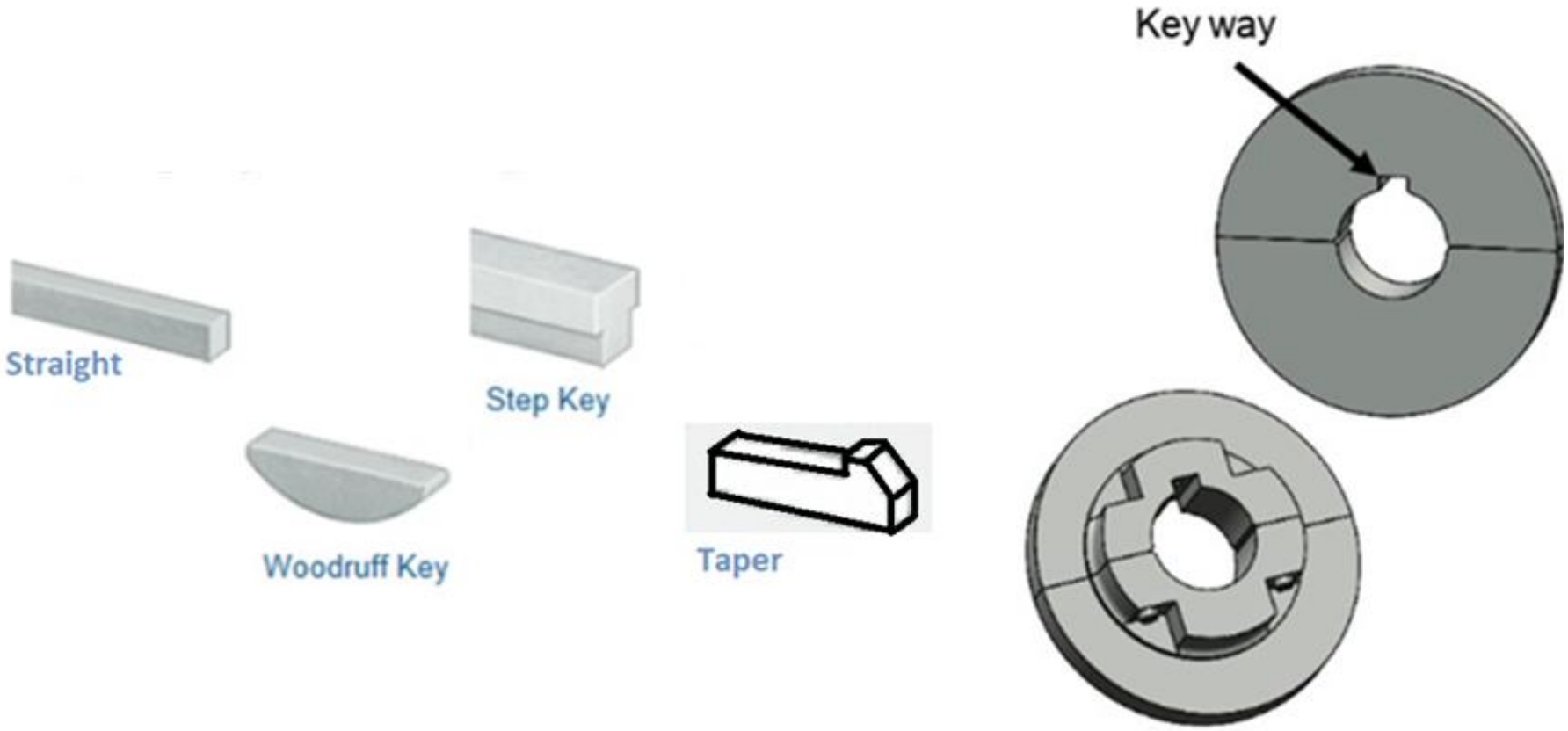
It is available in a variety of point styles and materials.



Commonly Used Fasteners

Key

A key is used to prevent relative motion between a shaft and a wheel, couplings, or similar parts attached to shafts.



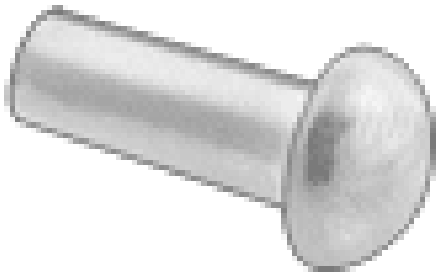
Commonly Used Fasteners

Rivet

A rivet is generally used to hold sheet metal parts together.

It is generally considered a permanent fasteners.

It is available in a variety of head styles and materials.



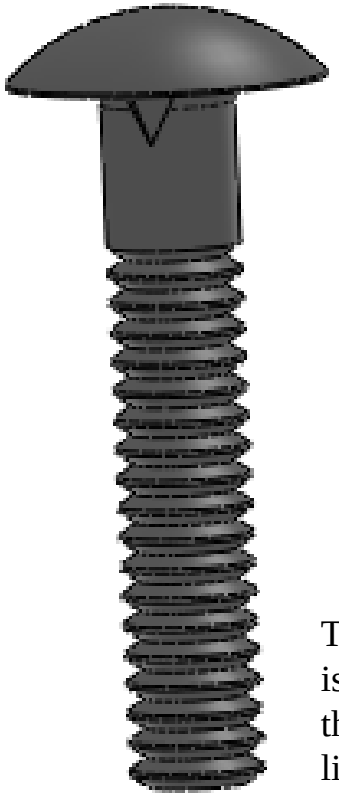
SAE Grades for Fasteners - SAE (J429)

The higher the number, the greater the fastener strength

The Society of Automotive Engineering has issued standard J429, which sets forth standards for the strength of a fastener.

The grades for inch-sized steel bolts range from 1 to 8, on the basis of the metal from which the bolt is made and the manner of manufacture.

Higher grade numbers mean increased strength with the exception that some grade 6 bolts are stronger than grade 7.



The SAE grade of a bolt is marked on it's head in the form of short radial lines, the number of lines being two less than the SAE grade (i.e.. 3 lines for grade 5).

SAE Grades for Fasteners - SAE (J429)

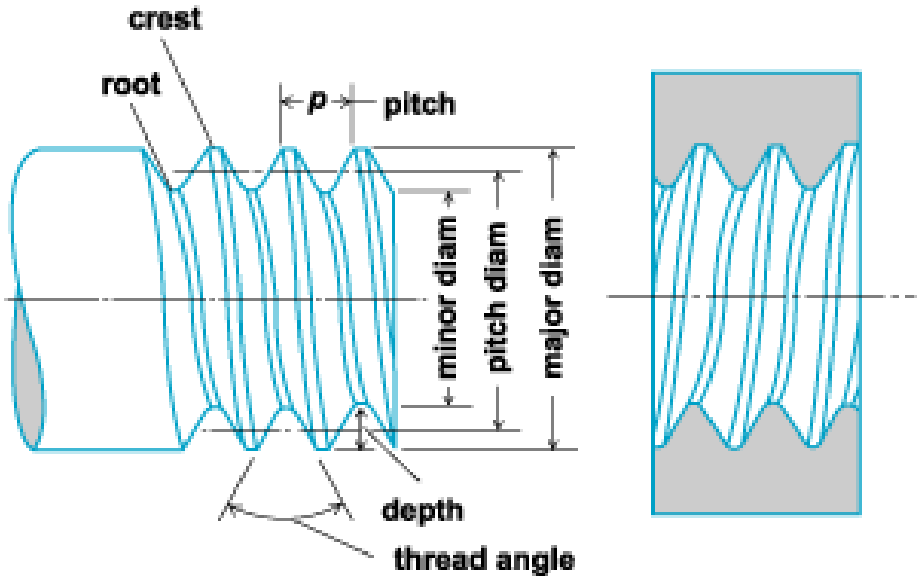
The higher the number, the greater the fastener strength

Identification Grade Mark	Specification	Fastener Description	Material	Nominal Size Range (in.)	Mechanical Properties		
					Proof Load (psi)	Yield Strength Min (psi)	Tensile Strength Min (psi)
 No Grade Mark	SAE J429 Grade 1	Bolts, Screws, Studs	Low or Medium Carbon Steel	1/4 thru 1-1/2	33,000	36,000	60,000
	ASTM A307 Grades A&B		Low Carbon Steel	1/4 thru 4	--	--	
	SAE J429 Grade 2		Low or Medium Carbon Steel	1/4 thru 3/4 Over 3/4 to 1-1/2	55,000 33,000	57,000 36,000	74,000 60,000
 No Grade Mark	SAE J429 Grade 4	Studs	Medium Carbon Cold Drawn Steel	1/4 thru 1-1/2	--	100,000	115,000
	SAE J429 Grade 5	Bolts, Screws, Studs	Medium Carbon Steel, Quenched and Tempered	1/4 thru 1 Over 1 to 1-1/2	85,000 74,000	92,000 81,000	120,000 105,000
	ASTM A449			1/4 thru 1 Over 1 to 1-1/2 Over 1-1/2 thru 3	85,000 74,000 55,000	92,000 81,000 58,000	120,000 105,000 90,000
	SAE J429 Grade 5.1	Sems	Low or Medium Carbon Steel, Quenched and Tempered	No. 6 thru 3/8	85,000	--	120,000
	SAE J429 Grade 5.2	Bolts, Screws, Studs	Low Carbon Martensitic Steel, Quenched and Tempered	1/4 thru 1	85,000	92,000	120,000

Thread Terminology

External thread (screw)
A thread on the external surface of a cylinder.

Internal thread (nut)
A thread on the internal surface of a cylinder.



Right-hand thread
A thread that when viewed axially winds in a clockwise and receding direction. Threads are *always right-hand* unless otherwise specified.

Left-hand thread
A thread that when viewed axially winds in a counterclockwise and receding direction. A left-hand thread must be designated *LH*.

Major diameter (Nominal diameter), D: The largest diameter of a screw thread.

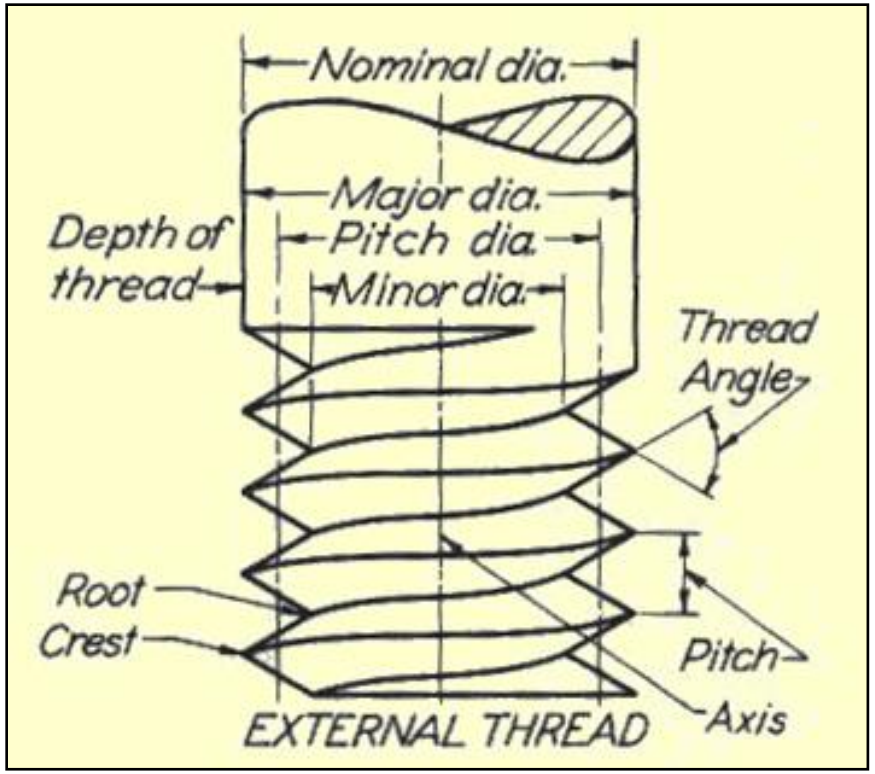
Minor diameter (tap drill diameter), d: The smallest diameter of a screw thread.

Thread Terminology

Pitch diameter
The diameter of an imaginary cylinder, the surface of which cuts the thread forms where the *width of the thread and groove are equal.*

Crest
The edge or surface that joins the sides of a thread and is farthest from the *cylinder or cone* from which the thread projects.

Root
The edge or surface that joins the sides of adjacent thread forms and coincides with the cylinder or cone from which the thread projects.



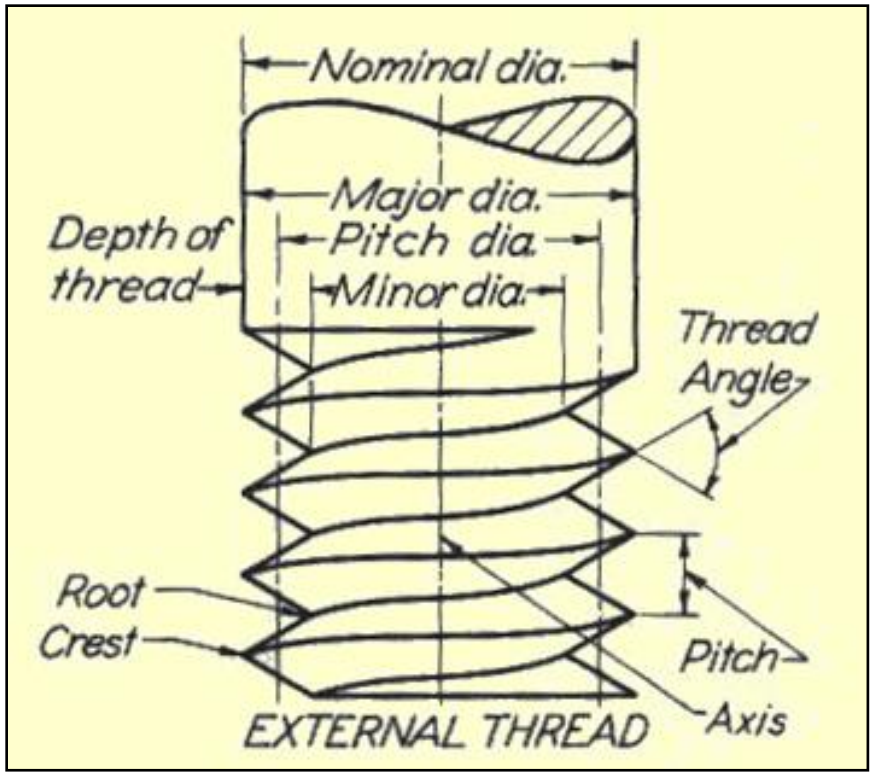
Depth of thread
The distance between crest and root measured normal to the axis.

Thread Terminology

Pitch, p
The distance between corresponding points on adjacent thread forms measured parallel to the axis.

Threads per inch, n
The reciprocal of the pitch and the value specified to govern the size of the thread form. **(n = 1/p)**

Lead, L
The distance a threaded part moves axially, with respect to a fixed mating part, in one complete revolution.
(the distance advanced parallel to the axis when the screw is turned one revolution.)

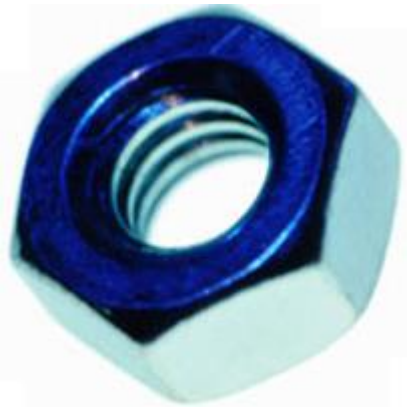


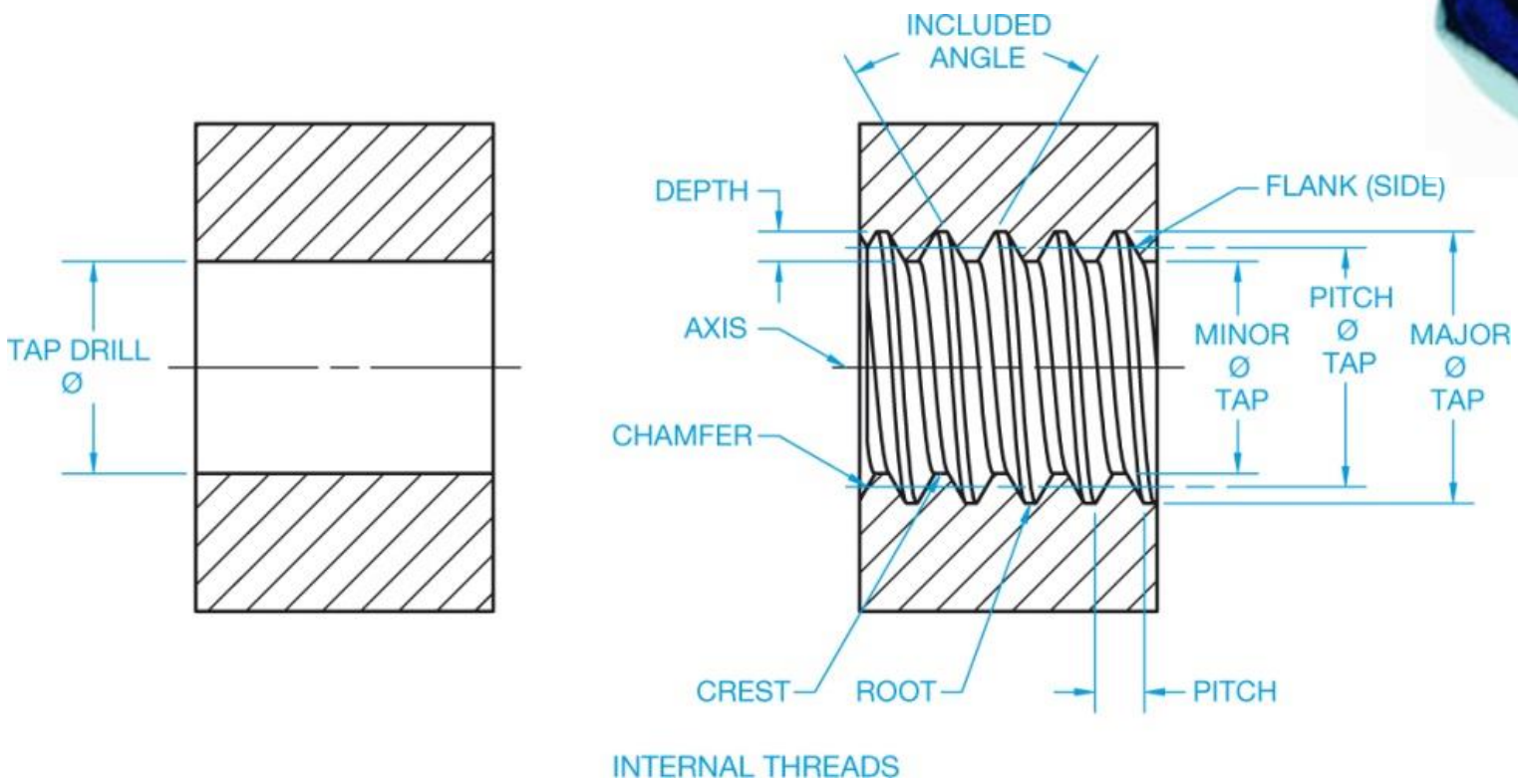
Single threaded screw
A single helical groove is cut or formed on a cylinder.
Threads are always single *unless otherwise specified*.

Multiple thread: Multiple helical grooves are cut on a cylinder.

Thread Terminology

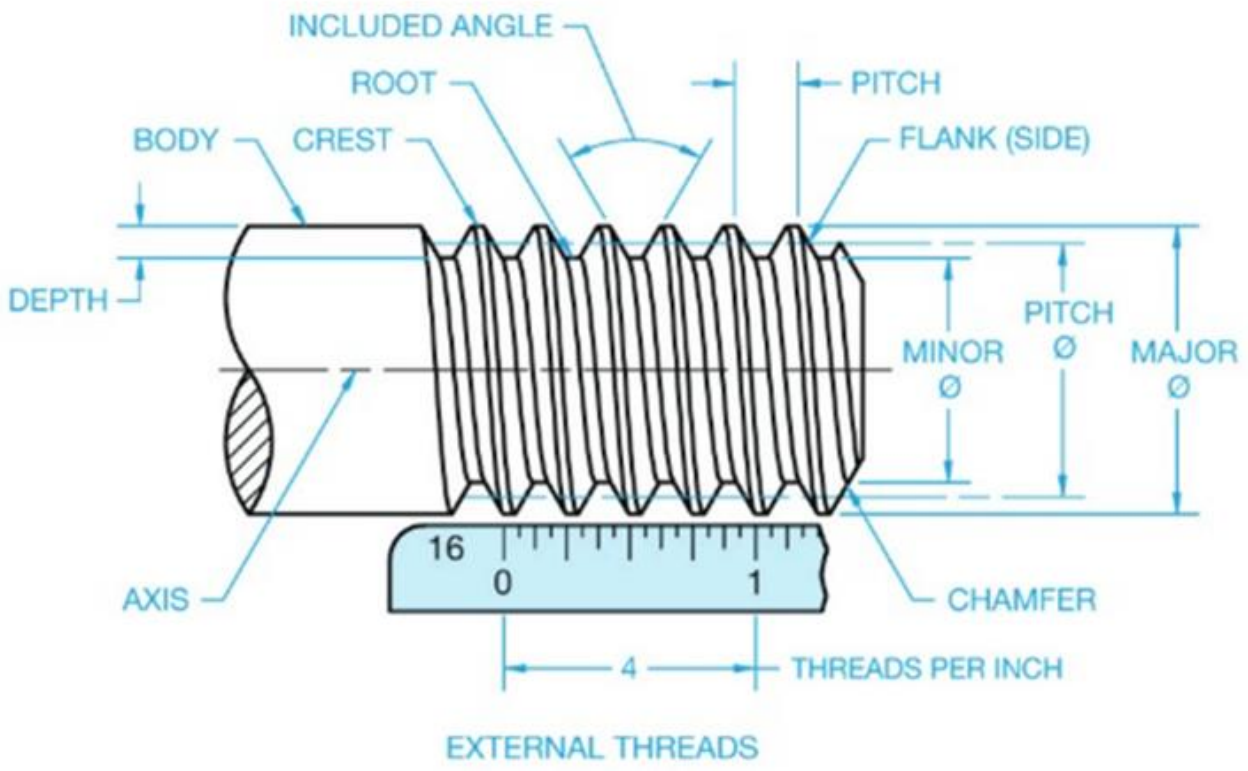
An internal (female) thread
is a ridge of a uniform section in the form of a helix on the internal surface of a cylinder or cone.
Designated by the suffix "B"





Thread Terminology

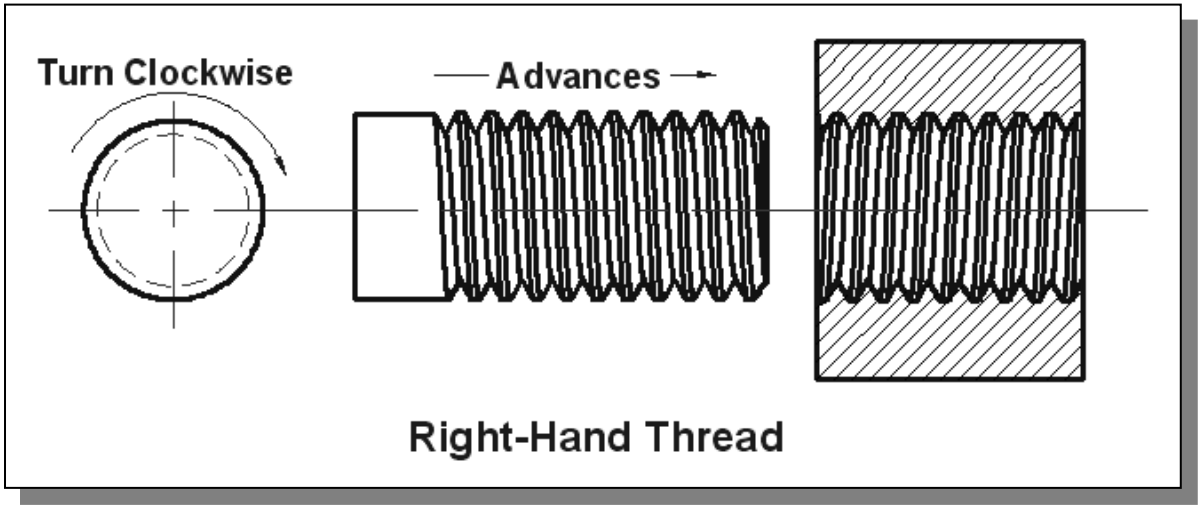
An external (male) thread
is an edge of a uniform section in the form of a helix on the external surface of a cylinder or cone.
Designated by the suffix "A"



Thread Terminology

Right-Hand Thread (RH):

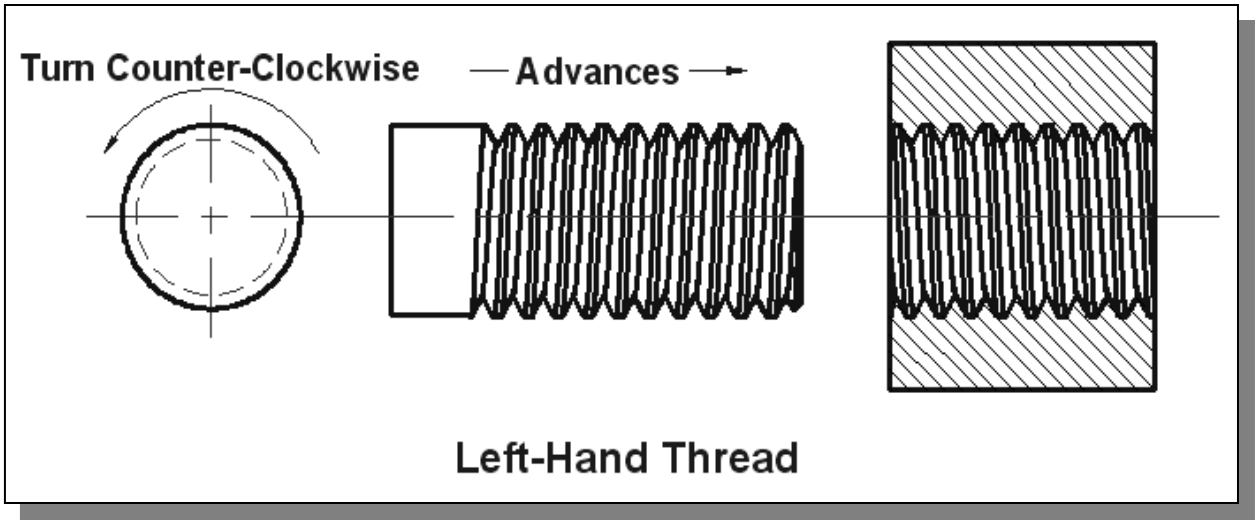
- A thread which advances into a nut when turned clockwise
- Threads are assumed to be Right-handed unless otherwise specified



Thread Terminology

Left-Hand Thread (LH)

- A thread which advances into a nut when turned counter-clockwise
- All left-hand threads are labeled **LH**



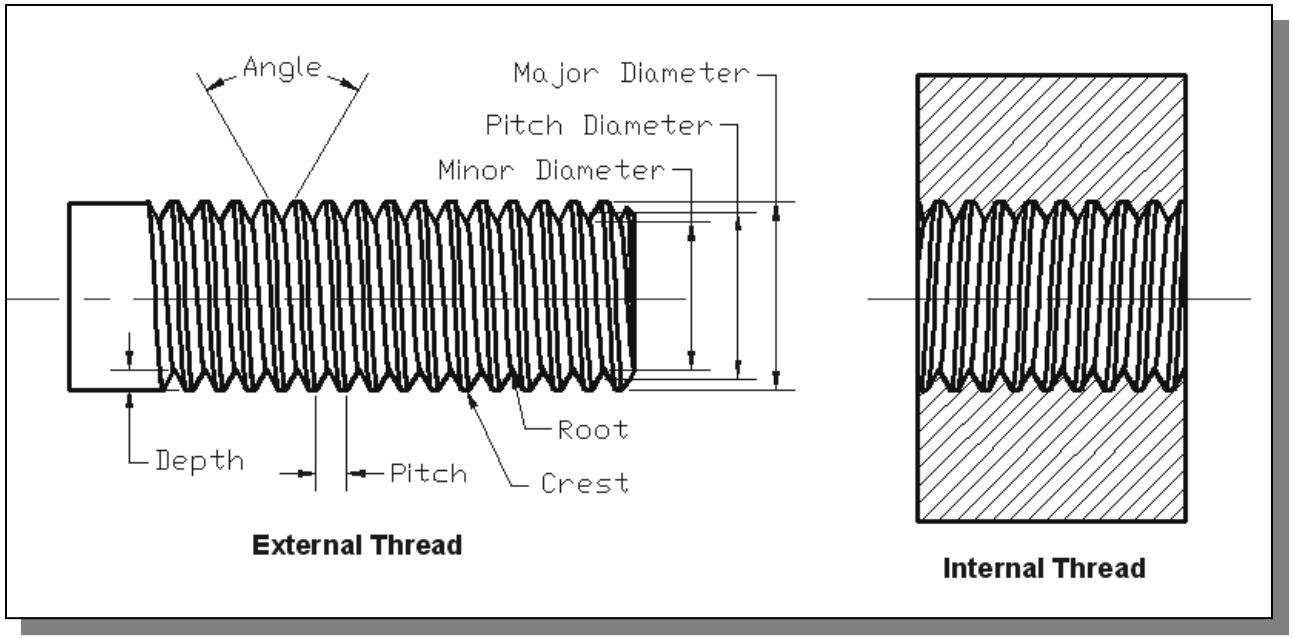
Thread Terminology

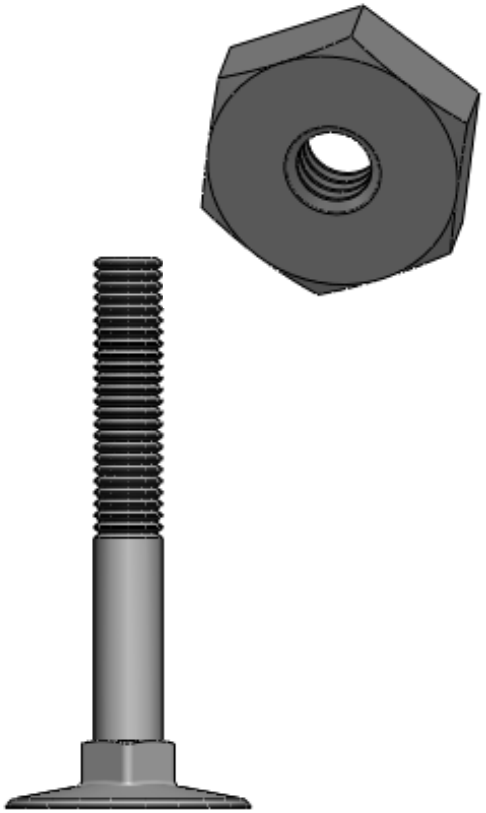
Major Diameter

The largest diameter of a screw thread.

Minor Diameter

The smallest diameter of a screw thread.





Thread Terminology

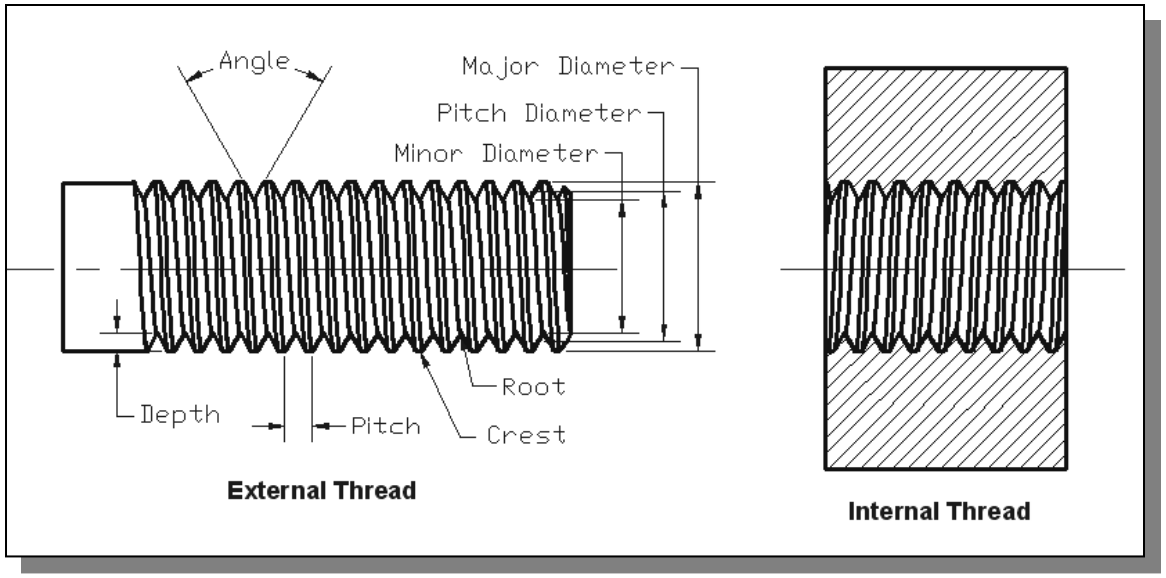
Threads per inch

The reciprocal of the pitch and the value specified to govern the size of the thread form.

Single thread

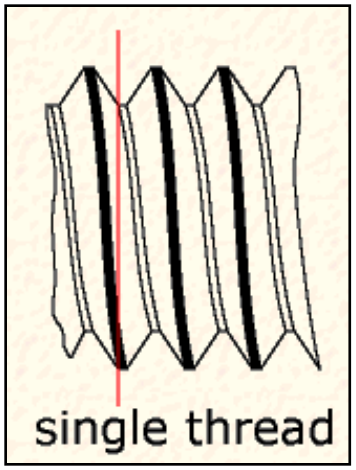
A thread having the thread form produced on only one helix of the cylinder. Threads are always single unless otherwise specified.

(note: Lead = pitch)

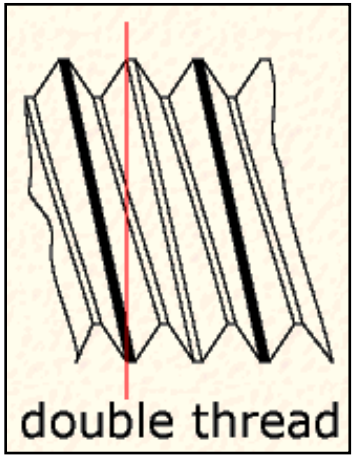


Thread Terminology

For a single threaded screw
In one complete revolution, the screw moves axially by one thread length.
(L = 1*p)



For multiple threaded screws
The lead is an integral multiple of the pitch.
On a double thread, lead is twice the pitch. **(L = 2*p)**
On a triple thread, lead is three times the pitch. **(L = 3*p)**

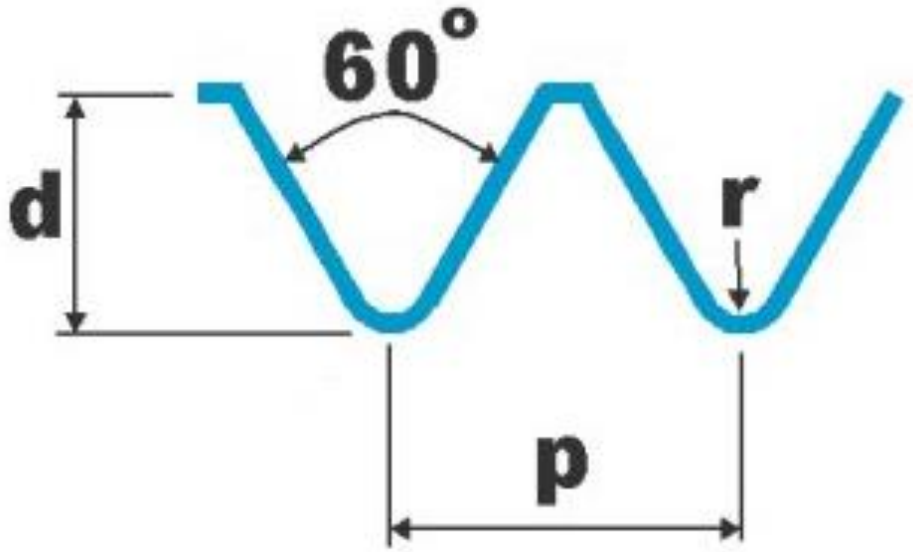


Double, triple, and even quadruple threads are used whenever a rapid advance is desired, as on valves.

Thread Terminology

Thread Forms/Profiles

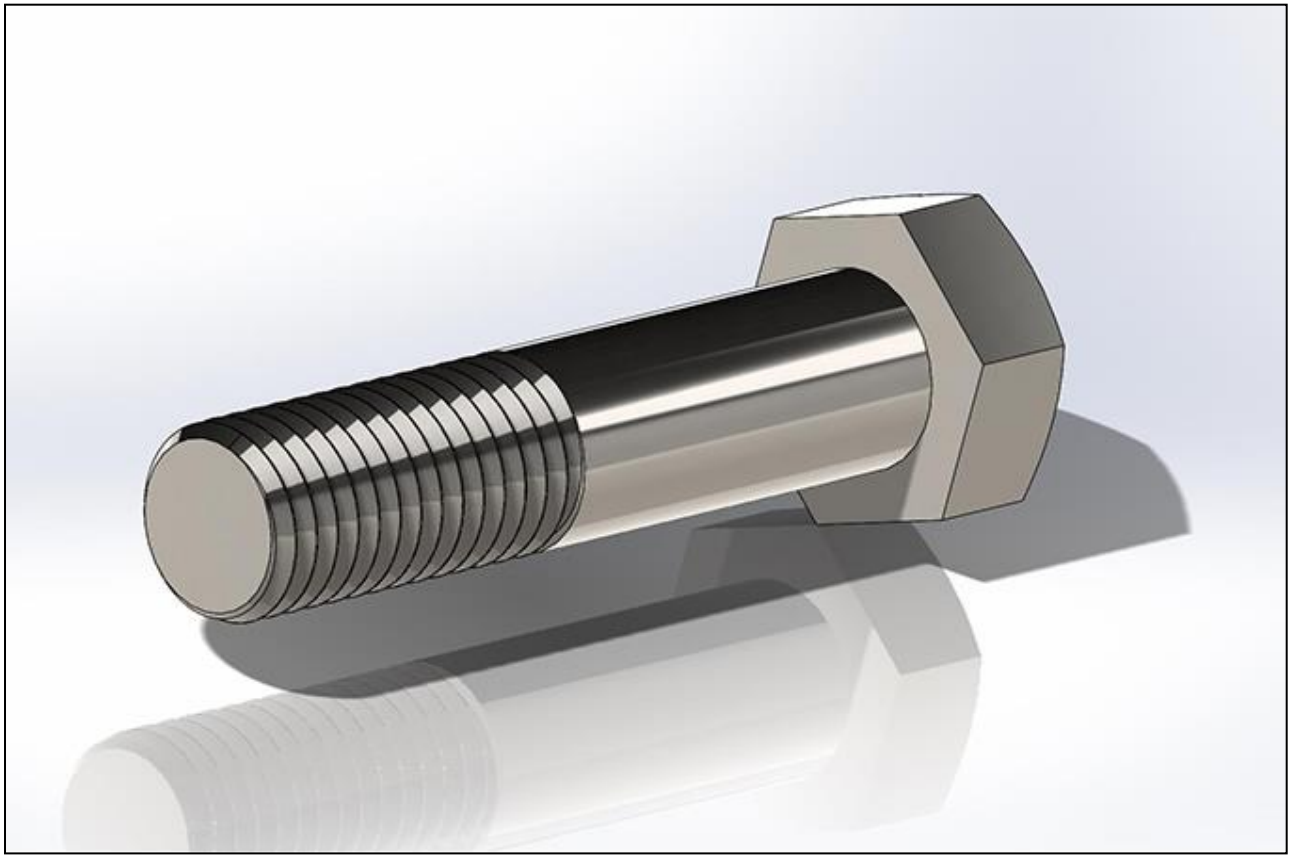
The most common screw thread form is the symmetrical V-Profile with an included angle of 60 degrees.



Threads on a drawing

There are three methods of representing screw threads on a drawing.

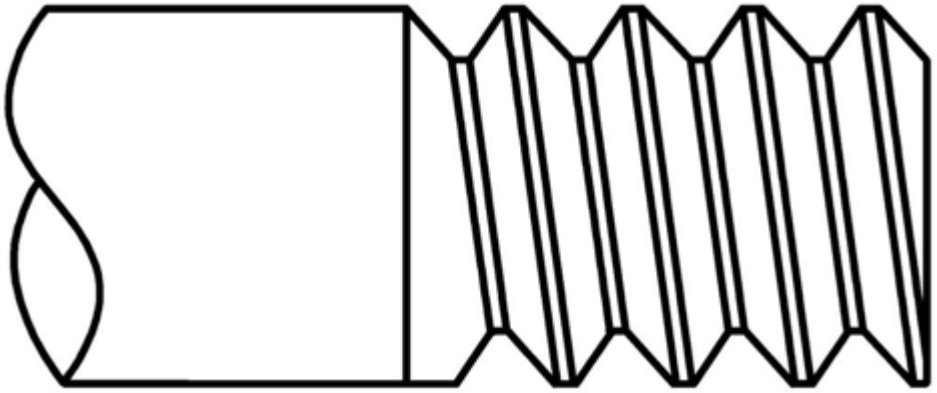
1. **Detailed**
2. **Simplified**
3. **Schematic**



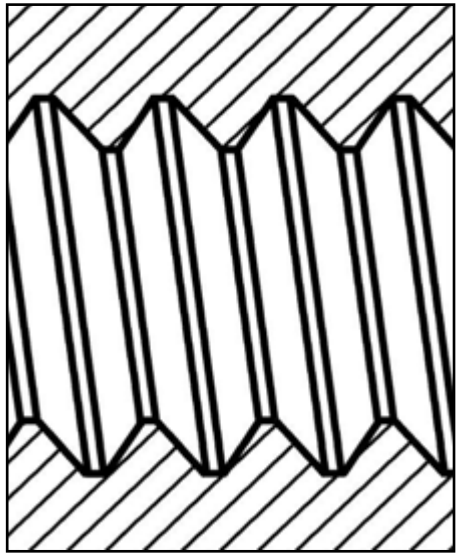
Note: In SOLIDWORKS the three are: Simplified, Cosmetic, and Schematic.

Threads on a drawing

The **Detailed** representation is a close approximation of the appearance of an actual screw thread.



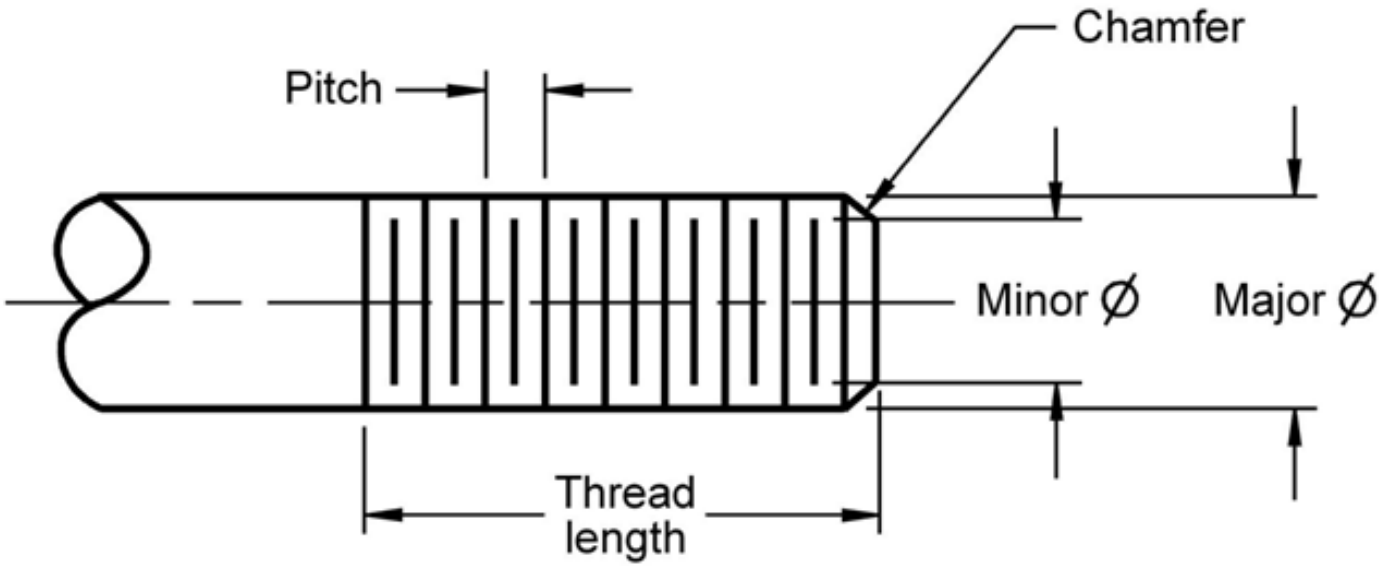
External Thread



Internal Thread

Threads on a drawing

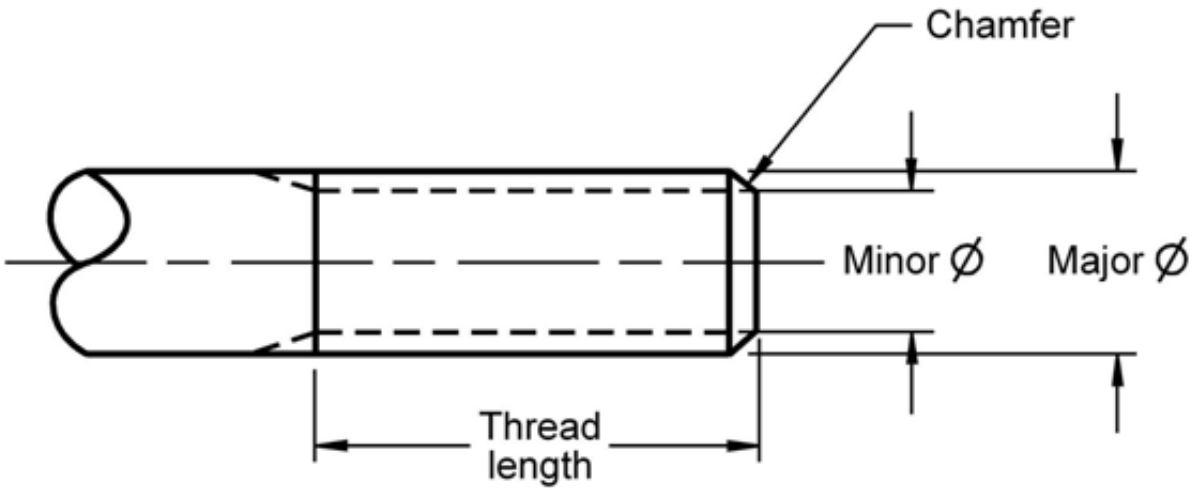
The **Schematic** representation uses staggered lines to represent the thread roots and crests.

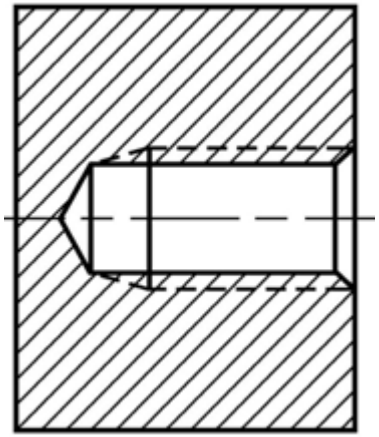


Note:
Should not be used for hidden internal threads or sections of external threads

Threads on a drawing

The **Simplified** representation uses visible and hidden lines to represent the major and minor diameters.

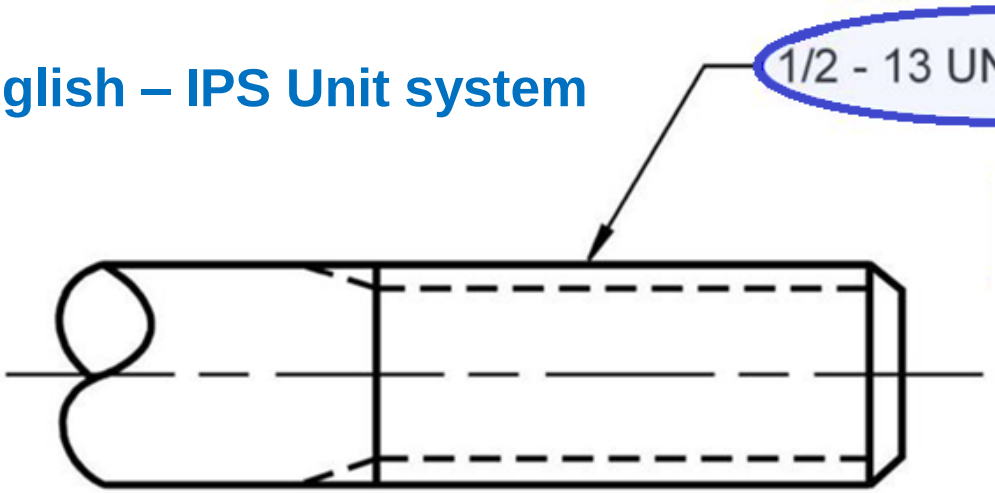




Threads on a drawing

- Threads are only symbolically represented on drawings.
- To provide the required information, a thread note must be included to identify the size and thread form.
- The note is shown with a leader line to the external or internal thread.

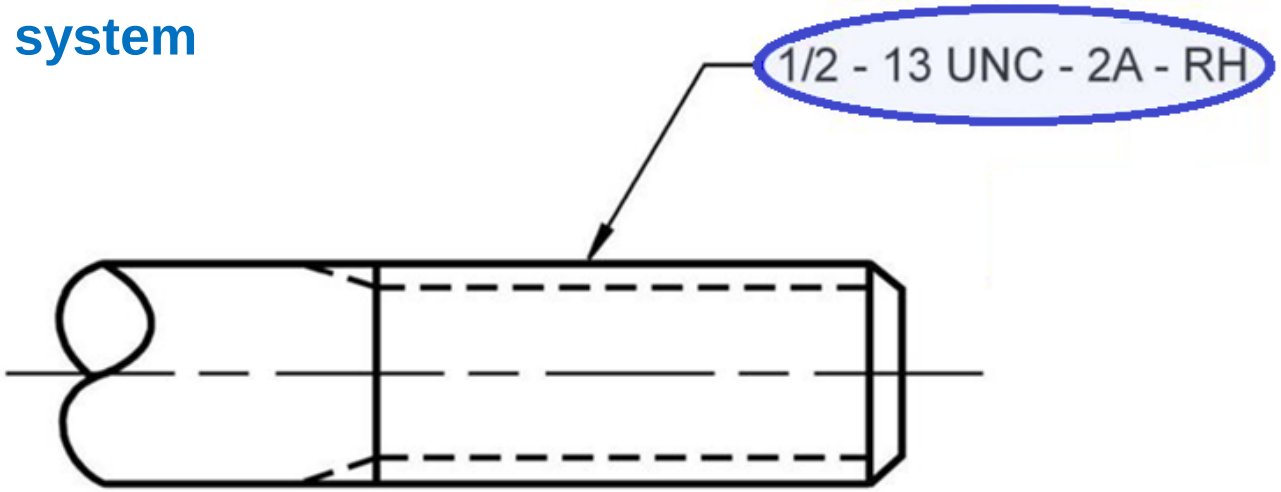
English – IPS Unit system



What does this mean?

Thread notes on a drawing
Unified and American National Thread Forms

English – IPS Unit system



Thread Note Explained:

1/2 = Designates major diameter in inches
13 = Designates the number of threads per inch
UNC = Designates thread series (UNC = course) ***see slide on Thread Series*** **Nomenclature**
2 = Designates thread class (2 = General purpose) ***see slide on Thread Class*** **Nomenclature**
A = Designates internal or external thread (A = Male)
RH = Designates right hand or left hand thread (RH = right hand)

Thread Series Nomenclature

Refers to the coarseness and form of the thread

UN = Basic Unified National thread series.

UNR = Basic Unified National thread series with external thread controlled root radius.

UNS = Special Unified National thread series.

UNRS = Special Unified National thread series with external thread controlled root radius.

UNC = Unified National Coarse thread series.

UNRC = Unified National Coarse thread series with external thread controlled root radius.

UNF = Unified National Fine thread series.

UNRF = Unified National Fine thread series with external thread controlled root radius.

UNEF = Unified National Extra Fine thread series.

UNREF = Unified National Extra Fine thread series with external thread controlled root radius.

Unified and American National Thread Forms

Major Diameter - Size Table

The numbered series #0 - #12 shows the gage diameter from which the thread is manufactured.

major diameter [in]	threads per inch			major diameter [mm]	tap drill size		
	coarse UNC	fine UNF	extra fine UNEF		coarse UNC	fine UNF	extra fine UNEF
#0 = 0.0600	–	80		1.5240		3/64 in	
#1 = 0.0730	64	72		1.8542	#53	#53	
#2 = 0.0860	56	64		2.1844	#50	#50	
#3 = 0.0990	48	56		2.5146	#47	#45	
#4 = 0.1120	40	48		2.8448	#43	#42	
#5 = 0.1250	40	44		3.1750	#38	#37	
#6 = 0.1380	32	40		3.5052	#36	#33	
#8 = 0.1640	32	36		4.1656	#29	#29	
#10 = 0.1900	24	32		4.8260	#25	#21	
#12 = 0.2160	24	28	32	5.4864	#16	#14	
1/4	20	28	32	6.3500	#7	#3	
5/16	18	24	32	7.9375	F	I	
3/8	16	24	32	9.5250	5/16 in	Q	
7/16	14	20	28	11.1125	U	25/64 in	
1/2	13	20	28	12.7000	27/64 in	29/64 in	
9/16	12	18	24	14.2875	31/64 in	33/64 in	
5/8	11	18	24	15.8750	17/32 in	37/64 in	
3/4	10	16	20	19.0500	21/32 in	11/16 in	
7/8	9	14	20	22.2250	49/64 in	13/16 in	
1	8	12	20	25.4000	7/8 in	59/64 in	

http://www.aasfasteners.com/glossary_of_screw_threads_gaging.htm

Thread Class Nomenclature

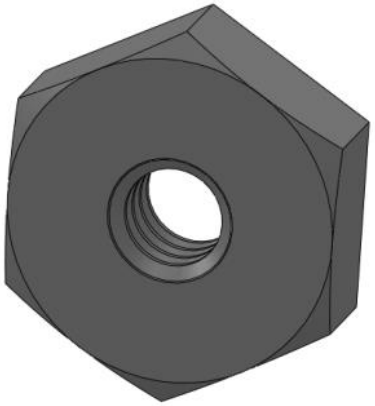
Refers to the fit of the thread: tight or loose

The basic profile of a thread is the theoretical (designed) profile.

Actual thread profiles must never cross the theoretical profile.

- Bolt threads will always *be equal to, or smaller than*, the basic profile.
- Nut threads will always *be equal to, or greater than*, the basic profile.

*A **thread class*** specifies the “fit” of a thread,
i.e. the tolerances and allowances that are applied to the basic profile.



Thread Class Nomenclature

Thread Tolerance Class

Class 1

The loosest fit.
Used on parts which require assembly with a minimum of binding.
Only used on bolts ¼ inch in diameter and larger.

Class 2

The most common fit.
For general purpose threads on bolts, nuts, and screws used in mass production.

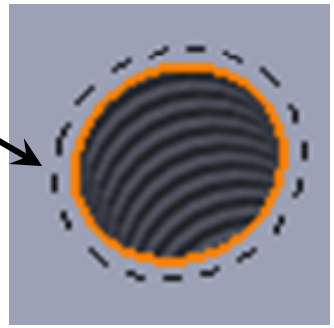
Class 3

The closest fit.
Used in precision assemblies where a close fit is desired to withstand stress and vibration.

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 1

English – IPS Unit system

.5-13x1 UNC–3B



Thread Note Explained:

1/2 = major diameter in inches
13 = number of threads per inch
1 = thread depth
UNC = thread series coarse
3 = thread class (3 = precision fit)
B = internal thread (female)

If not stated the thread is Right handed and Single threaded

To designate a double thread the word “DOUBLE” or “2” is placed after the class of fit, like this: .5-13x1 UNC–3B DOUBLE

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 2

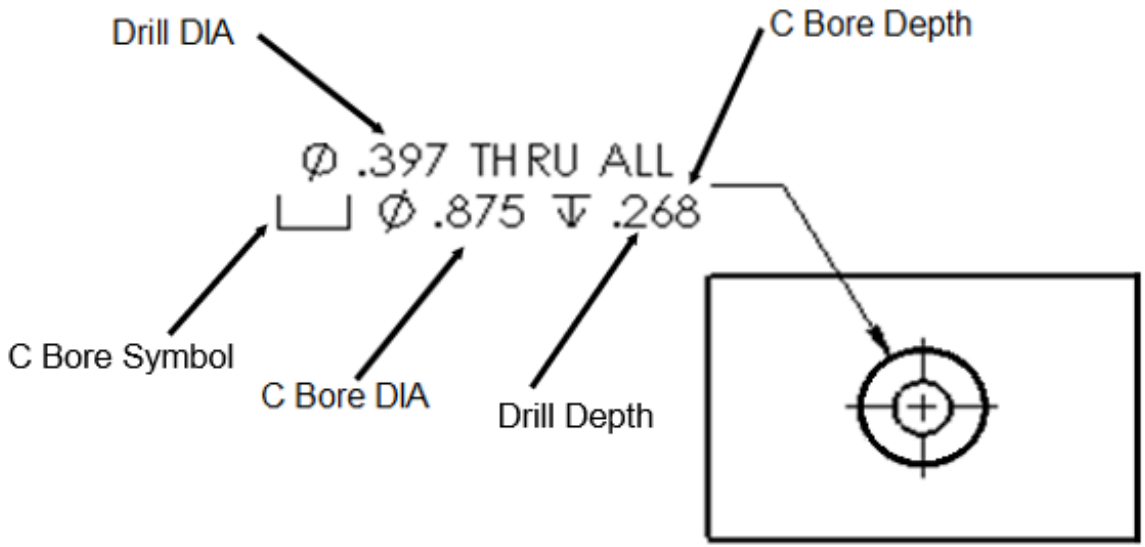
English – IPS Unit system

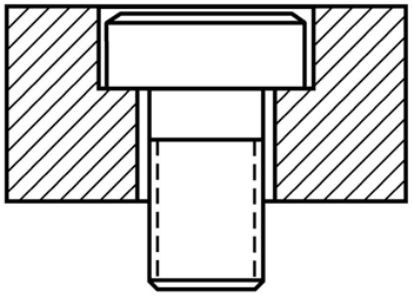
.250-20x2 UNC–2A-LH

Thread Note Explained:

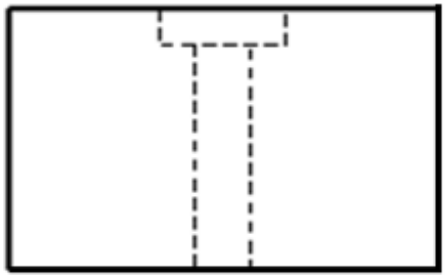
.250 = major diameter in inches
20 = number of threads per inch
2 = 2 inch thread length
UNC = thread series coarse
2 = thread class (2 = general purpose)
A = external thread
LH = left handed

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 3



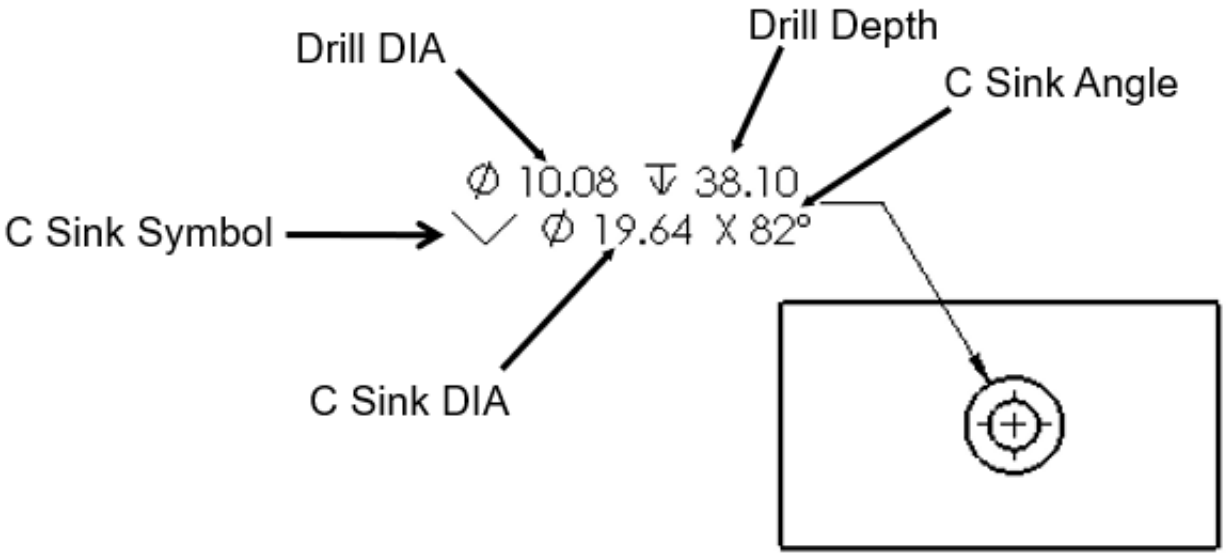


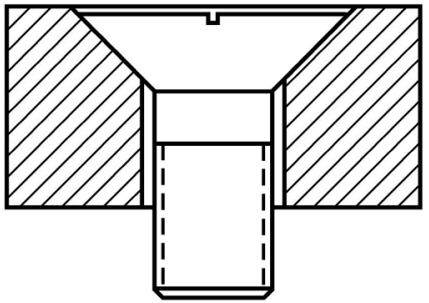
English – IPS Unit system



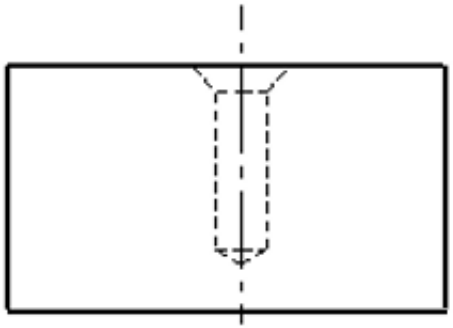
The difference between a C BORE and a spotface is that the machining operation occurs on a curved surface.

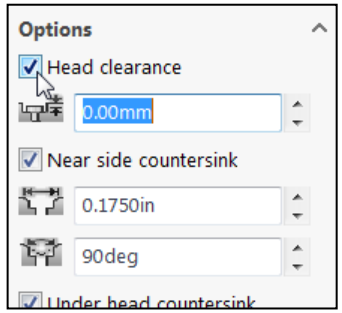
Thread Notes on a Drawing
Unified and American National Thread Forms
Example 4





English – IPS Unit system

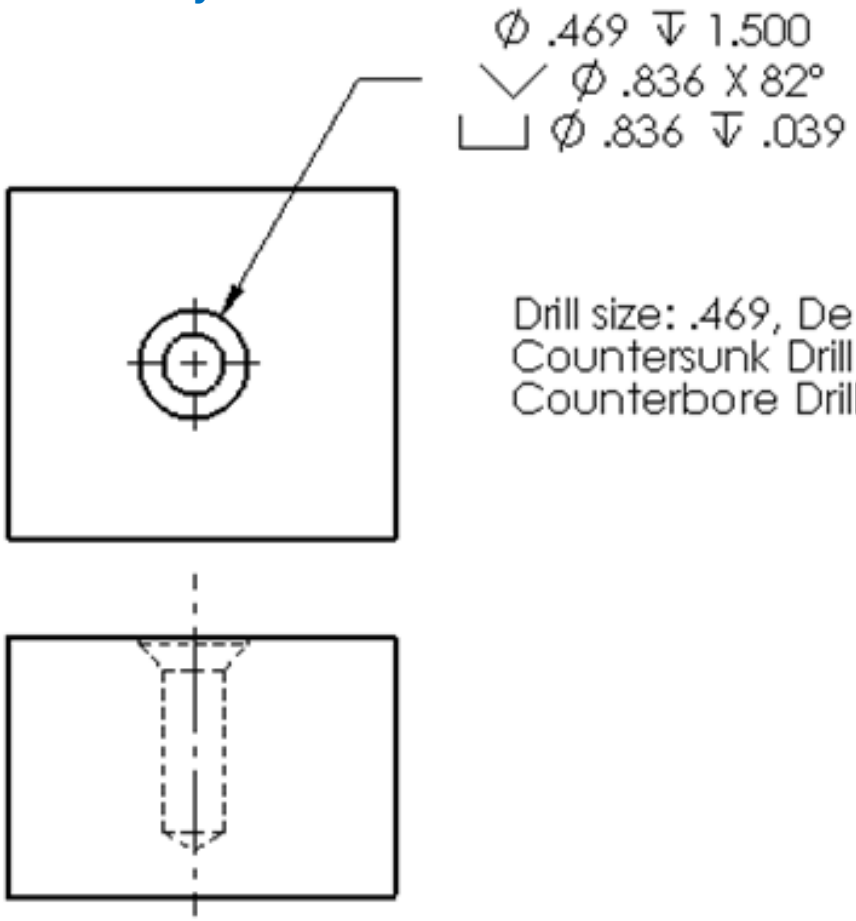




Note: SOLIDWORKS provides the ability to insert Head clearance for the Countersink hole.

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 5

English – IPS Unit system

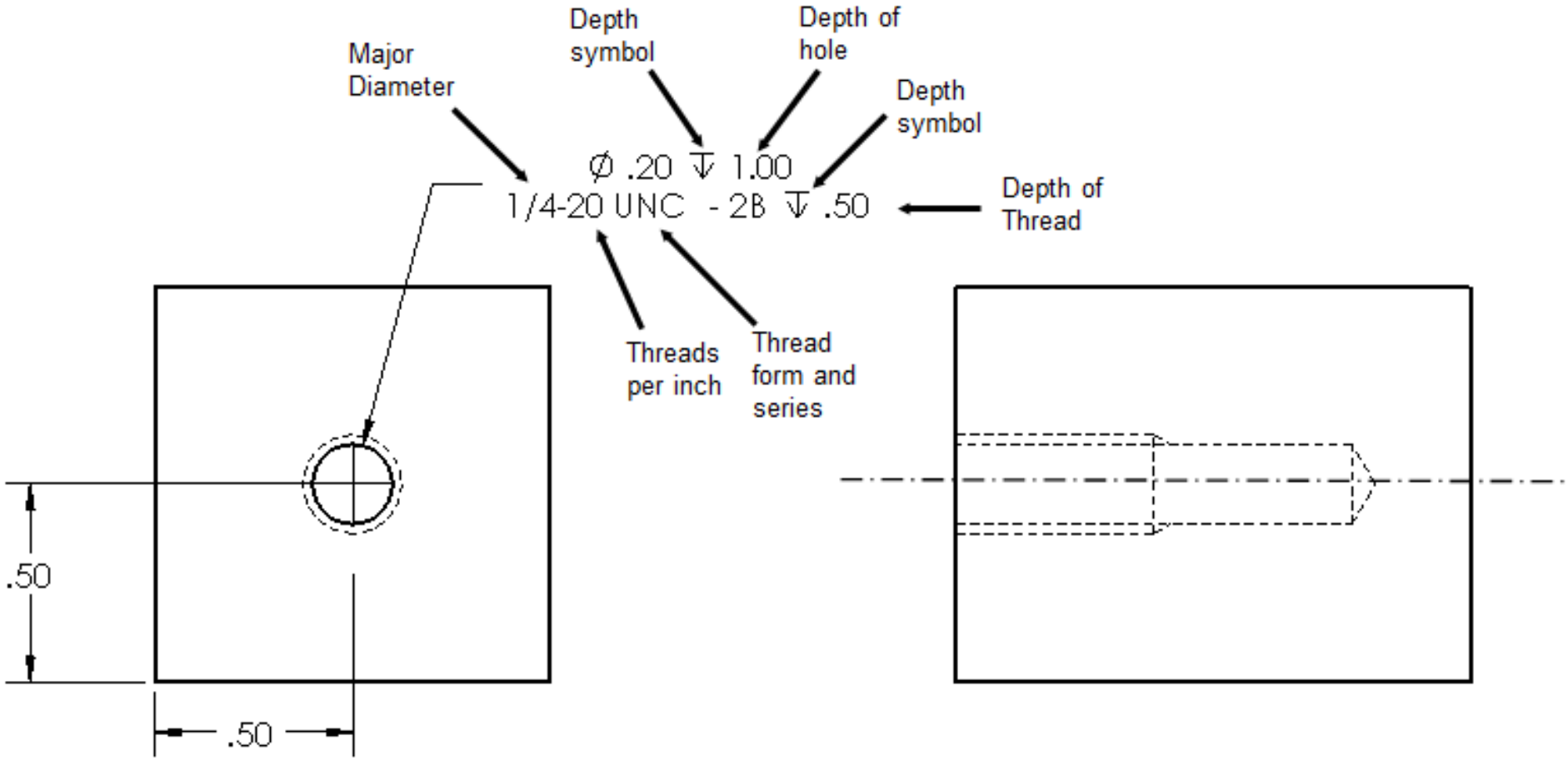


Drill size: .469, Depth 1.500
Countersunk Drill size: .836 x 82°
Counterbore Drill size: .836, Depth .039

Note: SOLIDWORKS provides the ability to insert Head clearance for the Counterbore hole.

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 6

English – IPS Unit system



Metric Thread Grade of Tolerance

Ranges from 3 to 9 with 3 being the finest and 0 being the coarsest.

Metric Thread Tolerance Class

Internal threads:

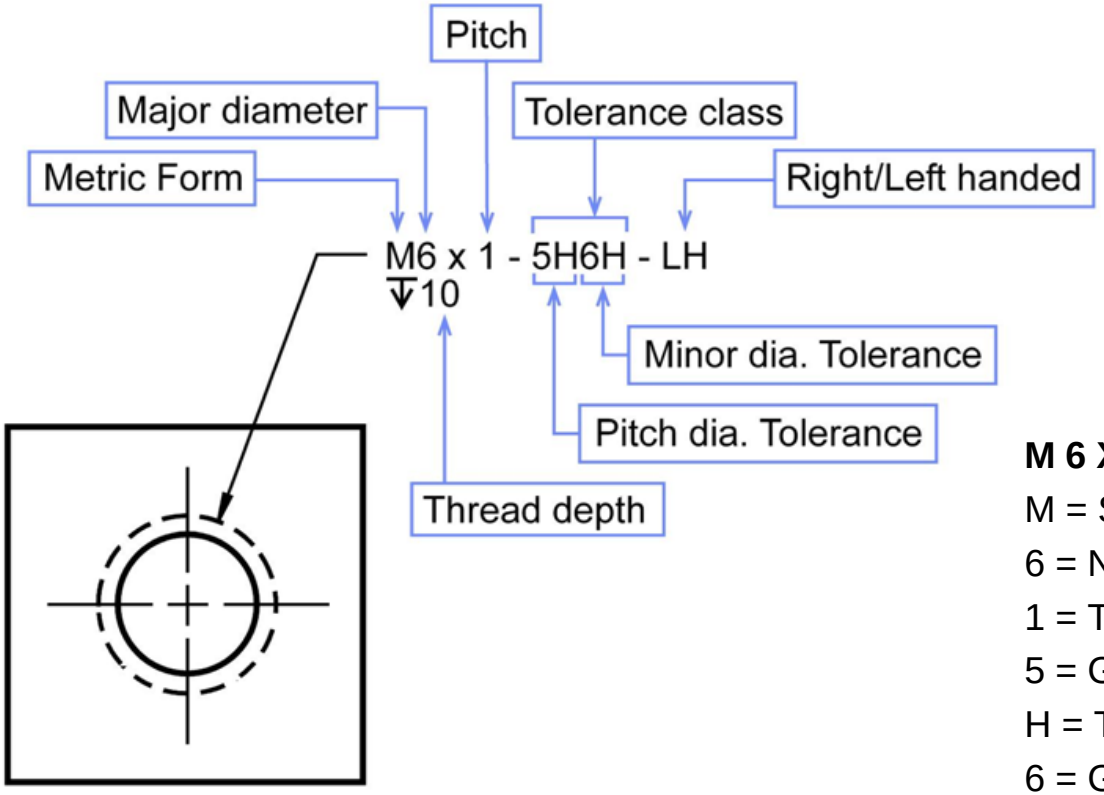
- G = Tight allowance
- H = No allowance

External threads:

- e = Large allowance
- g = tight allowance
- h = no allowance

Thread Notes on a Drawing
Unified and American National Thread Forms
Example 7

Metric – MMGS Unit system



M 6 X 1 - 5H6H - LH

M = Symbol for ISO metric threads

6 = Nominal major diameter in millimeters

1 = Thread pitch in millimeters

5 = Grade of tolerance for pitch diameter

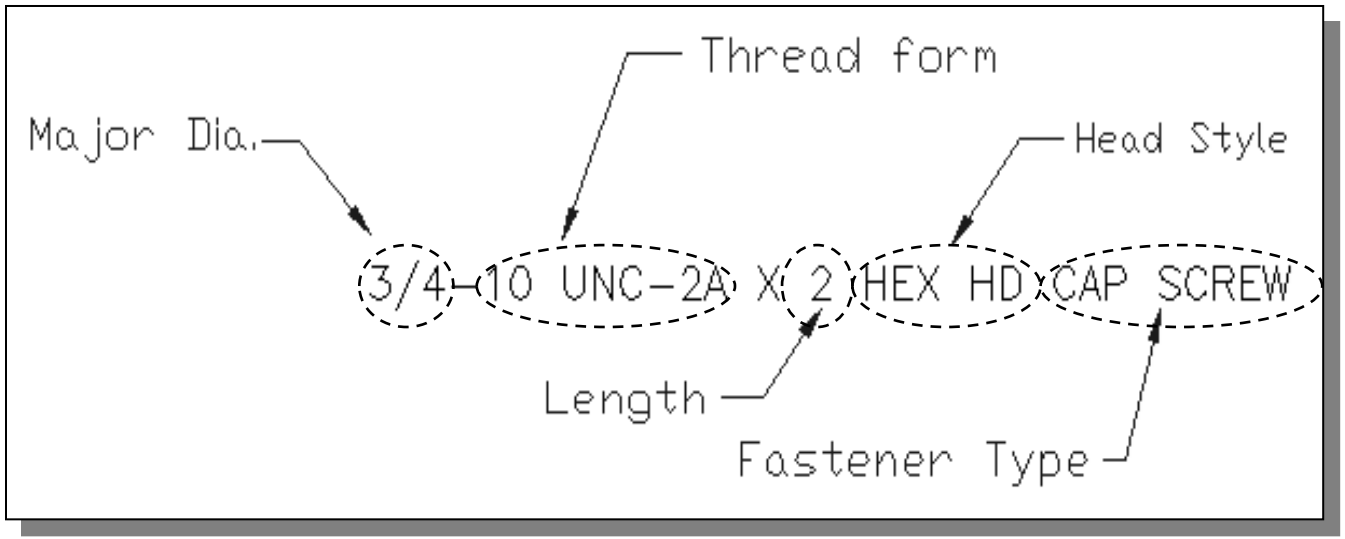
H = Tolerance class of pitch diameter

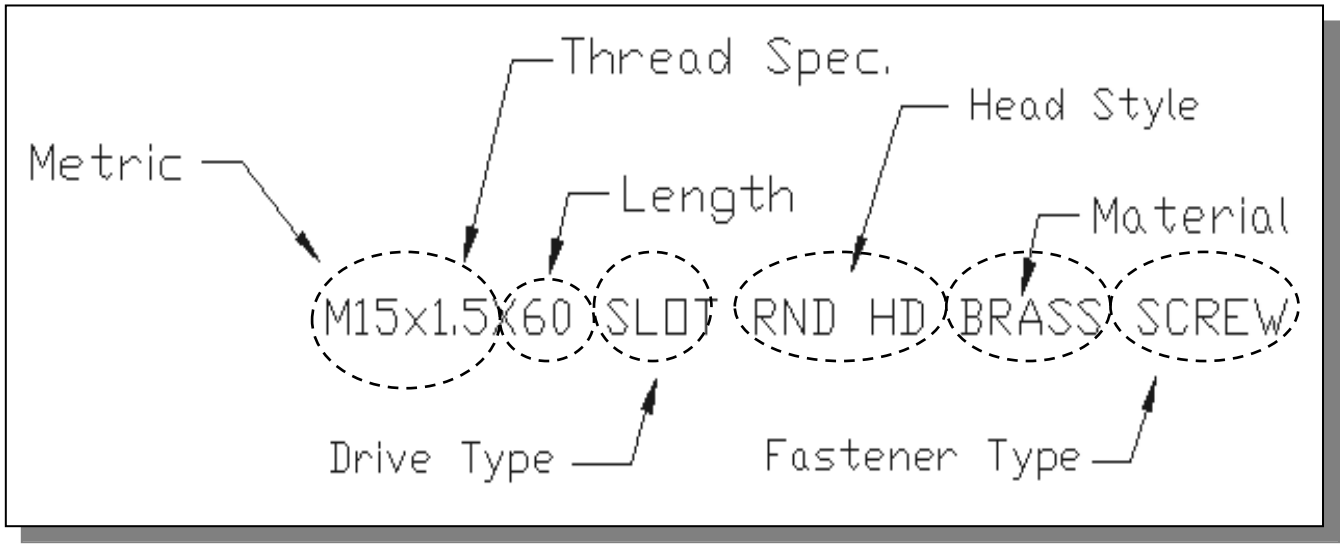
6 = Grade of tolerance for minor diameter

H = Tolerance class of minor diameter

LH = left handed

Thread Notes on a Drawing
Thread Specification - English vs. Metric
Example 8





END

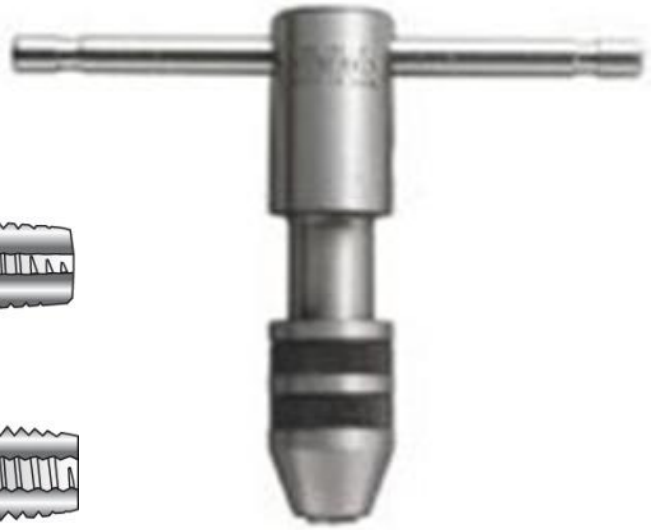
here

Threads – cutting them

Tapping – the process of cutting threads using a tap
Threading – the process of cutting threads using a die
Chasing – the process of cleaning up a thread (can use a tap or a die)

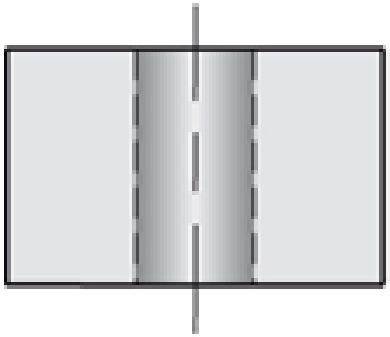
Major tap types:

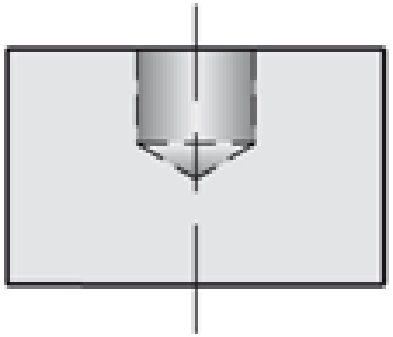
- **Taper**
- **Plug**
- **Bottoming**



Threads – cutting female threads

First a tap drill hole is cut with a twist drill.
The tap drill hole is a **little larger** than the minor diameter.
Start with a shaft the same size as the major diameter.

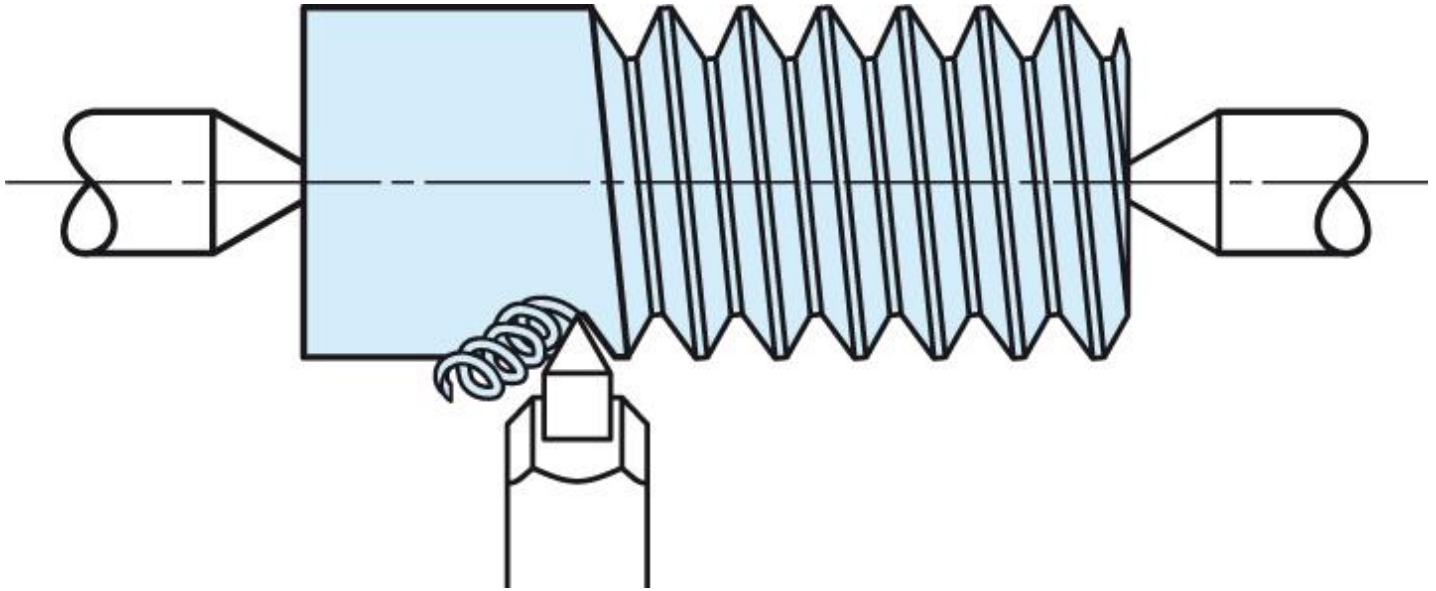




Minor Diameter: The smallest diameter of a screw thread.

Threads – cutting male threads

Start with a shaft the same size as the major diameter.
An external thread is cut using a die or a lathe.



Other Thread Form Notes

Acme example:

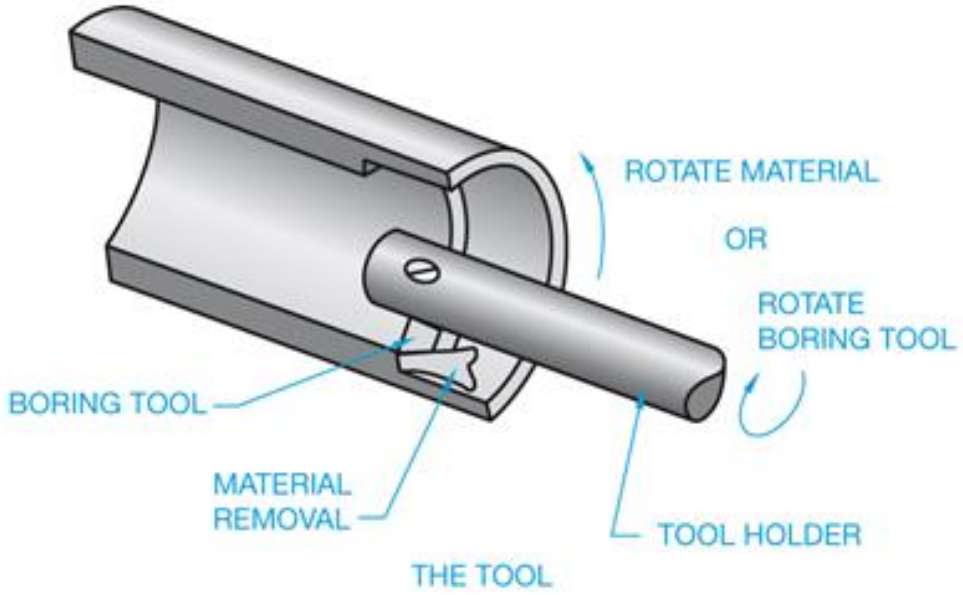
5/8–8 ACME–2

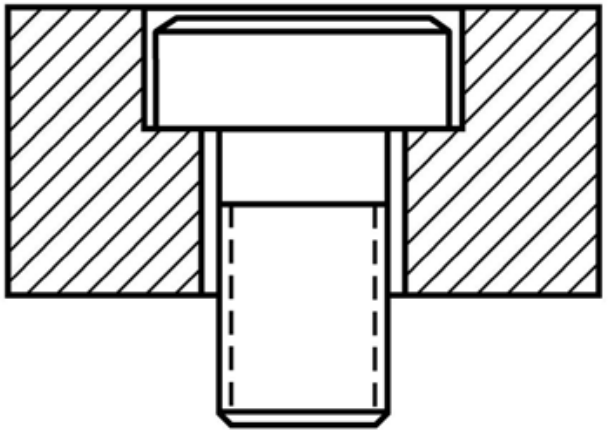
National Pipe Thread (NPT) example:

3/4–14 NPT

Bolt and Screw Clearances

Create a Counterbore





Bolt and Screw Clearances

Create a Countersink