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Exam Preview:

1. According to the reference material, there are three basic techniques are used to prevent threaded fasteners from loosening in service: preload, mechanical, and chemical.
   a. True
   b. False
2. Polyamide (nylon) can be used at sustained temperatures up to 250°F, polyimide (vespel) is good up to ___°F. It is difficult to determine which one of these plastic materials you have just by looking at them.
   a. 350
   b. 450
   c. 550
   d. 650
3. Taper pins must be driven into tapered holes that have been reamed with the proper taper reamer. The taper is the American standard taper of 1/4 inch per foot.
   a. True
   b. False
4. Reusable metal self-locking fasteners work well when first installed and can usually be reused __ times. When they are repeatedly removed and reinstalled, however, they tend to loose their grip and eventually become ineffective.
   a. 15
   b. 30
   c. 50
   d. 75

5. Cotter pins and lock wires do limit rotation of the fastener to 2 or 3 degrees; however, it only takes 2 degrees of rotation for a hard joint to lose 25 percent of the preload, and 6 degrees to lose ___ percent of the preload.
    a. 80
    b. 50
    c. 40
    d. 60
6. Taper pins must be driven into tapered holes that have been reamed with the proper taper reamer. The taper is the American standard taper of 1/4 inch per foot.
    a. True
    b. False
7. Using Table 075-5-2 LOCKWASHER STANDARDS, which of the following material is NOT acceptable for use in a lock washer under the MS35334, Washer, Lock-Flat, Heavy, Internal Tooth Standard?
    a. CRES
    b. Carbon Steel
    c. Phosphor Bronze
    d. Nickel-Copper-Aluminum
8. Threadlocking compounds may be used with all metals, glass, ceramics, and many thermoset plastics such as phenolic, polyester, and nylon. Most baked enamel finishes are not harmed by initial contact with threadlocking compounds but should be wiped clean within 6 hours.
    a. True
    b. False
9. Anaerobic threadlocking compounds begin to cure on an active surface as soon as they are deprived of contact with air. Full cure on steel without a primer requires approximately __ hours at 72°F. Curing time is halved for every 20°F increase and doubled for every 20°F decrease in temperature.
    a. 12
    b. 24
    c. 36
    d. 48
10. Using Table 075-5-6 PROOF TORQUE VALUES FOR FASTENERS INSTALLED WITH ANAEROBIC COMPOUND what is the specified torque for 1/2 in fastener?
    a. 5 ft-lb
    b. 8.3 ft-lb
    c. 12.5 ft-lb
    d. 17 ft-lb

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SECTION 5.

THREADED FASTENER LOCKING

075-5.1 GENERAL

075-5.1.1 THREADED FASTENER LOOSENING. Threaded fasteners tend to loosen in service unless certain precautions are taken in the design of the bolted joint and the installation of the fasteners. Loosening is usually caused either by vibration or by mechanical or thermal load cycling.The mechanisms that cause loosening under both these conditions are complex and beyond the scope of this manual.Knowledge of the basic principles involved, however, can help reduce the number of casualties caused by loosening of improperly installed fasteners.

075-5.1.2 VIBRATION. Vibration is the most frequent cause of fastener loosening. A screw thread, of course, is nothing more than a wedge or inclined plane wrapped around the shank of a bolt. Just as a wedge can be loosened by shaking or vibrating it from side to side, a nut and bolt will move relative to each other and loosen if the vibration is severe enough, or the joint design or assembly weak enough, for the parts to move.

075-5.1.3 LOAD CYCLING. Loosening of threaded fasteners due to load cycling is similar to loosening due to vibration except that the mechanism that causes the relative motion is different. In addition to the slope of the thread as it spirals around the bolt shank, there is a slope to the thread in the radial or outward direction. As a nut is tightened on a bolt, the taper of both threads tends to expand the nut. Both the threads tend to bend slightly. If, after a nut is tightened, the loads on the joint change enough to cause the forces that act on the bolt to change significantly, the nut will expand and contract radially with the cycling of the load. In addition, both threads will bend up and down. These movements are very small, but they are enough to cause relative sliding between the nut, bolt, and bearing surfaces. Just as with vibration, this will cause the fastener to loosen as the wedge of the threads moves back and forth.

075-5.1.4 Remember that, in general, the first objective of locking a fastener is to preserve the fastener preload. Sometimes, however, preload is not required, and sometimes, as in the pivot joints of pipe hanger legs, it is prohibited. In these cases preventing the loss of the fastener and subsequent disassembly of the joint becomes the objective. In all of these cases simply locking a nut onto a stud is not enough by itself; the stud must also be locked into its tapped hole. Likewise, in a nut and bolt assembly, locking the nut to its bearing surface is not enough; the bolt must also be prevented from rotating relative to the nut.

075-5.1.5 Four basic techniques are used to prevent threaded fasteners from loosening in service: preload, prevailing torque, mechanical, and chemical. The proper method for each application will be as specified on applicable technical documentation (drawing, technical manuals, etc.).

075-5.2 PRELOAD METHOD

075-5.2.1 The first line of defense against the loosening of threaded fasteners in service is to tighten them properly at installation. This may sound overly simplistic, but it is probably the least understood and least often satisfied requirement in fastener installation. Properly preloading a fastener all but eliminates the tendency of all the fastener components, studs, nuts, and bolts, to rotate relative to each other

075-5.2.2 Many otherwise competent mechanics seem to consider it degrading to resort to the use of a torque wrench to tighten a nut. This feeling is unjustified, because taking the time to apply the proper torque is a mark of an experienced craftsman. Extensive studies have shown that the only size nuts the average mechanic will properly tighten by feel are 1/2 and 5/8 inch. Smaller ones will be overtightened, many partially yielded, and larger ones undertightened.

075-5.2.3 With the exception of some unusual situations, a fastener that is tightened so that its clamping force (preload) is greater than any load that it meets in service will not loosen in service. Section 4 discusses preload and proper tightening in detail, and gives recommended torque values for applications where equipment manufacturer's data are unavailable.

075-5.3 PREVAILING TORQUE (SELF-LOCKING NUT) METHOD

075-5.3.1 GENERAL. For those unusual situations mentioned above, or where high clamping forces are not desired, such as for linkages using clevises or pipe hanger clamps, prevailing torque devices work well. These are commonly referred to as self-locking nuts. There are as many different types as there are manufacturers. However, the various types can be grouped into two categories: those that generate pressure between the threads of the nut and bolt in a way that permits frequent removal, and those that cause some thread deformation and therefore should only be used where frequent removal is unnecessary. Always keep in mind that simply using a self-locking nut on a stud does little good if the stud itself is not also locked into its threaded hole.

075-5.3.2 REUSABLE SELF-LOCKING FASTENERS. Several groups of self-locking fasteners are considered reusable. These consist of the family of plastic ring and plastic insert nuts and bolts, and spring beam nuts.

075-5.3.2.1 Plastic Ring and Insert Fasteners. The most widely used self-locking fasteners belong to the family of plastic ring nuts and plastic insert nuts and bolts.

075-5.3.2.1.1 Plastic Ring and Insert Temperature Limits. Two types of plastic are in common use in these fasteners, polyamide and polyimide. Polyamide (nylon) can be used at sustained temperatures up to 250°F, polyimide (vespel) is good up to 450°F. It is difficult to dtermine wich one of these plastic materials you have just by looking at them. The nylon inserts tend to be a light color, white or light green bordering on translucent, while the vespel tends toward red, brown, or even black. The high temperature Vespel (polyimide) is also much harder than the lower temperature Nylon (polyamide). If you can determine the manufacturer, then you can usually contact the manufacturer and identify the insert by its color.

075-5.3.2.1.2 Reusing Plastic Ring and Insert Fasteners. Before reusing either the plastic ring or the insert fasteners, check the condition of the plastic and the breakaway torque of the assembly. If the plastic is worn or torn, discard the fastener. If the plastic is in good condition, lubricate the threads and assemble the fastener until the locking element is fully engaged. Check the breakaway torque required to start removal rotation of the fastener with no axial load on it. New self-locking nuts manufactured to MIL-N-25027 should comply with the minimum breakaway torque values listed in Table 5-1. If the breakaway torque is less than that specified in Table 5-1 and no other guidance is available, discard the fastener and use a new one. These fasteners are usually good for approximately 15 reinstallations.

075-5.3.2.1.3 Plastic Ring Nuts. One of the more common self-locking devices is the family of plastic ring nuts (Figure 075-5-1), which deform their plastic inserts when they are installed. These are usually referred to as elastic stop nuts. At installation the resilient plastic material is forced to assume the shape of the mating threads, creating large frictional forces that resist rotation of the nut on the bolt. The part standards listed in Figure 075-5-1 for plastic ring nuts frequently used aboard ship are listed in MIL-N-25027, **Nut, Self-Locking, 250°F, 450°F, and 800°F.** Self-locking nuts whose breakaway torque is less than that shown in Table 075-5-1 shall not be reused.

NOTE

Elastic stop nut may require a longer bolt than do standard nuts; the elastic stop nut is thicker because of the addition of a plastic locking ring, and as a minimum the male thread shall protrude or at least be flush with locking element.

075-5.3.2.1.4 Plastic Insert Bolts and Nuts. A variation on the plastic ring nut is the plastic plug or pill. A hole or groove is machined in the side of the bolt or nut. Plastic plugs, which do not extend completely around the circumference of the fastener, are then inserted into the machined openings. As with the plastic ring nuts, these inserts deform at installation, forcing the nut to one side, thereby creating the antirotation friction force. Once the fastener is tightened, however, it tends to center itself. This centering causes some motion between the nut and bolt, especially if the fastener is not completely preloaded, making this type less effective than the plastic ring nuts. This type of fastener and its specifications are described in MIL-F-18240, **Fastener Element, Self-Locking, Threaded Fastener, 250°F Maximum.** See Figure - 075-5-2. Self-locking fasteners with a breakaway torque less than that in Table 075-5-1 shall be replaced.

Table 075-5-1 PLASTIC RING AND INSERT FASTENER BREAKAWAY TORQUE

Nominal Thread Size, inch	Minimum Breakaway Torque, in-lb
#2 (0.068)	*
#4 (0.112)	*
#5 (0.125)	*
#6 (0.138)	*
#8 (0.164)	*
#10 (0.190)	1.0
#12 (0.216)	1.0
1/4	1.5
5/16	2.5
3/8	4.0
7/16	5.0
1/2	7.5
9/16	10.0
5/8	12.5
3/4	20.0
7/8	30.0
1	40.0
1-1/8	50.0
1-1/4	60.0
1-3/8	70.0
1-1/2	90.0
1-3/4	100.0
2	120.0
2-1/4	140.0

Table 075-5-1 PLASTIC RING AND INSERT FASTENER BREAKAWAY TORQUE - Continued

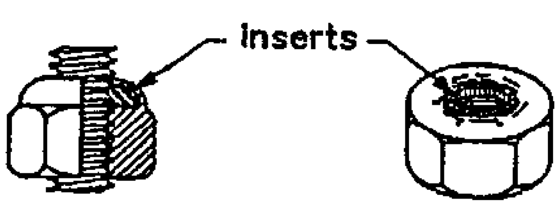
Nominal Thread Size, inch	Minimum Breakaway Torque, in-lb
2-1/2	165.0
*Must have some indication of torque increase as locking feature comes in contact with bolt.	

075-5.3.2.2 Reusable Metal (Spring Beam) Self-Locking Nuts. Spring beam (spring finger) nuts come in various shapes, although all are similar to that shown in Figure 075-5-3. This type of nut has thin slots cut down through the top few threads with the resulting fingers effectively bent inward. They appear similar to castellated nuts except that the cuts are much narrower. At installation, the bolt springs the fingers out, with the resulting spring action causing fingers to grip the bolt with a prevailing torque, even when the nut and bolt assembly is loose in its hole (not exerting any clamping force). The following part standards for reusable metal self-locking nuts are listed in MIL-N-25027:

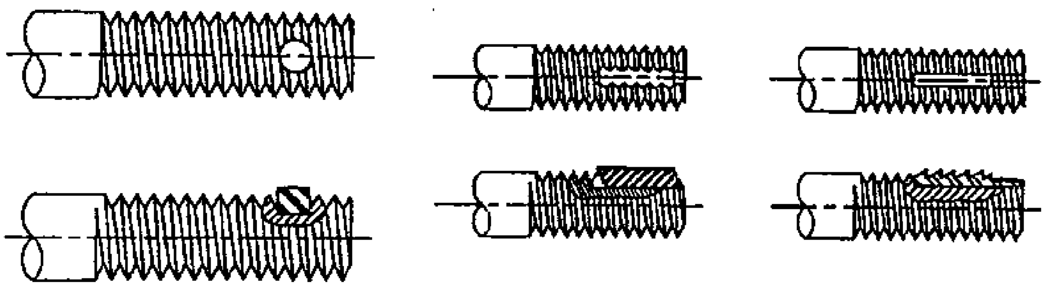
MS21046	Nut, Self-Locking, Hexagon-Regular Height, 450°F, 125 KSI Ftu
MS21046	Nut, Self-Locking, Hexagon-Regular Height, 800°F, 125 KSI Ftu

075-5.3.2.2.1 Metal Self-Locking Nut Temperature Limits. Corrosion-resistant steel self-locking nuts are available for applications up to 800°F (MIL-N-25027)

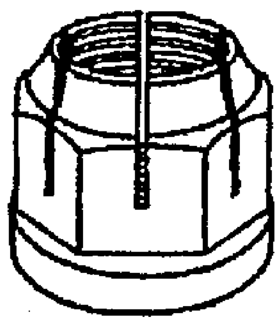
Standard	Title - Material
MS16228	Nut, Self Locking, Hexagon, Thin, UNC 3B (Nonmetallic Insert) Austenitic,Corrosion Resistant Steel, Nonmagnetic, 250°F
MS17828	Nut, Self Locking, Hexagon, Hexagon, Regular Height, Nonmetallic Insert, 250°F, Nickel Copper Alloy
MS17829	Nut, Self-Locking, Hexagon, Rgeular Height, Nonmetallic Insert, 250°F, Noncorrosion-Resistant Steel
MS17830	Nut, Self-Locking, Hexagon, Regular Height, Nonmetallic Insert, 250°F, 300 Series Corrosion-Resistnat Steel
MS21044	Nut, Self-Locking, Hexagon, Regular Height, 250°F, 125ksi Ftu and 60 ksi Ftu (Aluminum, Steel, Brass & CRES)
MS21083	Nut, Self-Locking, Hexagon, Nonmetallic Insert, Low Height, 250°F (Aluminum, Steel, Brass & CRES)
MIL-N-25027/1	Nut, Self-Locking, Heavy Hex, (Non-Metallic Insert) 250°F and 450°F, UNJC-3B, 1/4 Through 2-1/12 Inch Nominal Diameters, Nickel-Copper Alloy



075-5-1 Plastic Ring Nut



075-5-2 Types of Self-Locking Bolts



075-5-3 Spring Beam Nut

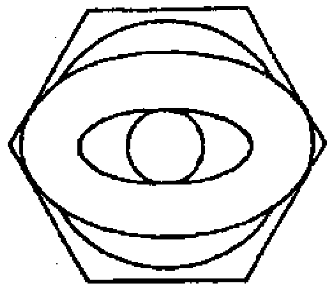
075-5.3.2.2.1 Reusing Metal Self Locking Fasteners. Reusable metal self-locking fasteners work well when first installed and can usually be reused 15 times. When they are repeatedly removed and reinstalled, however, they tend to loose their grip and eventually become ineffective. Check the amount of breakaway torque required to start rotation of the nut, using a torque wrench. Check this value against the specified torque (or compare it with the data in Table 5-1 if no other guidance is available). If the breakaway torque is below allowable torque limits, replace the nut.

WARNING

Do not use these nuts on studs unless the studs can be easily replaced.

075-5.3.3 NONREUSABLE SELF-LOCKING FASTENERS. Non-reusable self-locking fasteners are usually of the metal distorted thread or distorted collar type. In this fastener, some of the threads or the collar are distorted. At installation, the distortions are bent back into alignment. Most of this bending is elastic, like a spring, and the spring force keeps the threads tight. Some of the bending results in permanent deformation, however, of either or both the nut and the bolt threads. As a result, the number of times these nuts can be reused, if any, is limited. Since parts of the faste+ner are being deformed, if either high or low prevailing torque is experienced, replace the nut or the bolt or both. Carefully clean the threads on both the nut and the bolt and lubricate them before assembly, as some metals tend to gall when used with this type of nut (refer to Table 075-4-3).

075-5.3.3.1 Distorted Collar Nuts. Distorted collar nuts (Figure 075-5-4) either have an oval steel collar insert or a collar formed with a rounded triangular opening. As the nut is threaded on, the bolt forces the nut or collar back into round. The spring properties of the nut cause it to try to return to its distorted shape, creating high frictional forces between the nut and the bolt. These nuts are not commonly used on board ship. However, they may be found in high temperature components where plastic locking elements cannot be used or in specialized components as part of a positioning device.



075-5-4 Distorted Collar Nuts

075-5.3.3.2 Distorted Thread Nuts. Distorted thread nuts are made either with depressions on the face of the nut, which distort a few of the top threads locally, or depressions in the center of three of the wrench flats, which distort some of the threads in the center of the nut. In both designs, threading the nut on the bolt forces the threads back into round. As in the distorted collar nuts, the spring properties of the nut cause it to try to return to its distorted shape, creating high frictional forces between the nut and the bolt. Similar to the distorted collar nuts above, these nuts are not commonly found on board ship. They may also be found in high temperature components where plastic locking elements cannot be used or in specialized components as part of a positioning device.

075-5.3.4 JAM NUTS (LOCK NUTS). Jam nuts are an older variation of the prevailing torque concept. They are not usually recommended for new installations due to the tendency to use an improper thickness for the jam nut and to install them in the wrong relative positions.

075-5.3.4.1 Jam Nut Assembly. The jam nut assembly requires a regular or main nut and a thin jam nut, as shown in Figure 075-5-5. The assembly is installed with the thinner nut between the thick nut and the bearing surface. The main nut has to be as thick as if no jam nut were being used, because the main nut carries all the working load. The jam nut is usually about 2/3 as thick as the main nut. If the jam nut is too thin, however, the threads in the jam nut area will be damaged as the main nut will pull the bolt threads partially through the jam nut. Conversely, if the jam nut is too thick, the main nut cannot distort the threads enough.

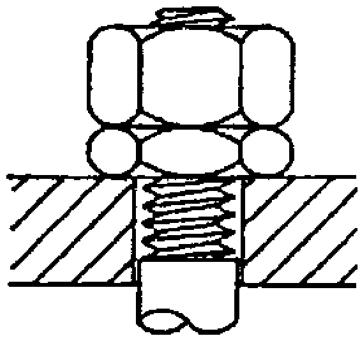
075-5.3.4.2 Tightening the Jam Nut. At assembly, first tighten the jam nut to the same or slightly less percentage of the preload torque specified for the main nut, based on the relation the jam nut thickness bears to the thickness of the main nut. Then hold it in position with a wrench while you tighten the main nut. For example, if the jam nut is 2/3 as thick as the nut, tighten the jam nut to 1/2 to 2/3 of the torque used for the main nut. Then, when the main nut is tightened to the preload torque specified for the bolt, it stretches the bolt (stud), thereby tending to pull it through the jam nut. Any vibration or load that tends to loosen the bolted joint will allow the bolt to shrink back to its original length, leaving the jam nut tight against the main nut. This creates the necessary prevailing torque to prevent the jam or main nut assembly from rotating on the bolt.

075-5.3.5 SETSCREWS. Setscrews are seldom used in the U.S. Navy. Setscrews can be used in a variety of ways to lock threads (see Figure 075-5-6). A setscrew can:

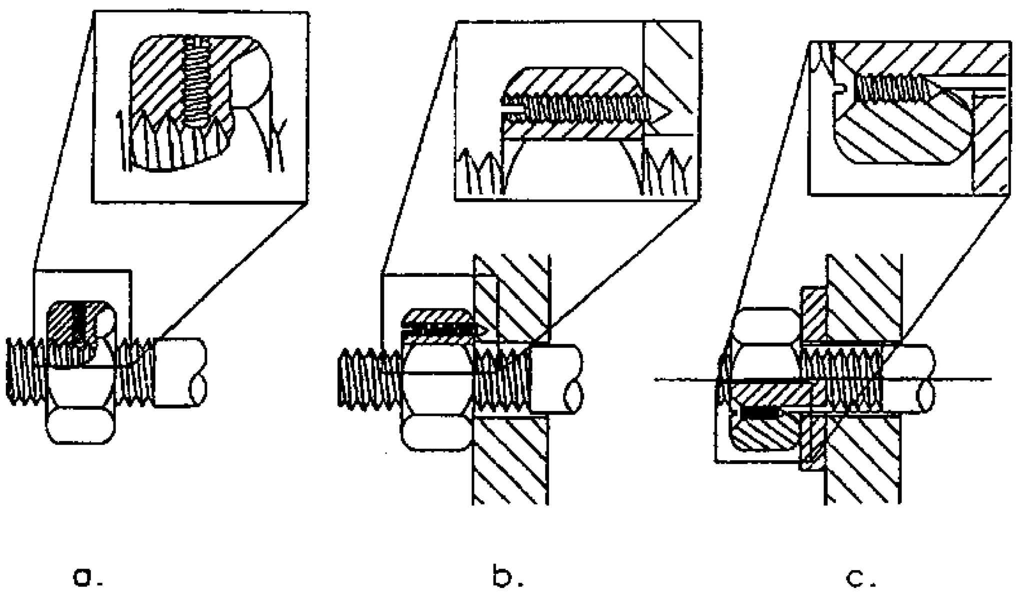
a. Jam a plug of softer material (plastic, copper, or lead) against the threads to be locked.

b. Be installed between the nut and a stationary member, physically restricting the nut from turning.

c. Be installed in a threaded hole drilled axially at the junction of the mating threads, physically restricting the nut from turning on the bolt.



075-5-5 Jam Nut Assembly



075-5-6 Setscrews

NOTE

Methods b and c are not recommended for applications where the fastener is highly loaded, as the nut is significantly weakened by the extra hole. The use of setscrews also tends to create another problem, because now you have to find a way to lock the setscrew.

075-5.4 MECHANICAL METHOD

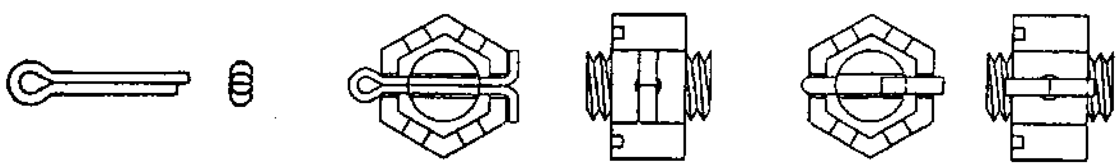
075-5.4.1 GENERAL. Mechanical locking devices come in a wide variety of designs, but they fall into one of three basic types: pins, wires, or tabs. Generally, these devices work well where the objective is to prevent total disassembly of the joint. Where the objective is to maintain a specified fastener preload, however, they have their drawbacks. Cotter pins and lock wires do limit rotation of the fastener to 2 or 3 degrees; however, it only takes 2 degrees of rotation for a hard joint to lose 25 percent of the preload, and 6 degrees to lose 40 percent of the preload. A second problem with cotter pins and lockwire is that they are not very strong, especially lock wire. It takes only a few foot-pounds of torque to shear a lock wire and only slightly more for cotter pins. Driven pins and tabs also have their problems, which are discussed in the applicable sections. The information below describes the various mechanical methods for locking fasteners that you may encounter aboard ship. Use these methods only where specified on equipment drawings or in equipment technical manuals.

075-5.4.2 PINS. Various types of pins have been designed to prevent nuts from rotating on bolts. They are used in one of three ways: (1) with castellated nuts, (2) in holes drilled through the body of the nut (using an extra tall nut and drilling the hole in the center of a wrench flat) and through the bolt, and (3) through the bolt at a point beyond the nut.

075-5.4.2.1 Cotter Pins. Cotter pins (cotter keys) are used with castellated nuts and installed as shown in Figure 075-5-7. Cotter pins may be found in the Afloat Shopping Guide under Federal Supply Class 5315.

CAUTION

When cutting off excess lengths of cotter pins, be careful to keep the cut end from getting into open machinery or flying out and injuring personnel. Hold the end with a suitable plier while it is being cut or, if you are careful not to let the cut end fall out of the rag, hold a rag over the end while you are cutting it.



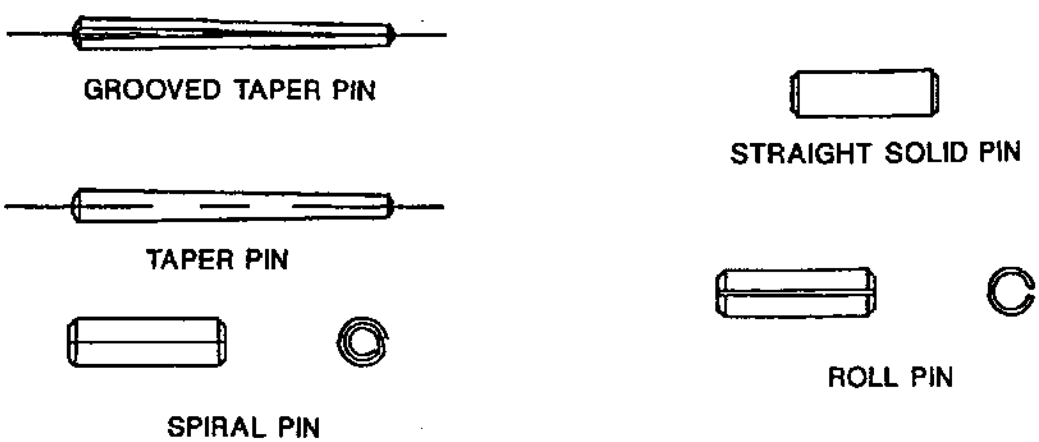
075-5-7 Cotter Pin

075-5.4.2.1.1 Installing Cotter Pins. Cotter pins are usually installed with the long end of the pin on the side toward the end of the bolt and the head of the cotter pin resting in the slot in a castellated nut. The long end of the pin is bent up and back over the end of the bolt. The remaining end is then cut to a suitable length and bent down over the flat of the nut. Where an interference or safety problem exists, the cotter pin can be rotated 90 degrees with its head outside of the slot in the nut and the ends bent back around the sides of the nut. An additional option is to install the cotter pin with its head in a slot, grip the ends of the pin with a plier, twist the end 90 degrees so that the twist is distributed over the length of the pin, and then bend the ends back around the nut.

075-5.4.2.1.2 Installation Problems. Two primary difficulties are associated with using cotter pins and castellated nuts. First, it is often difficult to torque the nut properly and get the holes to line up at the same time. This often requires trying several different nuts until one fits. Second, when using a new, undrilled bolt, it is difficult to drill a hole in the bolt with the fastener installed, especially with high-strength bolts that are hardened. The hole must be centered and drilled at right angles to the bolt centerline. Also, the drill chips must be kept out of any open sections of machinery. It is also very difficult to properly mark the hole's location with the fastener properly torqued and then remove the bolt and take it to a shop for drilling. Nevertheless, if the hole cannot be drilled properly with portable drills, or if the drill chips could fall into open machinery, the fastener must be removed for drilling. It is also good practice to break the sharp edges at the ends of the hole in the bolt after drilling.

075-5.4.2.2 Driven Pins. The next two threaded fastener locking methods are rarely used but you may encounter them. These methods consist of driving different types of pins through holes drilled through the fastener. Several different types of drive pins are used. The more common ones being taper pins, grooved taper pins, straight pins, roll-pins, and spiral-pins. These are shown in Figure 075-5-8. Drive pins may be found in the Afloat Shopping Guide under Federal Supply Class 5315.

075-5.4.2.2.1 Drive Pin Through Nut and Bolt. This locking method drives a pin through a hole that has been drilled through the nut and bolt. The same problems exist here as with cotter pins, only more so. Here, the hole has to be drilled with the nut and bolt assembled and properly torqued. Once the joint has been disassembled and then reassembled and properly retorqued, the holes will probably not line up, even if the same nut is back on the same bolt. The only place this process will work is where the nuts need not be tightened significantly or torqued to a specified value, such as in linkage clevises. Other locking methods should be considered first, however.



075-5-8 Types of Drive Pins

075-5.4.2.2.2 Drive Pin Through Bolt Only. This locking method drives the pin through a hole drilled through the bolt beyond the nut. This method is used where a few rotations of the nut can be tolerated but complete loosening of the joint is to be prevented.

075-5.4.2.3 Use of Hardened Drive Pins. Wherever possible use a roll-pin or a spiral-pin. These are hardened pins and will resist shearing better than nonhardened taper or straight pins.

CAUTION

Never drive a pin into, bend a tab onto, use staking, peen, or otherwise hammer on any fastener assembly that is supported by a ball, roller, needle, or other rolling element bearing. You wouldn’t beat on a ball bearing with a hammer would you? Hammering on a shaft that is supported by ball bearings is the same thing, or maybe worse. The performance of a specially designed quiet ball bearing can easily be ruined and any rolling element bearing damaged by impact forces. If this situation exists, use a self-locking fastener or chemical method that is appropriate for the temperatures involved.

075-5.4.2.3.1 Installing Roll Pins and Spiral Pins. Roll pin and spiral pins are driven into straight holes. The pins are slightly larger than a standard drill for the stated size. The pins have a short taper on each end to help start them into the hole. As the pins are driven in, they compress and remain tight until driven out.

075-5.4.2.4 Installing Straight Pins. Straight pins should be driven into interference fit holes; however, it is acceptable to drive them into size-on-size holes (i.e., holes with the same diameter as the pin). In the latter case, either leave the pin too long and peen it over on each end or make it too short and stake it in place at each end.

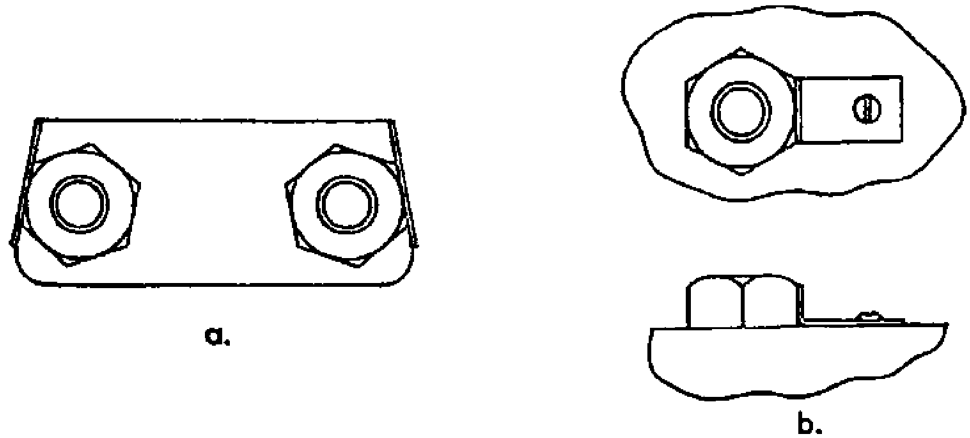
075-5.4.2.5 Installing Taper Pins. Taper pins must be driven into tapered holes that have been reamed with the proper taper reamer. The taper is the American standard taper of 1/4 inch per foot. The pins are numbered from 0 to 10 to designate their size. The number 0 pin has a large-end diameter of 0.156 inch, the number 10 pin has 0.706 inch. Properly sized and tapered reamers are available with numbers the same as the pin they are to be used with. Drive the taper pin in until it is tight but not so tight as to distort it. The taper is slight enough to wedge the pin firmly in place and prevent it from loosening in service and yet permit it to be driven out when required.

075-5.4.2.6 Aligning Holes for Pins. Where fastener preload torque requirements are specified, they must be met. If you cannot align the locking pinholes within those limits, try other nuts or replace and redrill the entire fastener. Note that only one hole is permitted in a stud or a bolt.

075-5.4.2.7 Substitutions for Pin-Type Locking Devices. Where service has been satisfactory, continue to use the pins. If loosening in service or difficulty in achieving proper preload torque has been a problem, however, replace them with self-locking fasteners. If a self-locking fastener is installed where another fastener is called for, submit a waiver request to document this configuration change.

075-5.4.3 TAB LOCKS. Tab locks (Figure 075-5-9) have a tab bent against one or more of the wrench flats of the nut or bolt to prevent the nut or bolt from turning. You can keep the tab lock itself from turning in a number of ways: You can bend a second tab against a nearby flange or over a nearby edge. Where the equipment permits, you can drill a hole into the adjacent surface and bend a tab into the hole. Where the configuration permits, a tab lock can be made to fit under two adjacent bolts or nuts. You can also use a screw to lock the tab to the adjacent surface, but the screw now has to be locked by some means such as anaerobic thread-locking compound. Special tab locks that lock by means of an internal key slot or flat surface are sometimes used on studs or shafts with key slots or flat sections cut to accept them.

075-5.4.3.1 Installing Tab Locks. Tighten the fastener to the minimum specified torque limit. Stop tightening at this point and check to see if a flat face is presented to the tab. If not, continue to tighten until alignment is reached but not more than the maximum specified torque. Do not bend the tab until you have completed all required retorquing. Never try to bend a tab against a corner. If you cannot make the flat side face the tab, use another nut or bolt. Always torque with clean, lubricated threads and a clean, lubricated nut or bolt face (bearing surface). See paragraph 075-4.6.1 for further guidance concerning lubrication.



075-5-9 Tab Locks

075-5.4.3.2 Tab Bend Radius. Whenever a tab is bent, the outside of the bend radius areas should be inspected for cracks, especially for aluminum tabs. Tabs are not designed for re-bending; therefore, unless multiple tabs are provided or the tab lock is pre-bent and screwed into place, the tab lock should not be reused.

075-5.4.4 STAKING AND PEENING. Avoid staking, peening, center punching, and similar methods of locking threads that distort the threads after assembly. Although these methods may be replaced in kind if loosening has not been a problem, they should always be replaced with self-locking fasteners whenever disassembly is required. This does not apply to straight pins that have been staked or peened in place. If staking or peening is to be used, the screw, stud, or bolt should be staked or peened at two points around the circumference. This allows at least two subsequent removals or reinstallations.

075-5.4.4.1 Staking. Staking usually involves moving material, usually with a center punch, from an adjacent surface against the head of a recessed screw or bolt, or deforming external threads beyond the nut. It also includes various other forms of distorting either the fastener or the adjacent material with punches or chisels in an attempt to lock a fastener.

075-5.4.4.2 Peening. Peening is similar to staking except it usually involves forging (peening) the end of a pin or bolt to expand it. In the case of a bolt or stud, it prevents the nut from coming off. However, it may permit some rotation of the nut. In the case of a pin, the ends of the pin are simply expanded so that the pin cannot back out of the hole.

075-5.5 SAFETY WIRE METHOD

075-5.5.1 GENERAL. The primary purpose of safety wiring is to prevent complete loss of a fastener. It's not particularly effective in preventing minor relative nut and bolt rotation and subsequent loss of preload. Safety wire is installed by passing single strand, relatively ductile, wire through the drilled holes of adjacent bolt or capscrew heads, or, in the case of studs, through the slots of castellated nuts and the aligned holes in the ends of studs. Many components such as diesel engines, compressors, and gas turbines, still have safety wired fasteners, especially in internal locations. It's effective in preventing complete loss of the fastener. It is, however, an ineffective method for preventing loss of preload; some rotation can still occur, even with the best of tying techniques. Rotation of only a few degrees can reduce the preload by 50 percent. In addition, because it must be bent and twisted, ductile wire is usually used. Ductile wire, however, is weak and stretches easily, allowing significant fastener rotation. Safety wire may be used to replace previous existing safety wire. If loose or broken wires or loose fasteners are found at disassembly, however, self-locking fasteners may be installed at reassembly. If a self-locking fastener is installed where safety wire is called for, submit a waiver request to document this configuration change. If no other guidance is provided, install safety wire in accordance with MS33540,**General Practices for Safety Wiring and Cotter Pinning.** Use only safety wire that complies with MS20995, **Safety or Lock Wire.**

075-5.5.2 REWIRING. When rewiring, always use the type of wire specified for the application. Do not use wire that was previously used, except under emergency conditions. Replace used wire as soon as the proper wire is available.

075-5.5.3 TIGHTENING SAFETY WIRED FASTENERS. All torquing operations must be completed before you install the safety wire. Do not loosen or overtorque the fastener to achieve a better wire alignment.

075-5.5.4 WIRE INSTALLATION. Figure 075-5-10 shows acceptable safety wiring techniques. Additional guidance is provided in MS33540, **General Practices for Safety Wiring and Cotter Pinning.** Cut the excess wire and bend the end toward the nut or part. Projecting ends are a safety hazard.

075-5.6 LOCKWASHER METHOD

075-5.6.1 GENERAL. Many installations aboard ships, especially older ships, still use lockwashers in diesel engines and similar equipment to prevent threaded fasteners from loosening. These may be replaced with the same type of fastener if loosening has not been a problem. If loosening has been a problem, however, replace the lockwashers with self-locking fasteners. Standard lockwashers are detailed in ASME B18.21.1 (inch) and ASME B18.21.2M (metric). Lockwashers in common use consist of the helical spring, curved or conical spring, internal tooth, external tooth, and internal-external tooth type.

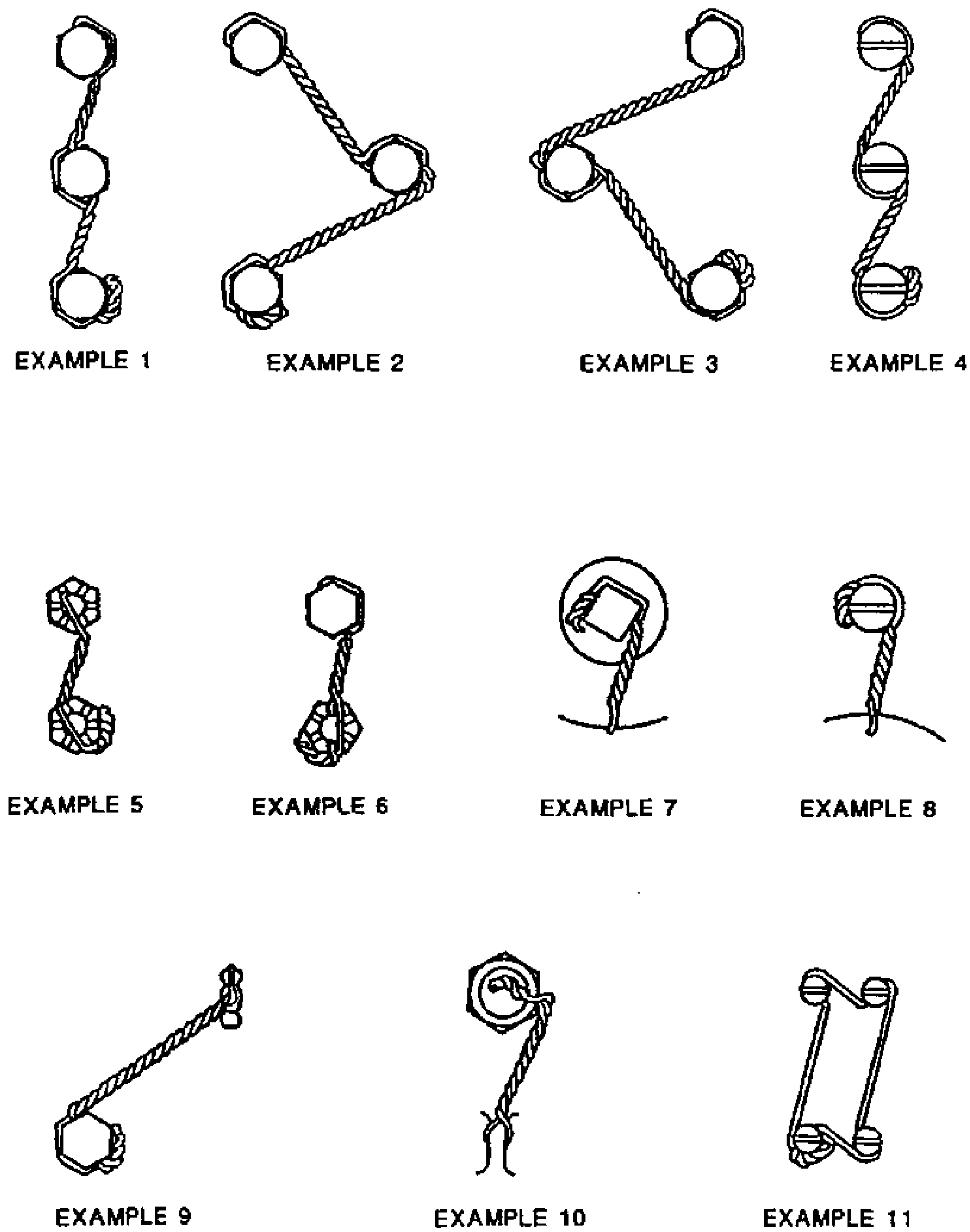
075-5.6.2 HELICAL SPRING LOCKWASHERS. The most frequently used lockwasher is the helical spring (split) type. The helical spring lockwasher (Figure 075-5-11) is flattened when the bolt is torqued down. Once compressed, it acts as a flat washer, contributing normal friction between the nut or bolt and the bearing surface during tightening. If the fastener clamping load relaxes, the spring action of the lockwasher will maintain some load between the threads of the fastener, reducing the tendency of the fastener to rotate. Some helical spring lockwashers have a sharp tooth on each end that bites into each bearing surface and prevents rotation. This type adds friction during tightening and will result in some reduction in preload. Because the helical spring lockwasher diameter is small and it tends to dig in when loosened, it is rarely used on soft materials or with oversized or elongated holes.

075-5.6.3 CURVED OR CONICAL SPRING LOCKWASHERS. Curved or conical (Belleville spring) lockwashers (Figure 075-5-12) have properties similar to the helical spring lockwasher. Unlike the helical spring lockwasher, however, they provide a relatively constant tension on the fastener over a significant range of deflection when the clamping load is reduced. They are also usually larger in diameter, which helps to distribute the clamping load better. Unless the washer is very thick, as thick or thicker than a heavy helical spring lockwasher, the tension produced is usually less than that produced by the helical spring lockwasher and therefore less effective. Some high load applications requiring high-strength fasteners use a large, thick, hardened version. Because the belleville spring washer has constant force characteristics, it is sometimes used to compensate for thermal expansion of some components while still maintaining the proper fastener preload. Where these types of washers are found, they shall continue to be used and replaced in kind.

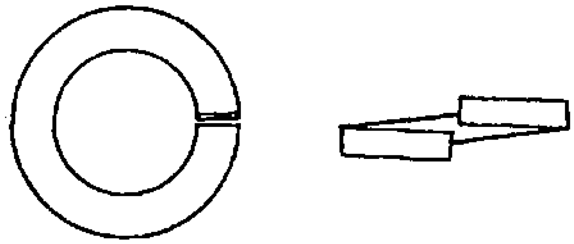
075-5.6.4 TOOTHED LOCKWASHERS. Toothed lockwashers (Figure 075-5-13) are washers with twisted or bent teeth around the outside, inside, or outside and inside. As the fastener is tightened, the teeth flatten, providing a somewhat uniform bearing surface. When the fastener loses its clamping load and tries to rotate the teeth bite into both bearing surfaces and resist rotation as long as the deflection range of the teeth is not exceeded. Tooth-type lockwashers are preferred for use in electrical applications since the teeth maintain a larger area of contact.

075-5.6.4.1 Internal Tooth Lockwashers. The light internal tooth type lockwashers are used under small-headed screws; the heavy internal-type lockwashers are used with large nuts and bolts.

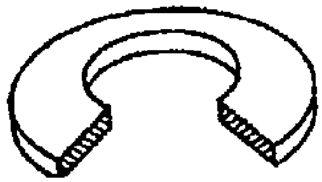
075-5.6.4.2 External Tooth Lockwashers. Where engagement of all the teeth by the bearing surfaces of both the fastener and the component can be ensured, the external tooth types provide better service than the internal types.



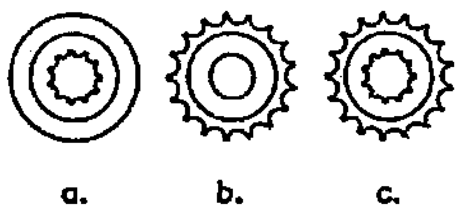
075-5-10 Safety Wiring Examples



075-5-11 Helical Spring Lockwasher



075-5-12 Curved or Conical Lockwasher



075-5-13 Toothed Lockwashers

075-5.6.4.3 Internal-External Tooth Lockwashers. For oversize holes or where a large bearing surface is required, the internal-external type lockwasher is recommended. The internal-external type is sometimes used as an insert between members that have oversize or elongated holes and require position adjustment before the fastener is tightened.

075-5.6.5 PART NUMBERS. As previously mentioned (paragraph 075-2.5.1), standard part numbers for lockwashers are identified in MIL-STD-1764, **Washers, Preferred for Design, Listing of** . Some of the lockwasher standards, covered in MIL-STD-1764, are listed in Table 075-5-2.

075-5.7 CHEMICAL METHOD

075-5.7.1 GENERAL. A number of chemical threadlocking compounds are available. Those approved for naval use are the anaerobic compounds that comply with MIL-S-22473, **Sealing, Locking, and Retaining Compounds; Single-Component,** and MIL-S-46163, **Sealing, Lubricating and Wicking Compounds: Thread-Locking, Anaerobic, Single-Component.** Table 075-5-3 lists some of the NSNs that may be used for procuring these anaerobic compounds. For systems and equipment in nuclear propulsion plants, only Grade AV and AVV per MIL-S-22473 are to be used unless otherwise specifically identified on applicable technical documentation. The appropriate **General Reactor Plant Overhaul and Repair Specification** Section 9090-3 provides restrictions on the use of locking compounds in the reactor plant.

075-5.7.2 ANAEROBIC THREADLOCKING COMPOUND. Anaerobic threadlocking compounds usually have methacrylate ester as a base. These compounds cure (polymerize or harden) in the absence of air hence the term anaerobic. The hardened compound then resists rotation of the parts because it has both bonded to the threads as an adhesive and penetrated the pores of the thread material to provide a mechanical lock.

Table 075-5-2 LOCKWASHER STANDARDS

Military Standards	Fasteners Sizes (nominal)	Materials
MS35333, Washer, Lock, Flat-Internal Tooth	#2 (0.086 inch) through 1.000 inch	Carbon Steel CRES Phosphor Bronze Tin-Bronze
MS35334, Washer, Lock-Flat, Heavy, Internal Tooth	0.250 (1/4 inch) through 0.875 (7/8 inch)	Carbon Steel
MS35335, Washer, Lock, Flat-External Tooth	#4 (0.112 inch) through 1.000 inch	Carbon Steel CRES Phosphor Bronze Tin-Bronze
MS35338, Washer, Lock-Spring, Helical, Regular (Medium) Series	#2 (0.086 inch) through 1.500 inch	Carbon Steel CRES Phosphor Bronze Tin-Bronze Nickel-Copper-Aluminum
MS35340, Washer, Lock-Helical Spring, Extra Duty (Extra Heavy) Series	#2 (0.086 inch) through 1.500 inch	Carbon Steel
MS35790, Washer, Lock-Countersunk, 100°F, External Tooth	#2 (0.086 inch) through 3/8 (0.375 inch)	Carbon Steel Phosphor Bronze Tin-Bronze
MS45904, Washer, Lock, Internal and External Tooth	#4 (0.112 inch) through 5/8 (0.625 inch)	Carbon Steel
MS51848, Washer, Lock-Helical Spring, Hi-Collar	#0 (0.060 inch) through 1.000 inch	Carbon Steel CRES

075-5.7.2.1 Material Compatibility. Threadlocking compounds may be used with all metals, glass, ceramics, and many thermoset plastics such as phenolic, polyester, and nylon. They will soften and sometimes craze (etching, shallow cracking) thermoplastics, however, including ABS, polycarbonate, vinyl, and methacrylate. They will also soften varnish and lacquer finishes. Most baked enamel finishes are not harmed by initial contact with threadlocking compounds but should be wiped clean within 1 hour. The cured compounds will not affect any of the above materials.

075-5.7.2.2 Cleaning and Surface Activation Requirements. All parts must be chemically cleaned and have active surfaces to achieve reasonable cure times and proper strength. Never apply the locking compounds to oily surfaces or surfaces that have only been cleaned with diesel oil or solvents that leave a thin film after drying. Primers are available from the locking compound manufacturers that activate the thread surface and also contain some trichloromethane as a solvent. These primers will provide a clean and active surface when used as directed on the container. Nevertheless, preliminary cleaning should still be done using an approved shipboard solvent, after which the parts can be wiped dry and the primer applied.

075-5.7.2.3 Anaerobic Compound Cure Time. Anaerobic threadlocking compounds begin to cure on an active surface as soon as they are deprived of contact with air. The time required to complete the initial stage of curing, or the point at which the compound is no longer liquid, is referred to as fixture time. Fixture time varies from 15 seconds to 30 minutes, depending on the grade of primer used and the ambient temperature. Full curing requires much more time. Full cure on steel without a primer requires approximately 24 hours at 72°F. Curing time is halved for every 20°F increase and doubled for every 20°F decrease in temperature.

075-5.7.2.4 Fastener Material Curing Characteristics. Anaerobic compounds will cure to some extent on almost any clean metal surface, but proper curing requires what is called an active surface, or an activator or heat applied to an inactive surface, or both. Table 075-5-4 shows common active and inactive surfaces.

075-5.7.2.5 Primers (Activators). Primers are available that will activate inactive material surfaces and accelerate the curing process within different times.

075-5.7.2.6 Assembly Time Requirements. Grade N is a general purpose primer. Fixture time with this primer is approximately 30 minutes, with full cure of the compound achieved in 24 hours. Grade T primer is a fast-curing primer that will provide a full cure in 6 hours. Fixture time with grade T primer is approximately 5 minutes. Table 075-5-5 lists some of the NSNs that may be used for procuring these primers in grades N and T. For special applications that require faster curing times, grade NF 736 primer with a cure time of 4 hours is available, but this primer requires great caution, since fixture occurs within 15 seconds and final tightening within a total of 30 seconds following application of the primer. The grade NF 736 primer may be obtained commercially. Use is subject to approval on a case basis. Primers to MIL-S-22473 can be used with anaerobic compounds to MIL-S-46163.

075-5.7.2.7 Using Heat to Cure. Heat can also be used to activate and accelerate the curing process. Complete cure will occur in 1 hour, provided the bond line temperature is held at 200°F to 250°F during that period. The use of heat may be an impractical way to accelerate curing unless special heating equipment is available, the fastener is readily accessible, and the component can accept the heat. Do not try to use a torch, as the temperature cannot be controlled accurately and the heat has to be applied for an hour.

075-5.7.2.8 Tightening Chemically Locked Fasteners. All threaded fasteners treated with anaerobic compounds should be assembled and given their final torquing while the compound is still liquid. When tightened wet, the fastener will have essentially metal-to-metal contact of the load bearing thread surfaces after curing. This provides a stronger joint and reduces the tendency of the initial fastener preload to relax with time. An additional benefit is that the compound, in its liquid form, acts as a lubricant to help achieve the proper fastener preload.

Table 075-5-3 LISTING OF ANAEROBIC COMPOUND TO MIL-S-46163

NSN (8030)	Type	Grade	Container	Size	Loctite No.
00-148-9833	I	K	10-Plastic Squeeze Bottles	10 cc each	271
01-158-6070	I	K	Plastic Squeeze Bottle	50 cc	271
01-063-7510	I	L	Plastic Squeeze Bottle	50 cc	277
01-054-3968	II	M	Plastic Squeeze Bottle	10 cc	222
01-069-3046	II	M	Plastic Squeeze Bottle	50 cc	222
01-055-6126	II	M	Plastic Squeeze Bottle	250 cc	222
01-104-5392	II	N	Plastic Squeeze Bottle	10 cc	242
01-014-5869	II	N	Plastic Squeeze Bottle	50 cc	242
01-025-1692	II	N	Plastic Squeeze Bottle	250 cc	242

Table 075-5-4 COMMON ACTIVE AND INACTIVE SURFACES

Active Surfaces	Inactive Surfaces (use activator primer)
Soft Steel or Iron	Bright Platings
Copper	Zinc
Brass	Anodized Surfaces
Manganese	Pure Aluminum
Bronze	Passivated Surfaces
Nickel	Stainless Steel
Commercial Aluminum (containing copper)	Titanium
	Cadmium
	Magnesium
	Plastics
	Natural or chemical black oxide on steel

Table 075-5-5 LISTING OF PRIMERS (ACTIVATORS) TO MIL-22473

NSN (8030)	Grade	Container	Size
00-082-2508	T	Bottle	4 oz
00-083-3442	T	Can	1 gal
00-181-8372	T	Aerosol Can	6 oz
00-900-2373	N	Bottle	4 oz
00-935-5816	N	Can	1 gal
00-980-3975	N	Can	6 oz

075-5.7.2.9 Tightening of Studs Set with Chemicals. Studs must be set while the locking compound is still liquid. Care should be taken to ensure the proper stud standout is maintained since little adjustment can be made after the compound has become fixed which requires 15 seconds to 30 minutes depending upon the primer used. Normally, the joint should not be assembled until the locking compound has cured which can take up to 24 hours if primers are not used. Using grades T or NF 736 primer will reduce the waiting times to 6 and 4 hours, respectively. Where heat at 200° to 250°F can be applied to the bond line and held between the specified limits, the waiting period can be reduced to 1 hour.

075-5.7.2.10 Threadlocking Compound Selection. Base selection of the specific compound on the type and material of the fastener on which it is to be used and the desired end result. Five variables are involved in the selection process: fastener type, fastener material, service temperature, required breakaway and prevailing torque (locking torque strength), and size of gap (class of thread fit) to be filled.

075-5.7.2.10.1 Standard Anaerobic Threadlocking Compounds. Unless otherwise specified, or where some unusual requirement exists, most shipboard threadlocking needs can be satisfied by one of the following anaerobic compound grades (or equivalent MIL-S-24733 grades):

a. MIL-S-46163 Type II, Grade M, (purple); 300°F service temperature, low strength, permits some fastener adjustment after curing, removable with hand tools, suitable for 1/4-inch and smaller fasteners.

b. MIL-S-46163 Type II, Grade N, (blue); 300°F service temperature, medium strength, general purpose, removable with hand tools, suitable for fasteners larger than 1/4 inch. This is the most commonly used grade.

c. MIL-S-46163 Type I, Grade K, (red); 300°F service temperature, high strength for fasteners up to 1 inch, permanent locking, requires heat (500°F) and hand tools to remove.

d. MIL-S-46163 Type I, Grade L, (red); 300 °F service temperature, high strength for fasteners over 1 inch, permanent locking, requires heat (500°F) and hand tools to remove.

e. NSN 8030-01-171-7628, (red); 450°F service temperature, high strength, permanent locking, requires heat (500°F) and hand tools to remove.

075-5.7.2.10.2 Fastener Type. For the purpose of selecting the proper grade of anaerobic thread locking compound, all threaded fasteners fall into one of the three following types: studs, fasteners 1/4-inch and smaller, and fasteners larger than 1/4 inch.

a. Studs. Unless otherwise specified, studs that must have their set end locked may be locked with an anaerobic threadlocking compound instead of a class 5 fit, provided that a class 2 to 3 thread fit is achieved and the requirements for cleaning, priming, temperature, and curing are met.
   1 The purpose of locking the set end of a stud is usually to enable the self-locking nut on the opposite end to be removed without backing the stud out of its tapped hole. To this end, use MIL-S-46163 Type II, Grade N, as its breakaway torque is greater than that of a reusable self-lockin g nut. Where greater locking torque strength or permanent locking is required, use NSN 8030-01-171-7628.
   2 NSN 8030-01-171-7628 requires the application of heat (500°F) for removal. If these temperatures cannot be applied safely, the stud may have to be drilled or otherwise machined out for removal.

b. Small Fasteners. Lock fasteners 1/4 inch and smaller with a low-strength compound such as MIL-S-46163, Type II, Grade M.

c. Large Fasteners. Lock fasteners larger than 1/4 inch with a medium-strength compound such as MIL-S-46163 Type II, Grade N.

075-5.7.2.10.3 Fastener Material. The locking torque strength of the anaerobic compound is partially dependent on the material of the fastener to which the compound is applied. Most torque strength data are based on the use of uncoated steel fasteners, which have a naturally active surface. Anaerobic compounds used on a zinc-coated fastener will develop only 70 percent of the torque strength of compounds used on a bare steel fastener; those used on an aluminum fastener will develop only 30 percent of the torque strength of compounds used with steel. Other nonferrous materials have similar properties. To get the best locking with all materials, always use a primer that will ensure a clean active surface (see paragraph 075-5.7.2.2).

075-5.7.2.10.4 Service Temperature. The service temperature for the fastener (design operating temperature) can be determined from the system or component specifications. If the service temperature is between -65°F and +300°F, most of the locking compounds will give satisfactory service over this temperature range. Where permanent locking is acceptable for non-nuclear applications, NSN 8030-01-171-7628 can be used between -65°F and +450°F.

075-5.7.2.10.5 Locking Torque Strength. The locking torque strength required is usually determined by the following three considerations:

a. Do you need to disassemble the fastener or remove the stud?

b. Can heat (500°F) be applied to the fastener?

c. Is a fastener preload specified?

The first consideration is based on maintenance requirements and usually is obvious. The second depends on the fastener material and on determining whether heating the fastener would damage the equipment. If a minimum preload is specified, locking compounds with a breakaway torque lower than the prevailing torque are unacceptable. The anaerobic threadlocking grades listed in paragraph 075-5.7.2.10.1 all have acceptable breakaway torque to prevailing torque ratios.

075-5.7.2.10.6 Gap Size (Class of Thread Fit). The gap size is determined by the class of thread fit. Studs are usually permitted to have a class 2 fit on their set end, but some applications specify a class 3 fit. All other shipboard threaded fasteners have a fit at least as tight as class 2. The anaerobic threadlocking grades listed in paragraph 075-5.7.2.10.1 will all fill the gaps associated with class 2 and tighter fits satisfactorily.

075-5.7.2.10.7 Inspection of Studs Set with Anaerobic Compounds. If no other guidance is provided, studs should be subjected to a torque inspection test following installation. The inspection torque applied is to provide assurance that the studs will not turn with normal nut installation and removal. The torques listed in Table 075-5-6 are essentially the maximum breakaway torque permitted for MIL-N-25027 self locking nuts. Normally, the joints will withstand much higher torques which are dependent upon the anaerobic compound used and the depth to which the stud is set. Inspection shall be in accordance with the following:

1. Allow the compound to cure for the time specified in paragraph 075-5.7.2.3.
2. Select the proper stud or studs for testing, one from a group of three or less or two from a group of four or more. Where two are selected they should be approximately 180 degrees apart.
3. On the stud to be tested, install a stud removal tool that grips the threads without damaging them. Apply the inspection torque from Table 075-5-6 in the direction that would loosen the stud. Stud removal tools are listed in the Afloat Shopping Guide under FSC 5120. If a stud removal tool is not available, double nuts may be used. The material of the nuts selected shall have low galling potential. ASTM A 194 Grade 7 or equivalent nuts are recommended for inspection of both ferrous and non-ferrous studs.
4. If the stud does not rotate on the application of the torque, installation of that stud is satisfactory. The stud installation is also satisfactory if the stud does not rotate more than 1/4 turn.
5. If any stud rotates more than 1/4 turn, every stud in the group shall be inspected and all which rotate more than 1/4 turn shall be removed, reinstalled. The reinstalled studs shall be subject to reinspection starting with step 1 above.

Table 075-5-6 PROOF TORQUE VALUES FOR FASTENERS INSTALLED WITH ANAEROBIC COMPOUND

Fastener Diameter (inches)	Torque (ft-lb) [1]	Fastener Diameter (millimeters)	Torque (N-M) [2]
1/4	2.5	3	0.6
5/16	5	4	1.2
3/8	6.7	5	2.1
7/16	8.3	6	4.0
1/2	12.5	8	9
9/16	17	10	14
5/8	25	12	21

Table 075-5-6 PROOF TORQUE VALUES FOR FASTENERS INSTALLED WITH ANAEROBIC COMPOUND - Continued

Fastener Diameter (inches)	Torque (ft-lb) [1]	Fastener Diameter (millimeters)	Torque (N-M) [2]
3/4	33	14	31
7/8	50	16	42
1	67	20	72
1-1/8	75	24	106
1-1/4	83	30	140
1-3/8	100	36	180
1-1/2	115		
1-3/4-5	150		
1-3/4-8	160		
2	180		
2-1/4	215		

[1] Ft-lbs may be converted to Newton-Meters by multiplying by 1.356.
[2] Newton-Meters may be converted to ft-lbs by multiplying by 0.738.

SECTION 6.

THREADED FASTENER REMOVAL

075-6.1 GENERAL

075-6.1.1 CONTROL. As the complexity and sophistication of ships increase, it becomes more and more important to treat threaded fasteners carefully. When fasteners are removed during equipment overhaul or repair, or for inspection, and are to be reused, a suitable control system for identifying, stowing, and handling them is required (i.e., tag and bag). This is important because some uniform strength fasteners used for equipment hold-down or other applications designed for HI shock are identical to or closely resemble standard fasteners (see paragraph 075-2.8.2 for further information on identifying uniform strength fasteners). Some applications, such as fitted bolts or class 5 interference fit studs, require that each fastener be identified by the hole from which it came.

075-6.1.2 LEFT-HAND THREADS. Most threaded fasteners have right-handed threads which are turned clockwise to tighten and obviously should be turned counter-clockwise to loosen. Some fasteners used on rotating elements of machinery, however, may use left-hand threads to prevent the fastener from loosening during operation. Pay particular attention to these areas and look carefully at the hand of the thread before loosening the fasteners. If you can't see any of the thread, examine the bolt head or nut for some kind of identification such as the letters LH or L, which denotes a left-hand thread. If the hand of the thread is not obvious, check the equipment manuals, technical manuals, and drawings. If you can find the number, check the APL for a replacement, it may give the hand. If none of these approaches work, then try to turn the fastener with a torque wrench. Start by trying to turn the fastener opposite to the direction of the component's rotation. Apply the torque slowly and build up to the value given in Table 075-4-1 for the fastener size in question. If the fastener turns but the torque required to turn it is increasing, then you are probably turning it the wrong way. Stop and try the other way and it should loosen. There is usually some margin in the specified torque values and you will not damage the fastener by exceeding the specified torque by 10%.

075-6.1.3 AVOIDING PROBLEMS. Don't let little mistakes lead to major problems. Few things are more frustrating than rounded-off wrench flats and broken studs or capscrews. Although there will always be some of these problems, you don't have to make a career out of them. A few simple precautions will greatly reduce the number of damaged fasteners and knuckles.

075-6.1.3.1 Plan Your Job. Examine the fasteners that you have to remove. Look for rust and corrosion. If you find it, clean off as much of the dirt, paint, and rust as you can so that you can get down to the threads and the joint between the fastener and its bearing surface. Apply penetrating oil and let it soak in. Penetrating oils are listed in the Afloat Shopping Guide (ASG) under FSC 9150. For propulsion plant equipment in nuclear powered ships, only penetrating fluid per MIL-P-24548 can be used. If the equipment will not be damaged, tapping on the fastener with a hammer will help the penetration. Make sure that you get your wrench all the way on the nut or head and pull on the wrench at as close to a 90-degree angle to the fastener centerline as you can. If you're working with a nut and bolt, turn the nut, not the bolt. If at all possible, use a 6-point socket or box-end wrench; they are far less likely to round off the corners. Open end wrenches are for fasteners located where you simply can't get a socket or box-end wrench on them. Twelve point socket and 12 point box-end wrenches are for special fasteners that require a 12 point wrench or socket.

075-6.1.3.2 Think Safety. Make sure that you hold the wrench on the nut straight and pull straight, if you don't, there is a good chance that the wrench will twist and round off the corners. There is also a good chance you will hurt yourself. Look at where your hand or your head will end up if the wrench slips or if the fastener breaks loose suddenly. If you see a problem, reposition the wrench or protect yourself with a rag.

075-6.1.3.3 Stubborn or Damaged Fasteners. After you have made the initial preparations outlined in the preceding two paragraphs, you are ready to start. If you suspect that the fastener is stuck, or if you have tried it and it is stuck, try an impact wrench with a six-point impact socket. The impact load will put more load on the nut than a steady pull will. Manual Impact Wrenches are listed in the ASG under FSC 5120. If this doesn't work see Section 9 for information on removing damaged or stubborn fasteners.

075-6.1.4 NORMAL REMOVAL. Most threaded fasteners are removed with ordinary hand tools: box and open-end wrenches or socket wrenches. The job will always go smoother if you use the best tool for the job. You'll waste more time and a lot more energy struggling with a wrench that's too short than you will in going to your tool box and getting one with a long enough handle. Get a long handle breaker bar for your socket set and use it. If you can get a power-driven nut runner, treasure it and use it; break the nut loose with the breaker bar and use the nut runner to remove it. Don't use an open-end wrench when you have a socket wrench and a ratchet handle that will fit. Use 3/8-drive sockets wherever you can; they are a lot easier to use overall.

075-6.1.4.1 If you are working with large fasteners, use large wrenches. Get 1-inch drive sockets; don't fool around with 2-inch diameter sockets on a 1/2-inch drive handle. If you have several large fasteners to loosen, get a 1-inch drive impact wrench and a six-point impact socket.

075-6.1.4.2 If you can turn the fastener but it's difficult because of rust or corrosion, don't keep turning until it seizes. Use penetrating oil to break down the rust and reduce thread friction so that you can remove the fastener without a major problem. For propulsion plant equipment in nuclear powered ships, only penetrating fluid per MIL-P-24548 can be used. Apply the chemical liberally to the thread area and to the bearing surface. Turn the fastener back a little bit and then apply more chemical. Once the fastener starts to turn more freely, apply more chemical and work the fastener back and forth. This will work the chemical into the thread area and you should then be able to remove the fastener. It helps to let it soak for several hours to allow the chemical to seep into the smallest cracks.

075-6.1.4.3 Several commercial products are on the market that are not corrosive and work well. They can be obtained from the ship's supply system or by local purchase. When using such products, observe the manufacturer's cautions and directions printed on the container. Some products contain corrosive chemicals that accelerate the corrosion of some metals with which they come in contact. Since these products tend to seep into small cracks and inaccessible areas and cause further damage, don't use them. Check the label on the container or ask the supplier about the potential corrosive nature of the products. Removing damaged or especially stubborn fasteners is detailed in Section 9 of this NSTM chapter.

075-6.1.5 REMOVAL OF CHEMICALLY LOCKED FASTENERS. Fasteners locked with an anaerobic compound can be disassembled by one or a combination of the following methods: applying high torque, applying heat, applying chemicals.

075-6.1.5.1 Using Torque to Loosen. First apply torque in excess of breakaway values (short of breaking the fastener) to break down the compound. Then, continue to apply torque at prevailing torque levels until the fastener is apart.

075-6.1.5.2 Using Heat and Torque to Loosen. If the above method does not loosen the fastener, apply heat to the fastener and continue to apply loosening torque. The compound will soften appreciably or decompose at 500°F.

075-6.1.5.3 Using Chemicals and Torque to Loosen. Chemicals are available which will loosen anaerobic compound. However, their use is generally prohibited aboard ship because of environmental or personnel hazards.

CAUTION

When applying heat, make sure that the heat applied will not damage the equipment, nearby seals or gaskets, or present a fire hazard. If you've applied chemicals to soften that locking compound, wash them off with appropriate solvents and dry the area before applying heat.

075-6.1.5.4 Nonanaerobic Locking Compounds. You may encounter many nonanaerobic locking compounds, and identifying them may be impossible. In any event, the procedures described above usually works for them also.

SECTION 7.

INSTALLATION OF THREADED FASTENERS

075-7.1 GENERAL

075-7.1.1 If you are only replacing undamaged fasteners removed for some inspection or repair operation, selecting the proper threaded fastener system is simple. Put the old fasteners back in the same joint they came out of and tighten them to the proper preload. The only potential problems here are: Which joint did which fastener come out of? What is the proper preload? and How are you going to measure the preload? Have you ever had to put a piece of equipment back together that someone else took apart? If you have, then you can understand the importance of tag and bag. The fasteners used for a particular joint should be thought of as a threaded fastener system. It takes the right combination of nuts, bolts, washers, locking devices, and joint design to ensure proper joint performance. Since you may not be the first person to take down a particular joint you should be alert to the possibility that the fasteners that are now in the joint may not be the correct ones. Check the ship's equipment and component APLs, and the technical manuals or component drawings before you start the job to see what fasteners you can expect to find. If you are working on a MIC Level I system, the quality assurance (QA) department must become involved in the overall job and with all new material taken from the MIC Level I supplies (see paragraph 075-3.2.1).

075-7.2 FASTENER SELECTION PROCEDURE

075-7.2.1 If possible, obtain technical input from NAVSEA using Table 075-3-7. When no other guidance is available, use the following:

1. Check max operating temp of system fastener will be exposed to.
2. Determine material fastener is clamping.
3. Select material which is suitable for the application.
4. Verify material selected can withstand operating temps.
5. Determine clamping force needed and select the fastener having sufficient strength greater than needed.
6. Select size, shape, & type fastener per other section of manual.
7. At next availability, obtain tech assistance to verify selection.

The following paragraphs discuss several specific topics related to the proper selection of fasteners. In addition, refer to Section 2 and Section 3 of this chapter for guidance on identifying fasteners, Section 4 for guidance on tightening fasteners, and Section 5 for guidance on locking threaded fasteners.

075-7.3 FIVE BASIC SITUATIONS

075-7.3.1 GENERAL. There are five basic situations that you will encounter in installing fasteners: 1) the original fasteners were removed without damage to them and were properly tagged for reinstallation, 2) there are damaged fasteners, 3) fasteners are missing, 4) the fasteners were not tagged for reinstallation, or 5) a combination of the above. There is an additional consideration that is common to each of the five basic situations: Are the fasteners you have now the correct ones, or were they mixed up during previous maintenance? When trying to identify lost or damaged fasteners, keep in mind that there is usually more than one fastener of the same type in a particular piece of equipment. Pipe line flanges, cover plates, pump casings, cylinder heads, connecting rods, and pipe hangers all have more than one fastener. Look at the remaining fasteners and see if they have legible markings, or look at the same equipment in another space on your ship or on another ship. You can then identify the fastener and get a new one.

075-7.3.2 NEW EQUIPMENT. If the component is new or has not been previously disassembled and the equipment or component has not experienced problems with leakage, breakage, or corrosion, you can be reasonably certain that its fasteners were the proper ones for the job. Check the machinery history records for any previous maintenance or modifications. If the fasteners were removed without damage and properly controlled (tagged and bagged), inspect them as described in paragraph 075-8.3, and then reinstall the fasteners using the installation procedures outlined in this section.

075-7.3.3 DAMAGED FASTENERS. If the original fasteners have been damaged, see paragraph 075-8.5 for thread repair procedures.

075-7.3.4 UNREPAIRABLE FASTENERS. For damaged fasteners that cannot be repaired, check Allowance Parts Lists to see if replacement fasteners are identified. If not on the APL, next check technical manuals or component drawings. If you have these documents, the correct replacement fastener can be determined and a new one obtained through the supply system. If you do not have these documents, inspect the original fastener for markings in accordance with paragraph 075-3.3.2 and Table 075-3-1. The markings will enable you to determine the material and grade of the previously installed fastener. If you have experienced no previous problem (leakage, breakage, or corrosion), you may use the same type fasteners as those removed as a temporary replacement fastener, while you try to obtain further documentation. If you cannot read the markings, see paragraph 075-7.3.5 below.

075-7.3.5 UNIDENTIFIABLE FASTENERS. If you cannot identify the correct fastener to be installed because: 1) the original fasteners have been lost, 2) the original fastener was not the proper one for the application, 3) the technical documentation does not have the necessary information, 4) the needed fastener cannot be identified by inspecting similar equipment, or 5) the original fasteners have no markings; refer to Section 2 for help in selecting an acceptable, temporary replacement fastener. Also, you may utilize the Inquiry & Technical Response Record Form (Table 075-3-7) to obtain technical assistance by facsimile transmission.

075-7.3.5.1 Determine the required fastener diameter, number of threads per inch, and length by measuring the original fastener; or measure the hole diameter, thickness of parts to be clamped, and assume a UNC Class 2A and 2B fit unless evidence indicates otherwise.

075-7.3.6 USE OF TEMPORARY FASTENERS. When temporary fasteners are used in accordance with paragraph 075-8.5, prepare a work request requesting a review of the replaced fastener at the next opportunity.

075-7.4 SELECTION OF PROPER THREADED FASTENER SYSTEMS

075-7.4.1 THREADED FASTENER SYSTEM. There is more to most bolted joints than just a nut and a bolt. A number of different elements usually make up a particular bolted joint. The proper combination of the following basic elements, taken together, make up the fastener system for a particular joint.

a. A capscrew, bolt, stud, or bolt-stud.

b. One or more nuts.

c. One or more washers.

d. One or more threadlocking devices.

e. One or more different chemical locking compounds.

f. Tapped holes.

g. Thread inserts.

h. Design requirements for the joint such as service temperature and pressure, gasket type (sealing), gasket material ″hardness″, joint materials, thread engagement length available, clearance or metal-to-metal contact joint faces, location environment (weather, bilge, shock grade, fire hazard).

You must address each of the remaining topics in Section 7 to be sure that all of the required components are properly installed.

075-7.4.2 TECHNICAL MANUALS AND SYSTEM DRAWINGS. The first step in performing any maintenance or repair operation on a piece of equipment is to READ THE INSTRUCTIONS. The second step is to FOLLOW THOSE INSTRUCTIONS. If you have the necessary manuals and drawings, then you can proceed and expect the job to be completed successfully.

075-7.4.3 UNAVAILABILITY OF TECHNICAL MANUALS. If the necessary technical manuals or drawings are not available, the topics in the remainder of Section 7 will enable you to properly install a safe fastener system until you can get the required specifications and either verify that what you did was satisfactory or make the necessary changes.

075-7.5 LENGTH OF THREAD PROTRUSION

075-7.5.1 MINIMUM THREAD PROTRUSION. A minimum thread protrusion length is given to ensure that all the threads are engaged. This is required to ensure a full-strength fastener. Equipment component drawings should specify the type, length, and size of bolt, stud, bolt-stud, etc. to be used to obtain the proper thread protrusion. If not specified on the drawings, threaded fasteners of commercially stocked lengths should be used. Threaded fasteners, when installed and tightened, should protrude a distance of at least one thread beyond the top of the nut or plastic insert. Excessive protrusion should be avoided, particularly when necessary clearances, accessibility, and safety are important. Thread protrusion is considered excessive if it could cause damage to machinery or harm to personnel. Where practicable, the number of threads protruding should not exceed five. In no case should thread protrusion exceed ten threads. In the case of a stud, excessive thread protrusion may indicate that the stud has not been properly driven in the blind hole. In self-locking nuts where the distance from the top of the nut to the locking element (plastic insert) is equal to or greater than the chamfer, the bolt or stud end may be flush with the top of the nut. For existing or reused fasteners where the thread protrusion exceeds 10 threads, verification should be made that the proper length fastener was installed. For existing installations utilizing standard nuts, acceptable minimum thread protrusion would be where the male thread, below any unthreaded chamfer or crown, is flush with the top of the nut. Washers should not be added to reduce protrusion except as specifically required by equipment component drawings or technical manuals.

075-7.5.2 MAXIMUM THREAD PROTRUSION. There is no maximum thread protrusion from the standpoint of the function of the fastener. Obviously, too much is a waste of material and weight. There is also a safety problem from long, sharp, threaded rods sticking out from equipment, and protruding threads can get in the way of other parts of the equipment. A good rule to follow is to always use the shortest standard length fastener that gives a minimum one thread protrusion. Small and/or short bolts come in 1/8- or 1/4-inch increments. As the fastener gets larger and longer the increments change to 1/2 inch. Up to a five-thread protrusion from a fastener is certainly reasonable, you shouldn't take a hacksaw to it for that; but if you have ten or more threads, you could probably have done a better job of selecting the length. There is no requirement to reduce the length of protrusion of existing fasteners before reinstalling them. There is also no reason you cannot cut off excess protrusion if it is obviously too long or in the way. However, you cannot use washers solely to reduce thread protrusion.

075-7.6 DEPTH OF ENGAGEMENT FOR STUDS AND CAPSCREWS

075-7.6.1 DETERMINING REQUIRED DEPTH OF ENGAGEMENT. The proper depth of engagement for studs and capscrews depends on several factors. The primary consideration is the relative strength of the stud and the material into which it is set. The set depth has to be greater when you are setting a high strength stud, such as ASTM A354 grade BD or K-Monel, into mild steel than when you are setting it into HY-80, if you want to develop the full strength of the fastener. Likewise, you do not need as great a set depth when you are setting a low-strength fastener into high-strength material; however, the set depth does have to be deep enough to grab enough of the stud threads to develop the full stud strength.

075-7.6.2 Where specific data is not available from equipment manuals or drawings, use of Table 075-7-1 and the following procedure from FED-STD-H28 is recommended:

a. When the ultimate strength of the stud or capscrew and the tapped hole material are similar, use the dimensions given in Table 075-7-1.

b. When the ultimate strength of the stud or capscrew and the tapped hole material are dissimilar, determine the material strength ratio R2 where

R_2 = tensile strength of tapped material over tensile strength of screw material

If R_2 is less than R_1 in Table 075-7-1, multiply the required length of engagement given in Table 07-7-1 by R_1 / R_2 . The tensile strength of fasteners made of various materials is given in Table 075-3-1 of Section 3 of this chapter.

075-7.7 SQUARENESS OF SPOTFACE WITH HOLE

075-7.7.1 FASTENER-BENDING LOADS. The bearing surface of bolt heads and nuts should always set flat on the bearing surface of the component in which they are used to keep from putting a bending load on the bolt. Bolts and studs do not take bending loads well. If a fastener already has a large tensile load, the addition of a relatively small bending load can cause it to fail.

Table 075-7-1 REQUIRED DEPTH OF ENGAGEMENT FOR TAPPED HOLES

Thread Designation	Minimum Required Length of Engagement	*R_1
1/4-20 UNC 2A	0.1566	0.8552
5/16-18 UNC 2A	0.2037	0.8723
3/8-16 UNC 2A	0.2466	0.8745
7/16-14 UNC 2A	0.2891	0.8677
1/2-13 UNC 2A	0.3331	0.8743
9/16-12 UNC 2A	0.3765	0.8737
5/8-11 UNC 2A	0.4163	0.8704
3/4-10 UNC 2A	0.5064	0.8778
7/8-9 UNC 2A	0.5957	0.8781
1-8 UNC 2A	0.6814	0.8728
1-1/8-7 UNC 2A	0.7609	0.8634
1-1/4-7 UNC 2A	0.8576	0.8766

Table 075-7-1 REQUIRED DEPTH OF ENGAGEMENT FOR TAPPED HOLES - Continued

Thread Designation	Minimum Required Length of Engagement	*R_1
1-3/8-6 UNC 2A	0.9270	0.8618
1-1/2-6 UNC 2A	1.0233	0.8719
1-3/4-5 UNC 2A	1.1801	0.8599
2-4.5 UNC 2A	1.3438	0.8586
2-1/4-4.5 UNC 2A	1.5334	0.8711
2-1/2-4 UNC 2A	1.6913	0.8649
*R_1 = Shear Stress Area Ratio R_1 = Shear Area of External Threads over Shear Area of Internal Threads		

075-7.7.2 EFFECT OF BEARING SURFACE ON TORQUE LOAD. If the bearing surface is not square with the bolt hole, the bearing load will be uneven and may cause local galling or compression failure of the material. This will increase the force required to turn the fastener and also make it more difficult to develop the proper clamping force.

075-7.8 HEX-HEAD BOLTS AND CAPSCREWS

075-7.8.1 DIFFERENCES BETWEEN HEX-HEAD BOLTS AND CAPSCREWS. Bolts are intended for use with nuts. Hex-head bolts are the most common type although occasionally a square head bolt may be used in some applications. In general, square-head bolts are usually used only as cheap, low strength, temporary fasteners during ship construction. Do not install bolts into tapped holes, use a cap screw. Hex head capscrews are similar in appearance to hex head bolts but have tighter manufacturing controls on straightness and alignment of the bearing surface with the thread centerline. This is done to make it easier to screw the cap screw into a tapped hole and, as discussed in paragraph 075-7.7.1, minimize the bending moment on the fastener. Often cap screws are more readily available and less expensive than bolts. Accordingly, cap screws can be substituted for bolts of the same material. However, bolts should never be substituted for cap screws.

075-7.8.2 TYPES OF BOLTS. Bolts come in six basic configurations as shown in Figure 075-7-1; roll-formed threads over their entire length, 2) cut threads over their entire length, 3) roll-formed threads on the end with a reduced shank diameter equal to the thread pitch diameter, 4) cut threads on the end with a full diameter shank, 5) cut threads on the end with the shank diameter reduced to the thread root diameter, and 6) cut threads on the end with an axial hole drilled through the head and down through the unthreaded portion of the shank to the beginning of the threads. Some of these configurations may also have a larger head-to-shank fillet radius and a more gentle transition from threads to shank. Be particularly careful not to interchange these different types of bolts, especially when working on engine cylinder head and bearing bolts, turbine casing bolts, or on foundation or hull integrity bolts. See paragraph 075-2.8.2 for a discussion on uniform or constant strength fasteners.

075-7.8.3 THROUGH BOLTS. The majority of bolts are used as through bolts; that is, they are inserted through the bolt holes of two or more items with the bolt head on one side and a nut on the other.

075-7.8.4 CAPSCREWS IN THREADED HOLES. There are many applications in which capscrews are installed in drilled and tapped holes. However, there are four major concerns associated with these applications.

a. Ensuring adequate depth of thread engagement.

b. Not bottoming or shouldering the bolt.

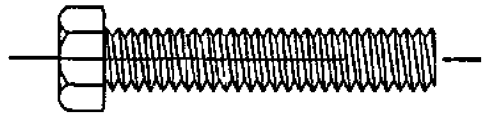
c. Not stripping or otherwise damaging the threads in the tapped hole.

d. Making sure that the hole is bottom-tapped and clean of all chips, dirt, and liquids.

075-7.8.4.1 Selecting Proper Screw Length. The first two concerns involve selecting the proper screw length. Make sure that you use a screw that is long enough to meet the minimum thread engagement required for the application (see paragraph 075-7.6), and yet not be bottomed out in the hole before developing the proper clamping force. Remember that, if you cut off part of the end of a screw to prevent it from bottoming, you may have to run the threads further up the shank to prevent shouldering the screw when you tighten it. Note that you cannot satisfactorily extend roll-formed threads by cutting as the shank is too small in diameter and the shallow threads that you do cut will weaken the fastener. Also, some screws are hardened after threading and any additional threading may not be practical.

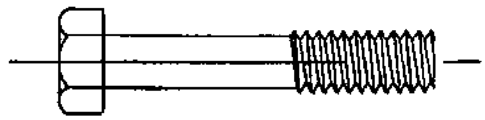
075-7.8.4.2 Preventing Damage to Tapped Threads. The next concern, that of not damaging the tapped threads, is the driving force behind the requirement to use studs. If you use a stud, make sure that the hole is drilled and tapped deep enough and that the stud is set deep enough before the equipment parts are assembled. Then, if you have to disassemble the equipment, you do not have to remove the stud and run the risk of ruining a tapped hole which you may not be able to repair.

075-7.8.4.3 Cleaning the Tapped Hole. The last concern is to make sure that the hole is clean, all of the threads are sound, and full threads extend to the bottom of the hole. This may be difficult to do in some applications; you may need to use a bottom tap. Make sure that you are using the proper tap for the specified thread fit. For example, in the case of a 1/2-inch coarse thread hole, there are five different tap diameters available: class 1B, 2B, 3B, NC5 IF, and NC5 INF. Each of these taps is designed to produce a particular class of thread fit. Note that starting, plug, and bottoming taps do not produce different classes of fit, they only offer different tapers on the end to assist in starting the tap. See paragraph 075-8.5 for a discussion on cleaning up the various thread fits. After all thread inspection and repair has been done, clean the hole with an appropriate solvent and use a blow gun to dry it out.

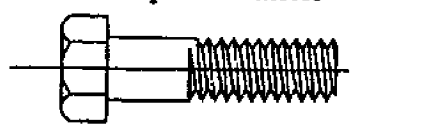


(1) Roll-formed threads over entire length

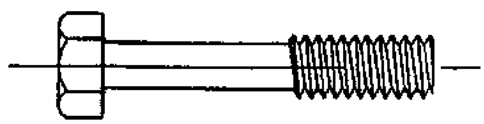
(2) Cut threads over entire length



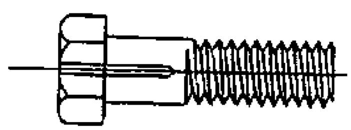
(3) Roll-formed threads on end with reduced shank diameter equal to thread pitch diameter



(4) Cut threads on the end with full diameter shank



(5) Cut threads on the end with shank diameter reduced to thread root diameter



(6) Cut threads on the end with an axial hole drilled through head and unthreaded shank

075-7-1 Types of Bolts

075-7.8.4.4 Use of Thread Locking, Lubricating, and Antiseize Compounds. Determine whether or not a chemical thread-locking compound will be needed. If it is needed, keep the hole clean and oil-free. The wet locking compound will serve as a thread lubricant while tightening the fastener. If no chemical locking compounds will be used, then either a thread lubricant or a combination lubricant and antiseize compound will be required. See paragraph 075-4.6 for information on proper thread lubricants and antiseize compounds.

075-7.9 FITTED BOLTS

075-7.9.1 WHY AND WHERE THEY ARE USED. Fitted bolts are special bolts designed to maintain equipment alignment and/or resist high shear loads. These bolts have a smoothly machined shank which is larger in diameter than the bolt threaded portion. For some applications that do not require a precise fit, a bolt with cut threads can be used, as the unthreaded shank of these bolts is slightly larger in diameter than the threaded portion (bolts with roll-formed threads cannot be used as fitted bolts due to their reduced diameter shank). Bolt-studs could also be used for these applications; however, it is not common practice.

075-7.9.2 HOLE PREPARATION. Bring the equipment into proper alignment and lock it in that position using the standard fasteners (bolt-studs and nuts). Drill the hole for the fitted bolts one drill size smaller than the desired fitted bolt size. A drill fixture should be used to make the holes square with the bearing surface. Then use either an expansion reamer or a series of straight reamers (ones with a slight taper on the starting end) to true up the holes and enlarge them to the desired size. Make sure that the final reaming is done with the material around the hole at room temperature.

075-7.9.3 FITTED BOLT PREPARATION. Measure the diameter of the previously prepared hole and have the machine shop prepare a fitted bolt in that same size for a size-on-size drive fit, or smaller, as required, to provide the desired clearance. If a precise fit is required, make sure that all final machining is done with the material at room temperature.

075-7.9.4 ALTERNATE FITUP PROCEDURE. Where standard size fitted bolts are available or where regular cut thread bolts are to be used, ream the hole to suit the bolt size. If you have easy access to the hole and it is easy to ream, you may want to fit the hole to the bolt in any case.

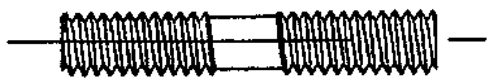
075-7.10 BOLT-STUDS

075-7.10.1 WHY AND WHERE THEY ARE USED. Bolt-studs can generally be used anywhere a bolt can be used. They are usually easier to install in tight quarters. Their primary advantage over bolts is greater fatigue resistance and higher absorption capability under high shock loads.

075-7.10.2 TYPES OF BOLT-STUDS. Bolt-studs come in five basic configurations (see Figure 075-7-2); 1) continuously threaded from end-to-end with roll-formed threads, 2) continuously threaded with cut threads, 3) roll-formed threads on each end with the unthreaded shank diameter in the middle equal to the thread pitch diameter, 4) cut threads on each end with a full diameter unthreaded shank in the middle, and 5) cut threads on each end with the unthreaded shank in the center reduced to the thread root diameter. Be particularly careful not to interchange these different types of bolt-studs, especially when working on engine cylinder head and bearing fasteners, or on foundation or hull integrity fasteners. See paragraph 075-2.8.2 for a discussion on the relative strengths and energy absorption capabilities of the five different types of bolt-studs shown in Figure 075-7-2.

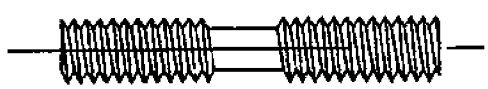
(1) Continuously threaded from end-to-end with roll-formed threads

(2) Continuously threaded with cut threads



(3) Roll-formed threads on each end with unthreaded shank diameter equal to thread pitch diameter

(4) Cut threads on each end with full shank diameter



(5) Cut threads on each end with unthreaded shank equal to thread root direction

075-7-2 Types of Bolt Studs

075-7.10.3 TIGHTENING. When determining the length of a bolt-stud for a particular application, be sure to allow enough extra length for a temporary jam nut on one end. When you try to tighten a bolt-stud with a nut on each end, especially self-locking nuts, one nut will always thread on first. That nut will then become easier to turn and the other nut will not go on any further. At this point, run the first nut on far enough to allow a jam nut to be installed. Tighten the jam nut against the permanent nut and treat the assembly as if it were a bolt head. You will then be able to run the other nut on the other end and tighten it while holding the jam nut with a wrench. After tightening, remove the jam nut without disturbing the inner nut.

075-7.11 STUDS

075-7.11.1 WHY AND WHERE THEY ARE USED. The choice of using a stud instead of a bolt is a serious decision for the equipment designer. A stud is stronger than a bolt and its use is less likely to lead to equipment damage during maintenance (stripping or cross-threading) than a bolt. Studs generally have a slightly better energy absorption capability and hence a better resistance to shock than do bolts or cap screws. See paragraph 075-2.8.2 for a discussion on uniform strength fasteners

075-7.11.2 TYPES OF STUDS. Studs come in five basic configurations: 1) continuously threaded from end-to-end with roll-formed threads, 2) continuously threaded from end-to-end with cut threads, 3) roll-formed threads on each end with the unthreaded shank diameter in the middle equal to the thread pitch diameter, 4) cut threads on each end with an full diameter unthreaded shank in the middle, and 5) cut threads on each end with the unthreaded shank in the center reduced to the thread root diameter. There may be some applications where noncontinuously threaded studs will have a coarse thread on one end and a fine thread on the other. Where studs are set with class 5 interference fit threads, the set end will have the class 5 fit and the nut end will have a class 2 fit or sometimes a class 3 fit; this includes both the continuously threaded and noncontinuously threaded types. Studs are marked on the nut end and must be installed so that the marking is visible when the stud is set. See paragraph 075-2.8.2 for a discussion on the relative strengths and energy absorption capabilities of the different types of studs.

075-7.11.3 SETTING STUDS. There are two reasons for setting studs: 1) to prevent them from loosening during equipment operation (it does no good to use a locknut if you do not lock the stud into the tapped hole), and 2) to prevent them from coming out when you remove the nut (studs are used to prevent damage to tapped holes in equipment that could result from frequent removal of cap screws. For applications above the temperature limit for chemical thread locking compounds specified in Section 075-5.7, studs should be set with either a class 5 interference fit or if specified on the applicable drawings, by bottoming the stud. Class 5 fit studs are difficult to set properly, therefore, a chemical thread locking compound should be used instead of a class 5 fit when the temperature requirements for the allowed thread locking compounds specified in Section 075-5.7 are met.

075-7.11.3.1 Class 5 Fit. Preparing class 5 fit studs and tapping their holes is a job for someone with experience in this type of work. Except for emergency situations where you do not have any choice, leave this job for an expert. Where class 5 fit studs must be used, care must be taken to ensure that the proper thread fits are achieved or else the stud will either back out of the hole in service or seize before it is driven completely in. It is also very important that the hole to be tapped is drilled square with the mating surface. This means using a drill fixture to align and support the drill. You cannot do this with a hand-held drill. After drilling the hole, leave the drill motor in place and hold the tap in alignment with a lathe center drill installed in the drill chuck, or better yet, get the machine shop to make you a centering tool by machining a point on a short piece of 1/4 inch rod. Then start the tap with a wrench and maintain the alignment by following the tap down with the drill and centering tool. There is probably no practical way to cut satisfactory class 5 fit threads on a stud using hand tools unless you have a high-quality die of the proper class and a die handle with a precise alignment collar. If you have access to more sophisticated drilling and threading equipment, use it.

075-7.11.3.1.1 There are many classes of interference fit threads. The proper combination of class and material must be used. Failure to do this may result in serious damage such as not being able to drive the stud deep enough, followed by breaking the stud off in the hole when you try to remove it. Paragraph 075-2.2.2.2.1 identifies recommended fits.

075-7.11.3.2 Nonstandard Class 5 Fit Threads. Be alert for nonstandard class 5 fit threads. A number of shipyards and repair facilities developed their own class 5 fit taps and dies before the current handbook H-28 and ASME standards were developed. If you have access to thread gauges and are familiar with their use, measure the existing hole threads and repair them as required. If not, you can use the standard class 5 taps and dies to determine what you have within reasonable limits. Start with the largest die or smallest tap and see if they will remove any metal. If they do not, change to the next size and try again. If the next size removes some metal, stop and go back to the last size as that is probably what you now have. Determine the material you have and use paragraph 075-7.11.3.1.1 to determine what fit you should have on the stud. Next, either install the stud if everything is within limits, or modify the stud and/or hole as required to meet the specified dimensions.

075-7.12 USE OF FLAT WASHERS

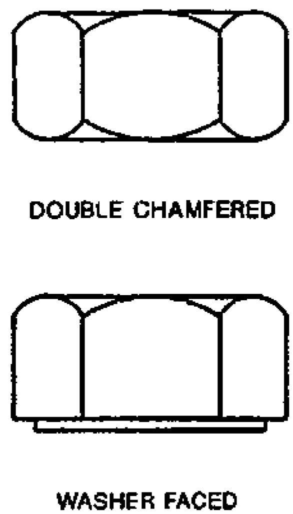
075-7.12.1 GENERAL. The bearing surfaces of most shipboard nut and bolt heads are washer faced and therefore do not require separate washers. However, where oversized or slotted holes are used for adjustment; thick, hard washers which cannot be deformed should be used. Some soft materials or thin-sheet metal covers will also require washers to distribute the bolt loads over a larger area. Here also, the washer must be thick enough and hard enough to distribute the load without being deformed itself. Some high-strength fasteners use a very thick, hard, slightly cup-shaped washer (belleville washer) to provide better preload control and some thread-locking capabilities.

075-7.12.2 WASHERS FOR EQUIPMENT SLIDING FOOT FASTENERS. Be careful when you are working with equipment holddown fasteners located in slotted or oversize holes designed to allow for thermal expansion of the equipment. These applications will have some sort of a bushing in the hole which is designed to permit tightening of the nut without restricting the sliding movement of the equipment. These bushings are often custom-fitted and must be checked to ensure that the equipment is still free to slide after the fastener is tightened. For these applications, a thick, hard washer is required so it cannot be forced down over the bushing, causing binding when the sliding foot tries to move.

075-7.13 INTERCHANGEABILITY OF NUTS

075-7.13.1 GENERAL. Many nut standards for plain hexagon nuts (see list below) do not distinguish between nuts that are ″double chamfered″ and those that are ″washer faced″ (see Figure 075-7-3). Therefore, when nuts are ordered from these standards either configuration may be received. However, the two configurations are completely interchangeable and substitution may be made without requesting prior authorization. The washer faced nut should be installed with the washer face toward the bearing surface.

075-7.13.2 STANDARDS FOR PLAIN HEXAGON NUTS WITH THE SAME PART NUMBER FOR DOUBLE CHAMFERED AND WASHER FACED CONFIGURATIONS. The following standards for plain hexagon nuts lists the same part number for both the double chamfered and washer faced configurations: MS35690, MS35691, MS51471, MS51472, MS51473, and MS51971.



075-7-3 Nut Configurations

SECTION 8.

THREADED FASTENER INSPECTION AND REPAIR

075-8.1 GENERAL

075-8.1.1 This section covers the inspection and repair of threaded fasteners on board ship. Some threaded fasteners, such as equipment holddown fasteners and hull integrity fasteners, require periodic inspection for proper torque and overall condition. In general, fasteners are not removed for inspection unless the joint has to be disassembled for other reasons. All fasteners removed during overhaul and repair operations should be cleaned and inspected prior to reinstallation. Damaged fasteners found during inspection should be discarded and replaced with new ones. If no spares are available, temporary repairs should be accomplished as described in paragraph 075-8.5. When fasteners are removed during equipment overhaul or repair, or for inspection, and are to be reused; a suitable control system for their identification, stowage, and handling must be used (i.e., tag and bag). This is important as some constant strength fasteners used for equipment holddown, or other applications designed for high shock, are very similar in appearance to standard fasteners (see Section 3for further information on identification of constant strength fasteners).

075-8.2 INSPECTION OF INSTALLED THREADED FASTENERS AND JOINTS

075-8.2.1 GENERAL INSPECTION. Inspect threaded fastener joints for missing fasteners or locking devices and for overall condition and tightness. Check for fasteners that are bent or cocked with respect to the hole centerline. Check for obvious looseness and, where required, check for proper torque.

075-8.2.1.1 Acceptance criteria for threads and self-locking fasteners:

a. Cracks are not acceptable.

b. Broken, chipped, or missing threads are not acceptable.

c. Isolated minor defects are allowed. An isolated minor defect is a single nick, gouge, or flattened thread, (after removal of sharp edges and raised metal) that has a depth greater than 1/64 inch but less than 1/2 the thread height (depth) and a width less than the thread spacing (pitch). Defects less than 1/64 inch may be ignored.

d. An isolated minor defect that exceeds the width criteria is acceptable when the total length of the defect does not exceed 15% of one thread length in any one complete thread. One complete thread or one thread length is defined as one complete rotation (360 degrees on a single thread), starting at a point along the thread.

e. Any combination of minor defects is acceptable when the total combined length of the defects does not exceed 15% of one thread on one complete thread.

f. Clearance fit threads must engage by hand.

g. Self-locking fasteners must have a positive reinstallation torque. Cuts or tears in self-locking elements which are deeper than the existing thread impressions are not acceptable.

075-8.2.2 RUST AND CORROSION. Check for corrosion of the entire joint area as well as the fastener threads, nuts, and heads. A surface layer of rust or corrosion on a fastener is no cause for alarm but excessive corrosion may indicate a weakening of the fastener. Surface rust or corrosion should be removed and the affected areas represerved. Fasteners that have spalled areas or are pitted should be replaced.

075-8.2.3 THREAD PROTRUSION. Check to see that at least one thread protrudes beyond the top of the nut. See paragraph 075-7.5.1 for detailed discussion. Thread protrusion is also acceptable if the male thread, below any unthreaded chamfer or crown, is flush with the top of the nut. Excessive protrusion should be avoided, particularly when necessary clearances, accessibility, and safety are important. In the case of a stud, excessive thread protrusion may indicate that the stud has not been driven to its proper set depth. For existing or reused fasteners, there is no requirement to reduce the existing thread protrusion except where excessive protrusion could damage machinery or injure personnel. Generally, thread protrusion of more than 10 threads should be avoided.

075-8.2.4 TAB WASHERS. Inspect tab washers for missing tabs or cracks where the tab is bent, especially on the outside of the bend radius. Defective tab washers should be replaced (see paragraph Section 5 for use of alternative locking devices).

075-8.2.5 CHECKING PRELOAD. In most cases, there is no way to accurately check the preload of an installed fastener without loosening it. However, where installed fasteners must be checked for proper torque, the only practical technique is to use a torque wrench (see paragraph Section 4 for proper torquing procedures). When a loose fastener is encountered, the temptation is to simply retorque it to the specified value. This approach may be acceptable in a few noncritical cases but, unless threads are cleaned and lubricated and proper torquing procedures followed, there is no assurance that the preload will be restored. Therefore, if a fastener is loose, or if insufficient preload is suspected, remove the fastener, clean and lubricate the threads, and reinstall the fastener tightening it in accordance with the procedures in Section 4. Whenever it is suspected that a fastener has been overtightened (excessively yielded), it should be discarded and a new one installed. There is no practical way to visually determine if minute cracks exist and to nondestructively determine if a fastener has been subjected to excessive strains.

075-8.3 VISUAL EXAMINATION OF FASTENERS PRIOR TO INSTALLATION

075-8.3.1 INSPECTING FOR PROPER APPLICATION TYPE. First, check fastener for markings. See Section 3 for instructions on interpreting fastener markings and information on fastener selection.

075-8.3.2 HEAD DAMAGE. Check for head damage. If a fastener has been used, identifying markings may have been obliterated, or the hex flats may have been rounded such that a wrench cannot tighten the fastener without slipping. If head damage is found, replace the fastener. Check the bearing surface for burrs or other damage that would increase friction when tightening. Minor damage to the bearing surface can be repaired by use of a fine stone. Be careful not to scratch or nick the fillet where the head joins the shank. If severe damage exists, replace the fastener. Check the fillet where the head joins the shank for cracks or nicks. If any are found, replace the fastener.

075-8.3.3 RUST OR CORROSION DAMAGE. A surface layer of rust or corrosion on a fastener is no cause for alarm, but excessive corrosion may indicate a weakening of the fastener. Surface rust or corrosion should be removed and the affected areas represerved. Fasteners that have spalled areas or are pitted should be replaced. Fasteners that show signs of coating failure, rust, or corrosion and are located in a corrosion-prone area should be replaced with new fasteners of appropriate materials or fasteners with appropriate protective coatings (see Section 2 for selection procedures).

075-8.3.4 OVERTIGHTENED (YIELDED) FASTENERS. Whenever you suspect that a fastener has been overtightened (excessively yielded), discard it and install a new one. There is no practical way to visually determine if minute cracks exist and to nondestructively determine if the fastener has been subjected to excessive strains.

075-8.3.5 THREAD FLATTENING. Check for thread flattening damage, where threads appear as flattened ridges instead of sharp ridges. This condition can be caused by improper installation or removal (see paragraph 075-8.5 for acceptable repair procedures).

075-8.3.6 SELF-LOCKING ELEMENTS. Check the condition of the plastic (nylon or vespel) locking elements in self-locking nuts. Replace self-locking nuts with loose or cracked elements and nuts with cracks in the metal surrounding the element.

075-8.4 ADDITIONAL EXAMINATIONS

075-8.4.1 GALLING. If a visual inspection does not indicate any apparent damage to an externally threaded fastener, run an undamaged nut onto the threads to check for galling. Galling is the tearing of the thread surfaces to the extent that metal is built up in small mounds making any further sliding action impossible. Depending on the extent of the galling, either filing the threads with a fine tapered thread file, using a lapping compound, or using a cleanup die-nut may relieve the condition (see paragraph 075-8.5).

075-8.4.2 CHECKING SELF-LOCKING NUTS. Replace self-locking nuts which do not provide specified locking torque. Table 075-5-1 provides minimum recommended breakaway torques for previously used self-locking nuts up to 2-1/2 inches in diameter.

075-8.5 THREAD REPAIR

075-8.5.1 GENERAL. Except for minor damage which can be repaired as described herein, replace damaged fasteners if spares are available. When replacement spares are not available, temporary thread repairs may be possible. Damaged internal threads in the tapped holes of equipment or structure, depending on the extent of the damage and type of material, may either be cleaned up or permanently repaired, either by grinding out all of the old threads, plug welding the hole and retapping or by using thread inserts.

WARNING

Use of a die-nut on Ni-Cu-Al- (K-Monel) fasteners is not recommended as this very hard material will wear the die out quickly.

075-8.5.2 THREAD REWORK. If a cleanup tap or die-nut of the appropriate size and fit is available, use it to rework slightly damaged threads and to remove stubborn foreign material where necessary.

075-8.5.3 THREAD FILING. Flattened or galled threads on externally threaded fasteners, depending on the extent of the damage, can sometimes be cleaned up with a fine tapered thread file. Extensive filing will reduce the strength of the fastener, but this is usually a minor consideration if less than 50 percent of the threads are involved. Be careful not to nick the root of roll-formed threads as it is the rounded and work-hardened root that gives these threads their extra strength.

075-8.5.4 THREAD LAPPING. For minor galling damage, apply a lapping compound to the threads and run the nut up and down on the bolt or stud several times to smooth out the surface. Be sure to clean off all traces of lapping compound from the threads and surrounding area before assembling the joint.

075-8.6 REWORKING OF THREADED FASTENER JOINTS

075-8.6.1 FASTENER REMOVAL. All standard threaded fasteners have right-handed threads and should be turned counterclockwise to loosen except when the nut is on the back side of the machinery on which you are working, think about this for a moment. If turning the fastener is difficult due to rust or corrosion, apply penetrating oil to break down the rust and reduce thread friction so that the fastener can be removed without damage. Penetrating oils are listed in the Afloat Shopping Guide under FSC 9150. For propulsion plant equipment in nuclear powered ships, only penetrating fluid per MIL-P-24548 can be used. Apply the chemical liberally to the thread area and to the bearing surface. Try to turn the fastener and then apply more chemical and work the fastener back and forth. This will work the chemical into the thread area and you should then be able to remove it. It helps to let it soak for several hours as these chemicals will seep into the smallest cracks. If you still cannot break the fastener loose and feel that you are about to wring it off, stop and get a torque wrench. Apply about 10 percent more torque than the maximum specified for the fastener you are working on. If the fastener does not loosen, refer to Section 9 where removal of damaged or especially stubborn fasteners is detailed.

075-8.6.2 SUBMARINE FASTENER APPLICATIONS. General guidelines for fasteners for overhaul, repair and conversion of combatant submarines is contained in NAVSEA S9505-AM-GYD-010, **Submarine Fastening Criteria (Non-Nuclear).** The guidance therein does not supersede torque requirements or procedures of applicable drawings or technical manuals.

075-8.6.3 REWORK/REPLACEMENT OF CLASS 5 INTERFERENCE FIT THREADS. For non-high temperature applications (less than 300°F), Class 5 interference fit studs may be replaced by studs installed using anaerobic-locking compounds. For higher temperature applications, Class 5 (interference fit) studs are required unless specific approval is obtained for use of anaerobic or other thread locking compounds.

075-8.6.3.1 Replacements Using Anaerobic Compounds. The following procedure applies for using replacement studs installed with anaerobic compounds.

a. Remove existing studs. Retap holes. While Class 3 threads are preferred, Class 2 threads are acceptable.

b. Clean the hole thoroughly by repeated flushing and scrubbing with a general purpose liquid detergent (MIL-D-16791 or equivalent) and a soft wire brush. See FSC Class 7930 in Afloat Shopping Guide. Blow out all liquid, and dry with oil-free compressed air or a clean cloth.

c. If studs are in good condition, use thread die to clean up the studs to a Class 3 (preferred) or Class 2 (acceptable) dimensions. If studs are damaged, obtain new studs. Scrub the studs with the same detergent used to clean the tapped holes and dry with oil free compressed air.

d. Apply primer (activator) as required. See paragraphs 075-5.7.2.2 and 075-5.7.2.5 for selection of primers.Table 075-5-5 provides stock numbers for primers. Apply sparingly to both male and female threads in accordance with manufacturers directions.

e. Apply anaerobic locking compound to both male and female threads. (Select anaerobic compound in accordance with the guidance in paragraph 075-5.7.2.) Apply enough compound so that the gap between the male and female threads will be completely filled.

f. Install the studs using the standout specified on the installation drawing. No lubricant is to be used as the anaerobic compound will act as a lubricant. See paragraph 075-5.7.2.9 for more detailed instructions.

g. After curing is completed, ensure the studs are properly bonded by applying an inspection torque in accordance with paragraph 075-5.7.2.10.7.

075-8.6.3.2 Replacement Interference Fit Studs. Because of many slight variations in thread forms used by various activities it is not possible to provide detailed guidance for the replacement of interference fit threads. In many cases the repair or replacement of interference fit threads may be beyond forces afloat capability. The following general information applies.

a. Reinstallation of a removed interference fit stud may sometimes be feasible. Clean tapped hole and stud in accordance with paragraph 075-8.6.3.1, above.

b. Apply appropriate thread lubricant sparingly.

c. Install studs using the standout specified on applicable drawings.

d. Subject each stud to an inspection torque the same as for a stud set with anaerobic compound. It is recommended that the torque in Table 075-5-6 be used. If a torque wrench is not available, any unused (new) self-locking nut with a plastic element may be used. If a self-locking nut with plastic element is to be installed, it is recommended that the torque in Table 075-5-6 for Grade N Locking Compound be used. If the stud turns when the torque is applied the installation is unsatisfactory.

e. When installations are unsatisfactory, reinstallation without use of a lubricant and a repeat of the inspection torque may be attempted. If still unsatisfactory, an oversize custom fit stud will be required.

f. Prior to manufacturing or selecting an oversize stud, measure the tapped hole threads at three places: near the bottom, midway, and three threads from the top of the hole. Take thread readings as accurately as possible.

g. Provide the tap hole dimensions taken above to an engineering activity (shipyard, NAVSEA) which has a copy of ASME B1.12, Class 5 Interference-Fit Thread. Ask the engineering activity to determine the major pitch diameter required to maintain the same interference as that which would be obtained using the thread forms recommended in paragraph 075-2.2.2.2.1.

h. Have a stud or studs made to the required dimensions.

i. Lubricate stud with the appropriate lubricant (see Table 075-4-3 for listing of lubricants).

j. Install studs to the specified standout length.

k. Whenever some studs are set with anaerobic compound and others are interference fit, document the installation with a sketch with each location numbered and the set end pitch diameter readings recorded.

075-8.6.4 REMOVAL AND REUSE OF ASSEMBLED STUDS. The procedure for removal and reuse of locking compound assembled studs is as follows:

a. To remove studs which have been set with anaerobic (or non-anaerobic) locking compound, apply torque alone or in combination with chemicals or heat, as spelled out in paragraph 075-6.1.5.

b. Inspect the studs for damage as outlined in paragraphs 075-8.3 and 075-8.4. Discard and replace damaged studs. Also inspect the stud holes, repairing damaged threads or installing thread inserts as required (Note: If locking compound is intended for the replacement stud, use it on the thread insert as well).

c. Brush away the old compound with a wire brush and apply proper primer for the new locking compound. Then reinstall and inspect the stud in accordance with paragraph 075-5.7.2.10.7.

075-8.6.5 STEPPED STUDS. If a thread insert cannot be used and a larger stud size cannot be accommodated, internal thread damage can be remedied by replacing the existing stud with a stepped stud whose set end is one size larger than the existing stud. These stepped studs will not have as much energy absorption as the standard ones they replaced. A slight improvement in energy absorption capacity can be achieved by drilling out the large end such that it has the same tensile stress area as the small end. A fillet with a 1/8-inch radius should be left where the large and small shanks meet to reduce the stress concentration at that point. A slight chamfer can be machined in the opposite hole to accommodate the fillet. Remove the damaged threads in the hole by redrilling and tapping the hole to the next larger diameter. Then install the stepped stud in the normal manner. Stepped studs shall not be used in hull integrity joints, or for component or equipment bedplate or foundation holddown bolting without specific prior approval from NAVSEA for each application.

SECTION 9.

REMOVING DAMAGED OR STUBBORN THREADED FASTENERS

075-9.1 GENERAL

075-9.1.1 This section provides procedures for removing those fasteners on which all other removal methods (covered in Section 6) have failed. There will always be some fasteners that are either damaged or just stubborn, and even the best workmanship will not get them loose using normal tools and equipment. It is hoped that the procedures given here will help with those problem fasteners. For reactor plant applications, where maintenance or replacement requires the removal of stuck nuts or studs, removal shall be accomplished in accordance with the procedures provided in NAVSEA 389-0317.

075-9.2 PREVENTING PROBLEMS

075-9.2.1 Paragraph 075-6.1.3 discusses preventive techniques to maximize the chances of successfully removing fasteners using normal procedures. These procedures do not guarantee success in every case, but if you follow them the chances of success will be greatly improved.

075-9.3 NORMAL REMOVAL

075-9.3.1 Paragraph 075-6.1.4 gives normal threaded fastener removal procedures.

075-9.4 ROUNDED-OFF NUT AND HEAD CORNERS

075-9.4.1 GENERAL. Rounded-off corners, caused by rust or abuse, are a common fastener problem. This problem can be minimized by following the precautions outlined in paragraph 075-6.1.3. When this problem does occur, try the procedures in the following paragraphs.

075-9.4.2 NUTS INSTALLED ON THROUGH BOLTS AND BOLT-STUDS. If you are working with a nut installed on a through bolt (or bolt-stud) and don't need to save the bolt (providing personnel and equipment safety will not be compromised and you are sure that the nut is steel), just burn the nut off with a cutting torch. Otherwise, use an abrasive cutoff wheel or a hacksaw. Where access permits, cut diagonally through the nut from the side and into the bolt. You can also saw down through the end of the bolt and nut or just to the side of the bolt, being careful not to cut into the flange. The space you have to work in will dictate which method to use. You can try heating the nut to expand it also. Heat the nut quickly and try to turn it before the bolt heats up. If you need to save the bolt, use the procedures listed below for nuts on studs.

075-9.4.3 NUTS ON STUDS. If you are working with a stud, you may not want to damage the stud itself. You must be careful not to bend the stud or twist it off. Try the following steps in the order given:

1. Clean dirt, paint, and rust off of the nut, especially around the threads and where the nut bears on the flange.
2. Soak the area with a penetrating liquid. See Afloat Shopping Guide, FSC 9150 for penetrants. For propulsion plant equipment in nuclear powered ships, only penetrating fluid per MIL-P-24548 can be used. Allow as much time as is possible for penetration, keeping the thread and bearing areas wet.
3. Always use a six-point box-end wrench or socket. This may work if the corners of the nut were rounded off by a twelve-point wrench. Make sure that the wrench is all the way on the nut and on straight. If using a box-end wrench, use one with the least offset and pull on it in a straight line. If using a socket, use an extension and hold the handle at the top of the extension with one hand so that there is no side force being applied to the extension, only torque. If you are not dealing with delicate machinery and can get it on the nut, try an impact wrench with its heavy duty six-point socket first.
4. If the area you are working in and the equipment will permit it, apply some heat to the nut. Heat the nut quickly and try to turn it before the stud gets hot. The heat will tend to loosen any rust or corrosion and may expand the nut enough to loosen its grip on the threads. See Steps 3 and 8 for types of wrenches to use.

5. Once you are able to turn the nut, stop, add some penetrating oil and work the nut back and forth. This will work some lubricant into the threads and the nut will usually come off.
6. If at any point you cannot get a grip on the nut to turn it, skip to one of the more drastic procedures listed below.
7. If you can hit the nut with a hammer without damaging the stud or equipment, proceed as follows :
   a Find a heavy block of steel with square edges; about 10 pounds will do.
   b Have someone hold the block against one side of the nut.
   c Find a straight steel bar with one end that you can hold against the opposite side of the nut.
   d Drive the steel bar against the nut with a heavy machinist hammer. This may deform the nut between the bar and backup block enough to crush the rust in the thread area and allow some penetrating oil to soak in. The nut may turn then.
8. The next step is to try vise-grips or a pipe wrench, depending on the size of the nut.
9. Use of a sharp chisel is the next alternative. Hold the heavy backup block against one side of the nut and cut on the other side from the flat in towards the threads. This may spread the nut enough so that you can turn what is left of it. If you have a nut splitter tool, you can try to cut the nut with it first.
10. If the area and equipment will permit it, you can use a cutting torch to burn a steel nut off without ever touching the threads on the stud. Use a large enough tip and concentrate the preheat on the nut. If you work fast enough and hold the torch at the proper angle, the stud will not get hot enough to burn when you cut in the oxygen. Practice on some spare fasteners until you feel comfortable doing it.

075-9.4.4 CAPSCREWS. Capscrews present a somewhat different problem. If the corners were rounded off while trying to loosen the fastener, the threads may well be seized in the tapped hole. If this is the case, the fastener will probably twist off at the top of the hole. You do not want this to happen as it will be more difficult to drill out the remains of the fastener. If the corners of the head were just eaten away by rust, try some of the steps listed above for removing nuts on studs. If the threads are seized, do the following:

1. Locate the center of the head as precisely as you can. Take your time and do it carefully.
2. Determine the diameter of the shank and drill down through the head with a drill one size larger than the shank.
3. If you cannot drill the head (it may be too hard), grind it off.
4. Disassemble the equipment, if possible, and treat the fastener as a broken stud. Once you have relieved the tensile load on the capscrew by removing the head and gotten the equipment out of the way, you may be able to turn the fastener by the shank.

NOTE

Saving a portion of the unthreaded shank of the capscrew will allow you to find the center of the fastener for drilling it out of the hole.

075-9.5 SEIZED THREADS

075-9.5.1 The removal procedures for seized threads are essentially the same as those for rounded-off corners except you do not have the problem of how to turn the nut or capscrew.

075-9.6 BROKEN STUDS AND CAPSCREWS

075-9.6.1 GENERAL. Because both broken studs and capscrews are treated essentially the same except for class 5 fit studs or studs set with anaerobic locking compound, only studs will be referred to in the following paragraphs.

075-9.6.2 NONLOCKED STUDS. If the stud broke while tightening it, but it is not seized in the hole, you may be able to remove it with an ezy-out.

NOTE

If the stud is protruding enough to get a pair of vise grips engaged, try this before drilling for ezy-out.

075-9.6.2.1 Drilling an Axial Hole in a Stud. Before using the ezy-out, the first, and most important step is to find the center of the broken fastener. This is not easy as most studs break off at the top of the hole. From this location it is very difficult to find the center of the fastener. The complete diameter of the hole or the fastener cannot be seen and the spiral of the threads shifts the apparent center to one side. This is why it is so important to save some of the unthreaded shank of the capscrew to help in finding the fastener center. When you find the fastener center, carefully centerpunch it. Using a small drill bit, about one-fourth the diameter of the stud or 1/4 inch, whichever is less, drill a straight pilot hole down through the length of the stud. If the hole is not centered and you used a small drill bit, you may be able to true up the hole with a die-grinder. If possible, use a drill fixture to align the drill and hold it true with the stud centerline.

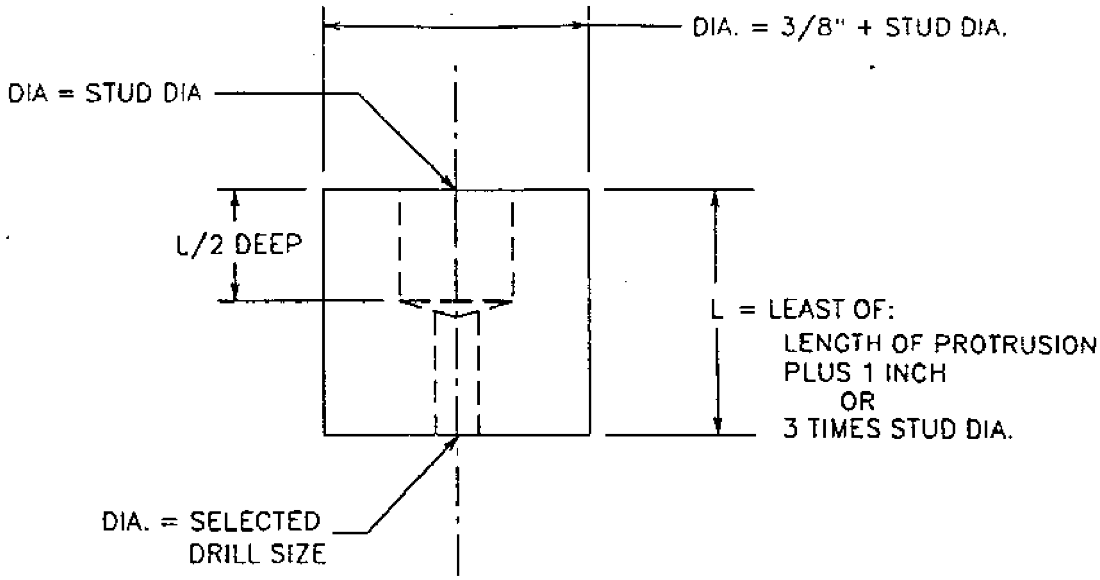
075-9.6.2.1.1 If some of the broken stud is left above the hole, use a drill guide included in a broken stud removal kit, to center the pilot hole or ask th machine shop to make one as follow:

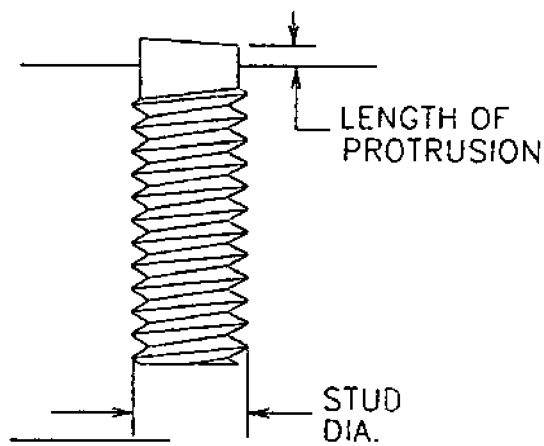
a. Find a piece of steel bar stock about 3/8 inch larger in diameter than the stud and three times as long as the diameter of the stud or the length of the broken stud’s protrusion plus one inch, whichever is less (see Figure 075-9.1).

b. Using a lathe or a rigid clamp on a heavy duty press, drill an axial hole in one end of the bar, equal to the stud diameter, and halfway down the length of the bar.

c. Without disturbing the setup holding the bar and using the drill size you plan to use for the pilot hole, drill the smaller hole the rest of the way through the bar. Then fit the guide over the broken stud and use the small hole to guide the drill. Harden the guide after you make it by preheating with a torch and quenching in water to keep the pilot hole drill from wearing out the guide; you may need it again.

075-9.6.2.2 Using Ezy-outs. If the stud broke from overtightening but the threads are not too badly seized, try using an ezy-out to remove the stud. For these applications, enlarge the hole to about three-fourths of the stud diameter using a standard tapered reamer for the last step. Since the ezy-out is tapered, tapering the hole will allow the ezy-out to distribute its grip over a much larger section of the stud. Since the ezy-out is made of high-strength material it can remove a stud that is larger than itself. A problem occurs when you have already twisted off a full-sized stud trying to remove the threaded part; you have already applied a torque equal to all that a full-sized stud could deliver. In this case, it is questionable whether an ezy-out will work, especially since the ezy-out tends to expand the stud making it fit even tighter in the hole. When you are enlarging the hole, be careful not to get it off center as you may need to drill the stud out if the ezy-out does not work. Be careful not to break ezy-out in the hole. Because the ezy-out is made of hardened material it will be very hard to drill out.





075-9-1 Broken Stud Drill Guide Removal Device

075-9.6.2.3 Drilling Out the Stud. If the stud threads are seized you will have to drill out the stud. This is rarely a completely satisfactory process as some of the threads always seem to get damaged in the process. After drilling the pilot hole to help guide the larger drill, select a drill a couple of sizes smaller than the drill size for the tapped hole. This is to allow for errors in centering the pilot hole. As you drill, examine the sides of the hole to see if you are breaking through to the threads. If you do break through, change to a smaller drill bit and complete the hole. Next, chip out the remains of the stud with a small chisel, a pick, a starting tap, or anything else that will work. If the hole is centered, drill through to the threads all the way down and the remains of the stud will unwind fairly easily.

075-9.6.2.4 Using EDM Equipment. If you are working on an expensive or difficult-to-replace piece of equipment, avoid damaging the threaded hole. Broken studs can be removed with no damage to the threads in the hole by using Electric Discharge Machining (EDM) equipment. (Note:This equipment may also be called a metal disintegrator.) The EDM works through the creation of a series of intermittent electric arcs that break down the hardest metals into very small particles. This cutting action is accomplished with an electrode in the head of the device which vibrates as it cuts. As the EDM cuts, coolant is pumped through the electrode to wash away the powdered metal. Larger repair facilities either have this equipment or can get it. It will eat out the stud, or broken tap, without touching the tapped hole internal threads. There are both portable and larger, fixed EDM machines.

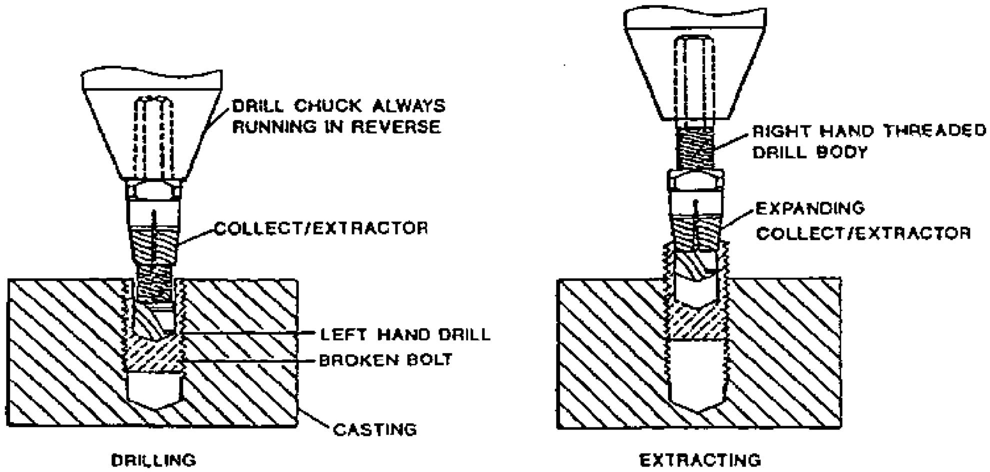
075-9.6.2.5 Power Driven Broken Bolt Extractor (NSN 5130-01-387-7451). This kit can be used to remove 1/4-, 5/16-, 3/8- and 1/2-inch diameter screws. Unlike conventional extractors which require drills, center drills, center punches, hammers, and wrenches, the power driven broken bolt extractor requires only a reversible power drill. It is very effective in removing bolts and studs without damaging the threads in the hole. Since this tool can be driven by electrical power, it has the ability of applying tremendous torque during the extraction process. Essentially, this extractor has the following two main parts.

a. The collet/extractor

b. This part is equipped with seven serrations, which bite onto the broken bolt.
   The drill tip and body

The tip is made out of high quality tool steel and is heat treated. It is able to drill into grade 8 and stainless steel bolts. The tip is equipped with self-centering feature to obtain perfect centering of the bolt. The tip is left hand cutting edge. This feature helps to loosen and sometimes even turn the bolt out during drilling. The body is short and tough. This feature helps the user control the tip with ease, while adding freedom and flexibility in close quarters. Follow instruction supplied with the kit.

075-9.6.3 CLASS 5 FIT AND LOCKED STUDS. If you have a broken, class 5 fit stud, start with the drilling procedure (paragraph 075-9.6.2.1) or use EDM equipment (paragraph 075-9.6.2.4) to remove the stud. If you think you may have to install an oversize stud anyway, drill a pilot hole and then drill the new size tap hole. If you have a low-temperature application and can use an anaerobic thread-locking compound, try to remove the broken stud and enlarge the hole threads to a class 3 fit. If the broken stud was locked with anaerobic compound, apply 500° heat to the area to break down the locking compound. Then follow the procedures for nonlocked removal. If you cannot use heat, go on to the drilling or EDM procedures.



075-9-2 Broken Bolt Extractor

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.