CHAPTER 7. AIRCRAFT HARDWARE, CONTROL CABLES, AND TURNBUCKLES

SECTION 1. RIVETS

GENERAL.

Standard solid-shank rivets and the universal head rivets (AN470) are used in aircraft construction in both interior and exterior locations. All protruding head rivets may be replaced by MS20470 (supersedes AN470) rivets. This has been adopted as the standard for protruding head rivets in the United States.

Roundhead rivets (AN430) are used in the interior of aircraft except where clearance is required for adjacent members.

Flathead rivets (AN442) are used in the interior of the aircraft where interference of adjacent members does not permit the use of roundhead rivets.

Brazierhead rivets (AN455 and AN456) are used on the exterior surfaces of aircraft where flush riveting is not essential.

Countersunk head rivets MS20426 (supersedes AN426 100-degree) are used on the exterior surfaces of aircraft to provide a smooth aerodynamic surface, and in other applications where a smooth finish is desired. The 100-degree countersunk head has been adopted as the standard in the United States. Refer to MIL-HD BK5 *Metallic Materials and Elements for Fight Vehicle Structures*, and U.S.A.F./Navy T./O. 1-1A-8, *Structural Hardware*."

Typical rivet types are shown in table 7-10.

MATERIAL APPLICATIONS.

Rivets made with 2117-T4 are the most commonly used rivets in aluminum alloy structures. The main advantage of 2117-T4 is that it may be used in the condition received without further treatment.

The 2017-T3, 2017-T31, and 2024-T4 rivets are used in aluminum alloy structures where strength higher than that of the 2117-T4 rivet is needed. See Metallic Materials and Elements for Flight Vehicle Structures (MIL-HDBK-5) for differences between the types of rivets specified here.

The 1100 rivets of pure aluminum are used for riveting nonstructural parts fabricated from the softer aluminum alloys, such as 1100, 3003, and 5052.

When riveting magnesium alloy structures, 5056 rivets are used exclusively due to their corrosion-resistant qualities in combination with the magnesium alloys.

Mild steel rivets are used primarily in riveting steel parts. **Do not** use galvanized rivets on steel parts subjected to high heat.

Corrosion-resistant steel rivets are used primarily in riveting corrosion-resistant steel parts such as firewalls, exhaust stack bracket attachments, and similar structures.

Monel rivets are used in special cases for riveting high-nickel steel alloys and nickel alloys. They may be used interchangeably with stainless steel rivets as they are more easily driven. However, it is preferable to use stainless steel rivets in stainless steel parts.

Copper rivets are used for riveting copper alloys, leather, and other nonmetallic materials. This rivet has only limited usage in aircraft.

Hi-Shear rivets are sometimes used in connections where the shearing loads are the primary design consideration. Its use is restricted to such connections. It should be noted that Hi-Shear rivets are not to be used for the installation of control surface hinges and hinge brackets. Do not paint the rivets before assembly, even where dissimilar metals are being joined. However, it is advisable to touch up each end of the driven rivet with primer to allow the later application of the general airplane finish.

Blind rivets in the MS20600 through MS20603 series rivets and the mechanically-locked stem NAS 1398, 1399, 1738, and 1739 rivets sometimes may be substituted for solid rivets. They should not be used where the looseness or failure of a few rivets will impair the airworthiness of the aircraft. Design allowables for blind rivets are specified in MIL-HDBK-5. Specific structural applications are outlined in MS33522. Nonstructural applications for such blind rivets as MS20604 and MS20605 are contained in MS33557.

7-3.—7-13. [RESERVED.]

SECTION 2. SCREWS

GENERAL. **In general, screws differ from bolts by the following characteristics.**

Screws usually have lower material strength, a looser thread fit, head shapes formed to engage a screwdriver, and the shank may be threaded along its entire length without a clearly defined grip. Screws may be divided into three basic groups: structural screws, machine screws, and self-tapping screws. Screws are marked as required by the applicable Army Navy (AN), National Aerospace Standard (NAS), or Military Standard (MS) drawing. Normally a manufacturer places his trademark on the head of the screw. Several types of structural screws are available that differ from the standard structural bolts only in the type of head.

It would be impossible to cover all screws that are available to the aviation market; therefore, only the most frequently used screws will be discussed in this text. Design specifications are available in MIL-HDBK-5, or U.S.A.F./Navy T.O.1-1A-8/NAVAIR 01-1A-8, Structural Hardware.

Typical screw types are shown in table 7-11.

STRUCTURAL SCREWS. **NAS502, NAS503, AN509, NAS220 through NAS227, and NAS583 through NAS590, may be used for structural applications, similar to structural bolts or rivets. These screws are fabricated from a material with a high-tensile strength and differ from structural bolts only in the type of head.**

MACHINE SCREWS. **These screws are available in four basic head styles: flathead (countersunk), roundhead, fillister, and socket head.**

Flathead machine screws (AN505, AN510, AN507, NAS200, NAS514, NAS517, and NAS662) are used in countersunk holes where a flush surface is desired.

Roundhead machine screws (AN515 and AN520) are general-purpose screws for use in nonstructural applications.

Fillister head machine screws (AN500 through AN503, AN116901 through AN116912, AN116913 through AN116924, AN116962 through AN116990, AN117002 through AN117030, and AN117042 through AN117070) are general-purpose screws that may be used as capscrews in light mechanical applications and are usually drilled for safety wire.

Socket head machine screws (NAS608 and NAS609) are designed to be driven into tapped holes by means of internal wrenches. They may be used in applications requiring high strength, compactness of assembled parts, or sinking of heads below surfaces into fitted holes.

PANHEAD SCREWS (NAS600 THROUGH NAS606, NAS610 THROUGH NAS616, NAS623, AND NAS1402 THROUGH NAS1406). **Flathead screws (MS35188 through MS35203), panhead machine screws (MS35024 through MS35219), and truss-head screws (AN526) are general-purpose screws used where head height is not important.**

SELF-TAPPING SCREWS. **The self-tapping screw taps their own mating thread when driven into untapped or punched holes slightly smaller than the diameter of the screw. Self-tapping machine screws (AN504 and AN530), may be used to attach minor** nonstructural parts. Self-tapping sheet metal screws (AN504, AN530, AN531 and NAS548) may be used in blind applications for the temporary attachment of sheet metal for riveting and the permanent assembly of nonstructural assemblies. The MS21318 is a roundhead drive screw used in the attachment of nameplates or in sealing drain holes, and is not intended to be removed after installation. They are normally installed by driving the screw into a drilled hole with a hammer.

CAUTION: Self-tapping screws should never be used as a replacement for standard screws, nuts, bolts, or rivets in any aircraft structure.

WOOD SCREWS **AN545 and AN550, MS35492 and MS35493 are screws used in wood structures of aircraft.**

7-20.—7-33. [RESERVED.]

SECTION 3. BOLTS

GENERAL. **"Hardware" is the term used to describe the various types of fasteners and small items used to assemble and repair aircraft structures and components. Only hardware with traceability to an approved manufacturing process or source should be used. This traceability will ensure that the hardware is at least equal to the original or properly-altered condition. Hardware that is not traceable or is improperly altered, may be substandard or counterfeit, since their physical properties cannot be substantiated. Selection and use of fasteners are as varied as the types of aircraft; therefore, care should be taken to ensure fasteners are approved by the Federal Aviation Administration (FAA) for the intended installation, repair, or replacement. Threaded fasteners (bolts/screws) and rivets are the most commonly used fasteners because they are designed to carry shear and/or tensile loads.**

BOLTS. **Most bolts used in aircraft structures are either general-purpose, internal-wrenching, or close-tolerance AN, NAS, or MS bolts. In certain cases, fastener manufacturers produce bolts of different dimensions or greater strength than the standard types. *Such bolts are made for a particular application, and it is of extreme importance to use like bolts in replacement.* Design specifications are available in MIL-HDBK-5 or USAF/Navy T.O. 1-1A-8/NAVAIR 01-1A-8. References should be made to military specifications and industry design standards such as NAS, the Society of Automotive Engineers (SAE), and Aerospace Material Standards (AMS). Typical bolt types are shown in table 7-12.**

IDENTIFICATION. **Aircraft bolts may be identified by code markings on the bolt heads. These markings generally denote the material of which the bolt is made, whether the bolt is a standard AN-type or a special-purpose bolt, and sometimes include the manufacturer.**

AN standard steel bolts are marked with either a raised dash or asterisk, corrosion-resistant steel is marked by a single dash, and AN aluminum-alloy bolts are marked with two raised dashes.

Special-purpose bolts include high-strength, low-strength, and close-tolerance types. These bolts are normally inspected by magnetic particle inspection methods. Typical markings include "SPEC" (usually heat-treated for strength and durability), and an aircraft manufacturer's part number stamped on the head. Bolts with no markings are low strength. Close-tolerance NAS bolts are marked with either a raised or recessed triangle. The material markings for NAS bolts are the same as for AN bolts, except they may be either raised or recessed. Bolts requiring non-destructive inspection (NDI) by magnetic particle inspection are identified by means of colored lacquer, or head markings of a distinctive type. (See figure 7-1.)

GRIP LENGTH. **In general, bolt grip lengths of a fastener is the thickness of the material the fastener is designed to hold when two or more parts are being assembled. Bolts of slightly greater grip length may be used, provided washers are placed under the nut or bolthead. The maximum combined height of washers that should be used is 1/8 inch. This limits the use of washers necessary to compensate for grip, up to the next standard grip size. Over the years, some fasteners specifications have been changed. For this reason, it is recommended when making repairs to an aircraft, whose original hardware is being replaced, that you must first measure the bolt before ordering, rather than relying on the parts manual for**

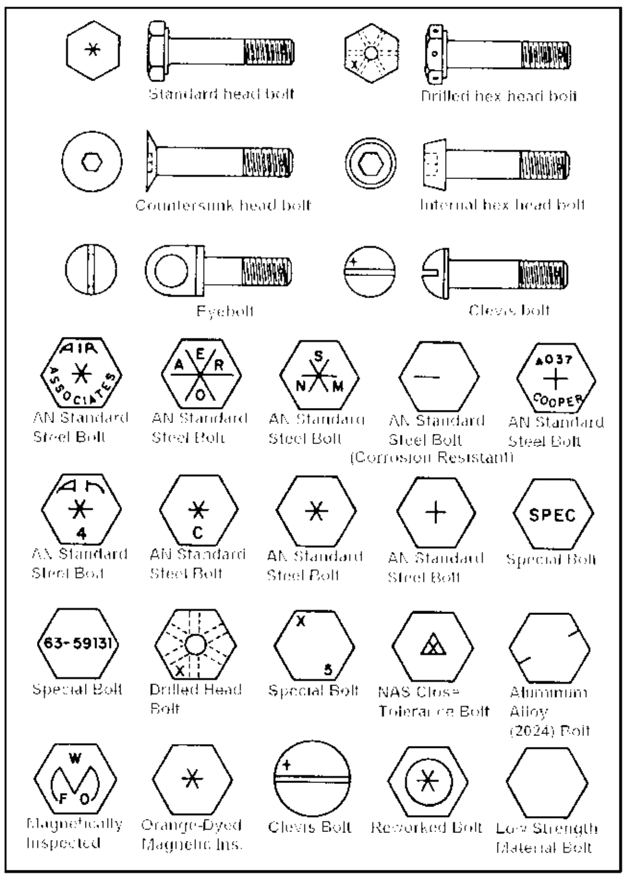


FIGURE 7-1. Typical aircraft bolt markings.

identification. In the case of plate nuts, if proper bolt grip length is not available, add shims under the plate. All bolt installations which involve self-locking or plain nuts should have at least one thread of the bolt protruding through the nut.

LOCKING OR SAFETYING OF BOLTS. **Lock or safety all bolts and/or nuts, except self-locking nuts. Do not reuse cotter pins or safety wire.**

BOLT FIT. **Bolt holes, particularly those of primary connecting elements, have close tolerances. Generally, it is permissible to use the first-lettered drill size larger than the nominal bolt diameter, except when the AN hexagon bolts are used in light-drive fit (reamed) applications and where NAS close-tolerance bolts or AN clevis bolts are used. A light-drive fit can be defined as an interference of 0.0006 inch for a 5/8 inch bolt. Bolt holes should be flush to the surface, and free of debris to provide full bearing surface for the bolt head and nut. In the event of over-sized or elongated holes in structural members, reaming or drilling the hole to accept the next larger bolt size may be permissible. Care should be taken to ensure items, such as edge distance, clearance, and structural integrity are maintained. Consult the manufacturer's structural repair manual, the manufacturer's engineering department, or the FAA before drilling or reaming any bolt hole in a critical structural member.**

TORQUES. **The importance of correct torque application cannot be overemphasized. Undertorque can result in unnecessary wear of nuts and bolts, as well as the parts they secure. Overtorque can cause failure of a bolt or nut from overstressing the threaded areas. Uneven or additional loads that are applied to the assembly may result in wear or premature failure. The following are a few simple, but important procedures, that should be followed to ensure that correct torque is applied.**

NOTE: Be sure that the torque applied is for the size of the bolt shank not the wrench size.

Calibrate the torque wrench at least once a year, or immediately after it has been abused or dropped, to ensure continued accuracy.

Be sure the bolt and nut threads are clean and dry, unless otherwise specified by the manufacturer.

Run the nut down to near contact with the washer or bearing surface and check the friction drag torque required to turn the nut. Whenever possible, apply the torque to the nut and not the bolt. This will reduce rotation of the bolt in the hole and reduce wear.

Add the friction drag torque to the desired torque. This is referred to as "final torque," which should register on the indicator or setting for a snap-over type torque wrench.

Apply a smooth even pull when applying torque pressure. If chattering or a jerking motion occurs during final torque, back off the nut and retorque.

NOTE: Many applications of bolts in aircraft/engines require stretch checks prior to reuse. This requirement is due primarily to bolt stretching caused by overtorquing.

When installing a castle nut, start alignment with the cotter pin hole at the minimum recommended torque plus friction drag torque.

NOTE: Do not exceed the maximum torque plus the friction drag. If the hole and nut castellation do not align, change washer or nut and try again. Exceeding the maximum recommended torque is not recommended.

When torque is applied to bolt heads or capscrews, apply the recommended torque plus friction drag torque.

If special adapters are used which will change the effective length of the torque wrench, the final torque indication or wrench setting must be adjusted accordingly. Determine the torque wrench indication or setting with adapter installed as shown in figure 7-2.

Table 7-1 shows the recommended torque to be used when specific torque is not supplied by the manufacturer. The table includes standard nut and bolt combinations, currently used in aviation maintenance. For further identification of hardware, see chapter 7, section 11.

STANDARD AIRCRAFT HEX HEAD BOLTS (AN3 THROUGH AN20). **These are all-purpose structural bolts used for general applications that require tension or shear loads. Steel bolts smaller than No. 10-32, and aluminum alloy bolts smaller than 1/4 inch diameter, should not be used in primary structures. Do not use aluminum bolts or nuts in applications requiring frequent removal for inspection or maintenance.**

DRILLED HEAD BOLTS (AN73 THROUGH AN81). **The AN drilled head bolt is similar to the standard hex bolt, but has a deeper head which is drilled to receive safety wire. The physical differences preventing direct interchangeability are the slightly greater head height, and longer thread length of the AN73 through AN81 series. The AN73 through AN81 drilled head bolts have been superseded by MS20073, for fine thread bolts and MS20074 for coarse thread bolts. AN73, AN74, MS20073, and MS20074 bolts of like thread and grip lengths are universally, functionally, and dimensionally interchangeable.**

ENGINE BOLTS. **These are hex head bolts (AN101001 through AN101900), drilled shank hex head bolts (AN101901 through AN102800), drilled hex head (one hole) bolts (AN102801 through AN103700), and drilled hex head (six holes) bolts (AN103701 through AN104600). They are similar to each other except for the holes in the head and shank. Hex head bolts (AN104601 through AN105500), drilled shank hex head bolts (AN105501 through AN106400), drilled hex head (one hole) bolts (AN106401 through AN107300), and drilled hex head (six holes) bolts (AN107301 through AN108200) are similar to the bolts described in paragraph 7-42, except that this series is manufactured from corrosion-resistant steel.**

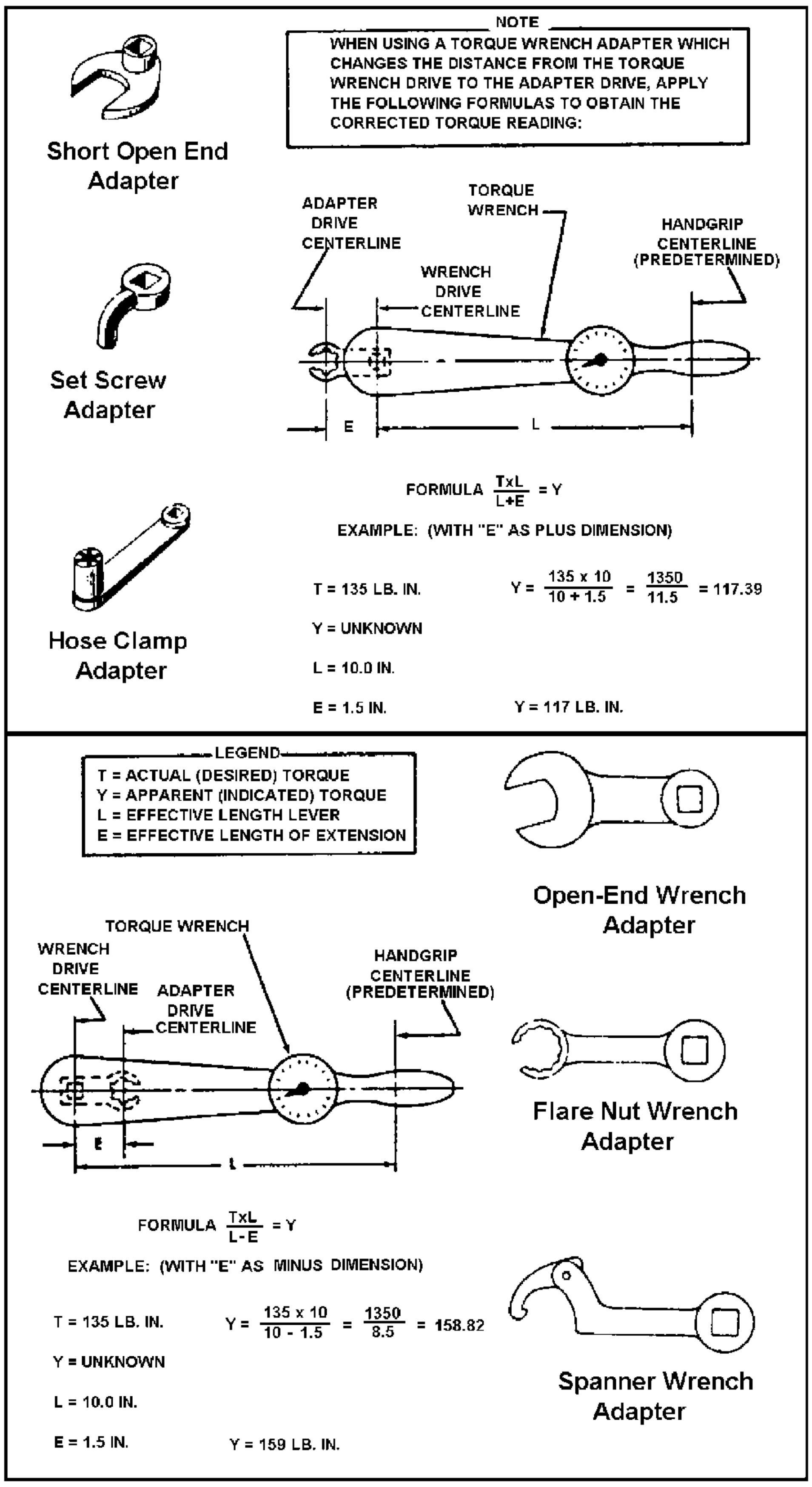


FIGURE 7-2. Torque wrench with various adapters.

TABLE 7-1. Recommended torque values (inch-pounds).

CAUTION THE FOLLOWING TORQUE VALUES ARE DERIVED FROM OIL FREE CADMIUM PLATED THREADS.				
	TORQUE LIMITS RECOMMENDED FOR INSTALLATION (BOLTS LOADED PRIMARILY IN SHEAR)		MAXIMUM ALLOWABLE TIGHTENING TORQUE LIMITS	
Thread Size	Tension type nuts MS20365 and AN310 (40,000 psi in bolts)	Shear type nuts MS20364 and AN320 (24,000 psi in bolts)	Nuts MS20365 and AN310 (90,000 psi in bolts)	Nuts MS20364 and AN320 (54,000 psi in bolts)
FINE THREAD SERIES				
8-36	12-15	7-9	20	12
10-32	20-25	12-15	40	25
1/4-28	50-70	30-40	100	60
5/16-24	100-140	60-85	225	140
3/8-24	160-190	95-110	390	240
7/16-20	450-500	270-300	840	500
1/2-20	480-690	290-410	1100	660
9/16-18	800-1000	480-600	1600	960
5/8-18	1100-1300	600-780	2400	1400
3/4-16	2300-2500	1300-1500	5000	3000
7/8-14	2500-3000	1500-1800	7000	4200
1-14	3700-5500	2200-3300*	10,000	6000
1-1/8-12	5000-7000	3000-4200*	15,000	9000
1-1/4-12	9000-11,000	5400-6600*	25,000	15,000
COARSE THREAD SERIES				
8-32	12-15	7-9	20	12
10-24	20-25	12-15	35	21
1/4-20	40-50	25-30	75	45
5/16-18	80-90	48-55	160	100
3/8-16	160-185	95-100	275	170
7/16-14	235-255	140-155	475	280
1/2-13	400-480	240-290	880	520
9/16-12	500-700	300-420	1100	650
5/8-11	700-900	420-540	1500	900
3/4-10	1150-1600	700-950	2500	1500
7/8-9	2200-3000	1300-1800	4600	2700

The above torque values may be used for all cadmium-plated steel nuts of the fine or coarse thread series which have approximately equal number of threads and equal face bearing areas.

* Estimated corresponding values.

CLOSE-TOLERANCE BOLTS.

Close-tolerance, hex head, machine bolts (AN173 through AN186), 100-degree countersunk head, close-tolerance, high-strength bolts (NAS333 through NAS340), hex head, close-tolerance, short thread, titanium alloy bolts (NAS653 through NAS658), 100-degree countersunk flathead, close-tolerance titanium alloy bolts (NAS663 through NAS668), and drilled hex head close-tolerance titanium alloy bolts (NAS673 through NAS678), are used in applications where two parts bolted together are subject to severe load reversals and vibration. Because of the interference fit, this type of bolt may require light tapping with a mallet to set the bolt shank into the bolt hole.

NOTE: Elimination of friction in interference fit applications may sometimes be attained by placing the bolt in a freezer prior to installation. When this procedure is used, the bolt should be allowed to warm up to ambient temperature before torquing.

CAUTION: Caution must be exercised in the use of close-tolerance bolts for all critical applications, such as

landing gear, control systems, and helicopter rotary controls. Do not substitute for close-tolerance fasteners without specific instructions from the aircraft manufacturer or the FAA.

INTERNAL WRENCHING BOLTS (NAS144 THROUGH NAS158 AND NAS172 THROUGH NAS176). **These are high-strength bolts used primarily in tension applications. Use a special heat-treated washer (NAS143C) under the head to prevent the large radius of the shank from contacting only the sharp edge of the hole. Use a special heat-treated washer (NAS143) under the nut.**

INTERNAL WRENCHING BOLTS (MS20004 THROUGH MS20024) AND SIX HOLE, DRILLED SOCKET HEAD BOLTS (AN148551 THROUGH AN149350). **These are very similar to the bolts in paragraph 7-45, except these bolts are made from different alloys. The NAS144 through NAS158 and NAS172 through NAS176 are interchangeable with MS20004 through MS20024 in the same thread configuration and grip lengths. The AN148551 through AN149350 have been superseded by MS9088 through MS9094 with the exception of AN149251 through 149350, which has no superseding MS standard.**

TWELVE POINT, EXTERNAL WRENCHING BOLTS, (NAS624 THROUGH NAS644). **These bolts are used primarily in high-tensile, high-fatigue strength applications. The twelve point head, heat-resistant machine bolts (MS9033 through**

MS9039), and drilled twelve point head machine bolts (MS9088 through MS9094), are similar to the (NAS624 through NAS644); but are made from different steel alloys, and their shanks have larger tolerances.

CLOSE-TOLERANCE SHEAR BOLTS (NAS464). **These bolts are designed for use where stresses normally are in shear only. These bolts have a shorter thread than bolts designed for torquing.**

NAS6200 SERIES BOLTS. **These are close tolerance bolts and are available in two oversized diameters to fit slightly elongated holes. These bolts can be ordered with an "X" or "Y" after the length, to designate the oversized grip portion of the bolt (i.e., NAS6204-6X for a 1/4 inch bolt with a 1/64 inch larger diameter). The elongated hole may have to be reamed to insure a good fit.**

CLEVIS BOLTS (AN21 THROUGH AN36). **These bolts are only used in applications subject to shear stress, and are often used as mechanical pins in control systems.**

EYEBOLTS (AN42 THROUGH AN49). **These bolts are used in applications where external tension loads are to be applied. The head of this bolt is specially designed for the attachment of a turnbuckle, a clevis, or a cable shackle. The threaded shank may or may not be drilled for safetying.**

7-52.—7-62. [RESERVED.]

SECTION 4. NUTS

GENERAL. **Aircraft nuts are available in a variety of shapes, sizes, and material strengths. The types of nuts used in aircraft structures include castle nuts, shear nuts, plain nuts, light hex nuts, checknuts, wingnuts, and sheet spring nuts. Many are available in either self-locking or nonself-locking style. Typical nut types are shown in table 7-13. Refer to the aircraft manufacturer's structural repair manual, the manufacturer's engineering department, or the FAA, before replacing any nut with any other type.**

SELF-LOCKING NUTS. **These nuts are acceptable for use on certificated aircraft subject to the aircraft manufacturer's recommended practice sheets or specifications. Two types of self-locking nuts are currently in use, the all-metal type, and the fiber or nylon type.**

DO NOT use self-locking nuts on parts subject to rotation.

Self-locking castellated nuts with cotter pins or lockwire may be used in any system.

Self-locking nuts should not be used with bolts or screws on turbine engine airplanes in locations where the loose nut, bolt, washer, or screw could fall or be drawn into the engine air intake scoop.

Self-locking nuts should not be used with bolts, screws, or studs to attach access panels or doors, or to assemble any parts that are routinely disassembled before, or after each flight. They may be used with anti-friction bearings and control pulleys, provided the inner race of the bearing is secured to the supporting structure by the nut and bolt.

Metal locknuts are constructed with either the threads in the locking insert, out-of-round with the load-carrying section, or with a saw-cut insert with a pinched-in thread in the locking section. The locking action of the all-metal nut depends upon the resiliency of the metal when the locking section and load-carrying section are engaged by screw threads. Metal locknuts are primarily used in high temperature areas.

Fiber or nylon locknuts are constructed with an unthreaded fiber or nylon locking insert held securely in place. The fiber or nylon insert provides the locking action because it has a smaller diameter than the nut. Fiber or nylon self-locking nuts are not installed in areas where temperatures exceed 250 °F. After the nut has been tightened, make sure the bolt or stud has at least one thread showing past the nut. DO NOT reuse a fiber or nylon locknut, if the nut cannot meet the minimum prevailing torque values. (See table 7-2.)

Self-locking nut plates are produced in a variety of forms and materials for riveting or welding to aircraft structures or parts. Certain applications require the installation of self-locking nuts in channel arrangement permitting the attachment of many nuts in a row with only a few rivets.

NUT IDENTIFICATION FINISHES. **Several types of finishes are used on self-locking nuts. The particular type of finish is dependent on the application and temperature requirement. The most commonly used finishes are described briefly as follows.**

TABLE 7-2. Minimum prevailing torque values for reused self-locking nuts.

FINE THREAD SERIES	
THREAD SIZE	MINIMUM PREVAILING TORQUE
7/16 - 20	8 inch-pounds
1/2 - 20	10 inch-pounds
9/16 - 18	13 inch-pounds
5/8 -18	18 inch-pounds
3/4 - 16	27 inch-pounds
7/8 - 14	40 inch-pounds
1 - 14	55 inch-pounds
1-1/8 - 12	73 inch-pounds
1-1/4 - 12	94 inch-pounds
COARSE THREAD SERIES	
THREAD SIZE	MINIMUM PREVAILING TORQUE
7/16 - 14	8 inch-pounds
1/2 - 13	10 inch-pounds
9/16 - 12	14 inch-pounds
5/8 - 11	20 inch-pounds
3/4 - 10	27 inch-pounds
7/8 - 9	40 inch-pounds
1 - 8	51 inch-pounds
1-1/8 - 8	68 inch-pounds
1-1/4 - 8	88 inch-pounds

Cadmium-Plating. This is an electrolytically deposited silver-gray plating which provides exceptionally good protection against corrosion, particularly in salty atmosphere, but is not recommended in applications where the temperature exceeds 450 °F. The following additional finishes or refinements to the basic cadmium can be applied.

Chromic Clear Dip. Cadmium surfaces are passivated, and cyanide from the plating solution is neutralized. The protective film formed gives a bright, shiny appearance, and resists staining and finger marks.

Olive Drab Dichromate. Cadmium-plated work is dipped in a solution of chromic acid, nitric acid, acetic acid, and a dye which produces corrosion resistance.

Iridescent Dichromate. Cadmium-plated work is dipped in a solution of sodium dichromate and takes on a surface film of basic chromium chromate which resists corrosion. Finish is yellow to brown in color.

NOTE: Cadmium-plated nuts are restricted for use in temperatures not to exceed 450 °F. When used in temperatures in excess of 450 °F, the cadmium will diffuse into the base material causing it to become very brittle and subject to early failure.

Silver plating. Silver plating is applied to locknuts for use at higher temperatures. Important advantages are its resistance to extreme heat (1,400 °F) and its excellent lubricating characteristics. Silver resists galling and seizing of mating parts when subjected to heat or heavy pressure.

Anodizing for Aluminum. An inorganic oxide coating is formed on the metal by connecting the metals and anodes in a suitable electrolyte. The coating offers excellent corrosion resistance and can be dyed in a number of colors.

Solid Lubricant Coating. Locknuts are also furnished with molybdenum disulfide for lubrication purposes. It provides a clean, dry, permanently-bonded coating to prevent seizing and galling of threads. Molybdenum disulfide is applied to both cadmium and silver-plated parts. Other types of finishes are available, but the finishes described in this chapter are the most widely used.

CASTLE NUT (AN310). **The castle nut is used with drilled shank hex head bolts, clevis bolts, drilled head bolts, or studs that are subjected to tension loads. The nut has slots or castellations cut to accommodate a cotter pin or safety wire as a means of safetying.**

CASTELLATED SHEAR NUT (AN320). **The castellated shear nut is designed for use with hardware subjected to shear stress only.**

PLAIN NUT (AN315 AND AN335). **The plain nut is capable of withstanding large tension loads; however, it requires an auxiliary locking device, such as a checknut or safety wire. Use of this type on aircraft structures is limited.**

LIGHT HEX NUTS (AN340 AND AN345). **These nuts are used in nonstructural applications requiring light tension. Like the AN315 and AN335, they require a locking device to secure them.**

CHECKNUT (AN316). **The checknut is used as a locking device for plain nuts, screws, threaded rod ends, and other devices.**

WINGNUTS (AN350). **The wingnut is used where the desired torque is obtained by use of the fingers or handtools. Wingnuts are normally drilled to allow safetying with safety wire.**

SHEET SPRING NUTS (AN365). **Sheet spring nuts are commonly called speed nuts. They are used with standard and sheet metal self-tapping screws in nonstructural applications. They are used to support line and conduit clamps, access doors, etc. Their use should be limited to applications where they were originally used in assembly of the aircraft.**

7-73.—7-84. RESERVED.

SECTION 5. WASHERS

GENERAL. **The type of washers used in aircraft structure are plain washers, , and special washers. Typical washer types are shown in table 7-14.**

PLAIN WASHERS (AN960 AND AN970). **Plain washers are widely used with hex nuts to provide a smooth bearing surface, act as a shim to obtain the proper grip length, and to position castellated nuts in relation to drilled cotter pin holes in bolts. Use plain washers under lock washers to prevent damage to bearing surfaces. Cadmium-plated steel washers are recommended for use under boltheads and nuts used on aluminum alloy or magnesium structures to prevent corrosion. The AN970 steel washer provides a larger bearing surface than the plain type, and is often used in wooden structures under boltheads and nuts to prevent local crushing of the surface.**

LOCKWASHERS (AN935 AND AN936). **Lock washers may be used with machine screws or bolts whenever the self-locking or castellated type nut is not applicable. Do not use lock washers where frequent removal is required, in areas subject to corrosion, or in areas exposed to airflow. Use a plain washer between the lock washer and material to prevent gouging the surface of the metal.**

CAUTION: Lock washers are not to be used on primary structures, secondary structures, or accessories where failure might result in damage or danger to aircraft or personnel.

BALL SOCKET AND SEAT WASHERS (AN950 AND AN955). **Ball socket and seat washers are used in special applications where the bolt is installed at an angle to the surface or when perfect alignment with the surface is required. These washers are used together as a pair.**

TAPER PIN WASHERS (AN975). **Taper pin washers are used with the threaded taper pin. NAS143 and MS20002 washers are used with NAS internal wrenching bolts and internal wrenching nuts. They may be plain or countersunk. The countersunk washer (designated as NAS143C and MS20002C) is used to seat the bolthead shank radius, and the plain washer is used under the nut.**

7-90.—7-100. [RESERVED.]

SECTION 6. PINS

TAPER PINS. **Plain (AN385) and threaded (AN386) taper pins are used in joints which carry shear loads and where the absence of play is essential. The plain taper pin is usually drilled and secured with wire. The threaded taper pin is used with a taper-pin washer (AN975) and shear nut (safetied with a cotter pin) or self-locking nut (if undrilled). Typical pin types are shown in table 7-15.**

FLATHEAD PINS (AN392 THROUGH AN406). **Commonly called a clevis pin, this pin is used in conjunction with tie-rod terminals and in secondary controls which are not subject to continuous operation. The pin is normally installed with the head up, or forward, to prevent loss should the cotter pin fail or work out.**

COTTER PINS (AN380). **Cotter pins are used for securing bolts, screws, nuts, and pins. Use AN381 or MS24665 cotter pins in locations where nonmagnetic material or resistance to corrosion is desired. Cotter pins should not be reused.**

SPRING PINS. **The spring pin is designed for use in double-shear applications. The pins are manufactured with the diameter greater than the holes in which they are to be used. Spring pins are stronger than mild carbon steel straight pins, taper pins, or grooved pins of the equivalent size. The spring pin is compressed as it is driven into the hole, and exerts continuous spring pressure against the sides of the hole to prevent loosening by vibration. Spring pins require no other means of securing, and can be used inside one another to increase shear strength.**

Be careful when using these pins, since spring-pin performance depends entirely on the fit and the durability of the fit under vibration or repeated load conditions (especially in soft materials, such as aluminum alloys and magnesium). They should not be used in an aircraft component or system where the loss or failure of the pin might endanger safe flight.

The joints where spring pins are used for fastening shall be designed like riveted and bolted joints. Spring pins should not be mixed with other structural fasteners in the same joint. These pins, for primary structural applications, should be used only where there will be no rotation or relative movement of the joint. Spring pins may be reused if a careful inspection reveals no deformation of the pin or hole.

Be careful to observe that the hole has not enlarged or deformed preventing proper functioning of the spring pin. Where hole misalignment results in the pin gap closing or necessitates excess inserting force, the spring pin will not be used. The spring pin should not be used as a substitute for a cotter pin. When a spring pin is used in a clevis joint, it is recommended that the pin be held by the outer members of the unit for maximum efficiency and reduced maintenance.

QUICK-RELEASE PINS. **These pins are used in some applications where rapid removal and replacement of equipment is necessary. When equipment is secured with these pins, no binding of the spindle should be present. Spindle binding could cause the locking balls to remain in the open position which could result in the pin falling out under vibration.**

7-106—7-121. [RESERVED.]

SECTION 7. SAFETYING

GENERAL. The word *safetying* is a term universally used in the aircraft industry. Briefly, safetying is defined as: "Securing by various means any nut, bolt, turnbuckle etc., on the aircraft so that vibration will not cause it to loosen during operation." These practices are not a means of obtaining or maintaining torque, rather a safety device to prevent the disengagement of screws, nuts, bolts, snap rings, oil caps, drain cocks, valves, and parts. Three basic methods are used in safetying; safety-wire, cotter pins, and self-locking nuts. Retainer washers and pal nuts are also sometimes used.

Wire, either soft brass or steel is used on cylinder studs, control cable turnbuckles, and engine accessory attaching bolts.

Cotter pins are used on aircraft and engine controls, landing gear, and tailwheel assemblies, or any other point where a turning or actuating movement takes place.

Self-locking nuts are used in applications where they will not be removed often. Repeated removal and installation will cause the self-locking nut to lose its locking feature. They should be replaced when they are no longer capable of maintaining the minimum prevailing torque. (See table 7-2.)

Pal or speed nuts include designs which force the nut thread against the bolt or screw thread when tightened. These nuts should never be reused and should be replaced with new ones when removed.

SAFETY WIRE. Do not use stainless steel, monel, carbon steel, or aluminum alloy safety wire to secure emergency mechanisms such as switch handles, guards covering handles used on exits, fire extinguishers, emergency gear releases, or other emergency equipment. Some existing structural equipment or safety-of-flight emergency devices require copper or brass safety wire (.020 inch diameter only). Where successful emergency operation of this equipment is dependent on shearing or breaking of the safety wire, particular care should be used to ensure that safetying does not prevent emergency operation.

There are two methods of safety wiring; the double-twist method that is most commonly used, and the single-wire method used on screws, bolts, and/or nuts in a closely-spaced or closed-geometrical pattern such as a triangle, square, rectangle, or circle. The single-wire method may also be used on parts in electrical systems and in places that are difficult to reach. (See figures 7-3 and 7-3a.)

When using double-twist method of safety wiring, .032 inch minimum diameter wire should be used on parts that have a hole diameter larger than .045 inch. Safety wire of .020 inch diameter (double strand) may be used on parts having a nominal hole diameter between .045 and .062 inch with a spacing between parts of less than 2 inches. When using the single-wire method, the largest size wire that the hole will accommodate should be used. Copper wire (.020 inch diameter), aluminum wire (.031 inch diameter), or other similar wire called for in specific technical orders, should be used as seals on equipment such as first-aid kits, portable fire extinguishers, emergency valves, or oxygen regulators.

CAUTION: Care should be taken not to confuse steel with aluminum wire.

A secure seal indicates that the component has not been opened. Some emergency devices require installation of brass or soft

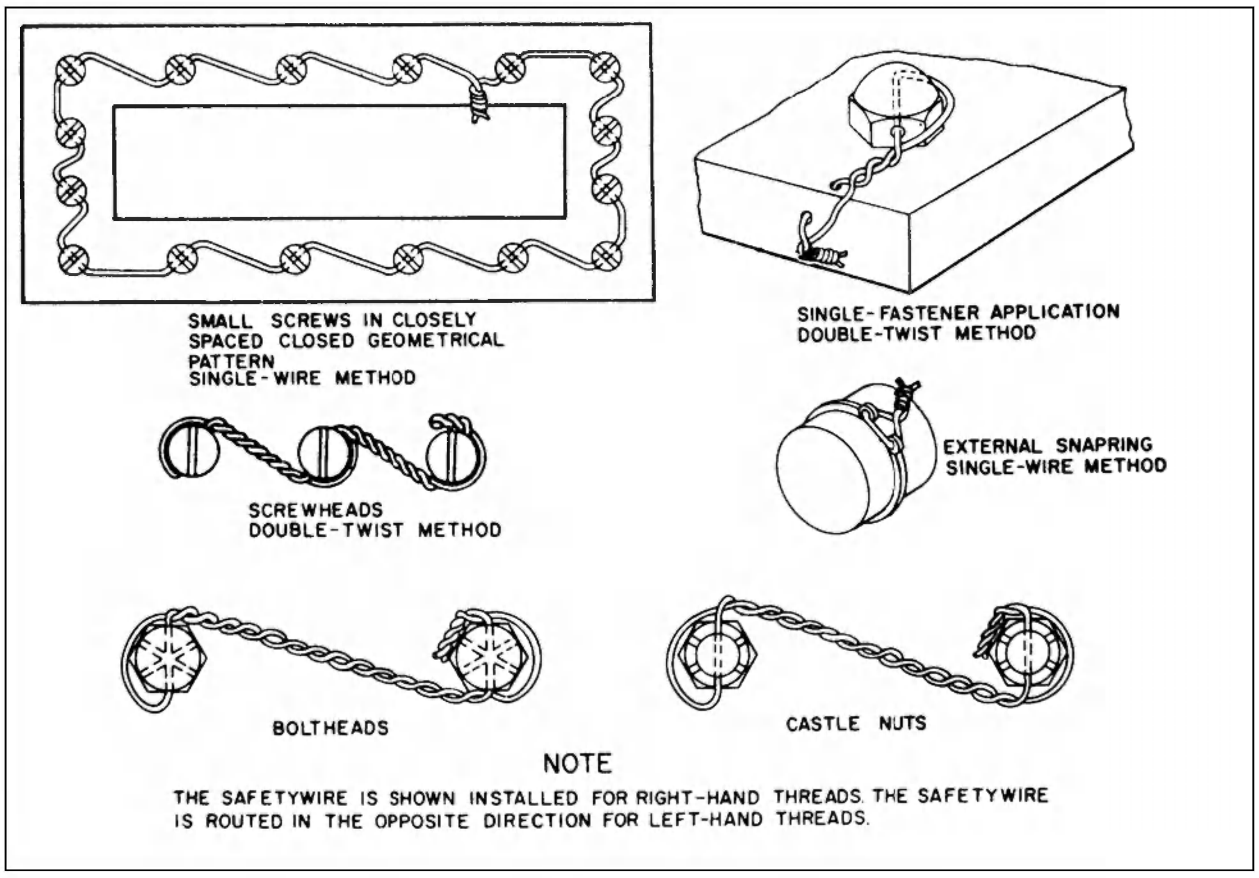


FIGURE 7-3. Securing screws, nuts, bolts, and snaprings.

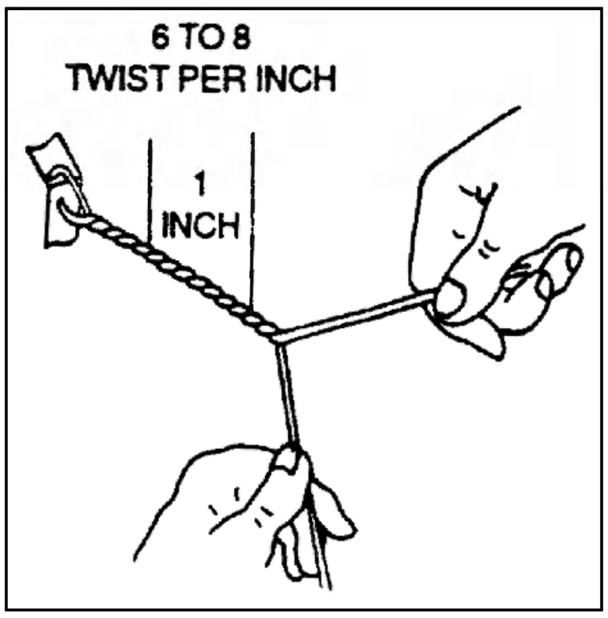


FIGURE 7-3a. Wire twisting by hand.

To prevent failure due to rubbing or vibration, safety wire must be tight after installation.

Safety wire must be installed in a manner that will prevent the tendency of the part to loosen.

copper shear safety wire. Particular care should be exercised to ensure that the use of safety wire will not prevent emergency operation of the devices.

SAFETY-WIRING PROCEDURES. **There are many combinations of safety wiring with certain basic rules common to all applications. These rules are as follows.**

When bolts, screws, or other parts are closely grouped, it is more convenient to safety wire them in series. The number of bolts, nuts, screws, etc., that may be wired together depends on the application.

Drilled boltheads and screws need not be safety wired if installed with self-locking nuts.

Safety wire must never be over-stressed. Safety wire will break under vibrations if twisted too tightly. Safety wire must be pulled taut when being twisted, and maintain a light tension when secured. (See figure 7-3a.)

Safety-wire ends must be bent under and inward toward the part to avoid sharp or projecting ends, which might present a safety hazard.

Safety wire inside a duct or tube must not cross over or obstruct a flow passage when an alternate routing can be used.

Check the units to be safety wired to make sure that they have been correctly torqued, and that the wiring holes are properly aligned to each other. When there are two or more units, it is desirable that the holes in the units be aligned to each other. Never overtorque or loosen to obtain proper alignment of the holes. It should be possible to align the wiring holes when the bolts are torqued within the specified limits. Washers may be used (see paragraph 7-37) to establish proper alignment. However, if it is impossible to obtain a proper alignment of the holes without undertorquing or overtorquing, try another bolt which will permit proper alignment within the specified torque limits.

To prevent mutilation of the twisted section of wire, when using pliers, grasp the wires at the ends. Safety wire must not be nicked, kinked, or mutilated. Never twist the wire ends off with pliers; and, when cutting off ends, leave at least four to six complete turns (1/2 to 5/8 inch long) after the loop. When removing safety wire, never twist the wire off with pliers. Cut the safety wire close to the hole, exercising caution.

Install safety wire where practicable with the wire positioned around the head of the bolt, screw, or nut, and twisted in such a manner that the loop of the wire fits closely to the contour of the unit being safety wired.

TWISTING WITH SPECIAL TOOLS. **Twist the wire with a wire twister as follows. (See figure 7-4.)**

CAUTION: When using wire twisters, and the wire extends 3 inches beyond the jaws of the twisters, loosely wrap the wire around the pliers to prevent whipping and possible personal injury. Excessive twisting of the wire will weaken the wire.

Grip the wire in the jaws of the wire twister and slide the outer sleeve down with your thumb to lock the handles or lock the spring-loaded pin.

Pull the knob, and the spiral rod spins and twists the wire.

Squeeze handles together to release wire.

SECURING OIL CAPS, DRAIN COCKS, AND VALVES. **(See figure 7-4a.) When securing oil caps and drain cocks, the safety wire should be anchored to an adjacent fillister-head screw. This method of safety wiring is applied to wingnuts, filler plugs, single-drilled head bolts, fillister-head screws, etc.; which are safety wired individually. When securing valve handles in the vertical position, the wire is looped around the threads of the pipe leading into one side of the valve,**

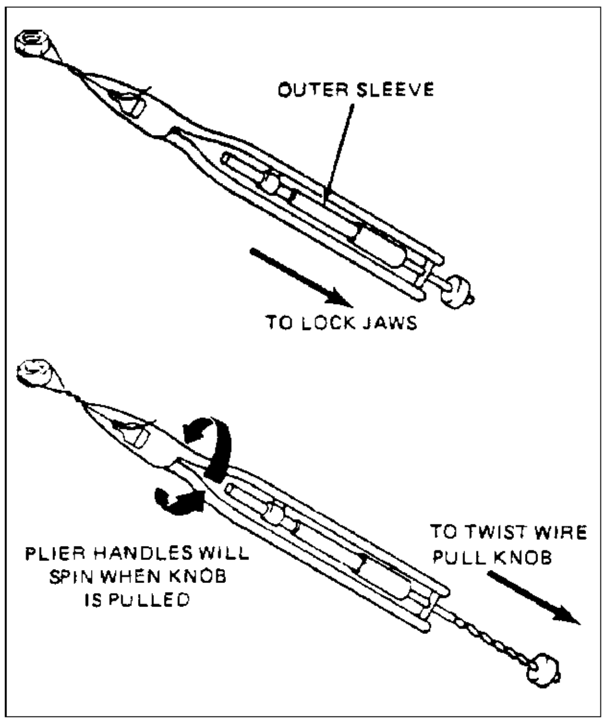


FIGURE 7-4. Use of a typical wire twister.

double-twisted around the valve handle, and anchored around the threads of the pipe leading into the opposite side of the valve. When castellated nuts are to be secured with safety wire, tighten the nut to the low side of the selected torque range, unless otherwise specified; and, if necessary, continue tightening until a slot lines with the hole. In blind tapped hole applications of bolts or castellated nuts on studs, the safety wiring should be in accordance with the general instructions of this chapter. Hollow-head bolts are safetied in the manner prescribed for regular bolts.

NOTE: Do not loosen or tighten properly tightened nuts to align safety-wire holes.

NOTE: Although there are numerous safety wiring techniques used to secure aircraft hardware, practically all are derived from the basic examples shown in figures 7-5 through 7-5b.

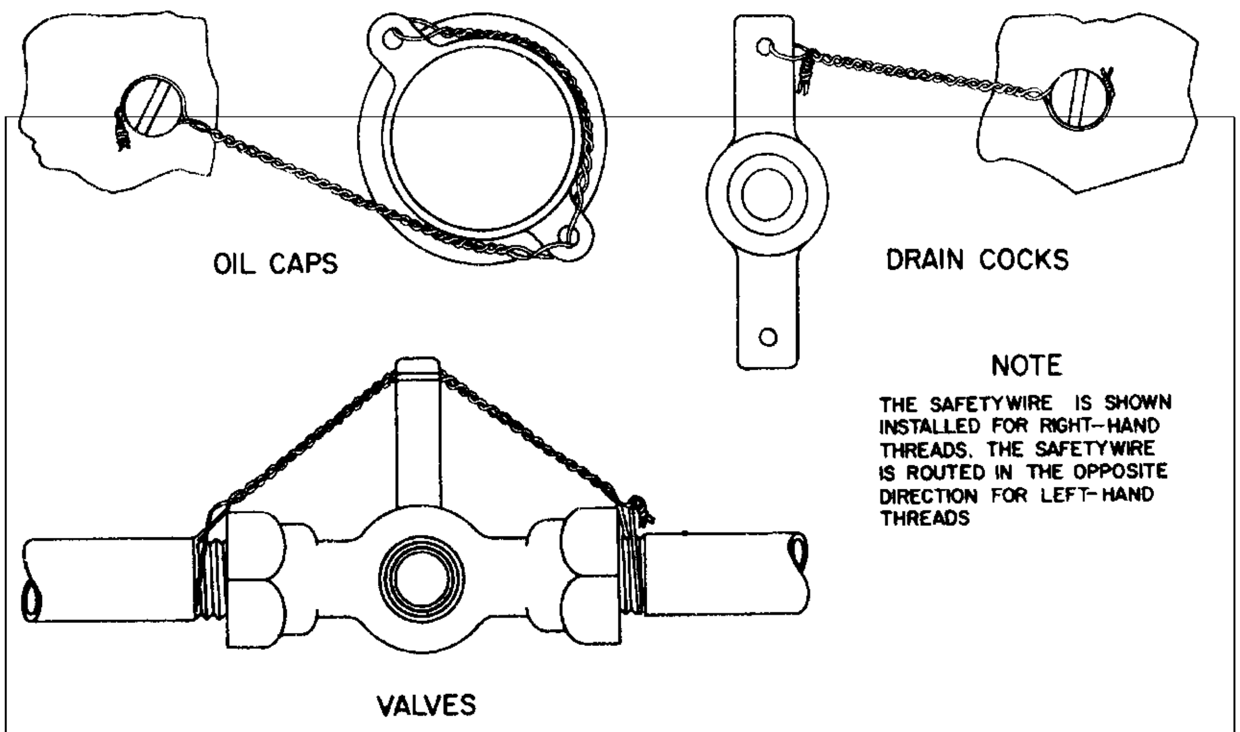
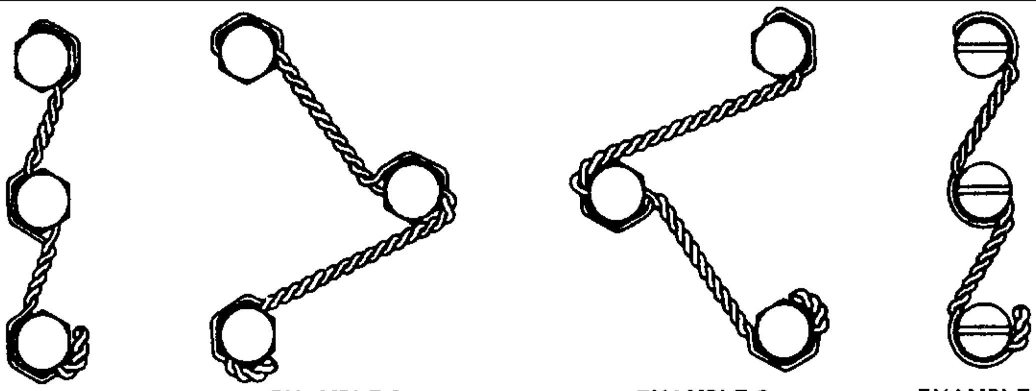


FIGURE 7-4a. Securing oil caps, drain cocks, and valves.

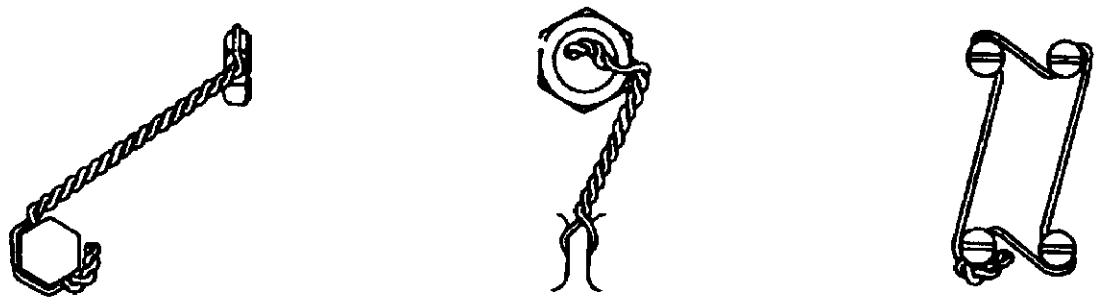


EXAMPLE 1 EXAMPLE 2 EXAMPLE 3 EXAMPLE 4

Examples 1, 2, 3, and 4 apply to all types of bolts, fillister-head screws, square-head plugs, and other similar parts which are wired so that the loosening tendency of either part is counteracted by tightening of the other part. The direction of twist from the second to the third unit is counterclockwise in examples 1, 3, and 4 to keep the loop in position against the head of the bolt. The direction of twist from the second to the third unit in example 2 is clockwise to keep the wire in position around the second unit. The wire entering the hole in the third unit will be the lower wire, except example 2, and by making a counterclockwise twist after it leaves the hole, the loop will be secured in place around the head of that bolt.

EXAMPLE 5 EXAMPLE 6 EXAMPLE 7 EXAMPLE 8

Examples 5, 6, 7, & 8 show methods for wiring various standard items, NOTE: Wire may be wrapped over the unit rather than around it when wiring castellated nuts or on other items when there is a clearance problem.



EXAMPLE 9

Example 9 shows the method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.

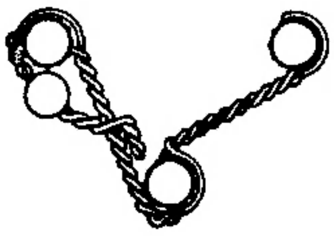
EXAMPLE 10

Hollow-head plugs shall be wired as shown with the tab bent inside the hole to avoid snags and possible injury to personnel working on the engine.

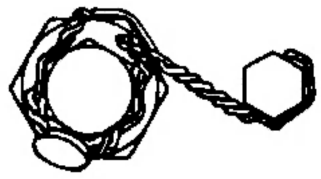
EXAMPLE 11

Correct application of single wire to closely spaced multiple group.

FIGURE 7-5. Safety-wiring procedures.



EXAMPLE 12



EXAMPLE 13

Examples 12 and 13 show methods for attaching lead seal to protect critical adjustments.

EXAMPLE 14

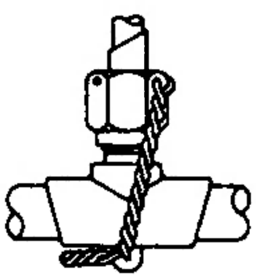
Example 14 shows bolt wired to a right-angle bracket with the wire wrapped around the bracket.

EXAMPLE 15

Example 15 shows correct method for wiring adjustable connecting rod.

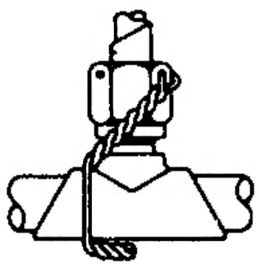
EXAMPLE 16

Example 16 shows correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.



EXAMPLE 17

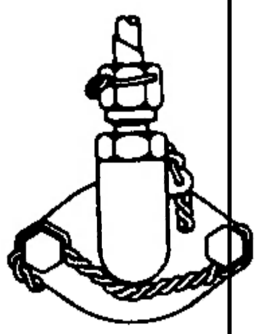
EXAMPLE 18



EXAMPLE 19

EXAMPLE 20

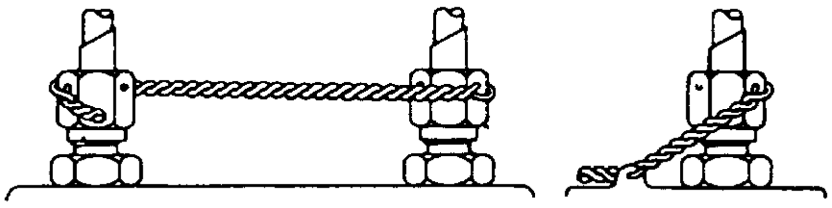
Fittings incorporating wire lugs shall be wired as shown in Examples 17 and 18. Where no lock-wire lug is provided, wire should be applied as shown in examples 19 and 20 with caution being exerted to ensure that wire is wrapped tightly around the fitting.



EXAMPLE 21

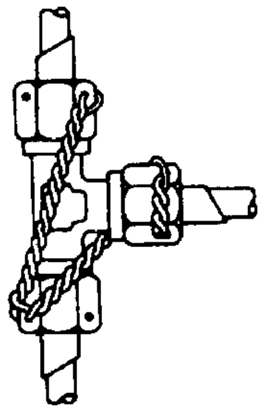
Small size coupling nuts shall be wired by wrapping the wire around the nut and inserting it through the holes as shown.

FIGURE 7-5a. Safety-wiring procedures.



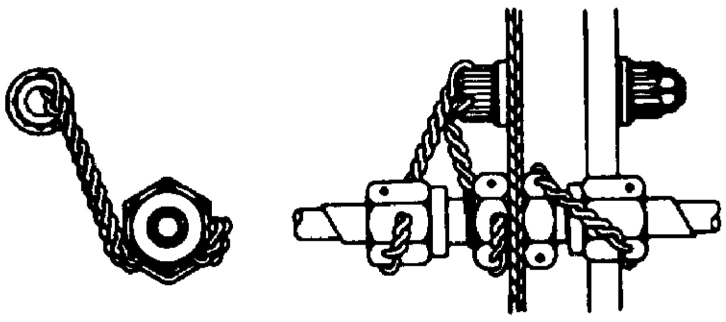
EXAMPLE 22 **EXAMPLE 23**

Coupling nuts attached to straight connectors shall be wired as, shown, when hex is an integral part of the connector.



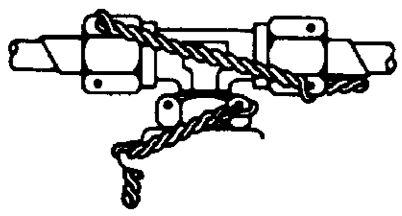
EXAMPLE 24

Coupling nuts on a tee shall be wired, as shown above, so that tension is always in the tightening direction.

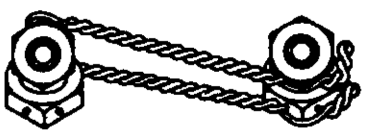


EXAMPLE 25

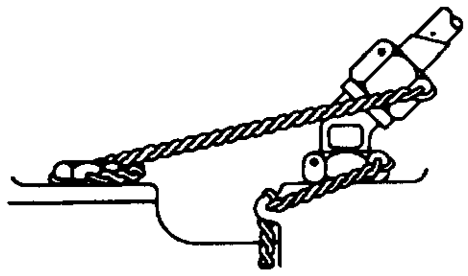
Straight Connector (Bulkhead Type)



EXAMPLE 26



EXAMPLE 27



EXAMPLE 28

Examples 26, 27, and 28 show the proper method for wiring various standard fittings with checknut wired independently so that it need not be disturbed when removing the coupling nut.

FIGURE 7-5b. Safety-wiring procedures.

SECURING WITH COTTER PINS.

Cotter pins are used to secure such items as bolts, screws, pins, and shafts. Their use is favored because they can be removed and installed quickly. The diameter of the cotter pins selected for any application should be the largest size that will fit consistent with the diameter of the cotter pin hole and/or the slots in the nut. Cotter pins should not be re-used on aircraft.

To prevent injury during and after pin installation, the end of the cotter pin can be rolled and tucked.

NOTE: In using the method of cotter pin safetying, as shown in figures 7-6 and 7-7, ensure the prong, bent over the bolt, is seated firmly against the bolt shank, and does not exceed bolt diameter. Also, when the prong is bent over the nut, ensure the bent prong is down and firmly flat against the nut and does not contact the surface of the washer.