"For a fresh approach to fastener training."

Training manual

THE BEST DESERVES THE BEST

JAMES GLEN

training manual

Welcome, Copyright & Disclaimer

Welcome to our first ‘stand alone’ publication of technical information for training.

This manual has been put together to provide an easy to understand summary of many issues that are common to most types of fasteners.

We hope it will benefit your organisation as a handy tool for training new and existing staff, and become a valued resource in the industry.

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Preface

This training manual is intended to provide a basic understanding and recognition of the products stocked in the JAMES GLEN product range as well as some other of the more common standard fasteners; as such, it is not intended as a highly technical reference publication.

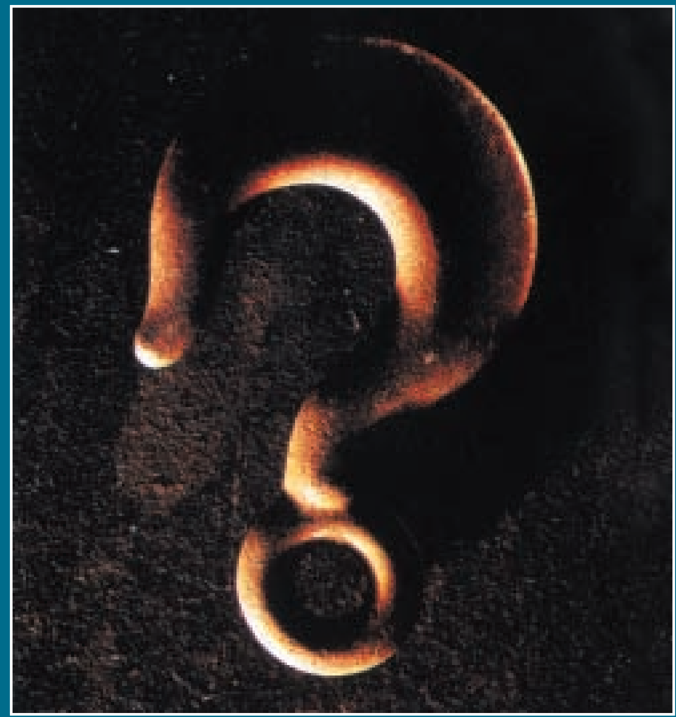
Specification of the appropriate fasteners for a particular application is the realm of appropriately qualified engineers and this manual does not attempt to provide the basis for specification.

The majority of the fasteners stocked in the James Glen product range are of the threaded type, which are essentially standard in nature and are tightened or assembled by rotational action.

Many of these products have common features such as driving methods, threads, heads, points, materials, finishes etc. While others may have additional unique features such as nylon inserts, serrations, tamper resistance, welding lugs or may be an adjunct to the primary fastener such as nuts, washers and cotter pins.

In this manual, we attempt to identify each of these features, the common and optional terminology for it, its use or purpose and the products likely to incorporate it, so that users of this manual improve their ability to quickly identify and describe a specific product.

We also attempt to provide a basic understanding of the mechanics of threaded fasteners, their materials and strength grades, how they work, how and where to measure them and which finishes are available, so that manual users are better equipped to provide superior customer service.



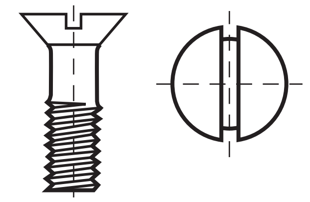
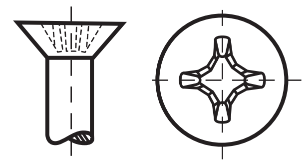
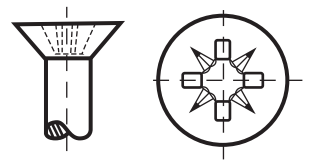
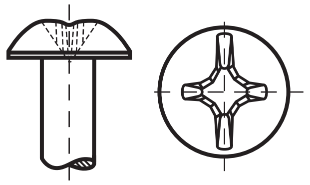
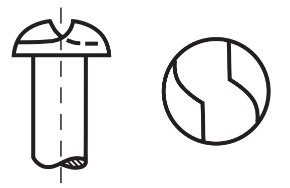
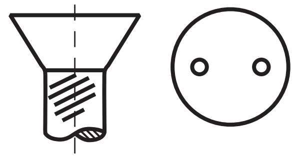
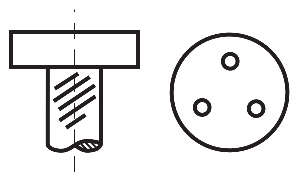
Training Manual

Section 1 – Characteristics

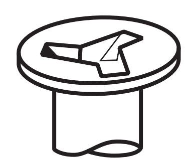
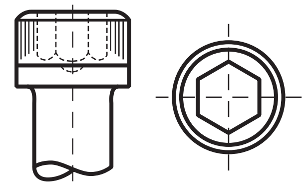
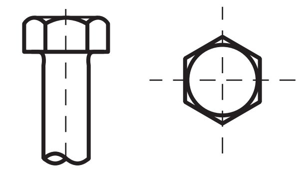
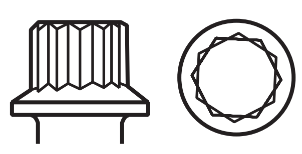
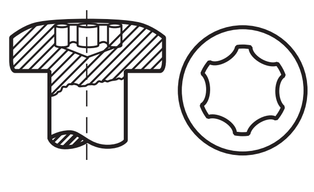
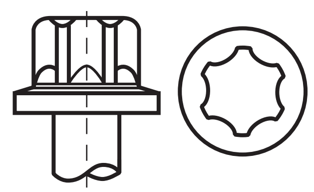
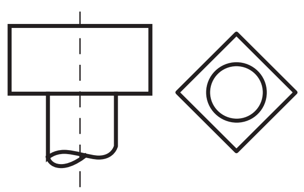
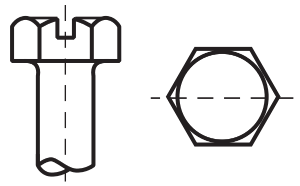
training manual

Driving Methods

The drive on a fastener is the feature through which rotational torque is applied. All threaded fasteners will have a drive feature or will have a retention feature to prevent rotation whilst the mating part is rotated - eg: a nut

SKETCH	DRIVE TYPE	USES	TOOLS
	SLOT	Commonly found on woodscrews and machine screws in domestic applications or where field retightening or removal may be required. Most suitable for hand operated tools. Oldest and simplest drive form.	Flat bladed common screwdriver.
	PHILLIPS RECESS (Type 1) (X-Recess) (Cross-Recess)	Commonly found on self tapping screws and machine screws, particularly where they can be power assembled eg: on a production line for domestic appliances.	Ideal for power operated tools and hand tools.
	POZIDRIVE RECESS (Type II or IA) (X-Recess)	As above, but is less prone to 'cam out' when drive tools are worn.	Power operated Pozidrive tools and Pozidrive hand tools.
	Combination (Phillips Recess & Slot) (X-Recess or Slot)	Most commonly found on mush head roofing screws and machine screws, allowing for power driven assembly and field removal or adjustment by common blade screwdrivers.	Power operated drive tools and hand tools, flat slot or cross recess.
	CLUTCH (One Way) (Jail Head)	Security applications usually on self-tappers, woodscrews or machine screws, eg: domestic window locks, jail cell hinges, door lock exposed screws. Declining popularity.	Conventional flat blade screwdriver to tighten. Cannot be easily removed without drilling and using a special removal tool.
	EYE DRIVE (Snake Eyes)®	Security applications, usually on self-tapping screws or machine screws where high assembly torque is not required, eg: into plastics.	Special hand screwdriver with 2-pin blade.
	TRI-EYE DRIVE (3 Pin Drive)	As above. Also seen on golf shoe spikes or plastic inserts.	Special hand driver with 3-pin drive.

Driving Methods *Continued*

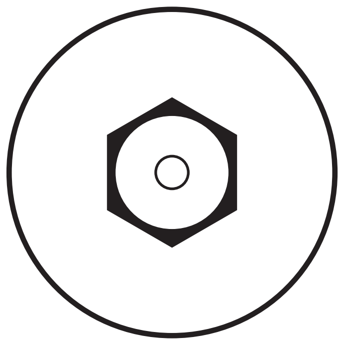
SKETCH	DRIVE TYPE	USES	TOOLS
	TRI-WING	Security applications usually confined to screw products, particularly in aircraft, public transport fittings and electrical appliances where fieldwork should only be carried out by authorised service personnel.	Special 3-bladed drivers both power and hand.
	HEXAGON RECESS	Principally used in high torque applications such as automotive, heavy equipment, tool die sets. Commonly associated with cap screws. (Also comes as square recess).	Hexagon socket key (Allen key) and hexagon power drivers.
	HEXAGON	The most common drive on bolt products – very versatile in drive torque range; economical to produce.	Hand driven ring and open ended spanners, hand or power driven with socket drivers.
	12-POINT (Double Hexagon)	Usually associated with a flange head and in high torque applications where there is a restriction on head size or where space limits hexagon driving tools eg: inside a recess.	12-point socket driver. In some circumstances a ring spanner could be used.
	INTERNAL TORX®	Gives very high driving torque capability with low risk of 'cam out'. Usually found in high production applications, particularly automotive and appliance industries. Usually restricted to screw products.	Normally power driven with special drive bits or hand driven with a torx® key.
	EXTERNAL TORX®	As with 12-point, usually associated with a flange head. Very high driving torque capability. Often found in automotive and aircraft engine applications. Usually restricted to bolt products.	Normally power driven with special drive sockets. Occasionally by hand with tension wrench and special sockets.
	SQUARE	Declining usage. Was often used in timber bridgework and where larger driving surface was required. Still used in a small version on square drive cap screws.	Hand driven with open-ended spanner or adjustable shifter.
	HEXAGON SLOT COMBINATION	Usually associated with screw products. Is useful where it can be power driven on the assembly line and removed or adjusted in service with a blade screwdriver. Usually head is indent hex and sometimes x-recess is also added.	Power driven with hexagon socket. Hand adjusted with blade screwdriver.

Driving Methods *Continued*

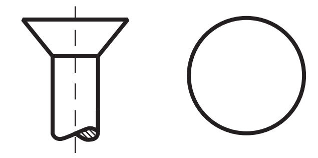
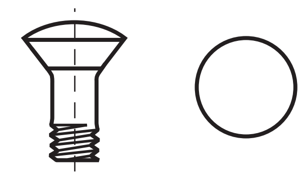
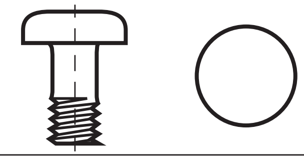
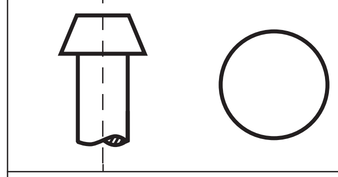
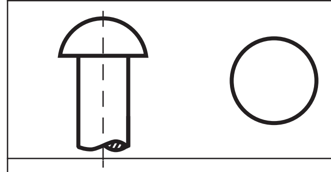
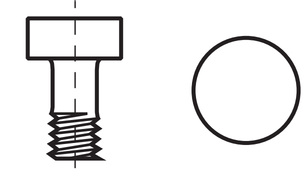
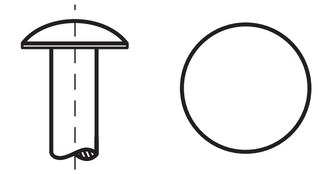
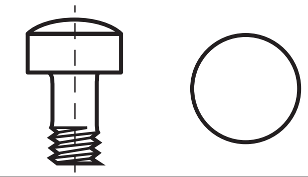
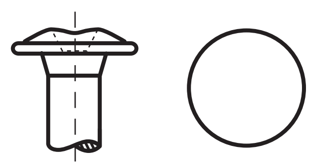
In addition to the clutch, eye drive and tri-wing security drives depicted, many of the recess type drives can be manufactured with a central post to prevent the entry of a conventional driving tool.

This is most common with hexagon recess and internal torx and would normally be confined to head styles that resist grasping with pliers or multigrips.

At best, most security products and products incorporating central posts can be classified as tamper resistant rather than tamper proof.

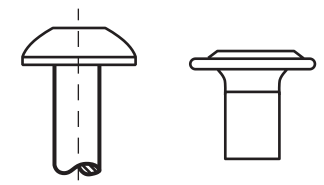
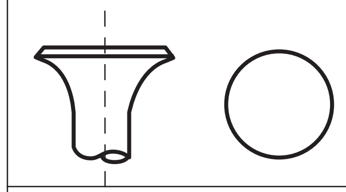
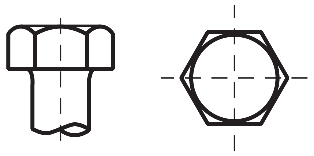
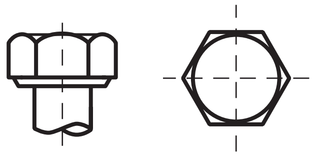
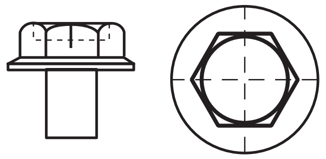
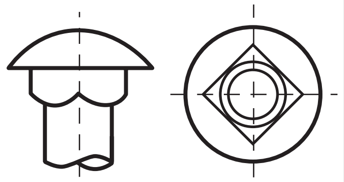
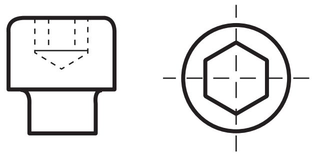
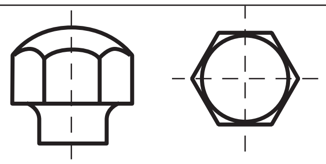


Head Styles

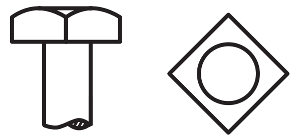
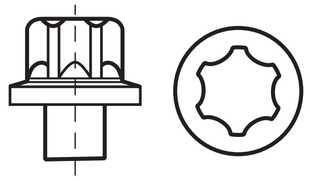
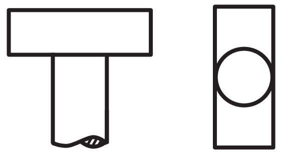
SKETCH	TITLE	COMMENTS
	COUNTERSUNK HEAD (Flat)	Most common usage is on screw products where a flush fit is required on the surface, eg: door hinges and timber joinery or into steel applications, eg: manhole cover plates. Can also be seen on bolt products, but usually accompanied by a retention device such as a square or a lug as in plow and earthmoving bolts.
	RAISED COUNTERSUNK (Oval & Instrument)	Most often associated with screw products in exposed applications. Usually will be chrome or nickel plated for appearance and is sometimes coupled with a cup washer to enhance the appearance, eg: fittings on public transport.
	PAN HEAD (American Style)	Predominantly used on screw products where a flat bearing surface is required or conversely, where a countersunk is not required. More economically produced than countersunk.
	PAN HEAD (English Style)	Now normally only found on solid rivets and on some hot forged products.
	ROUND HEAD (Cup, Snap & Button)	Declining popularity, but does provide deeper slot capability than pan and therefore, is more often used in woodscrews and machine screws. When recessed with hex or x-recess becomes one form of button head.
	CHEESE HEAD	Less popular than pan, but again gives a deeper slot capability, so is most commonly seen as a slot product on machine screws.
	TRUSS HEAD (Mushroom)	Larger diameter and lower profile head than round, pan or cup. Is most commonly seen with slot or combination slot x-recess on mush roofing bolt/nut product.
	FILLISTER HEAD (Raised Cheese)	Rarely specified these days; was formerly seen predominantly on machine screws.
	WAFER HEAD	Usually incorporating a recess and most commonly found on self-drilling building fasteners.

Section 1 – Characteristics

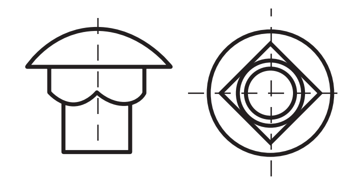
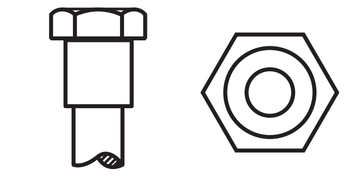
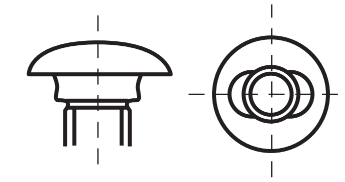
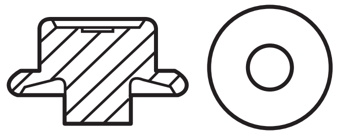
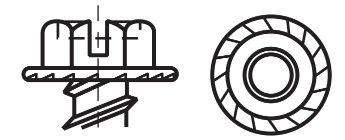
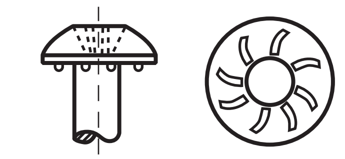
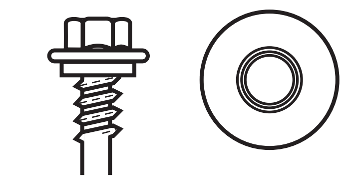
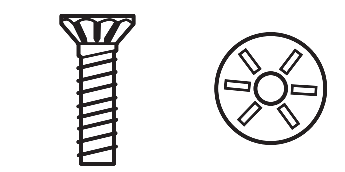
Head Styles *Continued*

SKETCH	TITLE	COMMENTS
	BUTTON HEADS	Usually incorporating a recess and most commonly found on self-tapping, self-drilling screws and machine screws. Sometimes incorporates a post to convert to a security or tamper resistant recess.
	BUGLE HEADS	Most commonly found on self-drilling screws used in plasterboard fixed to timber or steel frames. Designed to self-embed.
	HEXAGON HEADS	The most common head on bolt products and also seen on many screw products. Can come in several versions. This one is referred to as full bearing face. The manufacturer has the discretion to supply low tensile products as full bearing face.
	HEXAGON WASHER FACED HEAD	Hex washer faced is specified for hexagon high tensile bolts and setscrews in the Australian Standard - both unified and metric. It is at the manufacturers option for other products; therefore, it is not normally necessary to specify it except on specials. Note: USA market refers to bolts and set screw products as cap screws.
	HEXAGON FLANGE HEAD (Hex Washer Head)	On bolts, correctly termed hex flange head and when used on self-drilling screws, correctly termed hex washer head. Beware not to confuse with hex washer faced.
	CUP SQUARE HEAD (Coach Head)	Normally referred to simply as cup head, this standard product is predominantly used in timber applications or very occasionally, in steel with a square punched hole, eg: steel framed wheelbarrows.
	CAP HEAD	Normally incorporating a recess and usually associated with very high tensile products, eg: socket head cap screws.
	DOMED HEXAGON HEAD (Track Head)	Sometimes found on special bolts for engine heads, but more often on earthmoving equipment as crawler track retaining bolts.

Head Styles *Continued*

SKETCH	TITLE	COMMENTS
	SQUARE HEAD	Rarely seen now except on some mining specials with very oversize square across flats. Were used on timber bridgework and where larger bearing surface was required. Modern cold forming methods producing flange heads have hastened its demise.
	EXTERNAL TORX® FLANGE	Normally confined to special high tensile products in high torque applications.
	TEE HEAD	Occasionally used as a bolt head which is retained in a channel or where the space for a head is restricted and narrow. The head is usually, therefore, retained stationary and tension is achieved by rotating the mating part, eg: a nut.

Heads with Special Features

SKETCH	TITLE	COMMENTS
	SQUARE	Commonly found on cup bolts; also can be seen on raised countersunk (plow bolts/earth-moving) and hexagon (pump bolts). The square is used to retain the head while the mating nut is tightened.
	SHOULDER	Normally round and normally associated with hexagon heads. Often is used to allow a retained part of the assembly to rotate, eg: motor mower blades, tiltadoor hinges. Can also be used where a component in the assembly is made from crushable material which would not stand up to the tightened clamp force.
	OVAL	Usually associated with cup heads, agricultural and railway applications; also found on guardrail bolts. Used as a retention device in a slotted hole.
	WASHER RECESS	Found usually on self-drilling building fasteners; used to retain a neoprene or plastic sealing washer.
	FLANGE SERRATED (Whiz-Lock)	Hardened serrated teeth ramped to bite into mating surface upon loosening. Used in high vibration applications, particularly automotive; also used on nut products. With teeth ramped in the opposite direction, will act as a paint or coating remover and give excellent electrical contact.
	NIBS	Less aggressive than serrated, used on smaller fasteners to scrape paint or surface coating to give improved electrical contact. Often associated with mush or truss heads.
	HIGH FIX (High Grip)	A reverse thread applied to the shank just below the head allows a self-drilling building fastener to grip the crest of the sheeting material assisting the washer to achieve an improved seal.
	COUNTERSINK RIBS	Allows the screw to self-countersink the work piece on assembly, giving a flush finish. Flower heads which have notches on the outer edge, similarly ream a seating hole, allowing them to self-embed.

Thread Types

A thread is a ridge of uniform section in the form of a helix on the internal or external surface of a cylinder (IFI description) or it could be described as a sloping plane curled around a cylinder.

External threads are on bolts or screws.

Internal threads are on nuts.

There are many forms of threads but two types are in common use on fasteners.

Machine Screw Threads – used on bolts, setscrews, machine screws and designed to mate with preformed threads in nuts or tapped holes.

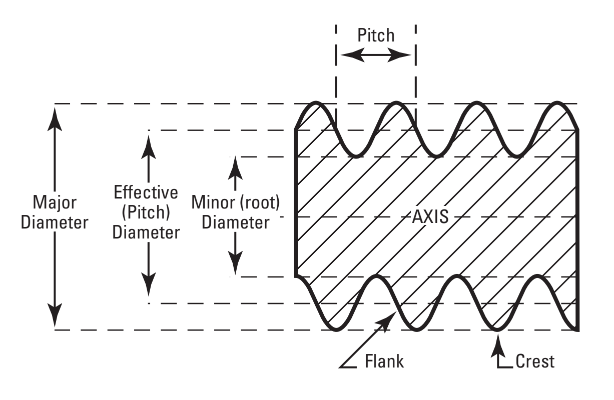
Exceptions may be thread forming screws like Taptite® or self-drilling screws like Teks® or thread cutters like Type 23's, which form or cut their own machine screw thread.

Spaced Threads – used on woodscrews, self-tapping screws, coach screws and Type 25 thread cutters. Designed to form its own thread, usually in a pre-drilled hole.

Exceptions may be self piercing screws such as needle points or self-drilling screws like Type 17's which create their own hole; some Teks® may also have spaced threads.

Machine Screw Threads

Basic Features: Major (nominal) diameter
Effective (pitch) diameter
Minor (root) diameter
Pitch
Flank
Crest



The major diameter can be measured with a simple calliper rule or slot gauge accurately enough to determine the nominal diameter. A bolt or screw is measured at the crests; a nut is measured at the thread roots.

The effective diameter, minor diameter, flank angle and pitch require specialist measurement equipment for technical accuracy. However, simple measurement at the thread crests will be accurate enough for most practical purposes in measuring pitch and determining thread designation.

For imperial threads, UNC, UNF, BSW and BSF, pitch is expressed in numbers of threads per inch, eg: 1/4 -20 UNC, the 20 being 20 threads per inch or 20 TPI.

For metric and BA threads, the pitch is a single thread measured and expressed in millimetres, eg: M10 x 1.5, the 1.5 being 1.5 mm from the same point on two adjacent threads.

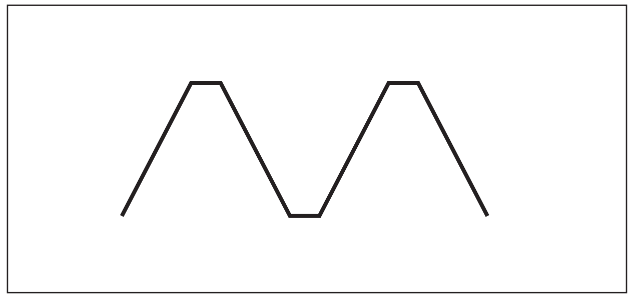
Thread Types (Machine Screw Threads) *Continued*

In ordering or referring to these threads, it is not necessary to state the pitch because absence of a thread pitch indicates reference to the standard Australian specification.

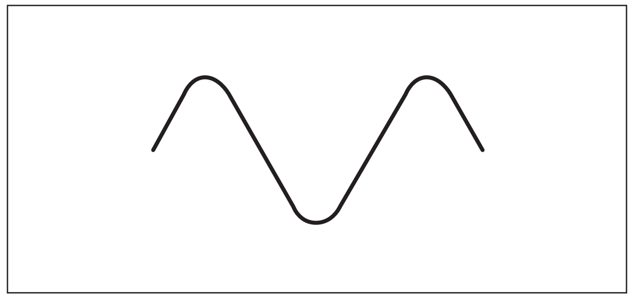
Pitch specification would be necessary when referring to metric fine threads which are not covered by Australian Standards and where several different pitches are possible internationally. Also when specifying 1" – 14 TPI UNF, which is the common international standard versus Australian standard 1" – 12 TPI UNF.

1"– 14 TPI UNF is also sometimes referred to as 1" – SAE and whilst not absolutely correct, this description may assist in recognition.

Note that in metric and unified, the crests and the roots theoretically should be flat; however, in practice, to aid manufacture and fit, they are rounded inside a maximum outline.

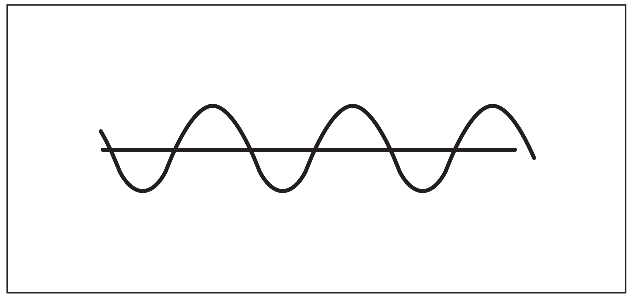


Unified and Metric (Theoretical)



Unified and Metric (In Practice)

Whitworth thread profile is more wave shaped, being a series of radius curves about the pitch line.



Whitworth

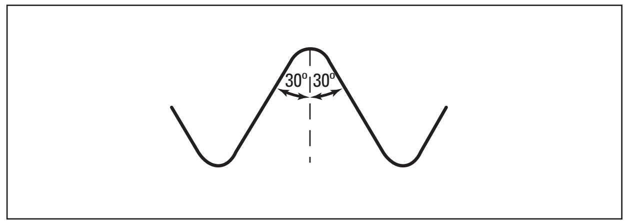
Threads which come to a point at the crest and root, are called complete threads; those that do not are called incomplete threads.

Most fastener machine screws thread forms are incomplete thread types.

Thread Types (Machine Screw Threads) *Continued*

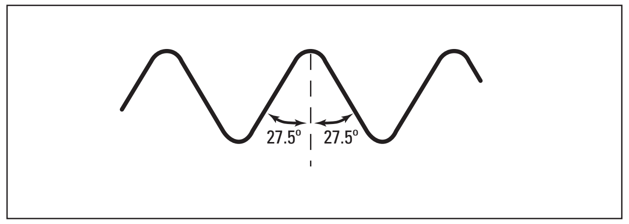
Thread Angles

Machine screw threads are symmetrical - the angle on both flanks being the same – refer to illustration.



Unified and Metric

Flank angles for METRIC, UNC and UNF are 30°
∴ a total thread angle of 60°

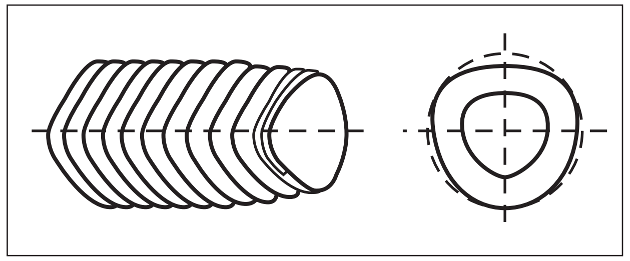


BSW and BSF

BSW and BSF are 27.5°
∴ a total thread angle of 55°

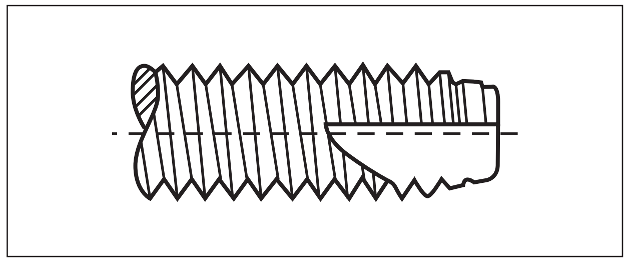
Because the pitch of some threads is common in the same diameters, it is possible to mate them, eg: BSW and UNC all diameters except 1/2 (where UNC is 12 TPI, BSW is 13 TPI), can be mated together. However, because the thread angles and the profiles differ, the 'fit' will be loose and the mechanical requirements of the fastener will not be achievable. Therefore, mixture of thread forms **must** be avoided.

Thread forming machine screws include Taptite® or TT



These screws have a tapered tri-lobular thread which roll forms its own mating thread whilst being driven into a prepared hole. Because of the resultant snug fit of the threads, the screw is vibration resistant. It can also be replaced by a conventional screw. Suitable for steel, die casting, aluminium.

Thread cutting machine screws include Type 23 screws

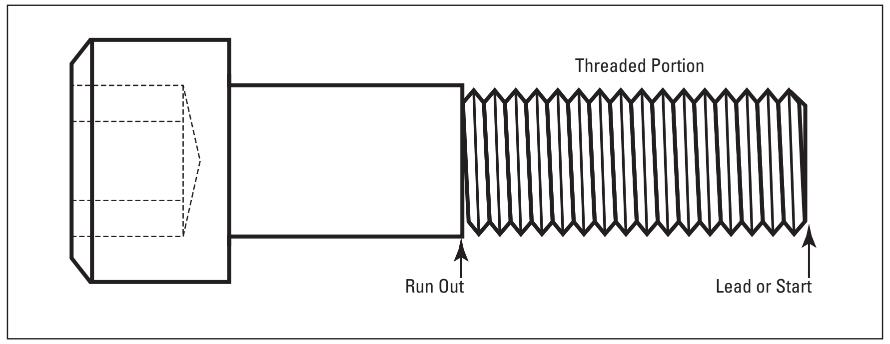


Which have a slot milled along the shank point. This will cut a thread in soft metals and hard plastics. Also used to remove paint from threads of captive nuts on painted panels, eg: automotive.

Thread Types (Machine Screw Threads) *Continued*

All machine screw threaded products, bolts or screws have common technical terms when referring to the thread

- Lead or start of thread
- Threaded portion
- Thread run out



Lead… is the point at which the thread groove is visible on the point of the screw.

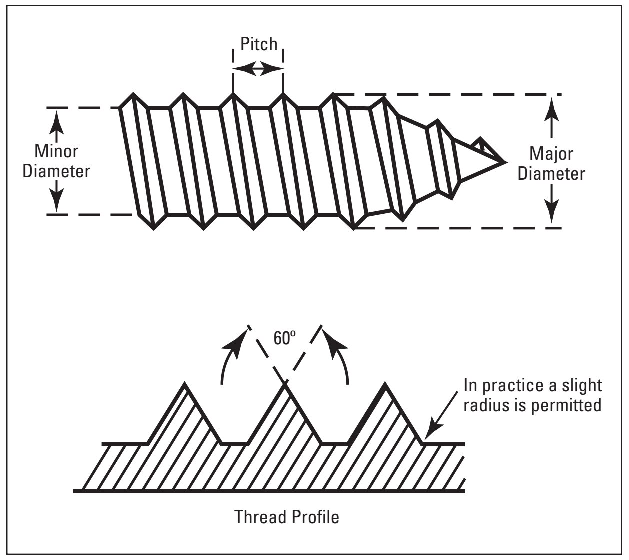
Threaded portion… is the total section of the screw on which there is a thread.

Thread run out… is the point at which the thread and the plain shank meet.

Thread Types *Continued*

Spaced Threads

Basic Features: Major (nominal) diameter
Minor (root) diameter
Pitch



The major diameter can be measured with a simple calliper rule or slot gauge accurately enough to determine nominal diameter. The measurement is taken on the crests.

The minor diameter and the pitch require specialist measuring equipment for technical accuracy. However, simple measurement at the crests will be accurate enough for most practical purposes in measuring pitch and determining thread designation.

The **diameter** of imperial spaced threads is expressed as – **gauge or 'number' #**

The **pitch** of imperial spaced threads is expressed as – **threads per inch (TPI)**

eg: a standard AB self-tapping screw, therefore, would be:–
6-20 where 6 is the gauge number and 20 is the TPI
or
10-16 where 10 is the gauge number and 16 is the TPI

For metric spaced threads which, apart from coach screws are a soft conversion from imperial, the diameter and pitch are expressed in mm. The pitch being the distance between the same point on two adjacent threads, again the crests will suffice as the measuring point.

eg: the equivalent to a 6-20 imperial would be 3.5-1.27 mm
where 3.5 mm is the equivalent for .138 (the major diameter of 6 gauge)
and 1.27 mm is the equivalent pitch for a thread of 20 TPI

To maintain simplicity, most spaced thread products continue to be referred to in their imperial designations and the use of pitch is not necessary for standard self tappers or for woodscrews.

eg: No. 6 STS or 6 gauge STS
No. 8 WS or 8 gauge WS is acceptable and sufficient

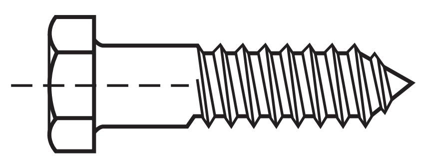
The proliferation of pitch availabilities in self-drilling type products, particularly the building fastener ranges, demands the use of pitch designations to ensure accurate description as many of these products can be available in two versions of spaced threads and a version of machine screw thread.

Thread Types (Spaced Threads) *Continued*

Coach Screws

Designed to form their own thread in pre-drilled holes in timber, they incorporate a woodscrew type rolled spaced thread which is dimensionally a soft conversion from imperial. However, designation of the size or nominal diameter is in millimetres, eg: M6, M8, M10 and the hexagon dimensions are the same as for hexagon metric commercial bolts.

As with woodscrews, there is no necessity to designate pitch in the description



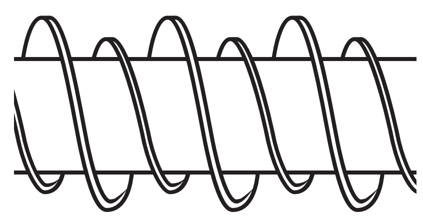
Self Tapping Screws

Designed to form a matching thread in the materials being joined. Usually into pre-drilled or pre-punched holes in sheet metals (needle point or S point versions self pierce or self drill).

They are heat treated and hardened, are often used into spring steel clips or speed nuts and can also be used in aluminium castings, plywoods, soft and high impact plastics, zinc die castings.

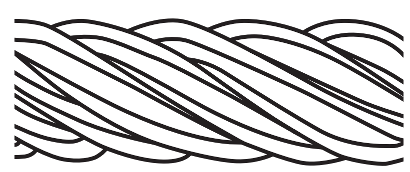
Thread Forming Screws

Hi - Lo designed for plastic materials it combines two thin walled threads, one higher, one lower. This gives a high pull out strength coupled with reduced incidence of plastic cracking



Type U (Hammer Drive)

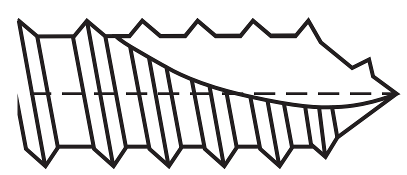
Designed for tamper proof fixing in plastic and metal castings. It features multiple start, very coarse spiral threads, is driven with a hammer and usually has a round or button shaped head



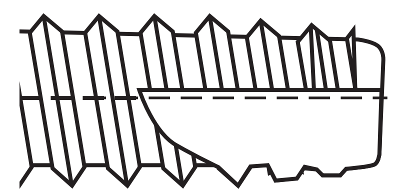
Thread Types (Spaced Threads) *Continued*

Thread Cutting

Type 17 designed for fixing sheet metal, fibro cement sheet, aluminium sheet or timber panelling to timber supports.
No drilling of either the sheets or the supports is necessary; the gimlet point will pierce and self drill the sheet and the milled slot will cut a pilot hole and thread whilst drilling



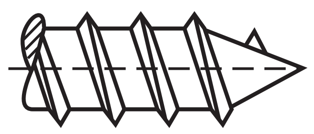
Type 25 Designed for use in die castings and or hard plastics. The blunt point assists square location into a prepared hole and the milled slot will cut the threads and clear the chips whilst driving



Woodscrews

Wormed or cut thread woodscrews – have sharply defined threads on a tapering shank to a gimlet point

Rolled thread woodscrews – employ a type 'A' spaced thread and a rolled taper point (this will look similar to a gimlet point). Both of these products are designed for quality cabinet making, furniture and joinery



Longthread woodscrews – have the same type 'A' spaced thread and gimlet style point as the above; however, the thread extends the full length of the screw to the underside of the head. These are designed for use in composite timbers such as particleboard and craftwood, giving longer thread engagement and higher pull out strength

***Note:** each of these woodscrews requires a pre-drilled hole and in high quality work, the wormed woodscrew also requires a counter bored and countersunk hole for quality results.*

*The are also some double threaded products called **twin start** or **twin fast** which usually have needle type points and two extra coarse threads running inside each other. This gives the same total number of threads engaging, so maintains pull out strength, but halves drive time.*

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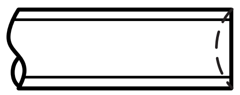
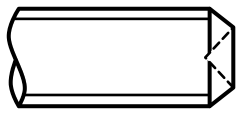
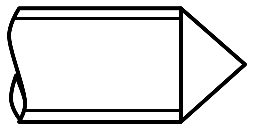
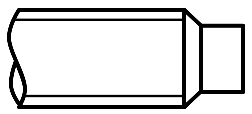
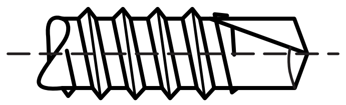
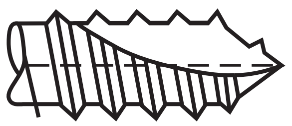
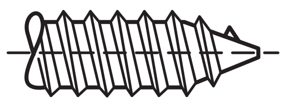
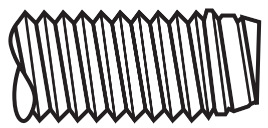
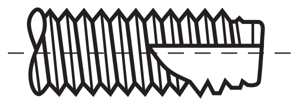
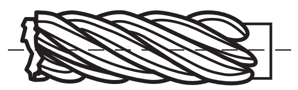
Point Types

SKETCH	TITLE	COMMENTS
	CHAMFER CUT POINT (Boltmaker Point)	The normal point found on most good quality hexagon bolts/set screws and cap screws. The chamfer is applied in a pointing station on a boltmaker prior to ejection through the thread rolling plates
	ROLLED POINT	A point that is found mostly on machine screws and cup head bolts, where the cold header product is simply roll threaded with no special attention to the end of the blank shank
	RADIUS POINT (Oval Point) (Round Point)	A radius point is kind to the surface of a mating part on which it bears. It may be found on a special screw which is being retightened regularly
	CUP POINT	Another point designed to bear on a mating part. Normally in a low tension assembly where the point contact assists retention. Sometimes has knurls on the tip circumference, known as knurled cup point.
	CONE POINT	Designed to positively locate a mating part by engaging in a drilled or prepared indentation. Only found on specials
	DOG POINT	As with cone points, this point locates a mating part. A dog point would tend to be more accurate and withstand greater load. Again, specials only
	DRILL POINT	A point very similar to a standard drill and designed to drill then tap or form a thread whilst driving. Some are milled points, some pinch pointed in special cold headers. There a re a number of proprietary versions – Drill Kwik®, Teks®, Pias®, etc
	TYPE 17	Designed to pierce and self drill sheet metal and drill timber supports, cutting threads whilst driving. The slot is applied by a milling shank slotter after thread rolling.
	NEEDLE POINT	A very sharp point made with special heading dies. Used to pierce light gauge sheet metals for self tapper type applications without having to drill. Very often used in construction of steel framed housing to secure plasterboard.
	TYPE AB POINT (Gimlet Point)	When on a self-tapper, it is called 'AB', on a woodscrew or coach screw is called 'gimlet'. A die produced point in the primary cold header, thread rolled leaving a thread start on the taper. This helps pull the screw into the hole and start the tapping groove.
	TYPE B POINT (Formerly Z)	Generally only found on self-tapping screws where either it is going into a blind hole where it will locate square more easily and give longer thread engagement, or where the point may protrude into an area where it could snag something or someone

Point Types *Continued*

SKETCH	TITLE	COMMENTS
	TAPTITE® (Type TT)	Tri-lobular point and body. Thread forming – refer to machine screw thread forms. Note other thread forming screws could include square-flow, and Type F, each with similar point treatment.
	TYPE 23	Milled slot point, machine thread screw, thread cutting - refer to machine screw thread forms.
	TYPE 25	Milled slot point, spaced thread screw, thread cutting – refer to spaced thread forms. Note: other spaced thread thread forming screws could include Type BF and Type Y.
	TYPE U (Hammer Drive)	Very similar to a dog point to give a positive location in the prepared hole

Nuts

The primary function of the nut in any threaded assembly is to act as the instrument through which the tension is induced into the bolt or screw and to continue to retain that tension and thus, the clamp load in the assembly.

The vast majority of nuts have hexagon drive faces but they come with a large variety of other features for a secondary purpose such as thread locking, face seating/location, load spreading, pinning, welding, capping.

All the machine screw threads, ISO-METRIC – coarse and fine, UNC, UNF, BSW, BSF, BA, are available.

Materials include carbon steels, stainless steels, brass, aluminium, nylon.

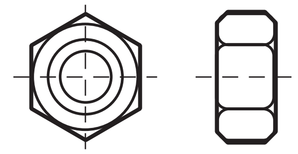
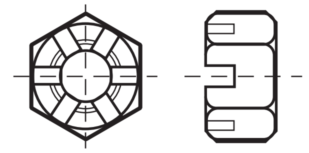
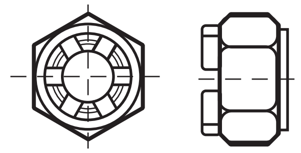
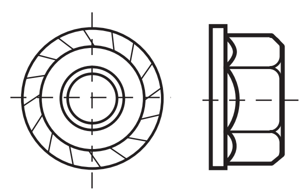
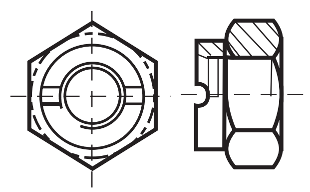
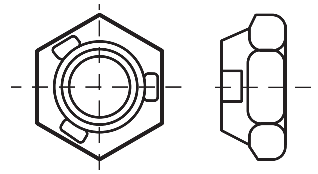
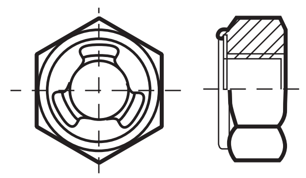
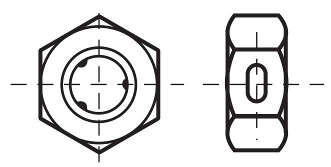
Finishes would normally include plain, zinc, galvanised, chrome.

Correct strength combinations of nuts and bolts will ensure that the nut is capable of tensioning the mating bolt to breaking point rather than the nut stripping; (a broken bolt is clearly evident, a stripped nut may not be). To ensure correct combinations, always use bolt and nut products with the same proof load designations;

eg: SAE Grade 8 bolts use Grade 8 nuts
SAE Grade 5 bolts use Grade 5 nuts
Property Class 8.8 bolts use Class 8 nuts
Note: Property Class 4.6 bolts use Class 5 nuts

Products purchased as a bolt and nut combination will be supplied with the correct nut by the manufacturer.

Nut Styles

SKETCH	NUT TITLE	COMMENTS
	PLAIN HEXAGON	The standard form general purpose nut – may be used with various washers. Also available in a thin or lock nut version. (JAM) Normally supplied double chamfered if cold formed. May also come with full bearing or washer face when machined.
	HEXAGON SLOTTED	A plain hexagon nut with slots cut to allow insertion of a split cotter pin through the nut and a drilled hole in the bolt totally preventing subsequent rotation in either direction. Often used in a non-tensioned assembly.
	HEXAGON CASTLE	Deeper than slotted so that full thread engagement is not compromised by the slots. In addition, the cotter pin head and split ends will be less proud when spread. Usually machined and with a washer face.
	HEXAGON FLANGE SERRATED LOCK NUT (Whiz Lock)	Special serrations on the flange face resist loosening in vibration applications. Also available as a plain flange to span a large hole or slot or spread the clamp load.
	HEXAGON NYLON INSERT LOCK NUT	A nylon insert on top of the nut creates a prevailing torque, resists loosening and allows reuse after several removals without significant performance loss. Also available in thin series.
	HEXAGON CONE TYPE LOCK NUT	Manufactured with a cone shaped top which is distorted after tapping to create a prevailing torque. Less reusable than nylon insert, but less susceptible to high temperature applications.
	HEXAGON GLENLOCH NUT	Incorporates a stainless spring steel insert developing prevailing torque to resist loosening. Also reusable without significant loss of performance. Less susceptible to high temperature or caustic applications.
	HEXAGON TWIN LOCK NUT	After tapping, a plain hexagon nut is distorted on three of the hexagon faces creating an internal thread distortion designed to create a prevailing torque. Low level reusability.

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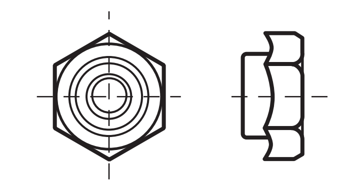
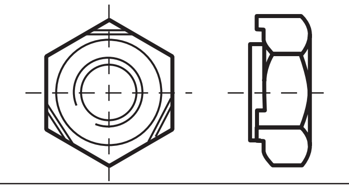
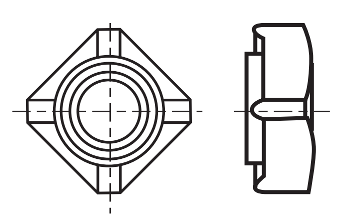
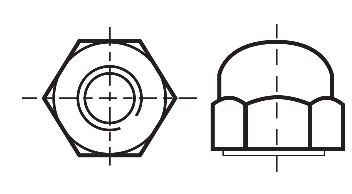
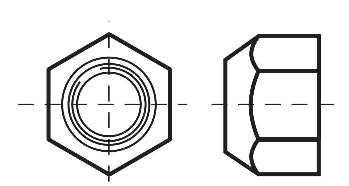
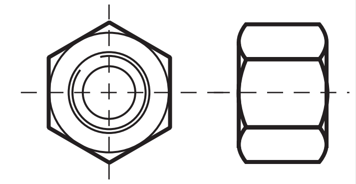
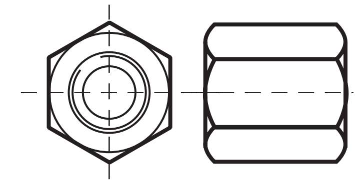
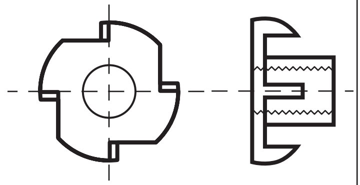
Nut Styles *Continued*

SKETCH	NUT TITLE	COMMENTS
	HEXAGON ROOT (Clinch) NUT	Nut has a central spigot and a conical machined undercut around the spigot. This nut is inserted into a thin sheet panel and the spigot peened over to secure it. Can also come with nylon insert.
	HEXAGON WELD NUT	Has three welding projections designed to melt and weld to a panel when special equipment applies high electrical current and high pressure. Can have a central spigot to aid location and prevent weld spatter entering threads.
	SQUARE WELD NUT	Has four welding projections. Works as above, but does require flatter surface. Can come with or without central spigot designed for location and to prevent weld splatter from fouling the thread.
	HEXAGON DOMED OR CAP NUT	Either machined with a closed domed end or capped in a secondary process after tapping. Used in decorative applications, or for protection from protruding threads. Usually chromed or polished.
	HEXAGON WHEEL NUT	Formed with a cone or taper end designed to mate with the tapered recess in an automotive wheel, giving positive location and increased bearing surface.
	HEXAGON DEEP (Thick) NUT	A plain hexagon nut with increased overall height, giving longer thread engagement. Used in special high torque applications with high tensile bolts or studs.
	COUPLING NUTS (Joining)	Similar to the deep nut above except longer/deeper. Used for connecting lengths of allthread.
	Tee Nuts	A pressed metal threaded product with spiked prongs. Designed to embed in timber to provide a solid thread form mostly found in furniture applications.

Nuts *Continued*

Thin Locknuts (Jam Nuts)

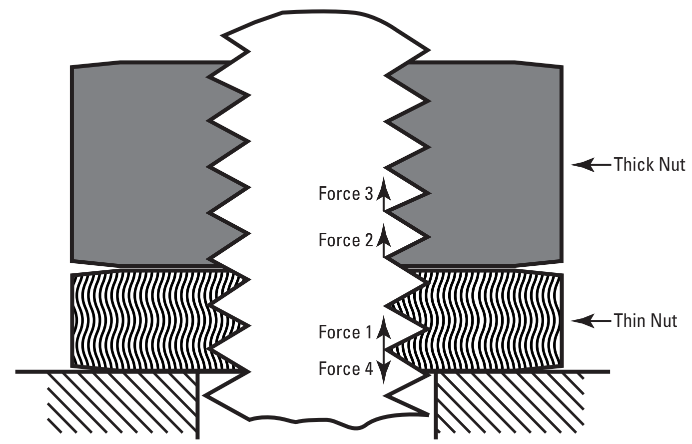
When used in conjunction with a standard nut with the intention of 'locking' the assembly, these nuts are commonly assembled incorrectly.

The correct assembly method is to apply the thin nut FIRST as shown in the diagram below.

- Tension the thin nut to snug tight – Force 1.
- Apply the standard nut and tension it to snug tight – Force 2
- While holding the thin nut against rotating, further tighten the standard nut to full design tension – Force 3 and Force 4

In effect, the two nuts are now working in opposite directions and are locked. The upper nut has to carry the higher load and therefore, has to be the thicker of the two.

These nuts will remain locked even if tension in the assembly is lost.



Washers

Washers come in a wide variety of designs and within those individual designs are a range of materials, dimensional variations and finishes.

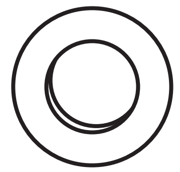
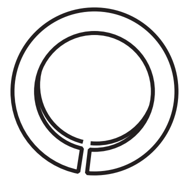
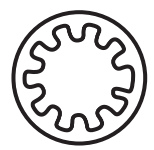
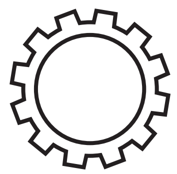
Many can be used either under the head of the fastener, bolt or screw, or under the nut.

Many can be encapsulated as an assembly on a screw or bolt, or occasionally with a nut; these products are called SEMS.

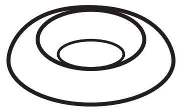
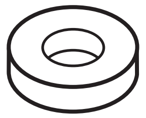
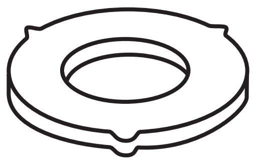
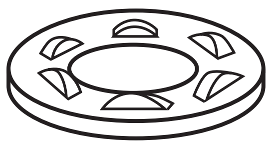
Most washer sizes will be designated by the diameter (size) of the fastener with which they are to be used.

- Basic Washers are employed to:
  - spread the clamp load over a larger surface area
  - cover an oversize or elongated hole
  - reduce the friction of the rotated component
  - protect the work piece surface from damage by the rotated component
  - provide a locking or vibration resistant function
- Specialist washers have been designed to perform particular functions in particular types of applications. These may be locking, load spreading, decorative, tension indicating, sealing, or a combination of these functions. Some of the most common are shown in the charts following.

Washers *Continued*

SKETCH	TITLE	COMMENTS
	FLAT (Black, Bright)	Common general purpose basic washer, can come in various dimensional standards, quality levels, materials, hardness grades and finishes. Could also be available square. Often used in conjunction with a split spring washer.
	SPLIT SPRING	Common locking washer, will come in a variety of thicknesses and sectional ratios. Available in various materials throughout a wide size range. Used to resist vibration loosening. Will damage surfaces it contacts.
	BELLEVILLE WASHER (Conical)	For use in high vibration applications where tension must be maintained if some loosening occurs. Can be used in stacks or series to increase the axial load or to increase the possible deflection length.
	INTERNAL TOOTH LOCK WASHER (Shake Proof)	Used with pan or cheese head machine screws to resist vibration. Minimal damage to surface.
	EXTERNAL TOOTH LOCK WASHER (Shake Proof)	Same as above except slightly more damaging to surface. Also available in countersunk version.
	WAVE	Can be available as full circle or split. Is used in place of spring washers where surface damage is to be avoided. Also used where some pressure is required on a free element of an assembly. Usually confined to small diameters. Similar products are crinkle washers.
	CURVED	Generally confined to light applications similar to above, where only very light pressure is required.

Washers *Continued*

SKETCH	TITLE	COMMENTS
	SCREW CUP (Cup)	Used under a countersunk screw where a decorative or appealing finish is required; eg. Automotive door trims. Normally would be nickel or chrome plated, or in stainless material.
	NEOPRENE (Neo)	A rubber type material used in roofing screw applications under washer head screws with sealing washer recess. Designed to create a waterproof seal between the screw and sheeting material. Can also be bonded to aluminium or stainless washers.
	CYCLONE WASHERS	Various styles to suit the range of roofing profiles. Bonded with neoprene, these washers spread the load over a large area of roof sheeting, reinforcing the sheeting against lifting over the screw heads in cyclonic conditions.
	STRUCTURAL	A hardened steel washer used in conjunction with structural bolts in heavy construction applications. The washer reduces galling between the tightened surfaces and spreads the load. The three external tabs identify it as a structural washer.
	LOAD INDICATING WASHER (Coronet)	Used in the structural industry to provided evidence that the required tension has been achieved. The raised protrusions will crush in relation to the load applied, providing a permanent witness that required tension was achieved.

THE BEST DESERVES THE BEST

JAMES GLEN
STAINLESS FASTENERS

Training Manual

Section 2 – Properties

Materials, Mechanical Properties and Markings

Metals used in fastener manufacture are elastic materials which will stretch (elongate) under applied loads and return to their original shape when the load is removed.

However, if sufficient load is applied, the material will stretch beyond its yield point and enter a plastic zone, losing its elasticity and becoming permanently stretched.

Further increased load on the material will stretch it to its ultimate tensile strength at which point the material will fracture.

The materials of our particular concern are:

Steels – low tensile (mild steel)
– high tensile
– stainless steel

The major factor in determining the load a material can carry is its **tensile strength**, which is related to its hardness.

The terms used to describe the strength and load bearing properties of a metal fastener are:

1. **Tensile Strength** – is an expression of the maximum capacity of a particular material to stretch under tension load, prior to failure.

   It is normally expressed in: pounds/tons – imperial terms
   kilonewtons (kn) – metric terms

2. **Yield Stress** (yield point) – is an expression of the theoretical point of stress (pressure) beyond which the material loses its elasticity and becomes permanently stretched; (realistically, a range rather than a single point).

   Stress is load ÷ area, ∴ the term will include a unit of area
   It is expressed as: lbf/in^2 (PSI) – imperial terms
   N/mm^2 (Mpa) – metric terms

3. **Proof Load Stress** – is an expression of the minimum stress a material must achieve, prior to permanent elongation and, the stress which would be applied to test and remeasure a specific fastener to prove it had not permanently stretched and that it will carry the required load.

   These terms will also include a unit of area, are approximately between 80% and 90% of the theoretical yield stress and are expressed in the same terms.

   Proof load stresses also apply to nuts and are the point at which the nut is deemed to have failed; (= to the bolt UTS in a given diameter)

4. **Ultimate Tensile Stress** – is the theoretical minimum point at which the material will fracture. It is expressed in the same terms as yield stress and proof load stress.

These properties are used to calculate the **proof load** and **breaking load** for each diameter of each grade or class of product. (The calculated figures for each of these properties are listed by diameter in the relevant standards).

Proof loads and breaking loads are expressed as:–
imperial ....pounds force (lbf)
metric ....kilonewton (Kn)
and are the units used by engineers in designing the elements of a joint.

Materials, Mechanical Properties and Markings *Continued*

The strength properties of an individual fastener are achieved by a combination of:–

– Appropriate base material selection
– Manufacturing processes

Low Tensile Bolts/Machine Screws
Low carbon grades of steel are improved in hardness (strength) by cold working.

High Tensile Bolts

Medium carbon grades of steel are improved in hardness (strength), after cold working, by controlled heat treatment and quenching.

Stainless Steel Products

Austenitic grades in various strengths are improved in hardness by cold working.

Martensitic grades in various strengths are improved, after cold working, by controlled heat treatment and quenching.

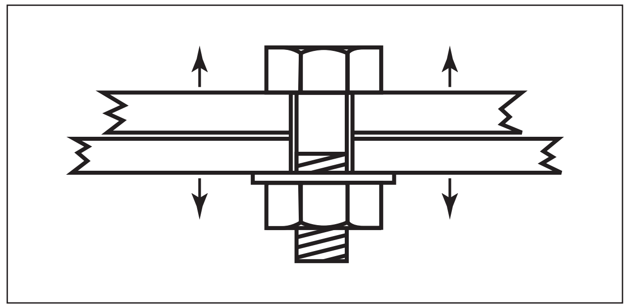
Self Tapping/Drilling Screws

Medium carbon grades of steel are improved in case hardness, after cold working, by heat treatment and quenching.

Loads

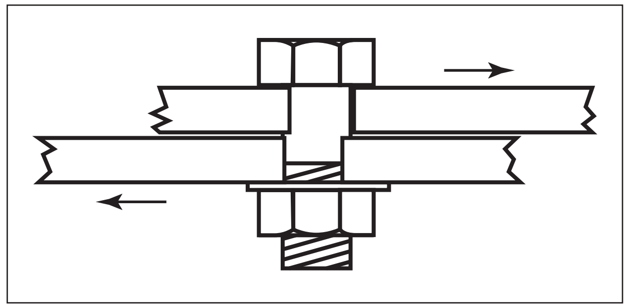
Fasteners carry loads in one of two ways:–

Tensile Load



Where the load is acting to separate the fastened components along the shank length, it is referred to as a **tensile load**. Tensile loads try to elongate the fastener.

Shear Load



Where the load is acting to separate the fastened components across the shank diameter, it is referred to as a **shear load**. Shear loads try to cut the fastener in half.
The load carrying capability of a fastener is somewhat less in shear than in tensile and will further vary if the shear plane is across the threads rather than the plane shank.

Some applications could exert a combination of tensile and shear loads.

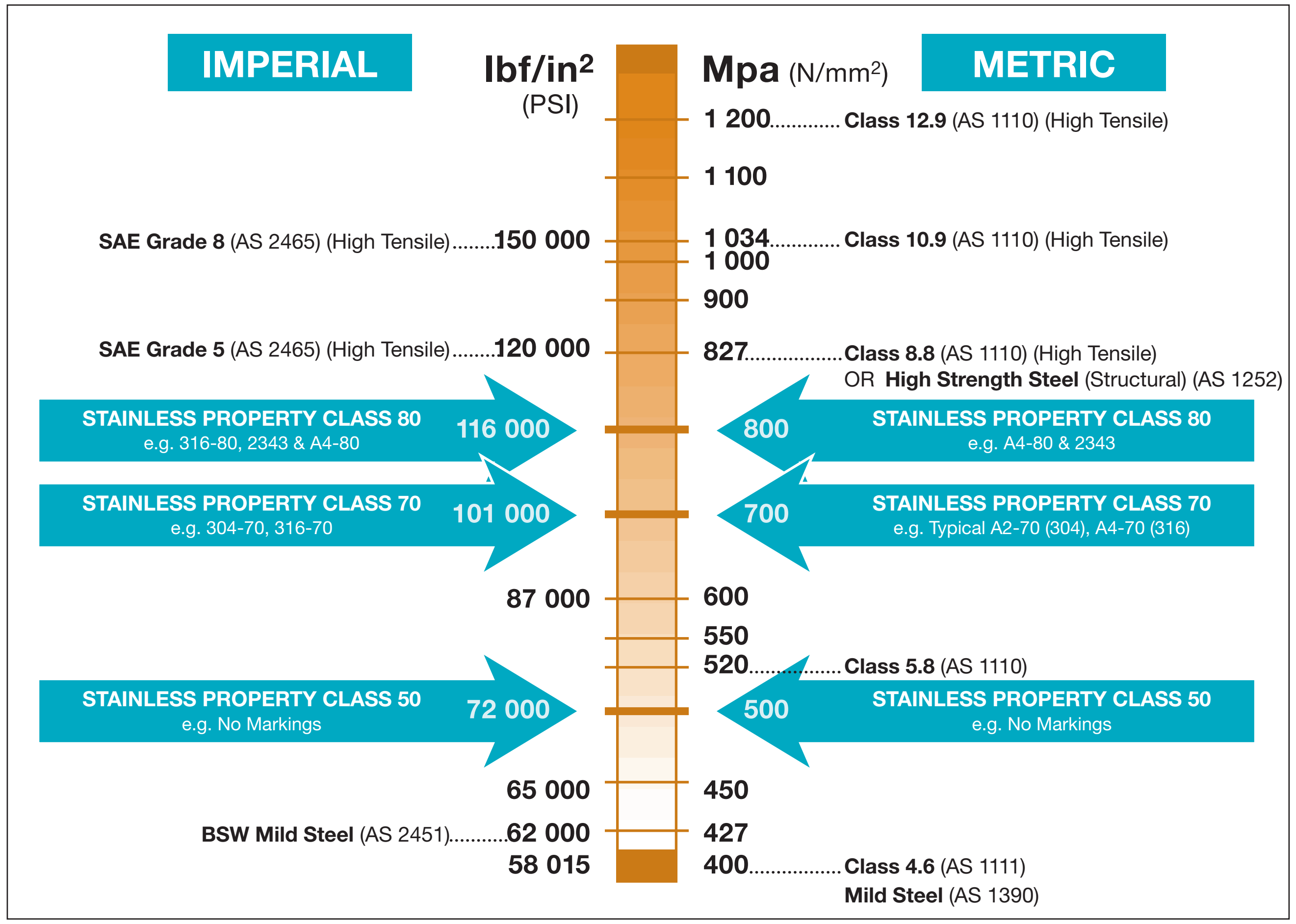
training manual

Materials, Mechanical Properties and Markings *Continued*

The strengths of a product group of fasteners are expressed:–

in the imperial system as **grades**
in the metric system as **product class**

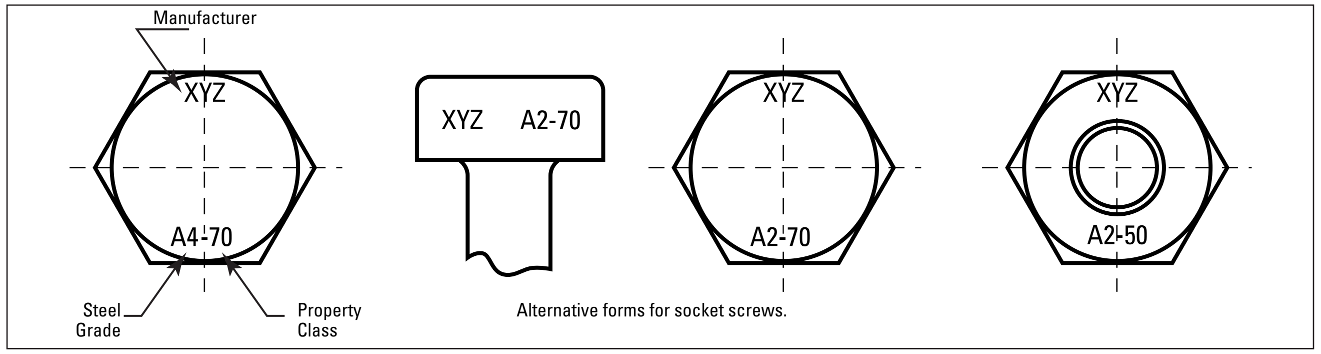
The approximate tensile strength comparison of steel grades and classes:–

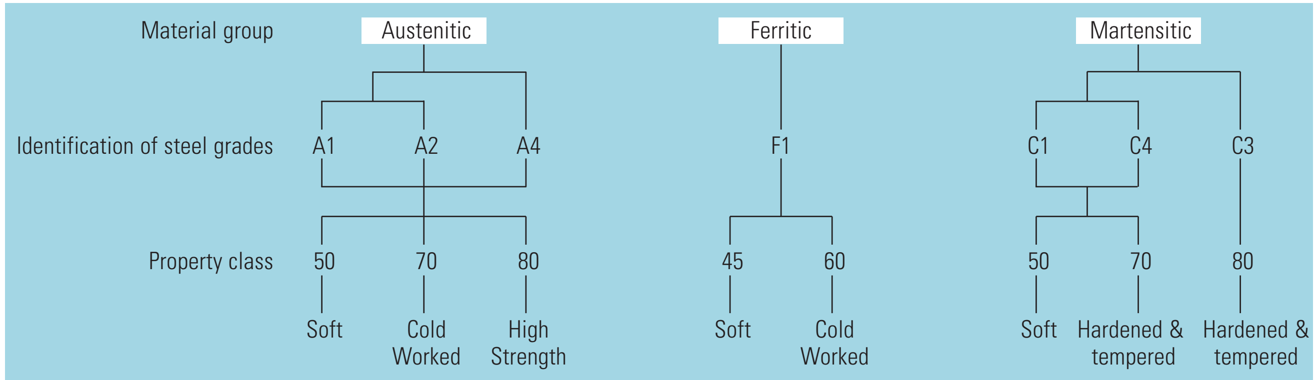


Accurate Conversion factors 1000 PSI (lbf/in²) = 6.8948 MPa
1 Mpa = 145.038 PSI (lbf/in²)

Materials, Mechanical Properties and Markings *Continued*

Stainless Steel Markings Only





A4-70

A = Austenitic steel (300 series)
1 = Free cutting stainless steel
2 = Cold formed stainless steel containing mainly chromium and nickel (known as 304)
4 = Cold formed stainless steel containing mainly chromium and nickel and molybdenum (known as 316)

Indicates the strength (property) class
50 = 1/10 of the tensile strength min 500 Mpa (approx 72000 psi)
70 = 1/10 of the tensile strength min 700 Mpa (approx 101000 psi)
80 = 1/10 of the tensile strength min 800 Mpa (approx 116000 psi)
Applies for sizes up to M20 only.

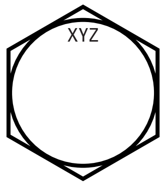
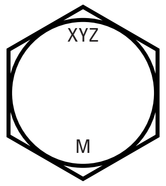
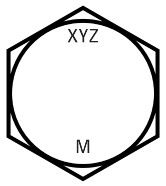
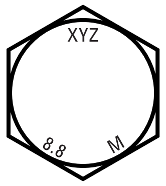
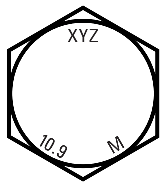
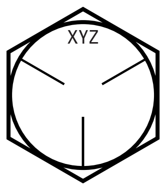
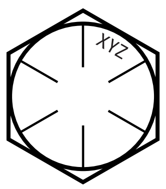
Bolts, Screws and Studs

Grade	Property Class	Tensile Strength Rm. M.Pa (N/mm2) min.	Yield Stress Pp 0.2 M.Pa (N/mm2) min	Elongation A1 min
A2 and A4	50	500	210	0.6d
A2 and A4	70	700	450	0.4d
A2 and A4	80	800	600	0.3d

Points to Note

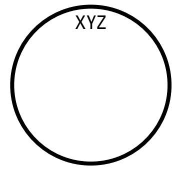
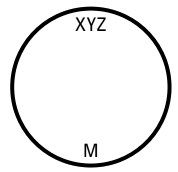
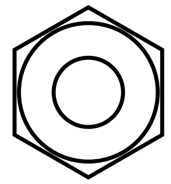
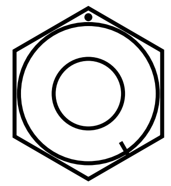
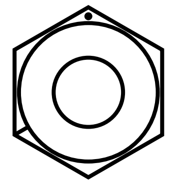
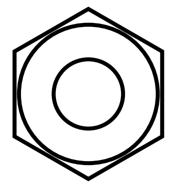
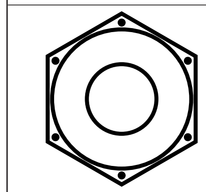
- Product markings are not uniform over all stainless fasteners.
- Where A2 and A4 are used without property class, assume it is lowest strength grade unless supplied with a certificate.
- A2 and A4 may be replaced with 304 or 316
- 'M' used in Australia on non-stainless product to indicate metric is not consistently used on stainless.

Materials, Mechanical Properties and Markings *Continued*

Marking	Standard	Description	Mechanical Properties		
			Property	1bf/in^2	Mpa
BOLTS					
	AS/NZS 2451	Hexagon BSW Mild Steel	Tensile Strength	62720	(432.5)
			Yield Stress	35840	(247)
			Proof Load Stress	–	–
	AS/NZS 1111	Hexagon ISO Metric Commercial 4.6	Tensile Strength	(58015)	400
			Yield Stress	(34809)	240
			Proof Load Stress	(32634)	225
	AS/NZS 1393	Hexagon ISO Metric Coach Screws 4.6	Tensile Strength	(58015)	400
			Yield Stress	–	–
			Proof Load Stress	–	–
	AS/NZS 1110	Hexagon ISO Metric Precision 8.8	Tensile Strength M5 – 16 M20 – 39	(116030) (120382)	800 830
			Yield Stress M5 – 16 M20 – 39	(92824) (95725)	640 660
			Proof Load Stress M5 – 16 M20 – 39	(84122) (87023)	580 600
	AS/NZS 1110	Hexagon ISO Metric Precision 10.9	Tensile Strength	(150840)	1040
			Yield Stress	(136336)	940
			Proof Load Stress	(120382)	830
	AS/NZS 2465	Hexagon Unified High Tensile UNC/UNF SAE Grade 5	Tensile Strength 1/4" – 1" 1 1/8 – 1 1/2	120000 105000	(827) (724)
			Yield Stress 1/4 – 1" 1 1/8 – 1 1/2	92000 81000	(634) (558)
			Proof Load Stress 1/4 – 1" 1 1/8 – 1 1/2	85000 74000	(586) (510)
	AS/NZS 2465	Hexagon Unified High Tensile UNC/UNF SAE Grade 8	Tensile Strength	150000	(1034)
			Yield Stress	130000	(896)
			Proof Load Stress	120000	(827)

Note: In these examples XYZ represents the Manufacturer's symbol.

Materials, Mechanical Properties and Markings *Continued*

Marking	Standard	Description	Mechanical Properties		
			Property	1bf/in^2	Mpa
BOLTS					
	A.S.B. 108 ANSI B 18.5	Cup Square BSW Mild Steel	Tensile Strength	58240	(402)
			Yield Stress	29120	(201)
			Proof Load Stress	–	–
	AS/NZS 1390	Cup Square ISO Metric 4.6	Tensile Strength	(58015)	400
			Yield Stress	(34809)	240
			Proof Load Stress	(32634)	225
NUTS					
	AS/NZS 2451	Hexagon BSW Mild Steel Nuts	Proof Load Stress	62720	(432.5)
	AS/NZS 1112	Hexagon ISO Metric Nuts Prop. Class 5	Proof Load Stress	(88473)	610
(Alternative marking can be letter 5 on one face or Hex flat)					
	AS/NZS 1112	Hexagon ISO Metric Nuts Prop. Class 8	Proof Load Stress	(124733)	860
(Alternative marking can be letter 8 on one face or Hex flat)					
	AS/NZS 2465	Hexagon Unified High Tensile UNC/UNF Nuts SAE Grade 5	Proof Load Stress – Up to 1" UNC UNF	120000 109000	(827) (751)
			Proof Load Stress – Over 1" UNC UNF	105000 94000	(724) (648)
	AS/NZS 2465	Hexagon Unified High Tensile UNC/UNF nuts SAE Grade 8	Proof Load Stress	150000	(1034)

Note: In these examples XYZ represents the Manufacturer's symbol.

Materials, Mechanical Properties and Markings *Continued*

The following three charts compare approximate indices of buying prices, application 'in-place' costs and product weights for bolts of different diameters and strength grades but having similar mechanical capabilities.

The 'in-place' costs give consideration to such factors as:

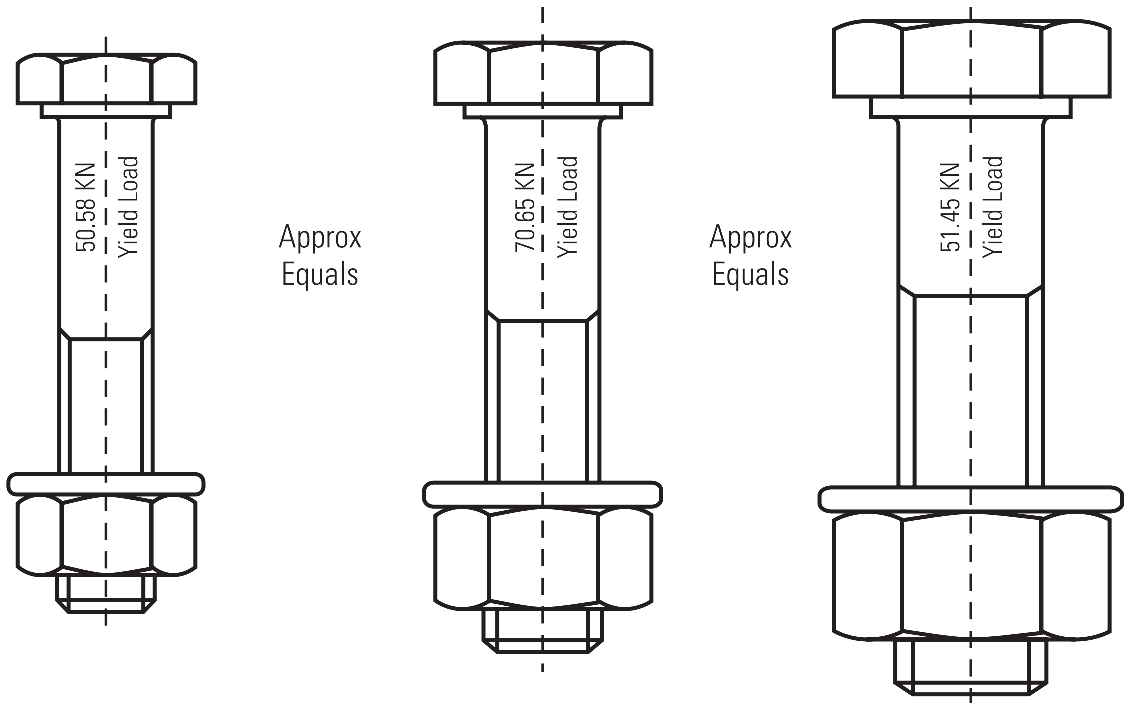
- relative numbers of fasteners for a given joint
- hole preparation labour and consumables
- insertion and tightening labour
- user handling, freight, warehousing (stainless examples also considered cost penalties for increased flange diameter to accommodate larger diameter fasteners).

These charts are not intended to accurately reflect a range of applications but simply to demonstrate that higher strength, smaller diameter, lighter products will normally provide a similar clamp load result at a somewhat lower 'in-place' cost.

As always the design engineer will take many other factors into consideration when selecting the appropriate fastener for a given application.

Mechanical Properties comparison Stainless Steel – Metric

Price Index		
100	195	390
CL 80 M12 x 55	CL 70 M16 x 60	CL 50 M20 x 65

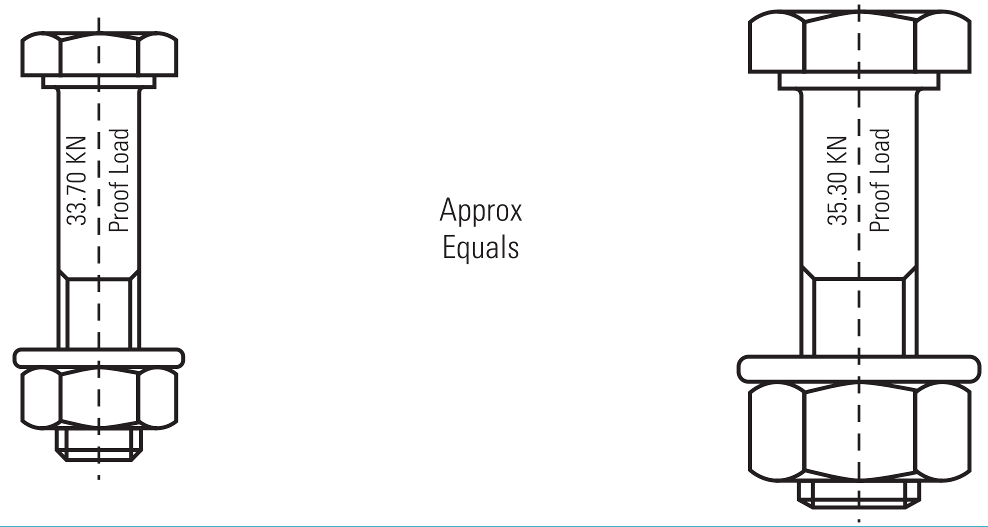


In Place Cost Index		
100	222	624

Weight Index		
100	200	360

Materials, Mechanical Properties and Markings *Continued*

Price Index	
100	152
PC 8.8 M10 x 40	PC 4.6 M16 x 45

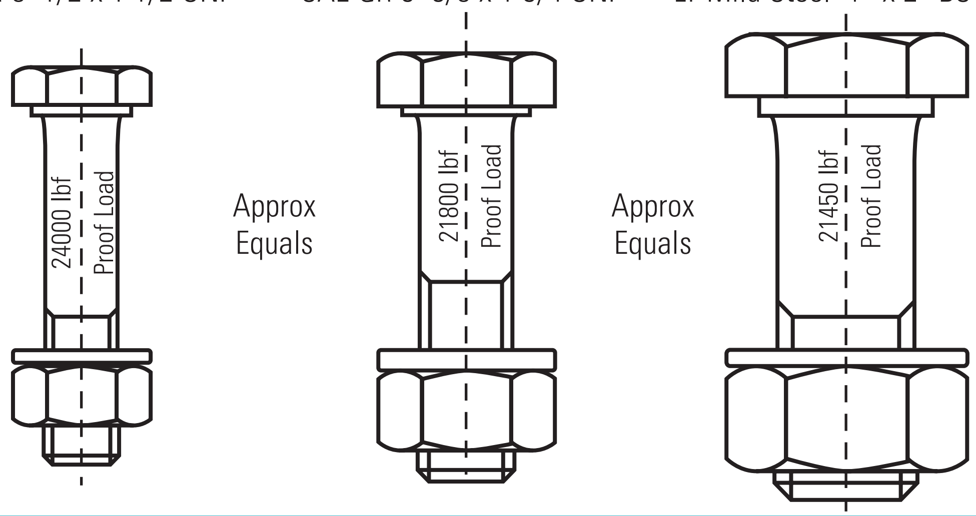


In Place Cost Index	
100	228

Weight Index	
100	280

Mechanical Properties Comparison Steel – Imperial

Price Index		
100	155	480
SAE GR 8 1/2 x 1 1/2 UNF	SAE GR 5 5/8 x 1 3/4 UNF	LT Mild Steel 1" x 2" BSW



In Place Cost Index		
100	198	462

Weight Index		
100	190	600

Materials, Mechanical Properties and Markings *Continued*

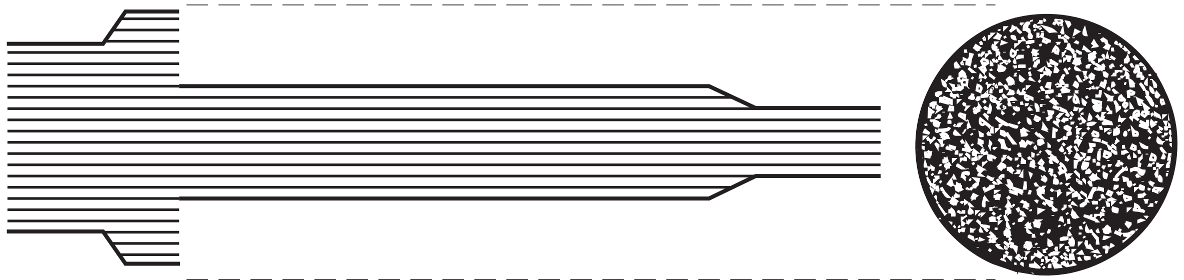
Cold Heading -v- Machining

Cold Heading

Below is a cold headed part formed from the diameter of wire shown to the right. Unbroken metal flow lines (grain) greatly increase fatigue life and enhance load-carrying ability.

Machining

Illustrated below is a representation of a bolt produced by machining a large diameter bar or wire. Grain or metal flow lines are broken through the head and washer section, which creates planes of weakness.

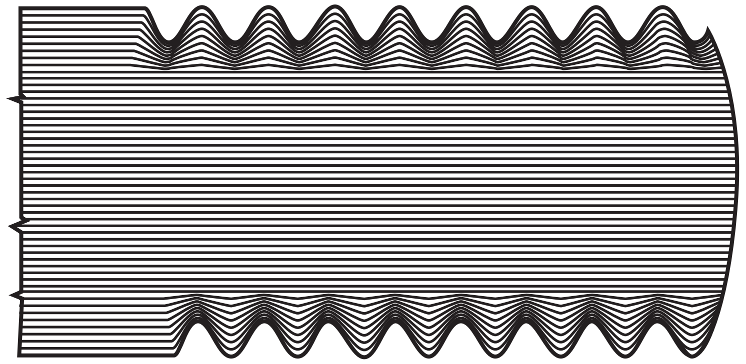


Materials, Mechanical Properties and Markings *Continued*

Thread Rolling -v- Thread Cutting

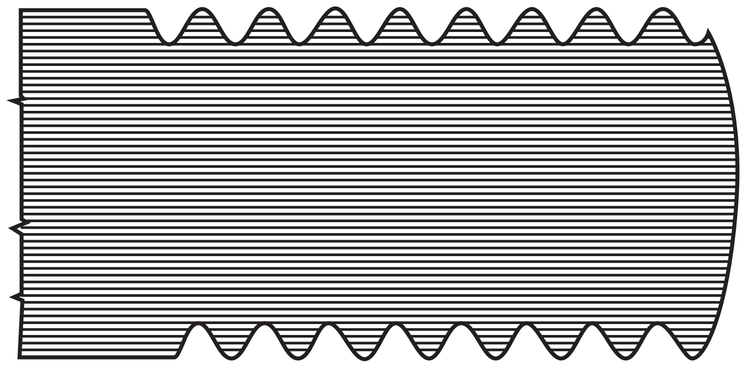
Thread Rolling

No metal is cut away, the grain flow lines are unbroken and curve around the thread profiles.
The cold rolling stresses the roots in compression, significantly increasing fatigue strength. Smooth roll dies create burnished roots and smooth flanks free from cutter tool marks, reducing potential galling and stress risers.



Thread Cutting

The grain flow lines are cut and planes of weakness are created.



training manual

Bolt Tensioning

To ensure a fastener performs in its application as the engineer intended, it must be adequately tensioned.

As a general rule, the joint will have been designed with sufficient numbers and sizes of fasteners to apply the required clamp load at 65% of the fastener proof load; ie. well below the fasteners yield point. (Note: gasketed or soft joint components significantly alter this).

To achieve a minimum pre-load in the fastener of 65% of proof load, the fastener needs to be stretched by tightening.

This can be done by various methods, each with varying degrees of accuracy, certainty and cost.

eg: The commonly accepted relationships are shown in the following chart.

Pre-Load Measuring Method	% Accuracy	Relative Cost
Feel or Operator Judgement	+ or - 35	1
Torque Wrench	+ or - 25	1.5
Turn of Nut	+ or - 15	3
Fastener Elongation	+ or - 3 to 5	15
Strain Gauges	+ or - 1	20

- **Operator Judgement**, tightening by feel, is the most common tensioning method for non-engineered and DIY type applications. It is generally satisfactory in these non-critical joints where loads are static and not subject to vibration; however, it is prone to significant under and over tightening by inexperienced operators.
- **Torque wrenches** are by far the most common tensioning method for engineered joints because of low cost and simplicity, but at + or - 25%, they lack accuracy.
- Approximately 85-90% of the torquing effort is used to combat the frictional forces in threads and mating surfaces of the bearing and rotating units; (stainless components can be even higher). Any reduction in friction will have a marked affect on the induced tension; ie. a 10% reduction could increase tension 80-90%.
- Lubrication, thread fit, tightening speed, surface finish or plating, all have some effect on the friction generated. Close attention to these factors and to torque wrench calibration can improve accuracy.
- The minimum lubrication required would be light oiling. The residue on plain finish mild steel and high tensile bolts is usually sufficient, but all plated products should be oiled and stainless steel products can benefit from a high quality solid type lubricant such as molybdenum disulphade.
- Tightening torque figures to achieve 65% or proof load are shown in the James Glen Technical Catalogue for mild steel, high tensile and stainless grades.
- **Turn of nut** is commonly used in structural bolting, but requires marking of the various components to verify the degree of turn achieved from 'snug tight'.

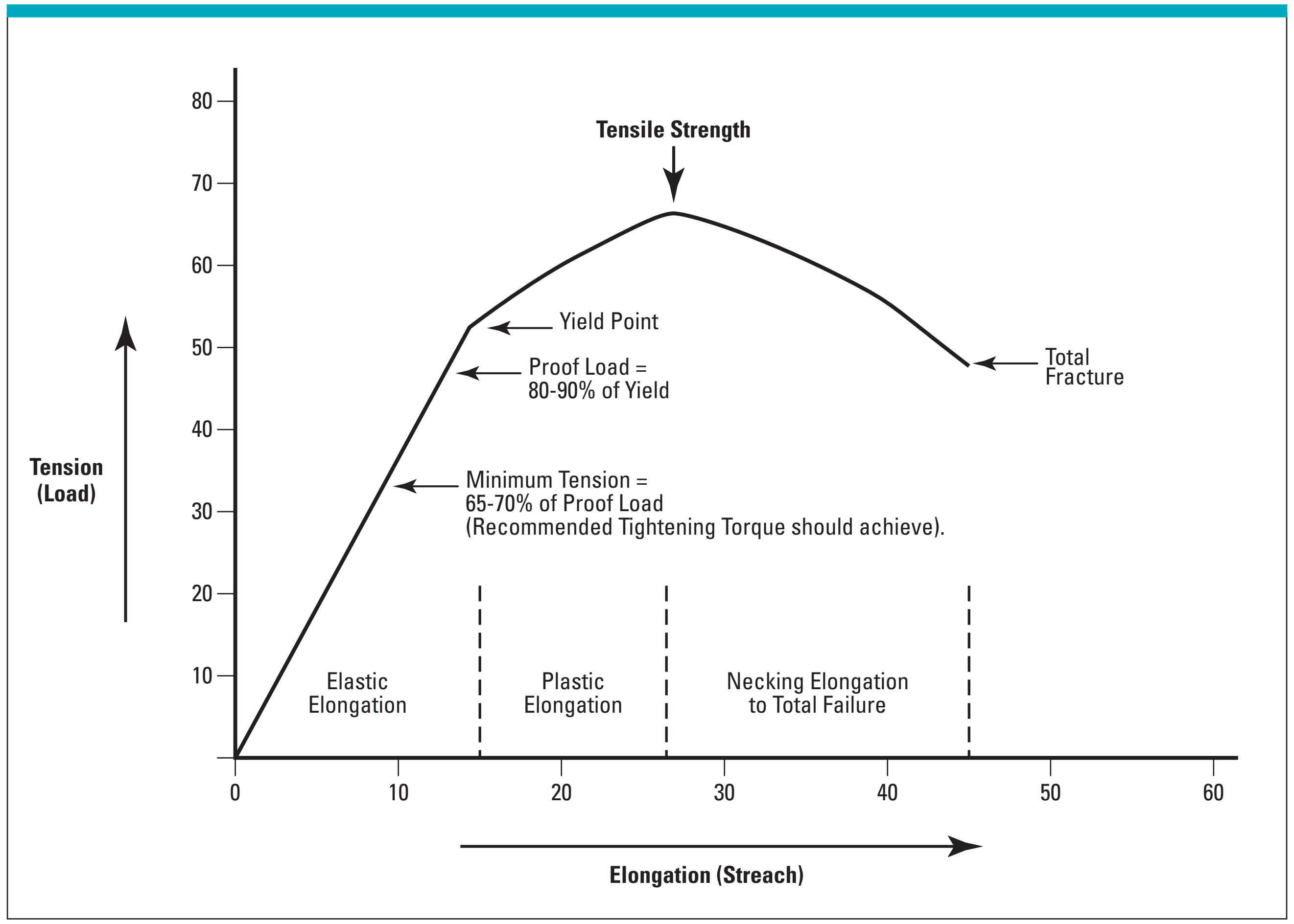
  Time consuming, but does provide some evidence for subsequent inspection, as do **load indicator washers** – slightly more expensive for slightly more accuracy and permanent evidence.
- **Fastener elongation** involving direct measurement of the degree of stretch along with **strain gauges** attached to the bolt shank, give excellent accuracy, but would only be justified economically in the most critical of circumstances.

Bolt Tensioning *Continued*

The following chart pictorially demonstrates the typical tension/elongation relationship, the various zones of elongation and points of tension.

- Elastic Elongation: elongation from which the fastener will recover when load is removed.
- Plastic Elongation: elongation which is permanent and renders the fastener non-reusable.
- Necking Elongation: elongation past the tensile strength of the fastener from where the diameter is reducing, the tension is decreasing and fracture results.
- Minimum Tension: the minimum tension used for design purposes = 65-70% of proof load and is the theoretical minimum tension the recommended tightening torque should achieve.
- Proof Load: the minimum point prior to permanent elongation and the test point for actual proof load testing.
- Yield Point: the point at which elasticity is lost and permanent elongation commences.
- Tensile Strength: the maximum load-carrying point prior to fracture.

Typical Tension/Elongation Chart



Finishes and Coatings

There are many finishes or coating applied to fasteners; some corrosion protective, some decorative, or there may be no added coating at all. Specifications for fastener coatings are contained in a number of Australian standards.

Plain Finish

(Black - Self Colour)

- An 'as produced' finish on carbon steel products having an oil residue which provides some shelf life but no real corrosion protection when in use.

  Today, less than 20% of carbon steel fasteners would be purchased plain finish.

- Stainless steel, brass and other non-ferrous materials protect themselves through a reaction of the surface to oxygen, creating a protective chromium oxide film.

Corrosion Protective Coatings

Zinc Plated

- The most economic and common fastener finish, comprising a thin coating of zinc applied either by electroplating or mechanically. A shiny silver grey appearance, it will normally be enhanced by a chemical chromate passivation conversion which applies a harder surface film. This can be clear (bluish tinge), or iridescent yellow which is thicker and gives marginally better protection.

  Clear is referred to as zinc, zinc clear, blue zinc.

  Yellow is referred to as zinc plate gold (ZPG), zinc yellow chromate (ZYC), zinc di-chromate, zinc yellow pass.

Cadmium Plated

- Formerly a popular electroplated or mechanically applied finish, looking like but giving slightly better protection than zinc and providing increased lubricity; also chromate converted. Very seldom used today due to its toxicity and environmental non-acceptability. If specified, it is usually through habit, error or ignorance and possible confusion with zinc.

Galvanised

- A very heavy coating of zinc applied by hot dipping in a bath of molten zinc, then centrifuge spinning for even distribution and removal of the excess, or mechanically cold welding a zinc powder in a barrel rumbling process. The hot dip finish is rougher and duller than electroplated finishes but because of the thickness achieved, gives considerably enhanced protection. Often it is wax coated to provide assembly lubrication.

Phosphate

- A thin, dull grey phosphate coating obtained by insertion in a solution containing phosphoric acid. Gives a lower level of protection than zinc in mild environments, but gives an excellent base for painting or organic lubrication. Often used in automotive industry.

Decorative or Secondary Purpose Coatings

Electro Brass

- A brass finish applied by electroplating. Appears similar to brass and is used in furniture or architectural fittings.

Black Japan

- A black enamel dipped finish, used in black fittings or furniture.

Black Zinc

- An electroplated zinc flash and black chromate dip - used in dark finish appliances.

Light Bronze Antique

- Copper electroplated and dipped, medium brown for matching oxidised copper fittings.

Dark Florentine Bronze

- Copper electroplated and dipped, dark brown for matching oxidised copper fittings.

Copper

- Electroplated, used as a base for nickel or for improved conductivity.

Finishes and Coatings *Continued*

Tin

- Electroplated, used to facilitate soldering.

Nickel

- Electroplated over copper, hard bright silver finish. Often used in electrical appliances and areas of condensation – not sacrificial.

Chrome

- Electroplated over nickel, very hard, bright, reflective finish; easy to clean or polish. Used in heavy condensation areas – not sacrificial.

Coating Thickness

With sacrificial protective coatings, the thicker the deposit, the longer the protection; however, there are practical and economic limitations to the thickness applied.

Zinc electroplating can provide thicknesses from a negligible flash of colour, for appearance, through normal commercial coatings of 3-5 microns (μm), to specified heavy coatings up to 12 microns (0.0005 in). Electroplating does not give an even cover; thicker concentration of deposit occurs on corners, points, thread crests and thinner concentrations on thread flanks and roots. This may cause thread galling on coatings above 8 microns average and adjustment by over-tapping of the nut may be required.

Hot dip galvanising will allow much heavier coatings, the normal commercial coating is approximately 50 microns (μm), which necessitates the over-tapping of the mating thread and is the maximum practical to avoid serious compromise of the fastener's strength. Unlike electroplating, the concentration of deposits is in the thread roots and internal corners. For this reason, thread diameters of less than M10 are not normally galvanised unless a subsequent light re-roll of the thread is performed.

Nuts supplied with galvanised bolts will have over-tapped threads to allow for the galvanised build-up on bolt threads and to reduce assembly galling.

Mechanical coating will result in a more even deposit and the point of over-tapping will be raised above 15 μm. Comparable thicknesses can be achieved but costs are generally much higher.

Hydrogen Embrittlement

High tensile or hardened fasteners above PC 8.8 or SAE Grade 5 are susceptible to hydrogen embrittlement in the cleaning and coating process, particularly electroplating. They absorb hydrogen atoms which concentrate in areas of stress, causing minute cracks which can suddenly and violently fail in service.

To avoid this potential, the hydrogen atoms can be diffused by baking the product immediately after plating, prior to chromating at a temperature of 190ºC to 210ºC for a period depending upon the grade and size of the product.

For this reason, it is most unadvisable to plate PC 10 or SAE Grade 8 and higher products after purchase, unless the Plater is also able to perform and guarantee the de-embrittlement process.

Finishes and Coatings *Continued*

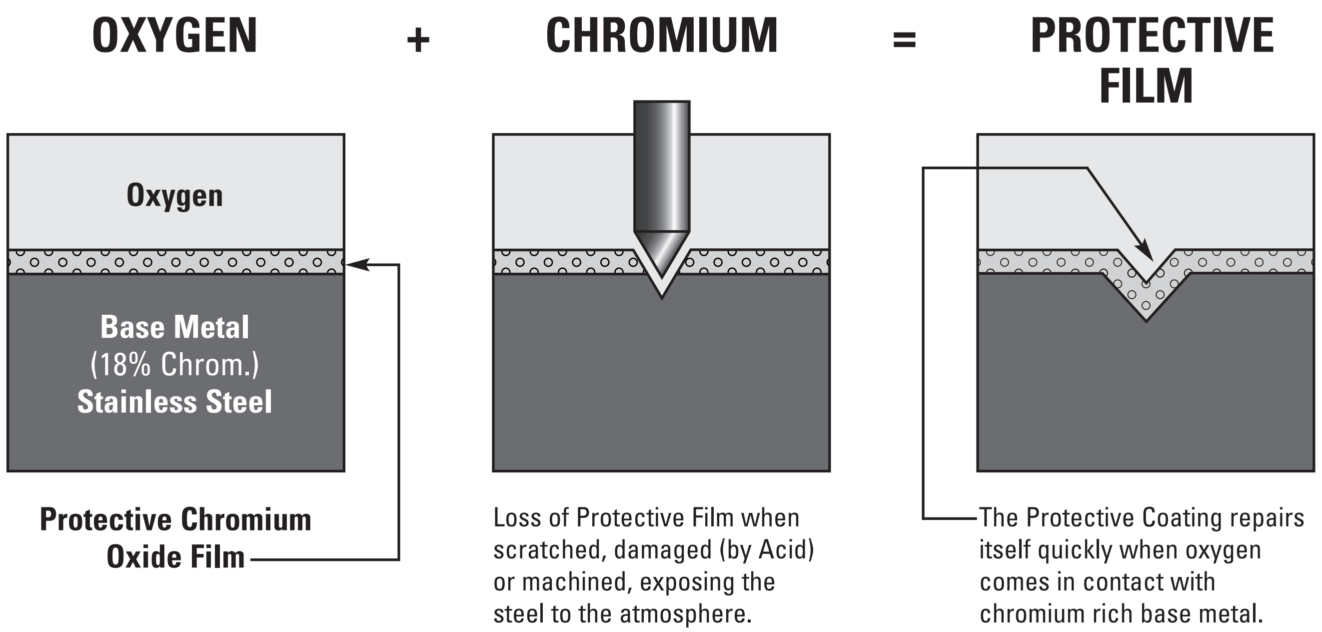
Life Expectancy

Service life of coatings prior to first signs of corrosion will vary considerably depending upon thickness and environment. Experience suggests the following:

Environment	Coatings	
	Heavy Zinc and Yellow Chromate 12µm, Average	Hot Dipped Galvanised 50µm Minimum
Heavily Polluted Industrial Areas	Less Than 1 Year	Less Than 5 Years
Coastal Areas	Less Than 2 Years	Less Than 30 Years
Inland Rural Areas	4 + Years	40 + Years
Dry Indoor Areas	20 + Years	Not Normally Used

Stainless Steel

Stainless Steel is self protecting, as shown below.



Finishes and Coatings *Continued*

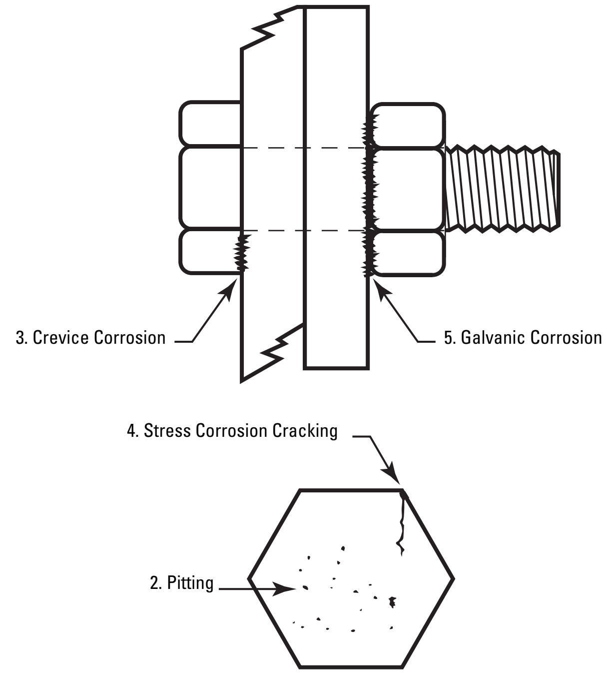
Corrosion

Apart from general corrosion (rust) caused by exposure of uncoated materials there are several other types of corrosion which effect ferrous and non ferrous materials.

They include:
2. Pitting
3. Crevice Corrosion
4. Stress Corrosion Cracking
5. Galvanic Corrosion

– Further information on types 2,3 and 4 may be available in future publications. Please consult your local representative if required.

– A selection chart to provide guidance on limiting the effects of type 5 – is referred to below.



Galvanic Corrosion

In addition to corrosion being caused by exposure of uncoated materials, it is also caused or enhanced by the combination of dissimilar or incompatible materials.

The following chart gives guidelines for the selection of materials or finishes based on this galvanic action:

Base Metal	Fastener Metal					
	Zinc/ Galvanised Steel	Aluminium	Steel, Cast Iron	Brass, Copper, Bronze, Monel	Stainless '4' Series	Stainless '3' Series
Zinc/Galv. Steel	A	B	B	C	C	C
Aluminium	A	A	B	C	N/R	B
Steel, Cast Iron	AD	A	A	C	C	B
Brass, Copper, Bronze, Monel	ADE	AE	AE	A	A	B
Stainless '4' series	ADE	AE	AE	A	A	A
Stainless '3' Series	ADE	AE	AE	AE	A	A

Key

A The corrosion of the base metal is not increased by the fastener

B The corrosion of the base metal is marginally increased by the fastener

C The corrosion of the base metal may be markedly increased by the fastener

D The plating on the fastener is rapidly consumed, leaving the bare fastener material

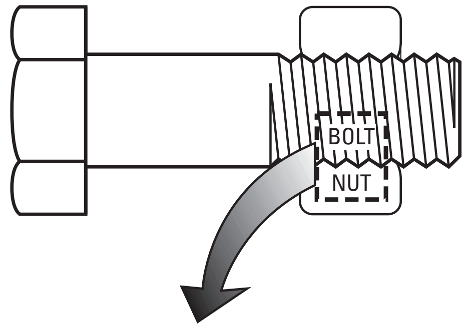
E The corrosion of the fastener is increased by the base metal

NR Not recommended

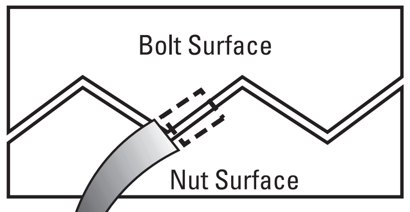
Galling

In technical terms Galling is a type of wear associated with the joining of two parts of material, and is actually precluded by another type of wear 'adhesion', which takes place before Galling can occur.

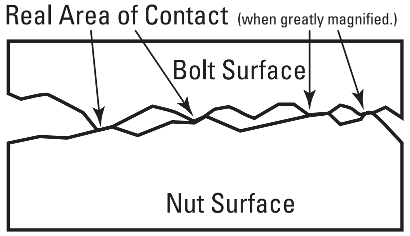
1.



2. Apparent Area of Contact



3. Real Area of Contact (when greatly magnified.)



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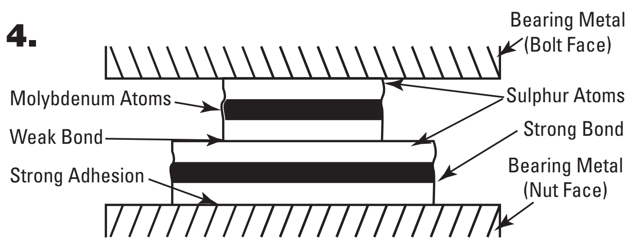
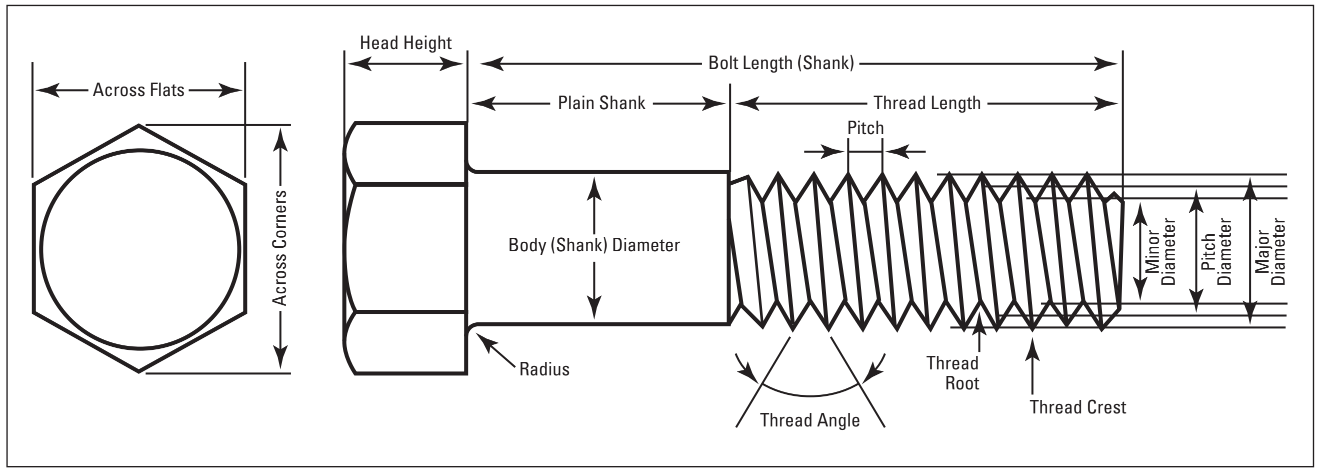


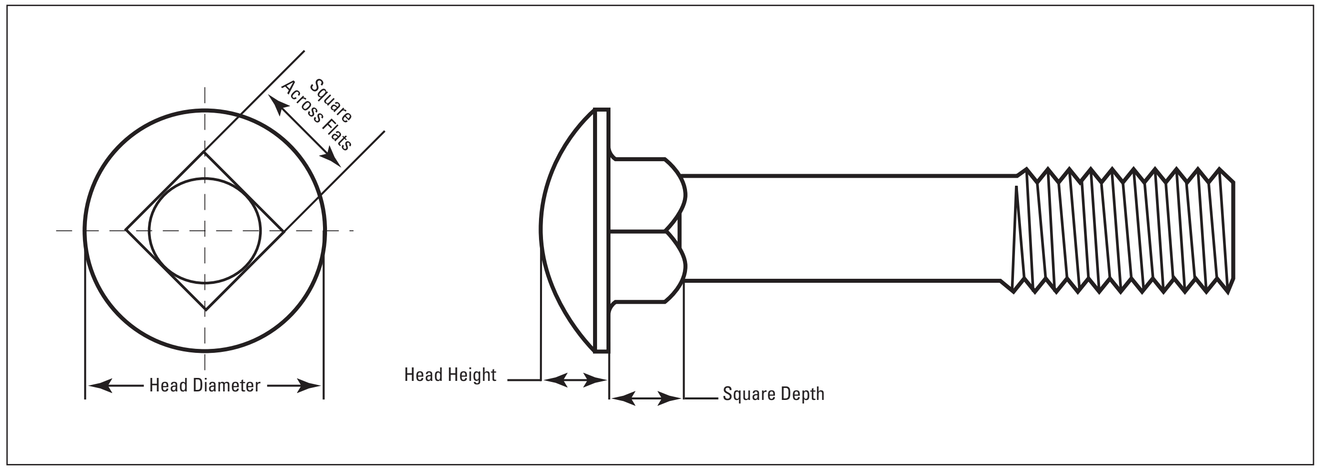
Best results for preventing galling are achieved when you;

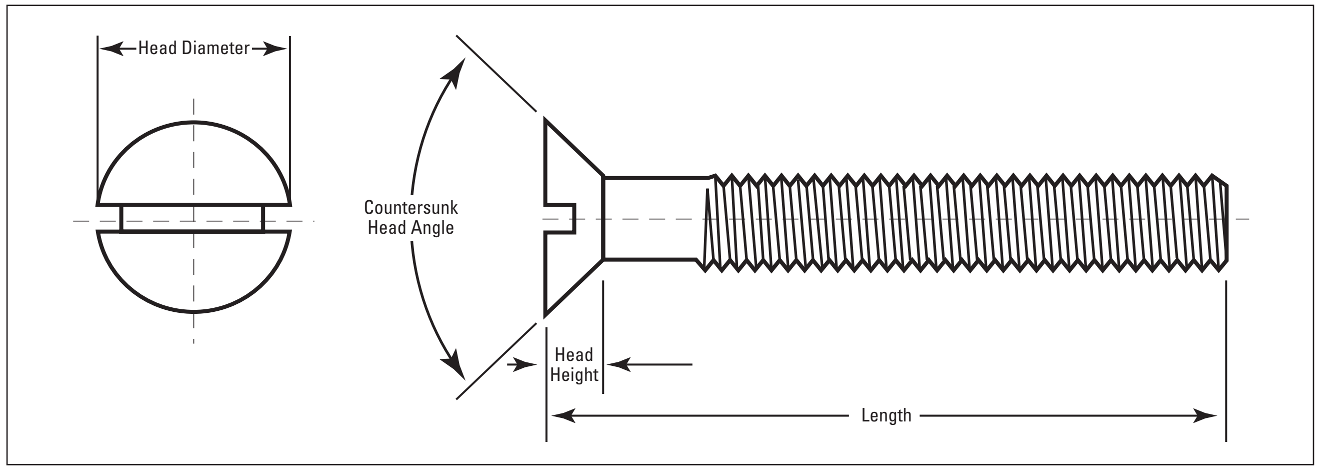
- Lubricate where possible before use with a solid type lubricant.
- Keep torque within guidelines.
- Use low speed applicators.
- Clean, grit free product is best.
- Select right quality and grade combination.
- Adjust torque guidelines for lubrication.

- Surface construction plays a large role and when greatly magnified as shown in the diagrams, we find the thread surface is in reality rough and irregular.
- When two surfaces are brought into contact as with fasteners, the high points as seen in fig 3 take the initial load.
- When pressure or static load is applied, these high points squash (deform) until the real contact area is increased to take the load.
- If relative motion is introduced (ie spinning a nut on a bolt or tightening) then wear may occur due to the protective oxides rubbing off at the high points, exposing the base metals and causing them to weld together.
- Adhesive wear occurs when the pressure/load is small and the weld is weak. A small amount of base material either transfers to the stronger side, or floats independently in the joint and is known as plastic deformation.
  This can be evidenced by spinning a nut on a bolt with your fingers, and noticing when the nut catches or sticks. When you push the nut over that point the transference of materials has occurred even though not seen by the eye.
- Galling, also known as seizing, cold welding or pick up, occurs under higher stresses where stronger bonds or welds are formed between base metals, mainly because the contact surfaces being deformed are larger.
- Generally the causes behind galling are due to high torque/tightening levels and fast application methods like speed/air guns.
- In particular, stainless steel presents the majority of galling problems, mainly due to its Low Heat dissipation at the point of contact where the build up occurs (eg the high points) and what is recognised as a high co-efficient of friction, which basically means it heats up very quickly when rubbed together.
- Solid type lubricants (Molybdenum Di-Sulphide) work as seen in fig 4, by creating layers over the materials that form a weaker bond than the base metals and forming a barrier that the high points cannot push through and therefore not allowing contact of the base materials.
  – Sulphur to Sulphur atoms are weak and break easily.
  – Sulphur to Molybdenum and base metals are strong.

Measuring Points and Terms







Note: Length of countersunk products is measured overall, including the head.
Length of non-countersunk products is measured from the underside bearing face of the head.

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