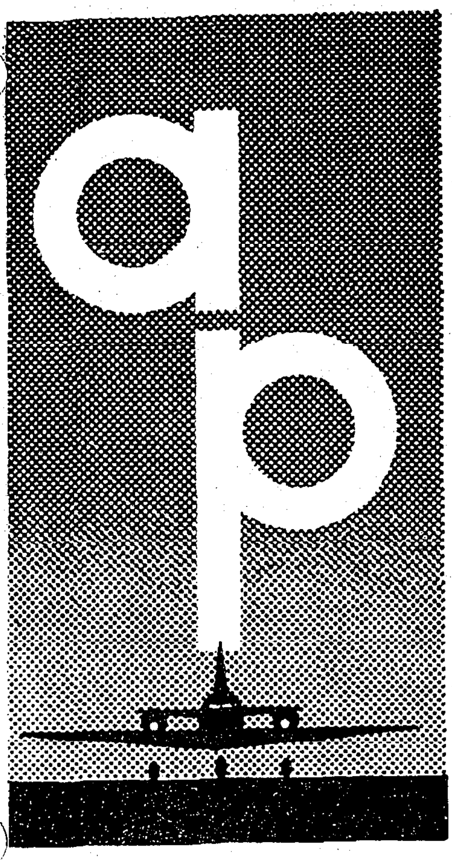
Attachment F:

Excerpts from FAA Advisory Circular 65-9A, Airframe & Powerplant Mechanics: General Handbook



AC65-9A

Airframe & Powerplant MECHANICS GENERAL HANDBOOK

CONSOLIDATED REPRINT
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRFRAME AND POWERPLANT

MECHANICS

GENERAL HANDBOOK

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

Flight Standards Service

First Edition 1970

First Revision 1976

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PREFACE

This handbook was developed and first printed in 1970 as one of a series of three handbooks for persons preparing for mechanic certification with airframe or powerplant ratings, or both. It is intended that this handbook will provide basic information on principles, fundamentals, and technical procedures in the subject matter areas common to both the airframe and powerplant ratings. Emphasis in this volume is on theory and methods of application.

The handbook is designed to aid students enrolled in a formal course of instruction as well as the individual who is studying on his own. Since the knowledge requirements for the airframe and powerplant ratings closely parallel each other in some subject areas, the chapters which discuss fire protection systems and electrical systems contain some material which is also duplicated in the Airframe and Powerplant Mechanics Powerplant Handbook, AC 65-12A, and the Airframe and Powerplant Mechanics Airframe Handbook, AC 65-15A.

This volume contains information on aircraft drawings, weight and balance, aircraft materials and processes, physics, electricity, inspection, ground support, and tools. Knowledge gained from the study of this handbook is essential before proceeding in a course of study in either the airframe or powerplant handbooks.

Because there are so many different types of airframes and powerplants in use today, it is reasonable to expect that differences exist in the components and systems of each. To avoid undue repetition, the practice of using representative systems and units is carried out throughout the handbook. Subject matter treatment is from a generalized point of view, and should be supplemented by reference to manufacturers' manuals or other textbooks if more detail is desired. This handbook is not intended to replace, substitute for, or supersede official regulations or the manufacturers' instructions.

Grateful acknowledgement is extended to the manufacturers of airframe and airframe components for their cooperation in making material available for inclusion.

Monsanto Chemical	Skydrol ® Fluids
Townsend Corporation	Cherry Rivets Acres Sleeves
J. O. King, Inc.	Acres Sleeves
Gravines, Inc.	Fire Extinguishers
Walter Kidde	Fire Extinguishers
DuPont DeNemours	Fire Extinguishants
National Fire Protection Association	Fire Extinguisher and Extinguishant Specifications
National Association of Fire Extinguisher Distributors	Fire Extinguishers
Flight Safety Foundation	Refueling Data
American Petroleum Institute	Aviation Fuels
Exxon	Aviation Fuels
Parker Hannifin	Aircraft Fittings

The advancements in aeronautical technology dictate that an instructional handbook must be under continuous review and brought up to date periodically to be valid. Flight Standards requested comments, from the certificated aviation maintenance technician schools, on the three handbooks. As a result of this survey, the handbooks have been updated to this extent: new material has been added in the areas which were indicated as being deficient, and some material has been rearranged to improve the teachability of the handbooks.

We would appreciate having errors brought to our attention, as well as receiving suggestions for improving the usefulness of the handbooks. Comments and suggestions will be retained in our files until such time as the next revision will be accomplished.

Address all correspondence relating to these handbooks to:

U.S. Department of Transportation
Federal Aviation Administration
Flight Standards National Field Office
P.O. Box 25082
Oklahoma City, Oklahoma 73125

The companion handbooks to AC 65-9A are the Airframe and Powerplant Mechanics Powerplant Handbook, AC 65-12A, and the Airframe and Powerplant Mechanics Airframe Handbook, AC 65-15A.

CHAPTER 6

AIRCRAFT HARDWARE, MATERIALS, AND PROCESSES

AIRCRAFT HARDWARE

Aircraft hardware is the term used to describe the various types of fasteners and miscellaneous small items used in the manufacture and repair of aircraft.

The importance of aircraft hardware is often overlooked because of its small size; however, the safe and efficient operation of any aircraft is greatly dependent upon the correct selection and use of aircraft hardware.

Identification

Most items of aircraft hardware are identified by their specification number or trade name. Threaded fasteners and rivets are usually identified by AN (Air Force–Navy), NAS (National Aircraft Standard), or MS (Military Standard) numbers. Quick-release fasteners are usually identified by factory trade names and size designations.

THREADED FASTENERS

Various types of fastening devices allow quick dismantling or replacement of aircraft parts that must be taken apart and put back together at frequent intervals. Riveting or welding these parts each time they are serviced would soon weaken or ruin the joint. Furthermore, some joints require greater tensile strength and stiffness than rivets can provide. Bolts and screws are two types of fastening devices which give the required security of attachment and rigidity. Generally, bolts are used where great strength is required, and screws are used where strength is not the deciding factor.

Bolts and screws are similar in many ways. They are both used for fastening or holding, and each has a head on one end and screw threads on the other. Regardless of these similarities, there are several distinct differences between the two types of fasteners. The threaded end of a bolt is always blunt while that of a screw may be either blunt or pointed.

The threaded end of a bolt usually has a nut screwed onto it to complete the assembly. The threaded end of a screw may fit into a female receptacle, or it may fit directly into the material being secured. A bolt has a fairly short threaded section and a comparatively long grip length or unthreaded portion, whereas a screw has a longer threaded section and may have no clearly defined grip length. A bolt assembly is generally tightened by turning the nut on the bolt; the head of the bolt may or may not be designed for turning. A screw is always tightened by turning its head.

When it becomes necessary to replace aircraft fasteners, a duplicate of the original fastener should be used if at all possible. If duplicate fasteners are not available, extreme care and caution must be used in selecting substitutes.

Classification of Threads

Aircraft bolts, screws, and nuts are threaded in either the NC (American National Coarse) thread series, the NF (American National Fine) thread series, the UNC (American Standard Unified Coarse) thread series, or the UNF (American Standard Unified Fine) thread series. There is one difference between the American National series and the American Standard Unified series that should be pointed out. In the 1-inch-diameter size, the NF thread specified 14 threads per inch (1–14NF), while the UNF thread specifies 12 threads per inch (1–12UNF). Both type threads are designated by the number of times the incline (threads) rotates around a 1-inch length of a given diameter bolt or screw. For example, a 4–28 thread indicates that a ¼-inch-diameter bolt has 28 threads in 1 inch of its threaded length.

Threads are also designated by Class of fit. The Class of a thread indicates the tolerance allowed in manufacturing. Class 1 is a loose fit, Class 2 is a free fit, Class 3 is a medium fit, and Class 4 is a close fit. Aircraft bolts are almost always manufactured in the Class 3, medium fit.

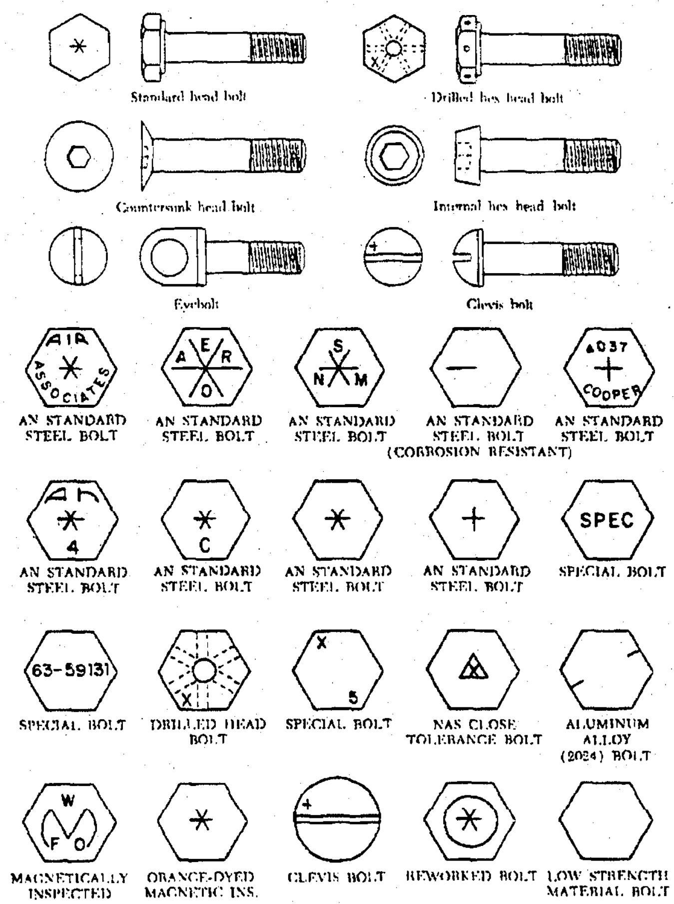


FIGURE 6–1. Aircraft bolt identification.

A Class 4 fit requires a wrench to turn the nut onto a bolt, whereas a Class 1 fit can easily be turned with the fingers. Generally, aircraft screws are manufactured with a Class 2 thread fit for ease of assembly.

Bolts and nuts are also produced with right-hand and left-hand threads. A right-hand thread tightens when turned clockwise; a left-hand thread tightens when turned counterclockwise.

AIRCRAFT BOLTS

Aircraft bolts are fabricated from cadmium- or zinc-plated corrosion-resistant steel, unplated corrosion-resistant steel, and anodized aluminum alloys. Most bolts used in aircraft structures are either general-purpose, AN bolts, or NAS internal-wrenching or close-tolerance bolts, or MS bolts. In certain cases, aircraft manufacturers make 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. Special bolts are usually identified by the letter "S" stamped on the head.

AN bolts come in three head styles—hex-head, clevis, and eyebolt (*see* figure 6–1). NAS bolts are available in hex-head, internal-wrenching, and countersunk head styles. MS bolts come in hex-head and internal-wrenching styles.

General-Purpose Bolts

The hex-head aircraft bolt (AN–3 through AN–20) is an all-purpose structural bolt used for general applications involving tension or shear loads where a light-drive fit is permissible (.006-inch clearance for a ⅝-inch hole, and other sizes in proportion).

Alloy steel bolts smaller than No. 10–32 and aluminum alloy bolts smaller than ¼-inch diameter are not used in primary structures. Aluminum alloy bolts and nuts are not used where they will be repeatedly removed for purposes of maintenance and inspection. Aluminum alloy nuts may be used with cadmium-plated steel bolts loaded in shear on land airplanes, but are not used on seaplanes due to the increased possibility of dissimilar-metal corrosion.

The AN-73 drilled-head bolt is similar to the standard hex-bolt, but has a deeper head which is drilled to receive wire for safetying. The AN-3 and the AN-73 series bolts are interchangeable, for all practical purposes, from the standpoint of tension and shear strengths.

Close-Tolerance Bolts

This type of bolt is machined more accurately than the general-purpose bolt. Close-tolerance bolts may be hex-headed (AN-173 through AN-186) or have a 100° countersunk head (NAS-80 through NAS-86). They are used in applications where a tight-drive fit is required (the bolt will move into position only when struck with a 12- to 14-ounce hammer).

Internal-Wrenching Bolts

These bolts, (MS-20004 through MS-20024 or NAS-495) are fabricated from high-strength steel and are suitable for use in both tension and shear applications. When they are used in steel parts, the bolthole must be slightly countersunk to seat the large corner radius of the shank at the head. In Dural material, a special heat-treated washer must be used to provide an adequate bearing surface for the head. The head of the internal-wrenching bolt is recessed to allow the insertion of an internal wrench when installing or removing the bolt. Special high-strength nuts are used on these bolts. Replace an internal-wrenching bolt with another internal-wrenching bolt. Standard AN hex-head bolts and washers cannot be substituted for them as they do not have the required strength.

Identification and Coding

Bolts are manufactured in many shapes and varieties. A clear-cut method of classification is difficult. Bolts can be identified by the shape of the head, method of securing, material used in fabrication, or the expected usage.

AN-type aircraft bolts can be identified by the code markings on the boltheads. The markings generally denote the bolt manufacturer, the material of which the bolt is made, and whether the bolt is a standard AN-type or a special-purpose bolt. AN standard steel bolts are marked with either a raised dash or asterisk; corrosion-resistant steel is indicated by a single raised dash; and AN aluminum alloy bolts are marked with two raised dashes. Additional information, such as bolt diameter, bolt length, and grip length may be obtained from the bolt part number.

For example, in the bolt part number AN3DD5A, the "AN" designates that it is an Air Force–Navy Standard bolt, the "3" indicates the diameter in sixteenths of an inch (3/16), the "DD" indicates the material is 2024 aluminum alloy. The letter "C" in place of the "DD" would indicate corrosion-resistant steel, and the absence of the letters would indicate cadmium-plated steel. The "5" indicates the length in eighths of an inch (5/8), and the "A" indicates that the shank is undrilled. If the letter "H" preceded the "5" in addition to the "A" following it, the head would be drilled for safetying.

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 that they may be either raised or recessed. Bolts inspected magnetically (Magnaflux) or by fluorescent means (Zyglo) are identified by means of colored lacquer, or a head marking of a distinctive type.

SPECIAL-PURPOSE BOLTS

Bolts designed for a particular application or use are classified as special-purpose bolts. Clevis bolts, eyebolts, Jo-bolts, and lock bolts are special-purpose bolts.

Clevis Bolts

The head of a clevis bolt is round and is either slotted to receive a common screwdriver or recessed to receive a crosspoint screwdriver. This type of bolt is used only where shear loads occur and never in tension. It is often inserted as a mechanical pin in a control system.

Eyebolt

This type of special-purpose bolt is used where external tension loads are to be applied. The eye is designed for the attachment of such devices as the fork of a turnbuckle, a clevis, or a cable shackle. The threaded end may or may not be drilled for safetying.

Jo-Bolt

Jo-bolt is a trade name for an internally threaded three-piece rivet. The Jo-bolt consists of three parts—a threaded steel alloy bolt, a threaded steel nut, and an expandable stainless steel sleeve. The parts are factory preassembled. As the Jo-bolt is installed, the bolt is turned while the nut is held. This causes the sleeve to expand over the end of the nut, forming the blind head and clamping against the work. When driving is complete, a portion of the bolt breaks off. The high-shear and tensile strength of the Jo-bolt makes it suitable for use in cases of high stresses where some of the other blind fasteners would not be practical. Jo-bolts are often a part of the permanent structure of late-model aircraft. They are used in areas which are not often subjected to replacement or servicing. (Because it is a three-part fastener, it should not be used where any part, in becoming loose, could be drawn into the engine air intake.) Other advantages of using Jo-bolts are their excellent resistance to vibration, weight saving, and fast installation by one person.

Presently, Jo-bolts are available in four diameters: The 200 series, approximately 3/16-inch in diameter; the 260 series, approximately 1/4-inch in diameter; the 312 series, approximately 5/16-inch in diameter; and the 375 series, approximately 3/8-inch in diameter. Jo-bolts are available in three head styles which are: F(flush), P(hex-head), and FA(flush millable).

Lockbolts

The lockbolt combines the features of a high-strength bolt and rivet, but it has advantages over both. The lockbolt is generally used in wing-splice fittings, landing-gear fittings, fuel-cell fittings, longerons, beams, skin-splice plates, and other major structural attachments. It is more easily and quickly installed than the conventional rivet or bolt and eliminates the use of lockwashers, cotter pins, and special nuts. Like the rivet, the lockbolt requires a pneumatic hammer or "pull gun" for installation; when installed, it is rigidly and permanently locked in place. Three types of lockbolts are commonly used, the pull type, the stump type, and the blind type. (See figure 6–2.)

Pull type. Pull-type lockbolts are used mainly in aircraft primary and secondary structures. They are installed very rapidly and have approximately one-half the weight of equivalent AN steel bolts and nuts. A special pneumatic "pull gun" is required to install this type of lockbolt. Installation can be accomplished by one person since bucking is not required.

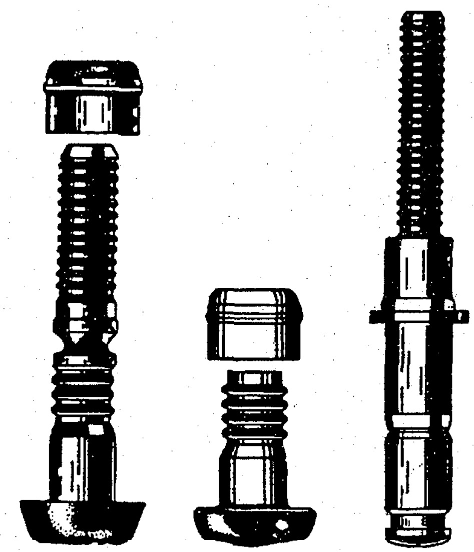


FIGURE 6–2. Lockbolt types.

Stump type. Stump-type lockbolts, although they do not have the extended stem with pull grooves, are companion fasteners to pull-type lockbolts. They are used primarily where clearance will not permit installation of the pull-type lockbolt. A standard pneumatic riveting hammer (with a hammer set attached for swaging the collar into the pin-locking grooves) and a bucking bar are tools necessary for the installation of stump-type lockbolts.

Blind type. Blind-type lockbolts come as complete units or assemblies. They have exceptional strength and sheet pull-together characteristics. Blind lockbolts are used where only one side of the work is accessible and, generally, where it is difficult to drive a conventional rivet. This type of lockbolt is installed in the same manner as the pull-type lockbolt.

Common features. Common features of the three types of lockbolts are the annular locking grooves on the pin and the locking collar which is swaged into the pin's lock grooves to lock the pin in tension. The pins of the pull- and blind-type lockbolts are extended for pull installation. The extension is provided with pulling grooves and a tension breakoff groove.

Composition. The pins of pull- and stump-type lockbolts are made of heat-treated alloy steel or high-strength aluminum alloy. Companion collars are made of aluminum alloy or mild steel. The blind lockbolt consists of a heat-treated alloy steel pin, blind sleeve and filler sleeve, mild steel collar, and carbon steel washer.

Substitution. Alloy steel lockbolts may be used to replace steel hi-shear rivets, solid steel rivets, or AN bolts of the same diameter and head type. Aluminum alloy lockbolts may be used to replace solid aluminum alloy rivets of the same diameter and head type. Steel and aluminum alloy lockbolts may also be used to replace steel and 2024T aluminum alloy bolts, respectively, of the same diameter. Blind lockbolts may be used to replace solid aluminum alloy rivets, stainless steel rivets, or all blind rivets of the same diameter.

Numbering system. The numbering systems for the various types of lockbolts are explained by the following breakouts (see figure 6-4).

GRIP NO.	GRIP RANGE Min.	GRIP RANGE Max.	GRIP NO.	GRIP RANGE Min.	GRIP RANGE Max.
1	.031	.094	17	1.031	1.094
2	.094	.156	18	1.094	1.156
3	.156	.219	19	1.156	1.219
4	.219	.281	20	1.219	1.281
5	.281	.344	21	1.281	1.344
6	.344	.406	22	1.344	1.406
7	.406	.469	23	1.406	1.469
8	.469	.531	24	1.469	1.531
9	.531	.594	25	1.531	1.594
10	.594	.656	26	1.594	1.656
11	.656	.718	27	1.656	1.718
12	.718	.781	28	1.718	1.781
13	.781	.843	29	1.781	1.843
14	.843	.906	30	1.843	1.906
15	.906	.968	31	1.906	1.968
16	.968	1.031	32	1.968	2.031
			33	2.031	2.094

FIGURE 6-3. Pull- and stump-type lockbolt grip ranges.

Pull-type lockbolt—

ALPP H T 8 8

- 8 — Grip length in 16ths of an inch.
- 8 — Body diameter in 32nds of an inch.
- T — Pin materials—
  - E = 75S-T6 aluminum alloy.
  - T = heat-treated alloy steel.
- H — Class fit—
  - H = hole filling (interference fit).
  - N = non-hole filling (clearance fit).
- ALPP — Head type—
  - ACT 509 = close tolerance AN-509 C-sink head.
  - ALPP = pan head.
  - ALPB = brazier head.
  - ALP509 = standard AN-509 C-sink head.
  - ALP426 = standard AN-426 C-sink head.

Blind-type lockbolt—

BL 8 4

- 4 — Grip length in 16ths of an inch, ±1/32 inch.
- 8 — Diameter in 32nds of an inch.
- BL — Blind lockbolt.

Lockbolt collar—

LC C 8

- 8 — Diameter of pin in 32nds of an inch.
- C — *Material—
  - C = 24ST aluminum alloy (green color).
  - F = 61ST aluminum alloy (plain color).
  - R = mild steel (cadmium plated).
- LC — Lockbolt collar.

* Use 25ST aluminum alloy with heat-treated alloy lockbolts only.
Use 61ST aluminum alloy with 75ST aluminum alloy lockbolts only.
Use mild steel with heat-treated alloy steel lockbolts for high temperature applications only.

Stump-type lockbolt—

ALSF E 8 8

- 8 — Grip length in 16ths of an inch.
- 8 — Body diameter in 32nds of an inch.
- E — Pin material—
  - E = 75S-T6 aluminum alloy.
  - T = heat-treated alloy steel.
- ALSF — Head type—
  - ASCT509 = close tolerance AN-509 C-sink head.
  - ALSF = flat head type.
  - ALS509 = standard AN-509 C-sink head.
  - ALS426 = standard AN-426 C-sink head.

FIGURE 6-4. Lockbolt numbering system.

¼-inch Diameter			5/16-inch Diameter		
GRIP NO.	GRIP RANGE Min.	Max.	GRIP NO.	GRIP RANGE Min.	Max.
1	.031	.094	2	.094	.156
2	.094	.156	3	.156	.219
3	.156	.219	4	.219	.281
4	.219	.281	5	.281	.344
5	.281	.344	6	.344	.406
6	.344	.406	7	.406	.469
7	.406	.469	8	.469	.531
8	.469	.531	9	.531	.594
9	.531	.594	10	.594	.656
10	.594	.656	11	.656	.718
11	.656	.718	12	.718	.781
12	.718	.781	13	.781	.843
13	.781	.843	14	.843	.906
14	.843	.906	15	.906	.968
15	.906	.968	16	.968	1.031
16	.968	1.031	17	1.031	1.094
17	1.031	1.094	18	1.094	1.156
18	1.094	1.156	19	1.156	1.219
19	1.156	1.219	20	1.219	1.281
20	1.219	1.281	21	1.281	1.343
21	1.281	1.343	22	1.343	1.406
22	1.343	1.406	23	1.406	1.469
23	1.406	1.469	24	1.460	1.531
24	1.469	1.531			
25	1.531	1.594			

FIGURE 6–5. Blind-type lockbolt grip ranges.

Grip Range. The bolt grip range required for any application should be determined by measuring the thickness of the material with a hook scale inserted through the hole. Once this measurement is determined the correct grip range can be selected by referring to the charts provided by the rivet manufacturer. Examples of grip-range charts are shown in figures 6–3 and 6–5.

When installed, the lockbolt collar should be swaged substantially throughout the complete length of the collar. The tolerance of the broken end of the pin relative to the top of the collar must be within the following dimensions:

Pin diameter	Tolerance Below		Above
3/16	.079	to	.032
¼	.079	to	.050
5/16	.079	to	.050
3/8	.079	to	.060

When removal of a lockbolt becomes necessary, remove the collar by splitting it axially with a sharp, cold chisel. Be careful not to break out or deform the hole. The use of a backup bar on the opposite side of the collar being split is recommended. The pin may then be driven out with a drift punch.

AIRCRAFT NUTS

Aircraft nuts are made in a variety of shapes and sizes. They are made of cadmium-plated carbon steel, stainless steel, or anodized 2024T aluminum alloy, and may be obtained with either right- or left-hand threads. No identifying marking or lettering appears on nuts. They can be identified only by the characteristic metallic luster or color of the aluminum, brass, or the insert when the nut is of the self-locking type. They can be further identified by their construction.

Aircraft nuts can be divided into two general groups: Non-self-locking and self-locking nuts. Non-self-locking nuts are those that must be safetied by external locking devices, such as cotter pins, safety wire, or locknuts. Self-locking nuts contain the locking feature as an integral part.

Non-self-locking Nuts

Most of the familiar types of nuts, including the plain nut, the castle nut, the castellated shear nut, the plain hex nut, the light hex nut, and the plain check nut are the non-self-locking type. (See figure 6–6.)

The castle nut, AN310, is used with drilled-shank AN hex head bolts, clevis bolts, eyebolts, drilled head bolts, or studs. It is fairly rugged and can withstand large tensional loads. Slots (called castellations) in the nut are designed to accommodate a cotter pin or lock wire for safety.

The castellated shear nut, AN320, is designed for use with devices (such as drilled clevis bolts and threaded taper pins) which are normally subjected to shearing stress only. Like the castle nut, it is castellated for safetying. Note, however, that the nut is not as deep or as strong as the castle nut; also that the castellations are not as deep as those in the castle nut.

The plain hex nut, AN315 and AN335 (fine and coarse thread), is of rugged construction. This makes it suitable for carrying large tensional loads. However, since it requires an auxiliary locking device such as a check nut or lockwasher, its use on aircraft structures is somewhat limited.

The light hex nut, AN340 and AN345 (fine and coarse thread), is a much lighter nut than the plain hex nut and must be locked by an auxiliary

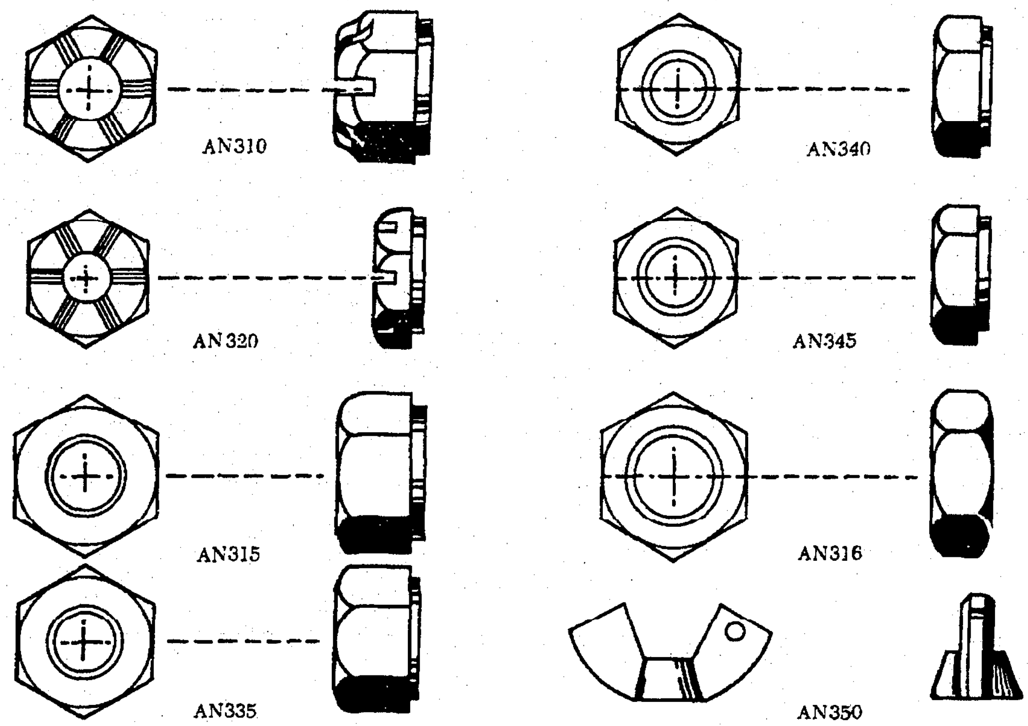


FIGURE 6–6. Non-self-locking nuts.

device. It is used for miscellaneous light-tension requirements.

The plain check nut, AN316, is employed as a locking device for plain nuts, set screws, threaded rod ends, and other devices.

The wing nut, AN350, is intended for use where the desired tightness can be obtained with the fingers and where the assembly is frequently removed.

Self-Locking Nuts

As their name implies, self-locking nuts need no auxiliary means of safetying but have a safetying feature included as an integral part of their construction. Many types of self-locking nuts have been designed and their use has become quite widespread. Common applications are: (1) Attachment of antifriction bearings and control pulleys; (2) Attachment of accessories, anchor nuts around inspection holes and small tank installation openings; and (3) Attachment of rocker box covers and exhaust stacks. Self-locking nuts are acceptable for use on certificated aircraft subject to the restrictions of the manufacturer.

Self-locking nuts are used on aircraft to provide tight connections which will not shake loose under severe vibration. Do not use self-locking nuts at joints which subject either the nut or bolt to rotation. They may be used with antifriction bearings and control pulleys, provided the inner race of the bearing is clamped to the supporting structure by the nut and bolt. Plates must be attached to the structure in a positive manner to eliminate rotation or misalignment when tightening the bolts or screws.

The two general types of self-locking nuts currently in use are the all-metal type and the fiber-lock type. For the sake of simplicity, only three typical kinds of self-locking nuts are considered in this handbook: The Boots self-locking and the stainless steel self-locking nuts, representing the all-metal types; and the elastic stop nut, representing the fiber-insert type.

Boots Self-Locking Nut

The Boots self-locking nut is of one-piece, all-metal construction, designed to hold tight in spite of severe vibration. Note in figure 6–7 that it has two sections and is essentially two nuts in one, a locking nut and a load-carrying nut. The two sections are connected with a spring which is an integral part of the nut. The spring keeps the locking and load-carrying sections such a distance

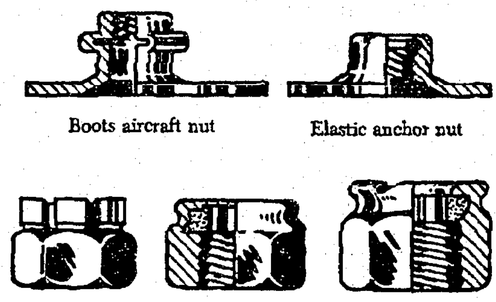


FIGURE 6–7. Self-locking nuts.

apart that the two sets of threads are out-of-phase; that is, so spaced that a bolt which has been screwed through the load-carrying section must push the locking section outward against the force of the spring to engage the threads of the locking section properly.

Thus, the spring, through the medium of the locking section, exerts a constant locking force on the bolt in the same direction as a force that would tighten the nut. In this nut, the load-carrying section has the thread strength of a standard nut of comparable size, while the locking section presses against the threads of the bolt and locks the nut firmly in position. Only a wrench applied to the nut will loosen it. The nut can be removed and reused without impairing its efficiency.

Boots self-locking nuts are made with three different spring styles and in various shapes and sizes. The wing type, which is the most common, ranges in size for No. 6 up to 1/4 inch, the Rol-top ranges from 1/4 inch to 9/16 inch, and the bellows type ranges in size from No. 8 up to 3/8 inch. Wing-type nuts are made of anodized aluminum alloy, cadmium plated carbon steel, or stainless steel. The Rol-top nut is cadmium-plated steel, and the bellows type is made of aluminum alloy only.

Stainless Steel Self-Locking Nut

The stainless steel self-locking nut may be spun on and off with the fingers, as its locking action takes place only when the nut is seated against a solid surface and tightened. The nut consists of two parts: a case with a beveled locking shoulder and key, and a threaded insert with a locking shoulder and slotted keyway. Until the nut is tightened it spins on the bolt easily, because the threaded insert is the proper size for the bolt. However, when the nut is seated against a solid surface and tightened, the locking shoulder of the insert is pulled downward and wedged against the locking shoulder of the case. This action compresses the threaded insert and causes it to clench the bolt tightly. The cross-sectional view in figure 6–8 shows how the key of the case fits into the slotted keyway of the insert so that when the case is turned the threaded insert is turned with it. Note that the slot is wider than the key. This permits the slot to be narrowed and the insert to be compressed when the nut is tightened.

Elastic Stop Nut

The elastic stop nut is a standard nut with the height increased to accommodate a fiber-locking collar. This fiber collar is very tough and durable and is unaffected by immersion in hot or cold water or ordinary solvents such as ether, carbon tetrachloride, oils, and gasoline. It will not damage bolt threads or plating.

As shown in figure 6–9, the fiber-locking collar is not threaded and its inside diameter is smaller than the largest diameter of the threaded portion or the outside diameter of a corresponding bolt. When the nut is screwed onto a bolt, it acts as an ordinary nut until the bolt reaches the fiber collar. When the bolt is screwed into the fiber collar, however, friction (or drag) causes the fiber to be pushed upward. This creates a heavy downward pressure on the load-carrying part and automatically throws the load-carrying sides of the nut and bolt threads into positive contact. After the bolt has been forced all the way through the fiber collar, the downward pressure remains constant. This pressure locks and holds the nut securely in place even under severe vibration.

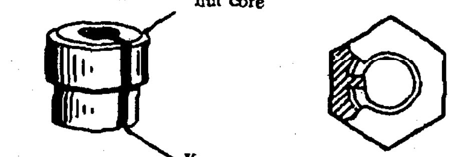


FIGURE 6–8. Stainless steel self-locking nut.

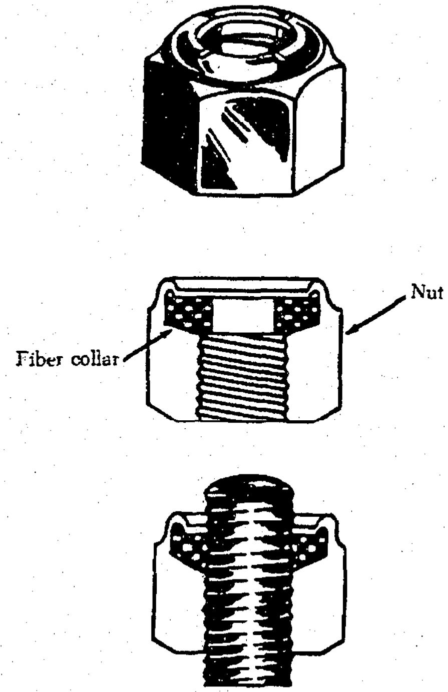


FIGURE 6–9. Elastic stop nut.

Nearly all elastic stop nuts are steel or aluminum alloy. However, such nuts are available in practically any kind of metal. Aluminum alloy elastic stop nuts are supplied with an anodized finish. Steel nuts are cadmium plated.

Normally, elastic stop nuts can be used many times with complete safety and without detriment to their locking efficiency. When reusing elastic stop nuts, be sure the fiber has not lost its locking friction or become brittle. If a nut can be turned with the fingers, replace it.

After the nut has been tightened, make sure the rounded or chamfered end of the bolts, studs, or screws extends at least the full round or chamfer through the nut. Flat end bolts, studs, or screws should extend at least $\frac{1}{32}$ inch through the nut. Bolts of $\frac{5}{16}$-inch diameter and over with cotter pin holes may be used with self-locking nuts, but only if free from burrs around the holes. Bolts with damaged threads and rough ends are not acceptable. Do not tap the fiber-locking insert. The self-locking action of the elastic stop nut is the result of having the bolt threads impress themselves into the untapped fiber.

Do not install elastic stop nuts in places where the temperature is higher than 250° F., because the effectiveness of the self-locking action is reduced beyond this point. Self-locking nuts may be used on aircraft engines and accessories when their use is specified by the engine manufacturer.

Self-locking nut bases are made in a number of forms and materials for riveting and welding to aircraft structure or parts. (See figure 6–10.) Certain applications require the installation of self-locking nuts in channels, an arrangement which permits the attachment of many nuts with only a few rivets. These channels are track-like bases with regularly spaced nuts which are either removable or nonremovable. The removable type carries a floating nut, which can be snapped in or out of the channel, thus making possible the easy removal of damaged nuts. Nuts such as the clinch-type and spline-type which depend on friction for their anchorage are not acceptable for use in aircraft structures.

Sheet Spring Nuts

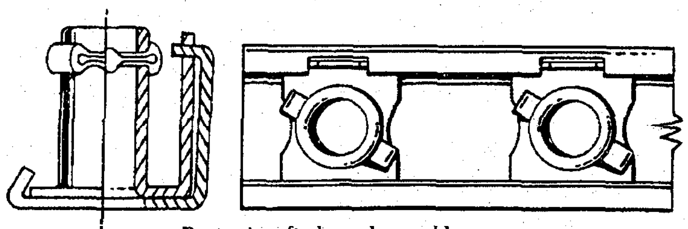
Sheet spring nuts, such as speed nuts, are used with standard and sheet-metal self-tapping screws in nonstructural locations. They find various uses in supporting line clamps, conduit clamps, electrical equipment, access doors, and the like, and are available in several types. Speed nuts are made from spring steel and are arched prior to tightening. This arched spring lock prevents the screw from working loose. These nuts should be used only where originally used in the fabrication of the aircraft.

Internal and External Wrenching Nuts

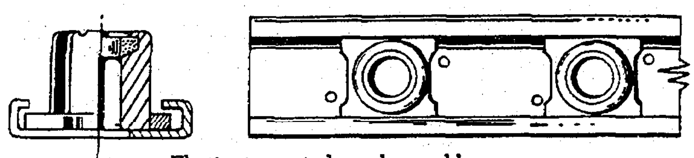
Two commercial types of high-strength internal or external wrenching nuts are available; they are the internal and external wrenching elastic-stop nut and the Unbrako internal and external wrenching nut. Both are of the self-locking type, are heat-treated, and are capable of carrying high-strength bolt-tension loads.

Identification and Coding

Part numbers designate the type of nut. The common types and their respective part numbers are: Plain, AN315 and AN335; castle AN310;



Boots aircraft channel assembly



Elastic stop nut channel assembly

FIGURE 6-10. Self-locking nut bases.

plain check, AN316; light hex, AN340 and AN345; and castellated shear, AN320. The patented self-locking types are assigned part numbers ranging from MS20363 through MS20367. The Boots, the Flexloc, the fiber locknut, the elastic stop nut, and the self-locking nut belong to this group. Part number AN350 is assigned to the wing nut.

Letters and digits following the part number indicate such items as material, size, threads per inch, and whether the thread is right or left hand. The letter "B" following the part number indicates the nut material to be brass; a "D" indicates 2017-T aluminum alloy; a "DD" indicates 2024-T aluminum alloy; a "C" indicates stainless steel; and a dash in place of a letter indicates cadmium-plated carbon steel.

The digit (or two digits) following the dash or the material code letter is the dash number of the nut, and it indicates the size of the shank and threads per inch of the bolt on which the nut will fit. The dash number corresponds to the first figure appearing in the part number coding of general-purpose bolts. A dash and the number 3, for example, indicates that the nut will fit an AN3 bolt (10–32); a dash and the number 4 means it will fit an AN4 bolt (¼–28); a dash and the number 5, an AN5 bolt (5/16–24); and so on.

The code numbers for self-locking nuts end in three- or four-digit numbers. The last two digits refer to threads per inch, and the one or two preceding digits stand for the nut size in 16ths of an inch.

Some other common nuts and their code numbers are:

Code Number AN310D5R:

AN310 = aircraft castle nut.
D = 2024-T aluminum alloy.
5 = 5/16-inch diameter.
R = right-hand thread (usually 24 threads per inch).

Code Number AN320-10:

AN320 = aircraft castellated shear nut, cadmium-plated carbon steel.
10 = ⅝-inch diameter, 18 threads per inch (this nut is usually right-hand thread).

Code Number AN350B1032:

AN350 = aircraft wingnut.
B = brass.
10 = number 10 bolt.
32 = threads per inch.

AIRCRAFT WASHERS

Aircraft washers used in airframe repair are either plain, lock, or special type washers.

Plain Washers

Plain washers (figure 6-11), both the AN960 and AN970, are used under hex nuts. They provide a smooth bearing surface and act as a shim

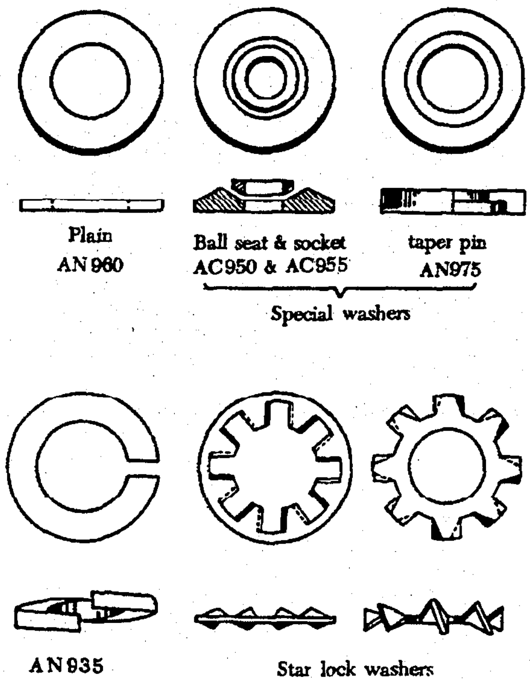


FIGURE 6–11. Various types of washers.

in obtaining correct grip length for a bolt and nut assembly. They are used to adjust the position of castellated nuts in respect to drilled cotterr pin holes in bolts. Plain washers should be used under lockwashers to prevent damage to the surface material.

Aluminum and aluminum alloy washers may be used under boltheads or nuts on aluminum alloy or magnesium structures where corrosion caused by dissimilar metals is a factor. When used in this manner, any electric current flow will be between the washer and the steel bolt. However, it is common practice to use a cadmium-plated steel washer under a nut bearing directly against a structure as this washer will resist the cutting action of a nut better than an aluminum alloy washer.

The AN970 steel washer provides a greater bearing area than the AN960 washer and is used on wooden structures under both the head and the nut of a bolt to prevent crushing the surface.

Lockwashers

Lockwashers, both the AN935 and AN936, are used with machine screws or bolts where the self-locking or castellated type nut is not appropriate. The spring action of the washer (AN935) provides enough friction to prevent loosening of the nut from vibration. (These washers are shown in figure 6–11.)

Lockwashers should never be used under the following conditions:

1. With fasteners to primary or secondary structures.
2. With fasteners on any part of the aircraft where failure might result in damage or danger to the aircraft or personnel.
3. Where failure would permit the opening of a joint to the airflow.
4. Where the screw is subject to frequent removal.
5. Where the washers are exposed to the airflow.
6. Where the washers are subject to corrosive conditions.
7. Where the washer is against soft material without a plain washer underneath to prevent gouging the surface.

Shakeproof Lockwashers

Shakeproof lockwashers are round washers designed with tabs or lips that are bent upward across the sides of a hex nut or bolt to lock the nut in place. There are various methods of securing the lockwasher to prevent it from turning, such as an external tab bent downward 90° into a small hole in the face of the unit, or an internal tab which fits a keyed bolt.

Shakeproof lockwashers can withstand higher heat than other methods of safetying and can be used under high-vibration conditions safely. They should be used only once because the tabs tend to break when bent a second time.

Special Washers

The ball-socket and seat washers, AC950 and AC955, are special washers used where a bolt is installed at an angle to a surface, or where perfect alignment with a surface is required. These washers are used together. They are shown in figure 6–11.

The NAS143 and MS20002 washers are used for internal wrenching bolts of the NAS144 through NAS158 series. This washer is either plain or countersunk. The countersunk washer (designated as NAS143C and MS20002C) is used to seat the bolt head shank radius, and the plain washer is used under the nut.

INSTALLATION OF NUTS AND BOLTS

Bolt and Hole Sizes

Slight clearances in boltholes are permissible wherever bolts are used in tension and are not subject to reversal of load. A few of the applications in which clearance of holes may be permitted are in pulley brackets, conduit boxes, lining trim, and miscellaneous supports and brackets.

Boltholes are to be normal to the surface involved to provide full bearing surface for the bolthead and nut and must not be oversized or elongated. A bolt in such a hole will carry none of its shear load until parts have yielded or deformed enough to allow the bearing surface of the oversized hole to contact the bolt. In this respect, remember that bolts do not become swaged to fill up the holes as do rivets.

In cases of oversized or elongated holes in critical members, obtain advice from the aircraft or engine manufacturer before drilling or reaming the hole to take the next larger bolt. Usually, such factors as edge distance, clearance, or load factor must be considered. Oversized or elongated holes in noncritical members can usually be drilled or reamed to the next larger size.

Many boltholes, particularly those in primary connecting elements, have close tolerances. Generally, it is permissible to use the first lettered drill size larger than the normal bolt diameter, except where the AN hexagon bolts are used in light-drive fit (reamed) applications and where NAS close-tolerance bolts or AN clevis bolts are used.

Light-drive fits for bolts (specified on the repair drawings as .0015-inch maximum clearance between bolt and hole) are required in places where bolts are used in repair, or where they are placed in the original structure.

The fit of holes and bolts cannot be defined in terms of shaft and hole diameters; it is defined in terms of the friction between bolt and hole when sliding the bolt into place. A tight-drive fit, for example, is one in which a sharp blow of a 12- or 14-ounce hammer is required to move the bolt. A bolt that requires a hard blow and sounds tight is considered to fit too tightly. A light-drive fit is one in which a bolt will move when a hammer handle is held against its head and pressed by the weight of the body.

Installation Practices

Examine the markings on the bolthead to determine that each bolt is of the correct material. It is of extreme importance to use like bolts in replacement. In every case, refer to the applicable Maintenance Instructions Manual and Illustrated Parts Breakdown.

Be sure that washers are used under both the heads of bolts and nuts unless their omission is specified. A washer guards against mechanical damage to the material being bolted and prevents corrosion of the structural members. An aluminum alloy washer should be used under the head and nut of a steel bolt securing aluminum alloy or magnesium alloy members. Any corrosion that occurs then attacks the washer rather than the members. Steel washers should be used when joining steel members with steel bolts.

Whenever possible, the bolt should be placed with the head on top or in the forward position. This positioning tends to prevent the bolt from slipping out if the nut is accidently lost.

Be certain that the bolt grip length is correct. Grip length is the length of the unthreaded portion of the bolt shank. Generally speaking, the grip length should equal the thickness of the material being bolted together. However, bolts of slightly greater grip length may be used if washers are placed under the nut or the bolthead. In the case of plate nuts, add shims under the plate.

Safetying of Bolts and Nuts

It is very important that all bolts or nuts, except the self-locking type, be safetied after installation. This prevents them from loosening in flight due to vibration. Methods of safetying are discussed later in this chapter.

TORQUE AND TORQUE WRENCHES

As the speed of an aircraft increases, each structural member becomes more highly stressed. It is therefore extremely important that each member carry no more and no less than the load for which it was designed. In order to distribute the loads safely throughout a structure, it is necessary that proper torque be applied to all nuts, bolts, studs and screws. Using the proper torque allows the structure to develop its designed strength and greatly reduces the possibility of failure due to fatigue.

Torque Wrenches

The three most commonly used torque wrenches are the flexible beam, rigid frame, and the ratchet types (figure 6–12). When using the flexible beam and the rigid frame torque wrenches, the torque value is read visually on a dial or scale mounted on the handle of the wrench.

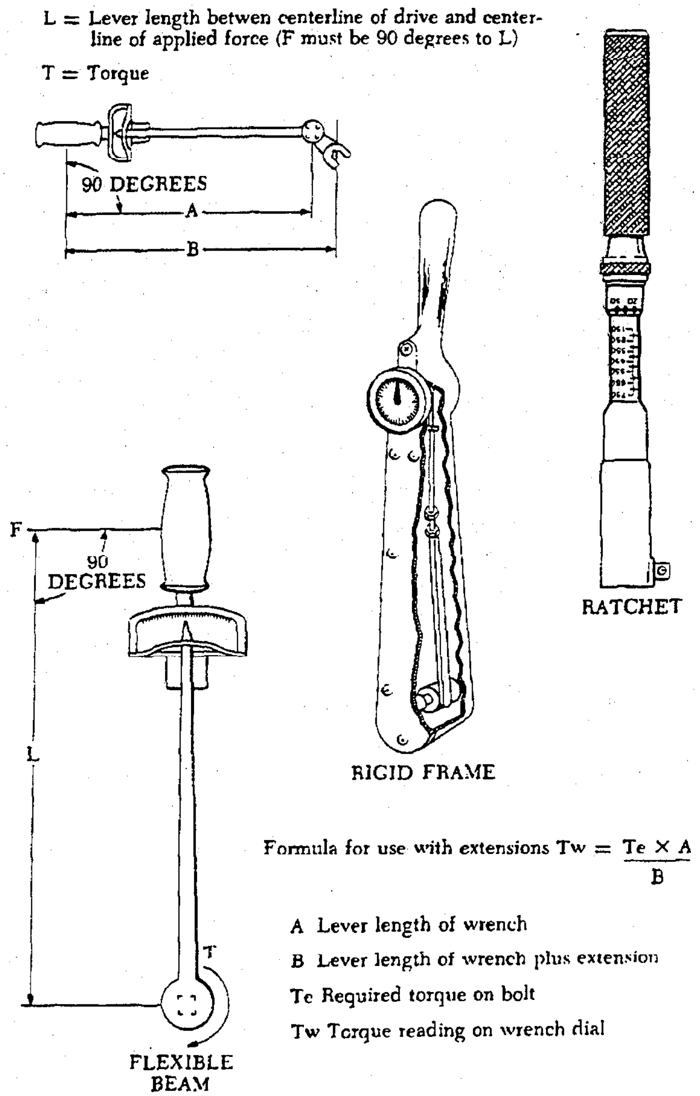
To use the ratchet type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion. (A fast or jerky motion will result in an improperly torqued unit.) When the applied torque reaches the torque value which indicated on the handle setting, the handle will automatically release or "break" and move

Basic formula $F \times L = T$

F = Applied force

L = Lever length betwen centerline of drive and centerline of applied force (F must be 90 degrees to L)

T = Torque



Formula for use with extensions $Tw = \frac{Te \times A}{B}$

A Lever length of wrench

B Lever length of wrench plus extension

Te Required torque on bolt

Tw Torque reading on wrench dial

FIGURE 6–12. Common torque wrenches.

Bolt, Stud or Screw Size		Torque Values in Inch-Pounds for Tightening Nuts			
		On standard bolts, studs, and screws having a tensile strength of 125,000 to 140,000 p.s.i.		On bolts, studs, and screws having a tensile strength of 140,000 to 160,000 p.s.i.	On high-strength bolts, studs, and screws having a tensile strength 160,000 p.s.i. and over
		Shear type nuts (AN320, AN364 or equivalent)	Tension type nuts and threaded machine parts (AN-310, AN365 or equivalent)	Any nut, except, shear type	Any nut, except shear type
8-32	8-36	7-9	12-15	14-17	15-18
10-24	10-32	12-15	20-25	23-30	25-35
1/4-20		25-30	40-50	45-49	50-68
	1/4-28	30-40	50-70	60-80	70-90
5/16-18		48-55	80-90	85-117	90-144
	5/16-24	60-85	100-140	120-172	140-203
3/8-16		95-110	160-185	173-217	185-248
	3/8-24	95-110	160-190	175-271	190-351
7/16-14		140-155	235-255	245-342	255-428
	7/16-20	270-300	450-500	475-628	500-756
1/2-13		240-290	400-480	440-636	480-792
	1/2-20	290-410	480-690	585-840	690-990
9/16-12		300-420	500-700	600-845	700-990
	9/16-18	480-600	800-1,000	900-1,220	1,000-1,440
5/8-11		420-540	700-900	800-1,125	900-1,350
	5/8-18	660-780	1,100-1,300	1,200-1,730	1,300-2,160
3/4-10		700-950	1,150-1,600	1,380-1,925	1,600-2,250
	3/4-16	1,300-1,500	2,300-2,500	2,400-3,500	2,500-4,500
7/8-9		1,300-1,800	2,200-3,000	2,600-3,570	3,000-4,140
	7/8-14	1,500-1,800	2,500-3,000	2,750-4,650	3,000-6,300
1"-8		2,200-3,000	3,700-5,000	4,350-5,920	5,000-6,840
	1"-14	2,200-3,300	3,700-5,500	4,600-7,250	5,500-9,000
1 1/8-8		3,300-4,000	5,500-6,500	6,000-8,650	6,500-10,800
	1 1/8-12	3,000-4,200	5,000-7,000	6,000-10,250	7,000-13,500
1 1/4-8		4,000-5,000	6,500-8,000	7,250-11,000	8,000-14,000
	1 1/4-12	5,400-6,600	9,000-11,000	10,000-16,750	11,000-22,500

FIGURE 6-13. Standard torque table (inch-pounds).

freely for a short distance. The release and free travel is easily felt, so there is no doubt about when the torquing process is completed.

To assure getting the correct amount of torque on the fasteners, all torque wrenches must be tested at least once a month or more often if necessary.

NOTE: It is not advisable to use a handle extension on a flexible beam type torque wrench at any time. A handle extension alone has no effect on the reading of the other types. The use of a drive-end extension on any type of torque wrench makes the use of the formula mandatory. When applying the formula, force must be applied to the handle of the torque wrench at the point from which the measurements were taken. If this is not done, the torque obtained will be in error.

Torque Tables

The standard torque table should be used as a guide in tightening nuts, studs, bolts, and screws whenever specific torque values are not called out in maintenance procedures. The following rules apply for correct use of the torque table (figure 6–13):

1. To obtain values in foot-pounds, divide inch-pounds by 12.
2. Do not lubricate nuts or bolts except for corrosion-resistant steel parts or where specifically instructed to do so.
3. Always tighten by rotating the nut first if possible. When space considerations make it necessary to tighten by rotating the bolt-head, approach the high side of the indicated torque range. Do not exceed the maximum allowable torque value.
4. Maximum torque ranges should be used only when materials and surfaces being joined are of sufficient thickness, area, and strength to resist breaking, warping, or other damage.
5. For corrosion-resisting steel nuts, use torque values given for shear type nuts.
6. The use of any type of drive-end extension on a torque wrench changes the dial reading required to obtain the actual values indicated in the standard torque range tables. When using a drive-end extension, the torque wrench reading must be computed by use of the proper formula, which is included in the handbook accompanying the torque wrench.

Cotter Pin Hole Line-Up

When tightening castellated nuts on bolts, the cotter pin holes may not line up with the slots in the nuts for the range of recommended values. Except in cases of highly stressed engine parts, the nut may be over tightened to permit lining up the next slot with the cotter pin hole. The torque loads specified may be used for all unlubricated cadmium-plated steel nuts of the fine- or coarse-thread series which have approximately equal number of threads and equal face bearing areas. These values do not apply where special torque requirements are specified in the maintenance manual.

If the head end, rather than the nut, must be turned in the tightening operation, maximum torque values may be increased by an amount equal to shank friction, provided the latter is first measured by a torque wrench.

AIRCRAFT SCREWS

Screws are the most commonly used threaded fastening devices on aircraft. They differ from bolts inasmuch as they are generally made of lower strength materials. They can be installed with a loose-fitting thread, and the head shapes are made to engage a screwdriver or wrench. Some screws have a clearly defined grip or unthreaded portion while others are threaded along their entire length.

Several types of structural screws differ from the standard structural bolts only in head style. The material in them is the same, and a definite grip length is provided. The AN525 washer-head screw and the NAS220 through NAS227 series are such screws.

Commonly used screws are classified in three groups: (1) Structural screws which have the same strength as equal size bolts; (2) machine screws, which include the majority of types used for general repair; and (3) self-tapping screws, which are used for attaching lighter parts. A fourth group, drive screws, are not actually screws but nails. They are driven into metal parts with a mallet or hammer and their heads are not slotted or recessed.

Structural Screws

Structural screws are made of alloy steel, are properly heat treated, and can be used as structural bolts. These screws are found in the NAS204 through NAS235 and AN509 and AN525 series. They have a definite grip and the same shear strength as a bolt of the same size. Shank tolerances are similar to AN hex-head bolts, and the threads are National Fine. Structural screws are available with round, brazier, or countersunk heads. The recessed head screws are driven by either a Phillips or a Reed and Prince screwdriver.

The AN509 (100°) flathead screw is used in