# Aircraft general engineering and maintenance practices

COURSE CODE : **Ao307**

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NEHRU GROUP OF INSTITUTION

# Basic Inspection

- **Techniques/Practices**

Before starting an inspection, be certain all plates, access doors, fairings, and cowling have been opened or removed and the structure cleaned.

- When opening inspection plates and cowling and before cleaning the area, take note of any oil or other evidence of fluid leakage.

# Preparation

- In order to conduct a thorough inspection, a great deal of paperwork and/or reference information must be accessed and studied before actually proceeding to the aircraft to conduct the inspection.
- The aircraft logbooks must be reviewed to provide background information and a maintenance history of the particular aircraft

# Aircraft Logs

- "Aircraft logs," as used in this handbook, is an inclusive term which applies to the aircraft logbook and all supplemental records concerned with the aircraft
- Aircraft that have been in service for a long time are likely to have several logbooks.
- The aircraft logbook is the record in which all data concerning the aircraft is recorded. Information gathered in this log is used to determine the aircraft condition, date of inspections, time on airframe, engines and propellers.
- It reflects a history of all significant events occurring to the aircraft, its components, and accessories, and provides a place for indicating compliance with FAA airworthiness directives or manufacturers' service bulletins.

# Aircraft Logs

- When the inspections are completed, appropriate entries must be made in the aircraft logbook certifying that the aircraft is in an airworthy condition and may be returned to service.
- When making logbook entries, exercise special care to ensure that the entry can be clearly understood by anyone having a need to read it in the future.
- Also, if making a hand-written entry, use good penmanship and write legibly.

# Checklists

- Always use a checklist when performing an inspection. The checklist may be of your own design, one provided by the manufacturer of the equipment being inspected, or one obtained from some other source.

# Fuselage and hull group.

- Fabric and skin—for deterioration, distortion, other evidence of failure, and defective or insecure attachment of fittings.
- Systems and components—for proper installation, apparent defects, and satisfactory operation.
- Envelope gas bags, ballast tanks, and related parts—for condition.

# Cabin and cockpit group.

- Generally—for cleanliness and loose equipment that should be secured.
- Seats and safety belts—for condition and security.
- Windows and windshields—for deterioration and breakage.
- Instruments—for condition, mounting, marking, and (where practicable) for proper operation.
- Flight and engine controls—for proper installation and operation.
- Batteries—for proper installation and charge.
- All systems—for proper installation, general condition, apparent defects, and security of attachment.

# Engine and nacelle group.

- Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks.
- Studs and nuts—for proper torquing and obvious defects.
- Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If cylinder compression is weak, check for improper internal condition and improper internal tolerances.
- Engine mount—for cracks, looseness of mounting, and looseness of engine to mount. e. Flexible vibration dampeners—for condition and deterioration.
- Engine controls—for defects, proper travel, and proper safe tying.
- Lines, hoses, and clamps—for leaks, condition, and looseness.
- Exhaust stacks—for cracks, defects, and proper attachment.
- Accessories—for apparent defects in security of mounting.
- All systems—for proper installation, general condition defects, and secure attachment.
- Cowling—for cracks and defects.

# Landing gear group.

- All units—for condition and security of attachment.
- Shock absorbing devices—for proper oleo fluid level.
- Linkage, trusses, and members—for undue or excessive wear, fatigue, and distortion.
- Retracting and locking mechanism—for proper operation.
- Hydraulic lines—for leakage.
- Electrical system—for chafing and proper operation of switches.
- Wheels—for cracks, defects, and condition of bearings.
- Tires—for wear and cuts.
- Brakes—for proper adjustment.
- Floats and skis—for security of attachment and obvious defects.

# Other group

- Wing and center section
- Empennage group
- Propeller group.
- Communication and navigation group.

# Severe Turbulence Inspection

- When an aircraft encounters a gust condition, the air load on the wings exceeds the normal wing load supporting the aircraft weight. The gust tends to accelerate the aircraft while its inertia acts to resist this change. If the combination of gust velocity and airspeed is too severe, the induced stress can cause structural damage.
- A special inspection should be performed after a flight through severe turbulence. Emphasis should be placed upon inspecting the upper and lower wing surfaces for excessive buckles or wrinkles with permanent set. Where wrinkles have occurred, remove a few rivets and examine the rivet shanks to determine if the rivets have sheared or were highly loaded in shear.
- Inspect all spar webs from the fuselage to the tip, through the inspection doors and other accessible openings. Check for buckling, wrinkles, and sheared attachments. Inspect for buckling in the area around the nacelles and in the nacelle skin, particularly at the wing leading edge.

# Severe Turbulence Inspection

- Check for fuel leaks. Any sizeable fuel leak is an indication that an area may have received overloads which have broken the sealant and opened the seams.
- If the landing gear was lowered during a period of severe turbulence, inspect the surrounding surfaces carefully for loose rivets, cracks, or buckling. The interior of the wheel well may give further indications of excessive gust conditions. Inspect the top and bottom fuselage skin. An excessive bending moment may have left wrinkles of a diagonal nature in these areas.
- Inspect the surface of the empennage for wrinkles, buckling, or sheared attachments. Also, inspect the area of attachment of the empennage to the fuselage. The above inspections cover the critical areas. If excessive damage is noted in any of the areas mentioned, the inspection should be continued until all damage is detected.

# Publications

- service bulletins, manuals, and catalogs;
- FAA regulations;
- airworthiness directives;
- advisory circulars;
- aircraft, engine and propeller specifications.

# Manufacturers' Service Bulletins/Instructions

Service bulletins or service instructions are two of several types of publications issued by airframe, engine, and component manufacturers.

- purpose for issuing the publication,
- name of the applicable airframe, engine, or component,
- detailed instructions for service, adjustment, modification or inspection, and source of parts, if required and
- estimated number of man hours required to accomplish the job.

# Maintenance Manual

The manufacturer's aircraft maintenance manual contains complete instructions for maintenance of all systems and components installed in the aircraft.

- A description of the systems (i.e., electrical, hydraulic, fuel, control)
- Lubrication instructions setting forth the frequency and the lubricants and fluids which are to be used in the various systems,
- Pressures and electrical loads applicable to the various systems,
- Tolerances and adjustments necessary to proper functioning of the airplane,

# Maintenance Manual

- Methods of leveling, raising, and towing,
- Methods of balancing control surfaces,
- Identification of primary and secondary structures,
- Frequency and extent of inspections necessary to the proper operation of the airplane,
- Special repair methods applicable to the airplane,
- Special inspection techniques requiring x-ray, ultrasonic, or magnetic particle inspection, and
- A list of special tools.

# Overhaul Manual

- The manufacturer's overhaul manual contains brief descriptive information and detailed step by step instructions covering work normally performed on a unit that has been removed from the aircraft.
- Simple, inexpensive items, such as switches and relays on which overhaul is uneconomical, are not covered in the overhaul manual.

# Structural Repair Manual

- This manual contains the manufacturer's information and specific instructions for repairing primary and secondary structures.
- Typical skin, frame, rib, and stringer repairs are covered in this manual. Also included are material and fastener substitutions and special repair techniques.

# Illustrated Parts Catalog

- This catalog presents component breakdowns of structure and equipment in disassembly sequence. Also included are exploded views or cutaway illustrations for all parts and equipment manufactured by the aircraft manufacturer.

# Code of Federal Regulations (CFRs)

- The CFRs were established by law to provide for the safe and orderly conduct of flight operations and to prescribe airmen privileges and limitations. A knowledge of the CFRs is necessary during the performance of maintenance, since all work done on aircraft must comply with CFR provisions.

# Airworthiness Directives

- A primary safety function of the FAA is to require correction of unsafe conditions found in an aircraft, aircraft engine, propeller, or appliance when such conditions exist and are likely to exist or develop in other products of the same design. The unsafe condition may exist because of a design defect, maintenance, or other causes. Title 14 of the Code of Federal Regulations (14 CFR) part 39, Airworthiness Directives, defines the authority and responsibility of the Administrator for requiring the necessary corrective action. The Airworthiness Directives (ADs) are published to notify aircraft owners and other interested persons of unsafe conditions and to prescribe the conditions under which the product may continue to be operated.

# Routine/Required Inspections

- For the purpose of determining their overall condition, 14 CFR provides for the inspection of all civil aircraft at specific intervals, depending generally upon the type of operations in which they are engaged. The pilot in command of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight.
- Therefore, the aircraft must be inspected before each flight. More detailed inspections must be conducted by aviation maintenance technicians at least once each 12 calendar months, while inspection is required for others after each 100 hours of flight. In other instances, an aircraft may be inspected in accordance with a system set up to provide for total inspection of the aircraft over a calendar or flight time period.

# Preflight/Post flight Inspections

- Pilots are required to follow a checklist contained within the Pilot's Operating Handbook (POH) when operating aircraft. The first section of a checklist includes a section entitled Preflight Inspection. The preflight inspection checklist includes a "walk-around" section listing items that the pilot is to visually check for general condition as he or she walks around the airplane. Also, the pilot must ensure that fuel, oil and other items required for flight are at the proper levels

# Annual/100-Hour Inspections

- Title 14 of the Code of Federal Regulations (14 CFR) part 91 discusses the basic requirements for annual and 100-hour inspections. With some exceptions, all aircraft must have a complete inspection annually. Aircraft that are used for commercial purposes and are likely to be used more frequently than noncommercial aircraft must have this complete inspection every 100 hours.

# Progressive Inspections

- Because the scope and detail of an annual inspection is very extensive and could keep an aircraft out of service for a considerable length of time, alternative inspection programs designed to minimize down time may be utilized.
- A progressive inspection program allows an aircraft to be inspected progressively. The scope and detail of an annual inspection is essentially divided into segments or phases (typically four to six).

# Altimeter and Transponder Inspections

- Aircraft that are operated in controlled airspace under instrument flight rules (IFR) must have each altimeter and static system tested in accordance with procedures described in 14 CFR part 43, appendix E, within the preceding 24 calendar months.
- Aircraft having an air traffic control (ATC) transponder must also have each transponder checked within the preceding 24 months. All these checks must be conducted by appropriately certified individuals.

# Continuous Inspections

- Continuous inspection programs are similar to progressive inspection programs, except that they apply to large or turbine-powered aircraft and are therefore more complicated. Like progressive inspection programs, they require approval by the FAA Administrator.
- The approval may be sought based upon the type of operation and the CFR parts under which the aircraft will be operated. The maintenance program for commercially operated aircraft must be detailed in the approved operations specifications (OpSpecs) of the commercial certificate holder.

# Propulsion Devices (Engines)

**Air-Breathing**

Use atmospheric air (+ some fuel) as main propellant

**Rockets**

Carry entire propellant (liquid/solid fuel + oxygen)

↓

Piston, **Gas Turbine** and Ramjet Engines

↓

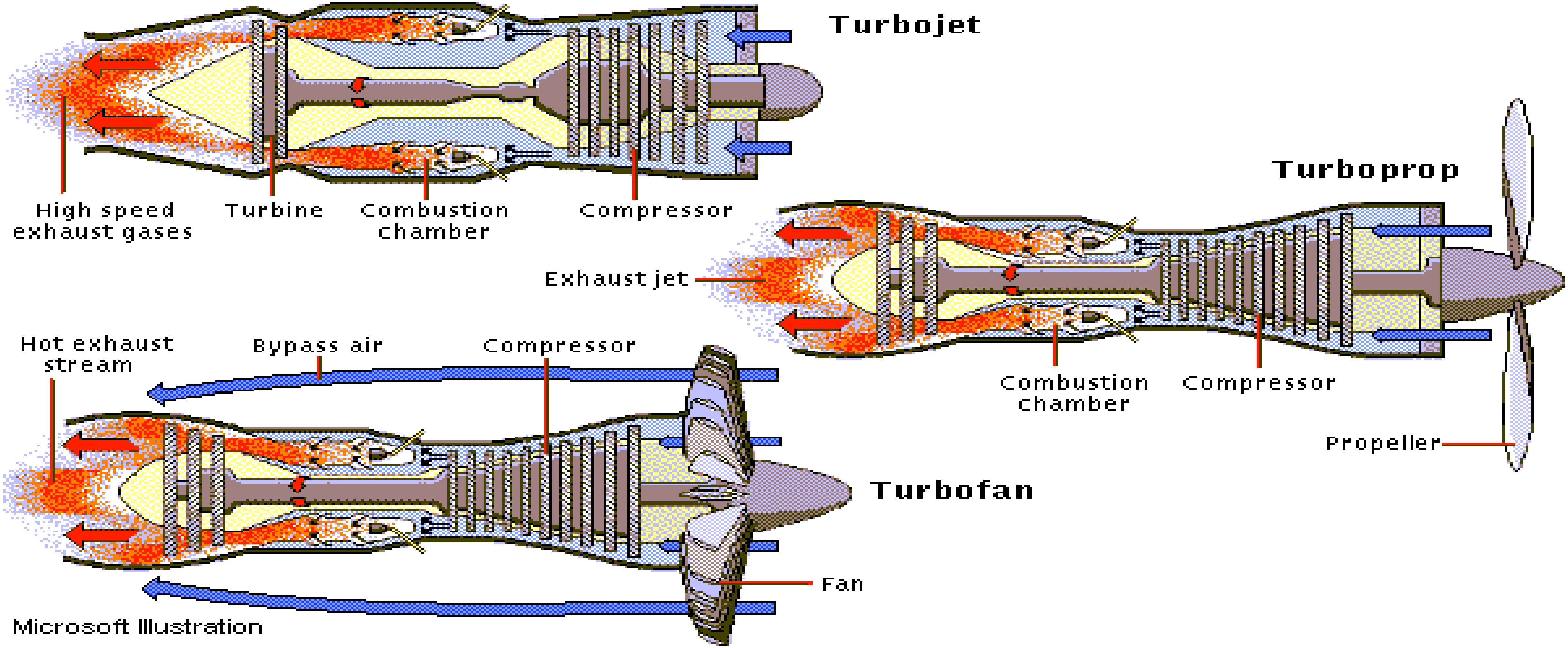
**Gas Turbine Engines** (most aircraft jet engines):

- Use high-temperature gases to power a propeller or produce direct thrust by expanding and accelerating the exhaust gases through a nozzle.
- Three main types: **Turbojet**, **Turbofan** and **Turboprop**

# Jet Engines – Basic Operation

- Air enters the trough the intake duct (cowl).
- Air compressed by passage through the compressor.
- Mixed with fuel in the combustion chamber.
    - Fuel is ignited,  Pressure and Temperature raised
- Some of the pressure used to turn a turbine;
    - Turbine shaft drives the compressor.
- Hot, high pressure air forced through a nozzle.
- The reaction force is the engine thrust.

# Jet Engine - Common Types



# Jet Engine - Common Types

- **Turbojets:**

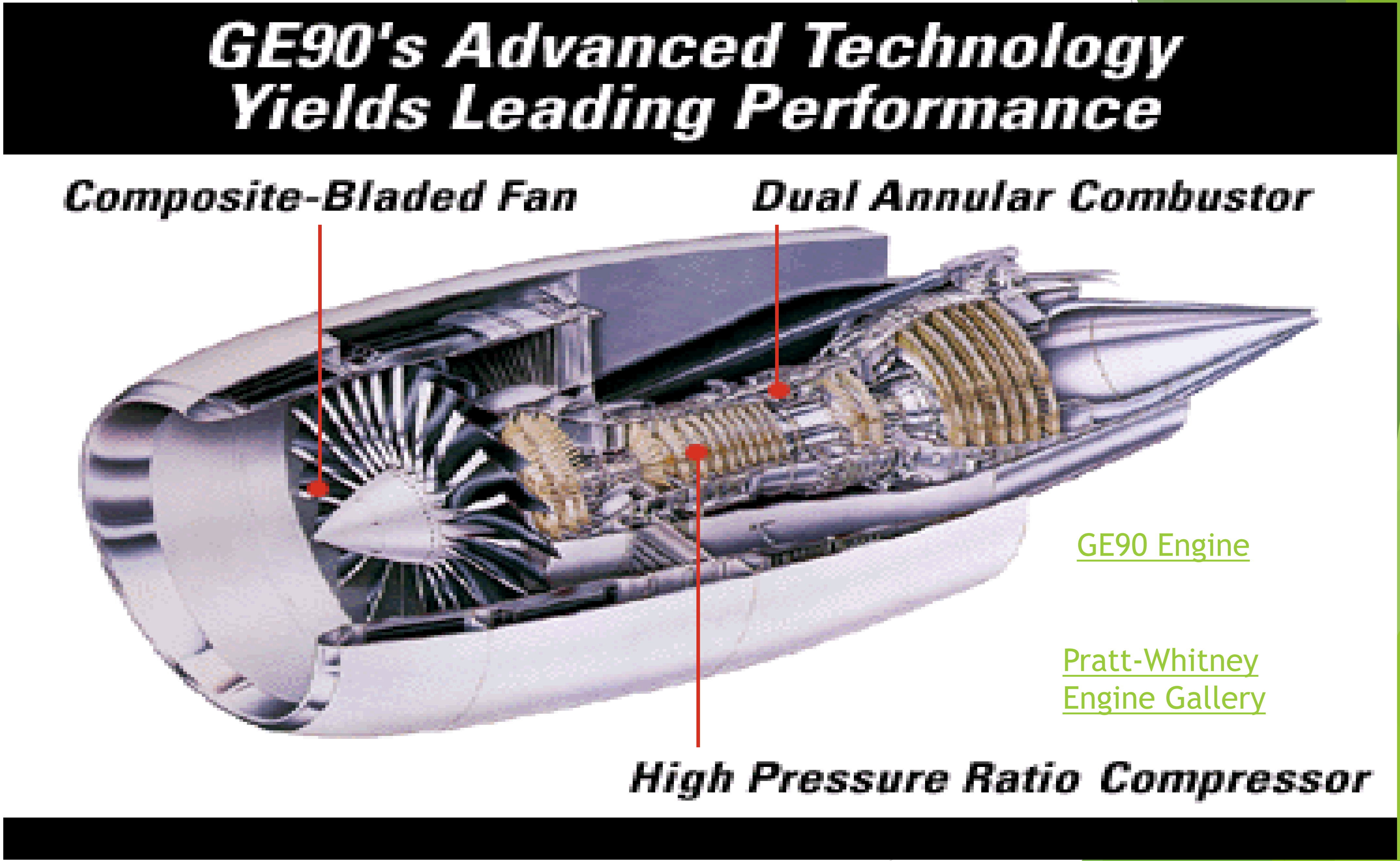
- Turbine used to drive the compressor.
- All intake air passes through the combustion chamber and exits through the nozzle.
- All thrust produced by hot, high-speed exhaust gases.

- **Turbofans (Fan-Jet):**

- A large propeller in the intake cowl, in front of compressor.
- Dramatically increases the amount of air pulled in the intake.
- Only a small percentage passed through the engine, the rest of cold air is Bypassed.
- Part of the thrust through the hot exhaust gases and part by the cold bypassed air. Produces cooler exhausts and quieter engines.
- High by-pass ratio are most commonly used in larger commercial aircraft.

- **Turboprops:**

- Jet engine used to turn a large propeller, which produces most (90% or more) of the thrust. Used in smaller aircraft.




GE90 Engine

Pratt-Whitney
Engine Gallery

# Jet Engine Combuster

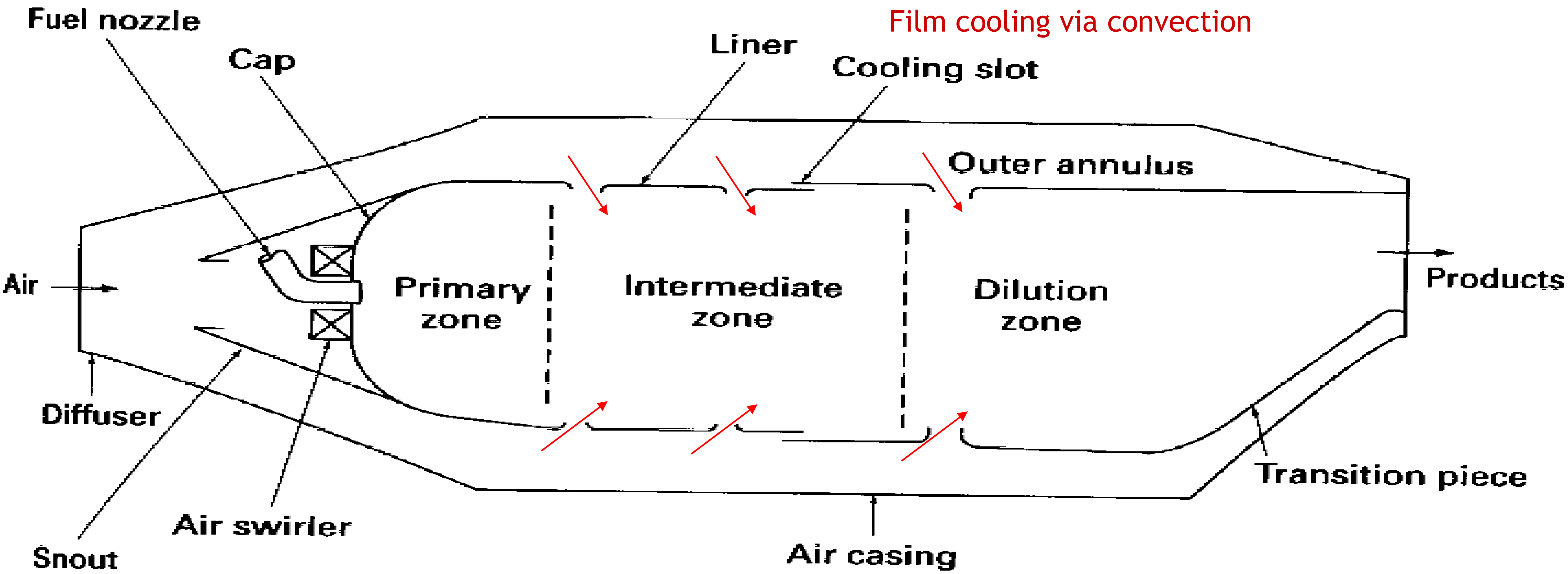



**FIGURE 11.3**
Main components of a gas turbine combustor [Lefebvre (1983), from *Gas Turbine Combustion*, p. 13, reproduced with permission of Taylor and Francis, Inc., Washington, D.C. All rights reserved.]

Turbulent flame (fuel self-ignited)

Flame stabilization

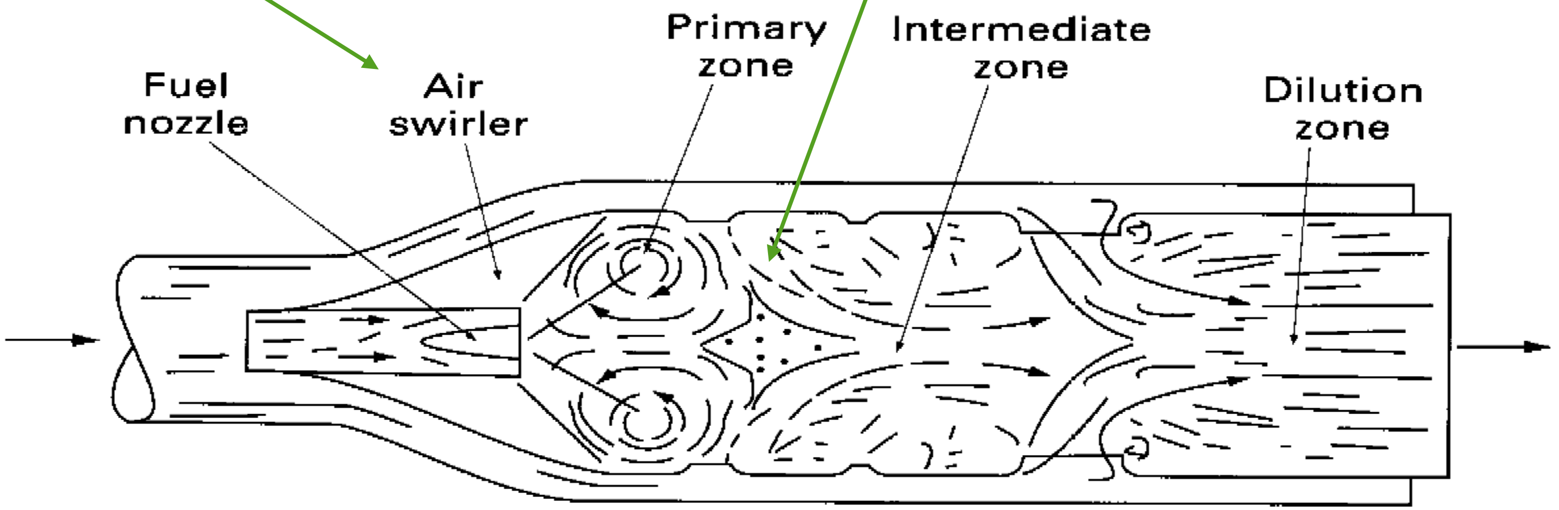
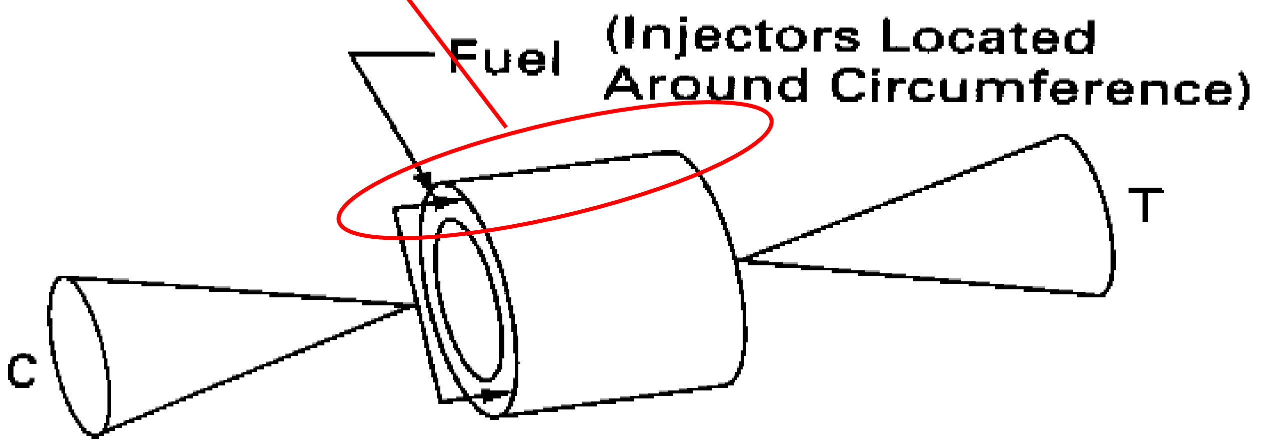



**FIGURE 11.4**
Flow pattern in combustor created by swirl vanes and radial jets (20% of air added in primary zone, 30% in intermediate zone, and 50% in dilution zone).

One annular section




(a) Annular

- Use spark plug to start the engine and re-light after flameout

# AEROSPACE RIVETS

- Aluminum and its alloys are difficult to solder. To make a good union and a strong joint, aluminum parts can be welded, bolted, or riveted together. Riveting is satisfactory from the standpoint of strength and neatness, and is much easier to do than welding. It is the most common method used to fasten or join aluminum alloys in aircraft construction and repair.

- A rivet is a metal pin used to hold two or more metal sheets, plates, or pieces of material together. A head is formed on one end when the rivet is manufactured. The shank of the rivet is placed through matched holes in two pieces of material, and the tip is then upset to form a second head to clamp the two pieces securely together. The second head, formed either by hand or by pneumatic equipment, is called a "shop head.

# AEROSPACE RIVETS

- Two of the major types of rivets used in the aircraft are the common solid shank type, which must be driven using a bucking bar, and the special (blind) rivets, which may be installed where it is impossible to use a bucking bar.

# Solid Shank Rivets

- Solid shank rivets are generally used in repair work. They are identified by the kind of material of which they are made, their head type, size of shank, and their temper condition.
- The designation of the solid shank rivet head type, such as universal head, roundhead, flathead, countersunk head, and brazier head, depends on the cross sectional shape of the head.
- The temper designation and strength are indicated by special markings on the head of the rivet.

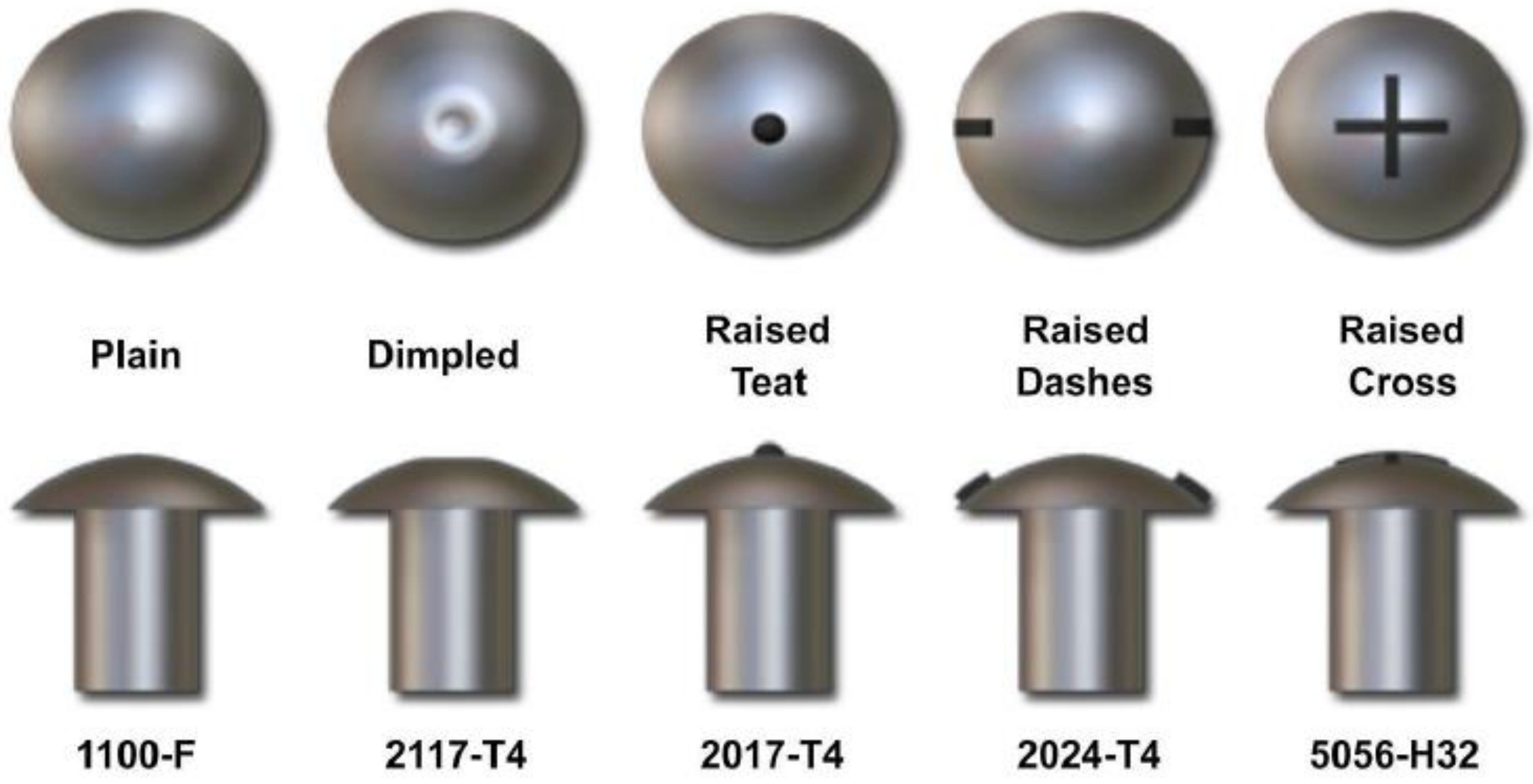



Figure 6-1 — Rivet head shapes and code numbers.

# Solid Shank Rivets

- The material used for the majority of aircraft solid shank rivets is aluminum alloy. The strength and temper conditions of aluminum alloy rivets are identified by digits and letters similar to those adopted for the identification of strength and temper conditions of aluminum and aluminum alloy stock.
- The 1100, 2017-T, 2024-T, 2117-T, and 5056 rivets are the five grades usually available.
- The 1100 rivet, which is composed of 99.45 percent pure aluminum, is very soft. It is for riveting the softer aluminum alloys, such as 1100, 3003, and 5052, which are used for nonstructural parts (all parts where strength is not a factor). The riveting of map cases is a good example of where a rivet of 1100 aluminum alloy may be used.

# Solid Shank Rivets

- The 2117-T rivet, known as the field rivet, is used more than any other for riveting aluminum alloy structures. The field rivet is in wide demand because it is ready for use as received and needs no further heat treating or annealing. It also has a high resistance to corrosion.
- The 2017-T and 2024-T rivets are used in aluminum alloy structures where more strength is needed than is obtainable with the same size 2217-T rivet. These rivets are annealed and must be kept refrigerated until they are to be driven. The 2017-T rivet should be driven within approximately 1 hour and the 2024-T rivet within 10 to 20 minutes after removal from refrigeration.
- The 5056 rivet is used for riveting magnesium alloy structures because of its corrosion resistant qualities in combination with magnesium.

# Solid Shank Rivets

- Metal temper is an important factor in the riveting process, especially with aluminum alloy rivets. Aluminum alloy rivets have the same heat treating characteristics as aluminum alloy stock. They can be hardened and annealed in the same manner as aluminum. The rivet must be soft, or comparatively soft, before a good head can be formed. The 2017-T and 2024-T rivets are annealed before being driven. They harden with age.

- The process of heat treating (annealing) rivets is much the same as that for stock. Either an electric air furnace, a salt bath, or a hot oil bath is needed. The heat treating range, depending on the alloy, is 625° F to 950° F. For convenient handling, rivets are heated in a tray or a wire basket. They are quenched in cold water (70° F) immediately after heat treating.

# Blind rivets

- In places accessible from only one side or where space on one side is too restricted to properly use a bucking bar, blind rivets are usually used. Blind rivets may also be used to secure nonstructural parts to the airframe.
- *Figure* shows a blind rivet that uses a mechanical lock between the head of the rivet and the pull stem. This lock holds the shank firmly in place from the head side.
- The self-plugging rivet is made of 5056-H14 aluminum alloy and includes the conical recess and locking collar in the rivet head. The stem is made of 2024-T36 aluminum alloy. Pull grooves that fit into the jaws of the rivet gun are provided on the stem end that protrudes above the rivet head. The blind end portion of the stem incorporates a head and a land (the raised portion of the grooved surface) with an extruding angle that expands the rivet shank.
- Applied loads for self-plugging rivets are comparable to those for solid shank rivets of the same shear strength, regardless of sheet thickness. The composite shear strength of the 5056-H14 shank and the

## Self-Plugging Mechanical Lock

2024-T36 pin exceeds 38,000 pounds per square inch (psi). Their tensile strength is in excess of 28,000 psi. Pin retention characteristics are excellent in these rivets. The possibility of the pin working out is minimized by the lock formed in the rivet head.

**Self-Plugging Friction Lock:**

Self-plugging friction lock rivets are available in universal and flush head styles and are manufactured from 2117 and 5056 aluminum alloy and Monel. Self-plugging friction lock rivets cannot be substituted for solid rivets, nor can they be used in critical applications, such as control surface hinge brackets, wing attachment fittings, landing gear fittings, and fluid-tight joints. Figure 6-4 shows a self-plugging friction lock rivet

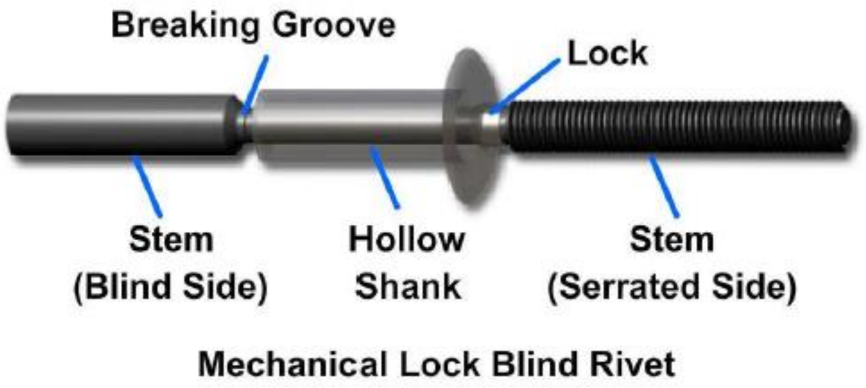



Figure 6-3 — Self-plugging rivet (mechanical lock).

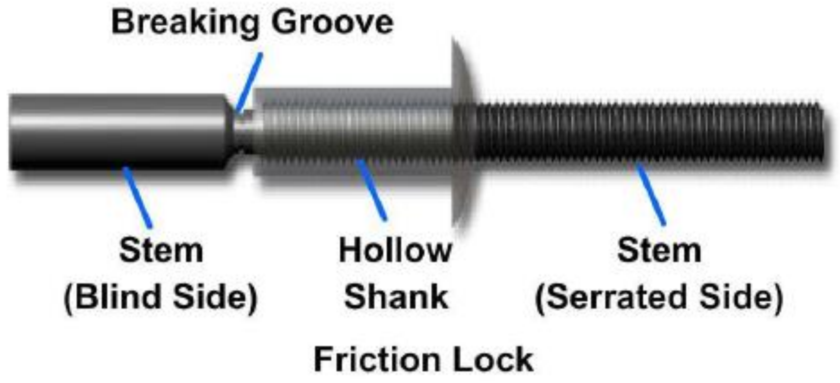


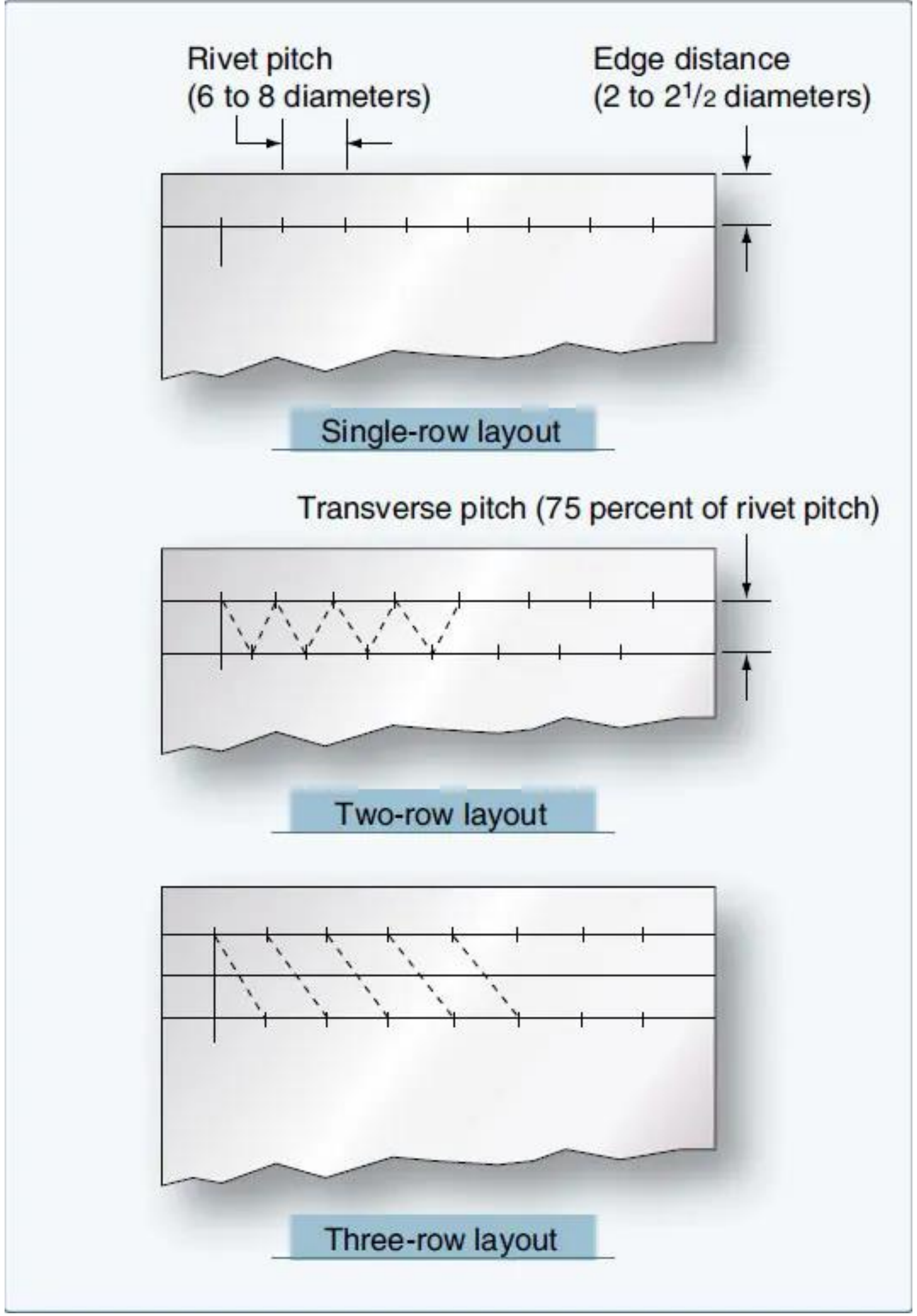

Figure 6-4 — Self-plugging rivet (friction lock).

# Identification

- AN426 or MS20426 - countersunk head rivets (100°).
- AN430 or MS20430 - roundhead rivets.
- AN441 - flathead rivets.
- AN456 - brazier head rivets.
- AN470 or MS20470 - universal head rivets.

# Rivet Layout Example

- The general rules for rivet spacing, as it is applied to a straight-row layout, are quite simple. In a one-row layout, find the edge distance at each end of the row and then lay off the rivet pitch (distance between rivets), as shown in Figure 4-81.
- In a two-row layout, lay off the first row, place the second row a distance equal to the transverse pitch from the first row, and then lay off rivet spots in the second row so that they fall midway between those in the first row. In the three-row layout, first lay off the first and third rows, then use a straightedge to determine the second row rivet spots.
- When splicing a damaged tube, and the rivets pass completely through the tube, space the rivets four to seven rivet diameters apart if adjacent rivets are at right angles to each other, and space them five to seven rivet diameters apart if the rivets are parallel to each other. The first rivet on each side of the joint should be no less than 21⁄2 rivet diameters from the end of the sleeve


Rivet pitch
(6 to 8 diameters)
Edge distance
(2 to 2 1/2 diameters)
Single-row layout
Transverse pitch (75 percent of rivet pitch)
Two-row layout
Three-row layout

# Sheet Metal Bending

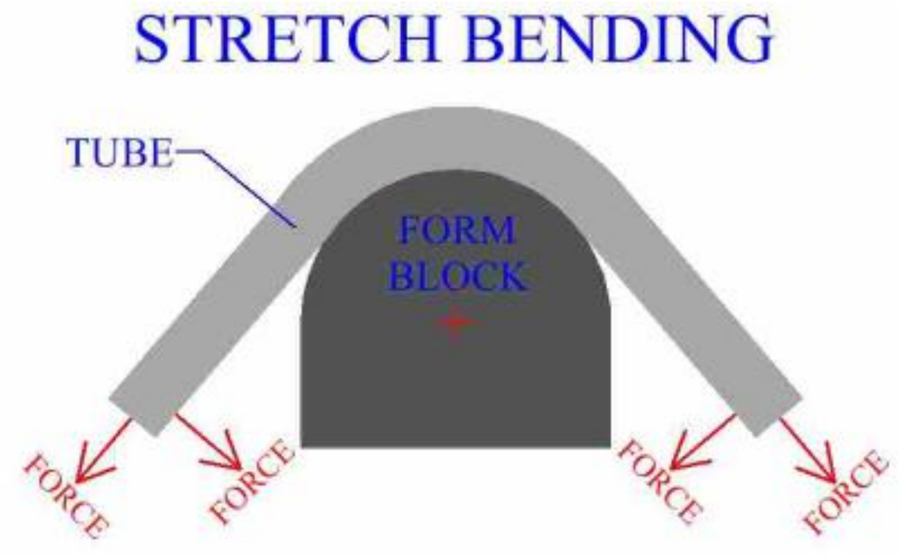
- Bending of sheet metal is a common and vital process in manufacturing industry. **Sheet metal bending** is the plastic deformation of the work over an axis, creating a change in the part's geometry.
- Similar to other metal forming processes, bending changes the shape of the work piece, while the volume of material will remain the same. In some cases bending may produce a small change in sheet thickness.
- For most operations, however, bending will produce essentially no change in the thickness of the sheet metal.
- In addition to creating a desired geometric form, bending is also used to impart strength and stiffness to sheet metal, to change a part's moment of inertia, for cosmetic appearance and to eliminate sharp edges.

# Metal Tube Bending

- Tubes, rods, bars and other cross sections are also subject to metal bending operations. It should be remembered that when bending a metal part, spring back is always a factor. Several special manufacturing processes have been developed for the bending of hollow tubes. These operations can also be used on solid rods.
- Hollow tubes have the characteristic that they may collapse when bent. Tubes may also crack or tear, the material's ductility is important when considering tube failure.
- As the bend radius goes down, the tendency to collapse increases. Bend radius in metal tube bending is measured from the tube's centerline. The other major factor determining collapse is the wall thickness of the tube.
- Tubes with a greater wall thickness are less likely to collapse. Bending a thick walled tube to a large radius is usually not a problem, as far as collapse is concerned.

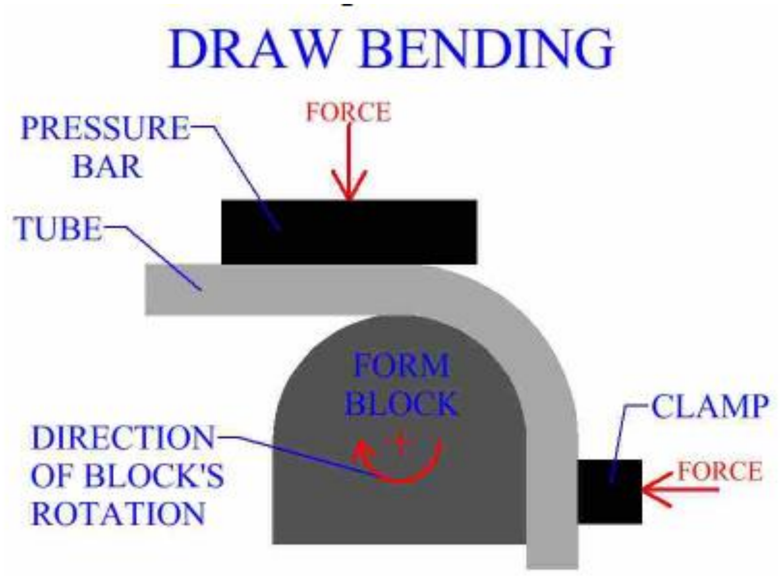
# STRETCH BENDING

Draw bending involves clamping the tube near its end to a rotating form block. A pressure pad is also used to hold the tube stock. As the form block rotates, the tube is bent.



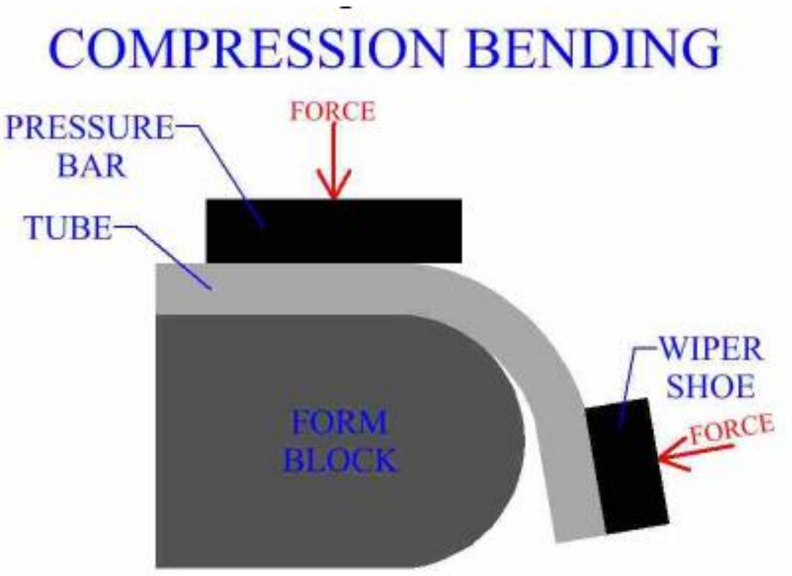
# DRAW BENDING

Compression bending is a tube bending process that has some similarities to edge bending of sheet metal with a wiping die. The tube stock is held by force to a fixed form block. A wiper like die applies force, bending the tube over the form block.



# COMPRESSION BENDING

Compression bending is often used to bend tube when speed and economy are important but tube roundness is not. It is used predominantly for the furniture market. In addition, a wiper die is needed to bend thin-wall tube. It prevents the tube from rippling.



# Tube Flaring

- Tube flaring is a method of forming the end of a tube into a funnel shape so it can be held by a threaded fitting. When a flared tube is prepared, a flare nut is slipped onto the tube and the end of the tube is flared. During tube installation, the flare is seated to a fitting with the inside of the flare against the cone-shaped end of the fitting, and the flare nut is screwed onto the fitting, pulling the inside of the flare against the seating surface of the fitting.

# Cable Splicing & Swaging

When swaging tools are used, it is imperative that all the manufacturer’s instructions, including ‘go’ and ‘no-go’ dimensions, be followed exactly to avoid defective and inferior swaging. Compliance with all of the instructions should result in the terminal developing the full-rated strength of the cable. The following basic procedures are used when swaging terminals onto cable ends:

# Cable Splicing & Swaging

- Cut the cable to length, allowing for growth during swaging. Apply a preservative compound to the cable end before insertion into the terminal barrel. Measure the internal length of the terminal end/barrel of the fitting to determine the proper length of the cable to be inserted. Transfer that measurement to the end of the cable and mark it with a piece of masking tape wrapped around the cable. This provides a positive mark to ensure the cable did not slip during the swaging process. NOTE: Never solder the cable ends to prevent fraying since the solder greatly increases the tendency of the cable to pull out of the terminal.
- Insert the cable into the terminal approximately one inch and bend it toward the terminal. Then, push the cable end all the way into the terminal. The bending action puts a slight kink in the cable end and provides enough friction to hold the terminal in place until the swaging operation is performed. [Figure 2-68]
- Accomplish the swaging operation in accordance with the instructions furnished by the manufacturer of the swaging equipment.

# Cable Splicing & Swaging

- Inspect the terminal after swaging to determine that it is free of die marks and splits and is not out of round. Check the cable for slippage at the masking tape and for cut and broken wire strands.
- Using a go/no-go gauge supplied by the swaging tool manufacturer or a micrometer and swaging chart, check the terminal shank diameter for proper dimension. [Figures 2-69 and 2-70]
- Test the cable by proof-loading locally fabricated splices and newly installed swage terminal cable fittings for proper strength before installation. This is conducted by slowly applying a test load equal to 60 percent of the rated breaking strength of the cable listed in Figure 2-71.