Al-Najaf Technical Institute
Aeronautical Technologies Department
Year Two
Subject: - Aircraft Maintenance

Lecturer Notes by Dr. Essam Al-Zaini

Source 1: - Aviation Maintenance Technician Handbook—Airframe Volume 1, 2012, U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION

Source 2: - Part 66 Cat. B1 Module 7 MAINTENANCE PRACTICES Volume 1

Chapter 1 Maintenance Practices and Tools

1.1. SAFETY PRECAUTIONS – AIRCRAFT AND WORKSHOP

Good housekeeping in hangars, shops, and on the flight line is essential to safety and efficient maintenance. The highest standards of orderly work arrangements and cleanliness should be observed during the maintenance of aircraft. When dealing with a particular system, component or procedure the understanding of the safety aspects that apply to that task are needed. Each personnel involved in maintenance should be aware of the safety aspects as they can lead to unexpected consequences. Where continuous work shifts are established, the outgoing shift should remove and properly store personal tools, roll away boxes, all work stands, maintenance stands, hoses, electrical cords, hoists, crates, and boxes that are superfluous to the work to be accomplished.

Basic Rules

The basic safety on the workplace starts with very simple rule – working and pedestrian zones should be separated. Pedestrian walkways or fire lanes should be painted around the perimeter inside the hangars. This should be done as a safety measure to prevent accidents and to keep pedestrian traffic out of work areas.

Electrical Safety

Every aircraft maintenance shop uses electrical power for day to day activities. Besides many useful functions, it can injure or kill if mishandled. Therefore, it is the responsibility of everyone that uses electrical power to be aware of the safety procedures regarding it.

The human body conducts electricity. Furthermore, electrical current passing through the body disrupts the nervous system and causes burns at the entry and exit points. Common 110/120-volt AC house current used in U.S.A. or 220/380-volt used in Europe is particularly dangerous because it affects nerves in such a way that a person holding a current-carrying wire is unable to release it. Since water conducts electricity, you must avoid handling electrical equipment while standing on a wet surface or wearing wet shoes. The water provides a path to ground and heightens the possibility of electric shock.

Consider how a typical electric drill (that has an AC motor inside a metal housing) creates an electrical hazard. One wire is connected to the power terminal of the motor, and the other terminal connects to ground through a white wire. If there are only two wires in the cord and the power lead becomes shorted to the housing, the return current flows to ground through the operator's body. However, if the drill motor is wired with a three-conductor cord, return current flows through the third (green) wire to ground. Most shop equipment operating on 110/120-volt or 220-volt single-phase alternating current utilizes.

Types of Fire vs. Extinguishing Agent

Class A fires respond best to water or water type extinguishers which cool the fuel below combustion temperatures.
Class B extinguishers are effective but not equal to the wetting / cooling action of the Class A extinguisher. Class B fires respond to carbon dioxide (CO_2), halogenated hydrocarbons (Halons) and dry chemicals, all of which displace the oxygen in the air thereby making combustion impossible. Foam is effective, especially when used in large quantities. Water is ineffective on class B fires and will cause the fire to spread.

Class C (US) or E (EU) fires involving electrical wiring, equipment, or current respond best to carbon dioxide (CO_2) which displaces the oxygen in the atmosphere making combustion improbable.

The CO_2 equipment must be equipped with a non-metallic horn to be approved for use on electrical fires. Two reasons for this must be considered: -

1. The discharge of CO_2 as through a metal horn can generate static electricity.
2. The static discharge could reignite the fire; - The metal horn if in contact with the electrical current would transmit that current to the extinguisher operator.

Halogenated hydrocarbons are very effective on Class C / E (US / EU) fires. The vapour reacts chemically with the flame to extinguish the fire. Dry chemicals are effective but have the disadvantage of contaminating the local area with powder. Also, if used on wet and energized electrical equipment, it may aggravate current leakage.

Water, wet water or foam is not acceptable agents for use on liquid or electrical equipment fires

Class D fires respond to application of dry powder, which prevents oxidation and the resulting flame. Application may be from an extinguisher or scoop or shovel. Special techniques are needed in combating fires involving metal. Manufacturer’s recommendations should be followed at all times. Areas which could be subjected to metal fires should have the proper protective equipment installed.

Under no conditions use water on a metal fire it will cause the fire to burn more violently and can clause explosion

Fire Extinguishing Agents

A fire is extinguished by either cooling the fuel below its kindling temperature or by depriving it of oxygen. All fire extinguishers work on one of these principles.

Water and Water Based Agents

Water can only be used for Class A fires, such as aircraft cabin fires, where electricity is not involved. Most modern water-type extinguishers consist of a container of water in which an antifreeze material has been mixed. The water is propelled from the extinguisher by a charge of carbon dioxide. Once the extinguisher is activated, all of the propellant is discharged and a new cartridge must be installed when the extinguisher is serviced.
Water extinguishes fires by cooling the fuel below the combustion temperature. Soda-acid and foam act on a fire the same as water by lowering the temperature. Foam has some effect on a petroleum base fire by preventing oxygen from getting to the fire.

Dry Chemical Agents

Sodium bicarbonate is the main chemical in use for extinguishing petroleum products and energized electrical equipment. The dry chemicals extinguish a fire by smothering it, cutting off oxygen, and the blanket of dry chemicals prevents re-flash fires. It also affords the operator some protection from the heat. All dry chemicals are non-conductors of electricity.

Dry chemicals are not suitable for using at home and offices as can reduce visibility and cause breathing problems

Gaseous Agents

Carbon dioxide (CO2): The carbon dioxide gas excludes oxygen from the fire and the fire dies out. Since carbon dioxide is heavier than air and is electrically nonconductive, it is effective on both petroleum products and energized equipment. Furthermore, carbon dioxide extinguishers are particularly well-suited for engine intake and carburetor fires, since they leave no residue.

Never use CO2 extinguishers on combustible metal fires as the cooling effect of the carbon dioxide on the metal can cause an explosive reaction of the metal

1.2 WORKSHOP PRACTICES

Tool and Equipment Usage

Tool and Equipment Classification
All tools and equipment are classified as:
- Standard tools;
- Specific tools;
- Ground support equipment (GSE).

In other hand tools and equipment are subdivided on tools or equipment which should be:
- Calibrated;
- Inspected;
- Serviced

Tool and Equipment from Store

All tools and some GSE are stocked within the store. When tool / GSE are served, tool register is updated by Shift Leader and signed by the Loaner.
The "Tool distribution register" normally includes:
- Name of the person receiving the tool;
- Marking of the tool, part number, serial number (if applicable);
- Where the tool is going to be used (tail number of the aircraft);
- Date and time of delivery;
- Date and time of return.

When the tool / GSE are returned to the store the Shift Leader is responsible to check number, condition and identification of the tool / GSE.

Use of Tool / GSE by Staff

Tool / GSE must remain in their original package, where it's applicable, during transportation or when not in use. It is responsibility of the user to verify that:
- Tool / GSE are serviceable before using;
- Tool is marked.
- Next inspection date has not been exceeded;
- Tool is still serviceable before return the tool to the store.

Prior to use, it must be ensured that the precision and tolerance of the tool / GSE are adequate for the work to be performed, as per the Task Card or AMM requirements. The GSE operation manual should be available for the user.

CAUTION 1: When tool / GSE were missed the Shift Leader is responsible to organize looking for missed tool / GSE. In order to assure that tool / GSE were not left on the aircraft lost tool or GSE report must be filled.

CAUTION 2: When tool / GSE were broken it must be mark with Tool / GSE Unserviceable Tag and removed from use.

1.3 TOOLS

The basic knowledge required in using the most common hand tools and measuring instruments used in aircraft repair work is outlined here.

Pounding Tools

Pounding tools include different types and weights of hammers and mallets, each with a very specific use. Since misuse of pounding tools can result in damage to aircraft components and injury to personnel, it is important to use these tools properly.

Peen Hammers

The ball peen hammers ranges in weight from one ounce to two or three pounds. One hammer face is always flat while the other is formed into the shape of a ball. The flat hammer face is used for pounding, but should not be used to drive a nail. The ball end of the hammer is typically used to peen over rivets in sheet metal work. However, this is not the method used for securing rivets in aircraft sheet metal work.

When using a hammer, it should be held near the end of the handle with the face of the hammer parallel to the work. A grip just tight enough to control the blow is best. The correct way to hold a hammer is shown in Fig. 3-7.

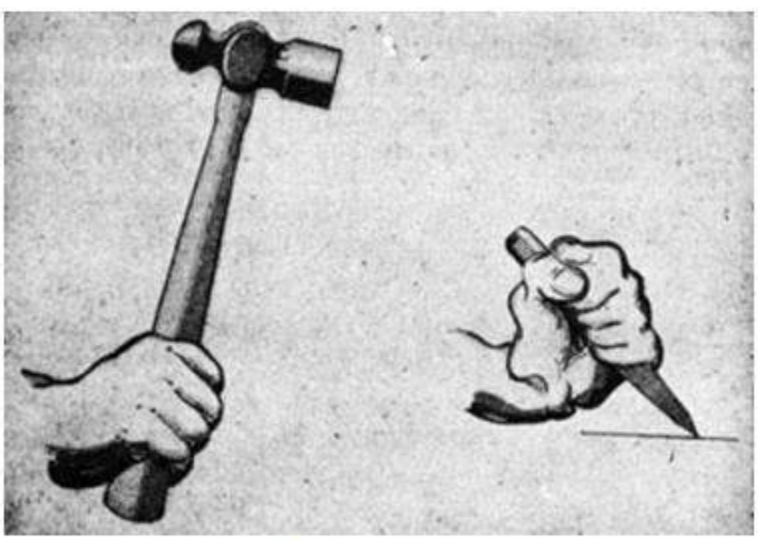

Figure 3-7. How to hold a hammer

Keep the hands and the hammer handle free from grease and oil, otherwise the hammer may slip from the grasp. It should also be remembered that oil or grease on the hammer face may cause it to slip off the work and lead to a painful bruise. Do not ruin the hammer handle by using it for pounding purposes.

Screwdrivers

The screwdriver can be classified by its shape, type of blade, and blade length. It is made for only one purpose, i.e., for loosening or tightening screws or screw head bolts. When using the common screwdriver (Fig. 3-8), select the largest screwdriver whose blade will make a good fit in the screw which is to be turned. A common screwdriver must fill at least 75 % of the screw slot. If the screwdriver is the wrong size, it cuts and burrs the screw slot, making it worthless. A screwdriver with the wrong size blade may slip and damage adjacent parts of the structures.

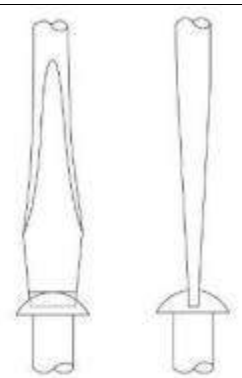

Figure 3-8. The common (slot) screwdriver

When using a screwdriver on a small part, always hold the part in the visa or rest it on a workbench. Do not hold the part in the hand, as the screwdriver may slip and cause serious personal injury. The ratchet or spiral screwdriver is fast acting in that it turns the screw when the handle is pulled back and then pushed forward. It can be set to turn the screw either clockwise or counter clockwise, or it can be locked in position and used as a standard screwdriver. The ratchet screwdriver is not a heavyduty tool and should be used only for light work.

CAUTION: When using a spiral or ratchet screwdriver, extreme care must be used to maintain constant pressure and prevent the blade from slipping out from the slot in the screw head. If this occurs, the surrounding structure is subject to damage.

CAUTION: Do not use a screwdriver to check an electrical circuit where the amperage is high.

CAUTION: Do not hold work in the hand while using a screwdriver.

Interlocking-joint or Tongue-and-Groove Water Pump Pliers

Interlocking-joint pliers are commonly called water pump pliers because they are often used to tighten the packing gland nut around a water pump shaft. These pliers have several curved grooves that make up a series of interlocking joints (Fig. 3-13).

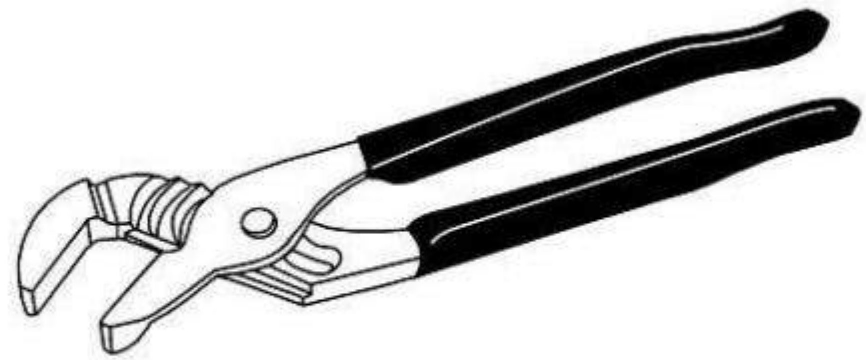

Figure 7.3.13. Interlocking-joint (water pump) pliers

Furthermore, the length of the handles allows a great deal of force to be applied to the jaws. Interlocking joint pliers are available in lengths from around five inches up to about 20 inches.

Vise-Grip Pliers

Vise-Grip is the registered trade name of the Petersen Mfg. Co for special compound-action type pliers. The opening of these jaws is adjustable by a knurled screw located in the end of the pliers handles (Fig. 3-14). When these handles are squeezed together compound leverage multiplies the effort and applies a tremendous force to the jaws. A toggle action clamps the jaws together so they will not open when the handles are released. The jaws are released by a small lever in one of the handles.

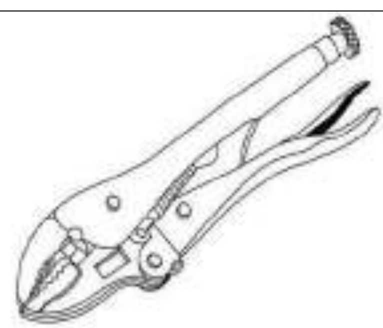

Figure 3-14. Vise-Grip™ pliers

Box-End Wrenches

Exceptionally tight nuts can spread the jaws on even the best open-end wrench. To break the torque on tight nuts a box-end wrench is used. Box-end wrenches have a six-or twelve-point opening attached to each end and offset from the axis of the handle by about 15 degrees (Fig. 3-29).

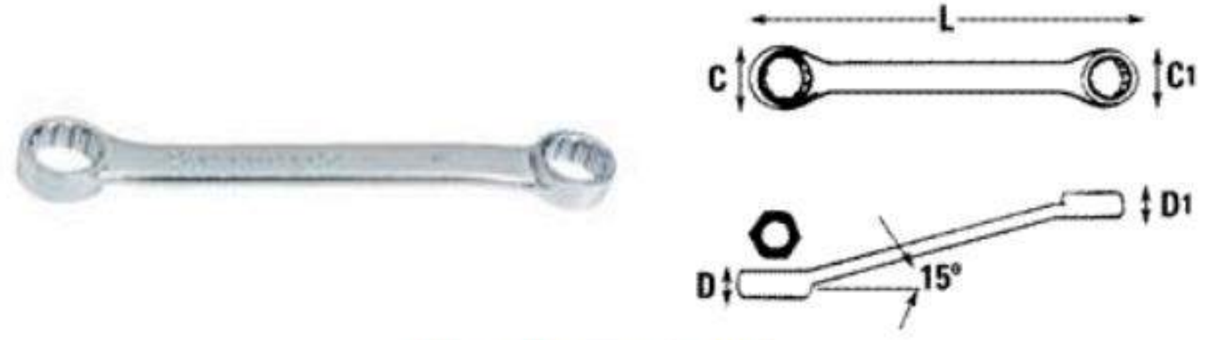

Figure 3-29. Box-end wrenches

Combination Wrench

The disadvantage of a box-end wrench is the limitation of always having to lift and reposition the wrench in order to continue loosening a fastener. On the other hand, an open-end wrench is much easier to slip off and onto a nut. The combination wrench (Fig. 3-31) has the advantage of both a boxend and an open-end wrench.

Special Wrenches
The category of special wrenches includes the spanner, torque, and alien wrenches.

Allen Wrench

Most headless setscrews are the alien type and must be installed and removed with an Allen wrench. Allen wrenches are six-sided bars in the shape of an L (Fig. 3-40). They range in size and fit into a hexagonal recess in the setscrew.

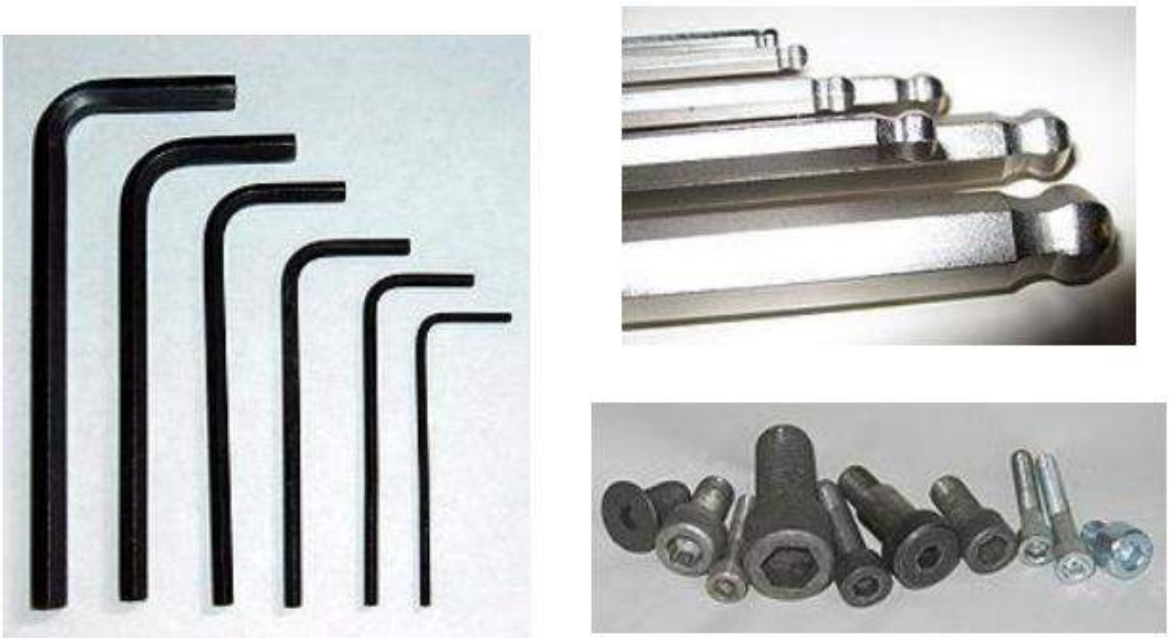

Figure 3-40. Allen wrenches and socket head screws

Some features of hex keys are:

- The tool is simple, small and light;
- The contact surfaces of the screw or bolt are protected from external damage;
- There are six contact surfaces between bolt and driver;
- The tool can be used with a headless screw;
- The screw can be inserted into its hole using the key;
- Torque is constrained by the length and thickness of the key;
- Very small bolt heads can be accommodated;
- The tool can be manufactured very cheaply, so one is often included with products requiring end-user assembly;
- Either end of the tool can be used to take advantage of reach or torque

Chisels

A chisel (Fig. 3-48) is a hard steel cutting tool which can be used for cutting and chipping any metal softer than the chisel itself. It can be used in restricted areas and for such work as shearing rivets, or splitting seized or damaged nuts from bolts.

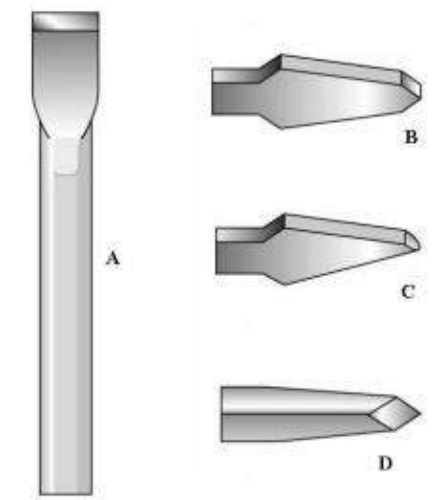

Figure 3-48. A flat head cape (A), round-nose (B, C), and diamond-point (D)metal chisel heads

When using a chisel, hold it firmly in one hand. With the other hand, strike the chisel head squarely with a ball-peen hammer.

Flat Chisels

The flat or cold chisel is the most common type of chisel used by the aviation technician. Flat chisels are made from square or octagonal stock, ranging from 5 /16 inch to 11/16 inch across. The cutting edge of a flat chisel is forged so it is slightly wider than the shank and is ground to an angle of approximately 70 degrees. This angle allows the chisel to cut or shear metal.

When cutting wire or round stock with a cold chisel, the following procedure is recommended:

1. Mark with a scriber or file, or with chalk or colour pencil, the point at which the cut is to be made;
2. Hold the work in place on the anvil or other suitable support. (It is advisable to protect the anvil with a piece of scrap metal.)
3. Hold the chisel with the cutting edge on the mark and the body of the chisel in a vertical position.
4. Strike the chisel a light blow with the hammer, and then examine the chisel mark on the work to make certain that the cut is at the desired point.
5. Drive the chisel into the work with vigorous blows. The last few strokes, however, should be made lightly in order to avoid unnecessary damage to the supporting surface.

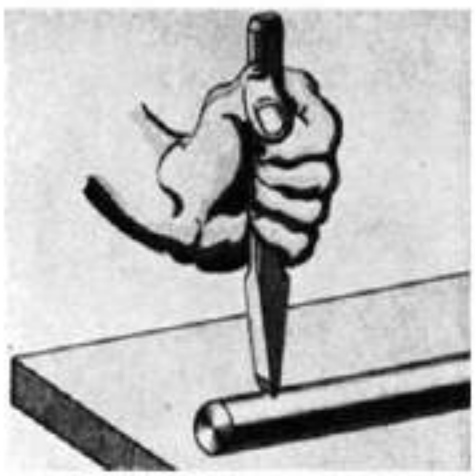

Figure 7.3.55. Cutting round stock with cold chisel

Construction of Twist Drill

Twist drills are made of carbon steel or high-speed alloy steel. Carbon steel drills are satisfactory for the general run of work and are less expensive, although they may lose their hardness if heated excessively. High-speed drills are used on tough metals and at high speeds. They will keep on cutting when red hot, but should be cooled in still air; if cooled quickly they may crack or split.
A twist drill is made up of three parts: the shank, the body, and the point (Fig. 3-81). The shank is the portion held in a chuck. Drills used in aircraft maintenance all have straight shanks (Fig. 3-81A); while drills turned by large drill presses typically have tapered shanks (Fig. 3-81B).

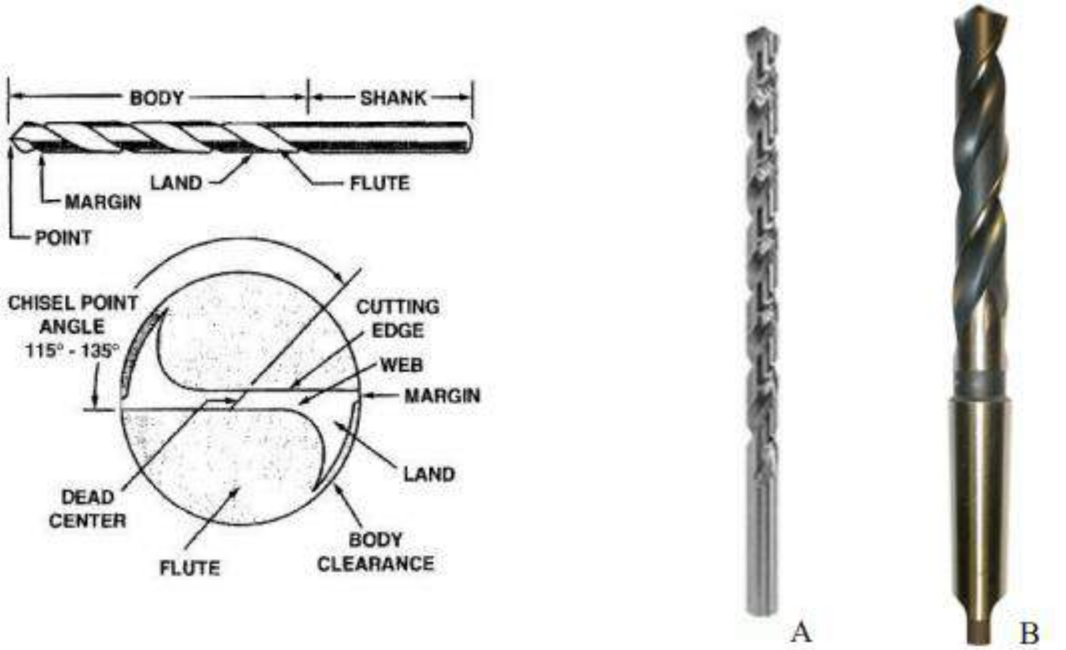

Figure 7.3.81. Construction of twist drill and straight (A) and tapered (B) shanks twist drills

Angle Grinder

An angle grinder, also known as a side or disc grinder is a handheld power tool used for cutting, grinding and polishing (Fig. 3-104).

Figure 3-104. Angle or disk grinder

Angle grinders can be powered by an electric motor, petrol engine or compressed air. The motor drives a geared head at a right-angle on which is mounted an abrasive disc or a thinner cut-off disc, either of which can be replaced when worn. Angle grinders typically have an adjustable guard and a side-handle for two-handed operation. Certain angle grinders, depending on their speed range, can be used as a sander, employing a sanding disc with a backing pad or disc. The backing system is typically made of hard plastic, phenolic resin, or medium-hard rubber depending on the amount of flexibility desired.

Angle grinders may be used both for removing excess material from a piece or simply cutting into a piece. There are many different kinds of discs that are used for various materials and tasks, such as cut-off discs (diamond blade), abrasive grinding discs, grinding stones, sanding discs, wire brush wheels and polishing pads.

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Source 2: - Part 66 Cat. B1 Module 7 MAINTENANCE PRACTICES Volume 1

Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 2 Aircraft Inspection

2.1 INTRODUCTION

Airplanes are designed and built to provide many years of service. For an airplane to remain airworthy and safe to operate, it should be operated in accordance with the recommendations of the manufacturer and ca red for with sound inspection and maintenance practices.

Aircraft inspection may range from a casual "walk around" to a detailed inspection involving complete disassembly and the use of complex inspection aids. This chapter will discuss aircraft inspection requirements and practices as well as review activities, such as servicing and lubrication, that generally accompany inspections.

2.2 REQUIRED AIRCRAFT INSPECTION

In establishing an aircraft's inspection requirements, it is necessary to consider the aircraft's size and type as well as the purpose for which it is used, and its operating environment. Some aircraft must be inspected each 100 hours of time in service, while others must be inspected only once every 12 calendar months. The inspection requirements for aircraft in various types of operation are stated in FAR 91.409.
Small aircraft usually fall under the requirements of annual, 100-h, and progressive inspections. Large aircraft (over 12,500lb = 5.7 tone) and turbine-powered multiengine airplanes (turbojet and turboprop) fall under the jurisdiction of a different set of inspection programs.

Annual and 1 00-Hour Inspections

The annual and 100-h inspections are designed to provide a complete inspection of aircraft at specified intervals. These inspections determine the condition of an aircraft and the maintenance required to return the aircraft to an acceptable condition of airworthiness.

For aircraft operating under FAR Part 91, the maximum interval between annual inspections is 12 calendar months, 356 meaning the aircraft will again become due for inspection on the last day of the same month, 12 months later.

In addition to an annual inspection, aircraft operated commercially are also required to have a 100-hour (h) inspection. The procedures and scope of these inspections are set forth in Appendix D of FAR Part 43 and should be followed in detail (see Figure 16- 1). The regulations speak of

100-h and annual inspections as being of identical scope; the only difference between the two is the persons authorized to perform them.

Certificated airframe and power plant maintenance technicians are authorized to perform a 100-h inspection. A certificated airframe and power plant maintenance technician holding an inspection authorization (lA) issued by the FAA may perform the annual inspection.

An annual inspection may be substituted for a 100-h inspection. The 100-h time limitation may be exceeded by not more than 10 h, if necessary, to reach a place where the inspection can be performed. The excess time, however, is included in computing the next 100 h of time in service.

As an example, an aircraft that flew 105 h between inspections would have only 95 h until the next inspection is due. However, the reverse does not apply. For example, an aircraft that has been inspected after only 90 h does not have 110 h before the next inspection. **There is no provision for exceeding an annual inspection**. To move an aircraft that is "out of annual" requires a **special flight permit from the local FAA flight standards district office (FSDO).**

APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and 100-Hour Inspections

(a) Each person performing an annual or 100-hour inspection shall, before that inspection, remove or open all necessary inspection plates, access doors, fairing, and cowling. He shall thoroughly clean the aircraft and aircraft engine.

(b) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the fuselage and hull group:

(1) Fabric and skin—for deterioration, distortion, other evidence of failure, and defective or insecure attachment of fittings.

(2) Systems and components—for improper installation, apparent defects, and unsatisfactory operation.

(3) Envelope, gas bags, ballast tanks, and related parts—for poor condition.

(c) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the cabin and cockpit group:

(1) Generally—for uncleanliness and loose equipment that might foul the controls.

(2) Seats and safety belts—for poor condition and apparent defects.

(3) Windows and windshields—for deterioration and breakage.

(4) Instruments—for poor condition, mounting, marking, and (where practicable) for improper operation.

(5) Flight and engine controls—for improper installation and improper operation.

(6) Batteries—for improper installation and improper charge.

(7) All systems—for improper installation, poor general condition, apparent and obvious defects, and insecurity of attachment.

(d) Each person performing an annual or 100-hour inspection shall inspect (where applicable) components of the engine and nacelle group as follows:

(1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks.

(2) Studs and nuts—for improper torquing and obvious defects.

(3) Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If there is weak cylinder compression, for improper internal condition and improper internal tolerances.

(4) Engine mount—for cracks, looseness of mounting, and looseness of engine to mount.

(5) Flexible vibration dampeners—for poor condition and deterioration.

(6) Engine controls—for defects, improper travel, and improper safetying.

(7) Lines, hoses, and clamps—for leaks, improper condition, and looseness.

(8) Exhaust stacks—for cracks, defects, and improper attachment.

(9) Accessories—for apparent defects in security of mounting.

(10) All systems—for improper installation, poor general condition, defects, and insecure attachment.

(11) Cowling—for cracks, and defects.

(e) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the landing gear group:

(1) All units—for poor condition and insecurity of attachment.

(2) Shock absorbing devices—for improper oleo fluid level.

(3) Linkage, trusses, and members—for undue or excessive wear, fatigue, and distortion.

(4) Retracting and locking mechanism—for improper operation.

(5) Hydraulic lines—for leakage.

(6) Electrical system—for chafing and improper operation of switches.

(7) Wheels—for cracks, defects, and condition of bearings.

(8) Tires—for wear and cuts.

(9) Brakes—for improper adjustment.

(10) Floats and skis—for insecure attachment and obvious or apparent defects.

(f) Each person performing an annual or 100-hour inspection shall inspect (where applicable) all components of the wing and center section assembly for poor general condition, fabric or skin deterioration, distortion, evidence of failure, and insecurity of attachment.

(g) Each person performing an annual or 100-hour inspection shall inspect (where applicable) all components and systems that make up the complete empennage assembly for poor general condition, fabric or skin deterioration, distortion, evidence of failure, insecure attachment, improper component installation, and improper component operation.

(h) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the propeller group:

(1) Propeller assembly—for cracks, nicks, binds, and oil leakage.

(2) Bolts—for improper torquing and lack of safetying.

(3) Anti-icing devices—for improper operations and obvious defects.

(4) Control mechanisms—for improper operation, insecure mounting, and restricted travel.

(i) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the radio group:

(1) Radio and electronic equipment—for improper installation and insecure mounting.

(2) Wiring and conduits—for improper routing, insecure mounting, and obvious defects.

(3) Bonding and shielding—for improper installation and poor condition.

(4) Antenna including trailing antenna—for poor condition, insecure mounting, and improper operation.

(j) Each person performing an annual or 100-hour inspection shall inspect (where applicable) each installed miscellaneous item that is not otherwise covered by this listing for improper installation and improper operation.

FIGURE 16–1 FAR 43, Appendix D.

In most instances, it is preferable to use the manufacturer's checklist since it was written specifically to include the procedures and details necessary to adequately inspect that particular make and model of aircraft (see Figure 16-2). The checklist will usually be found in the aircraft maintenance manual.

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	Inspection Time 50	100	500	1000
A. PROPELLER GROUP				
1. Inspect spinner and back plate for cracks	O	O	O	O
2. Inspect blades for nicks and cracks	O	O	O	O
3. Check for grease and oil leaks	O	O	O	O
4. Lubricate propeller per Lubrication Chart	O	O	O	O
5. Check spinner mounting brackets for cracks		O	O	O
6. Check propeller mounting bolts and safety (Check torque if safety is broken)		O	O	O
7. Inspect hub parts for cracks and corrosion		O	O	O
8. Rotate blades of constant speed propeller and check for tightness in hub pilot tube		O	O	O
9. Remove constant speed propeller; remove sludge from propeller and crankshaft			O	O
10. Inspect complete propeller and spinner assembly for security, chafing, cracks, deterioration, wear and correct installation		O	O	O
11. Check propeller air pressure (at least once a month)	O	O	O	O
12. Overhaul propeller				O
B. ENGINE GROUP				
CAUTION: Ground Magneto Primary Circuit before working on engine.				
1. Remove engine cowl	O	O	O	O
2. Clean and check cowling for cracks, distortion and loose or missing fasteners		O	O	O
3. Drain oil sump (See Note 2)	O	O	O	O
4. Clean suction oil strainer at oil change (Check strainer for foreign particles)	O	O	O	O
5. Clean pressure oil strainer or change full flow (cartridge type) oil filter element (Check strainer or element for foreign particles)	O	O	O	O
6. Check oil temperature sender unit for leaks and security		O	O	O
7. Check oil lines and fitting for leaks, security, chafing, dents and cracks (See	O	O	O	O
Note 4)	O	O	O	O
8. Clean and check oil radiator cooling fins		O	O	O
9. Remove and flush oil radiators			O	O
10. Fill engine with oil per information on cowl or Lubrication Chart	O	O	O	O
11. Clean engine	O	O	O	O
CAUTION: Use caution not to contaminate vacuum pump with cleaning fluid. Refer to Lycoming Service Letter 1221A.				
12. Check condition of spark plugs (Clean and adjust gap as required; adjust per Lycoming Service Instruction No. 1042)		O	O	O
13. Check cylinder compression (Refer to AC 43.13-1A)		O	O	O
14. Check ignition harness and insulators (High tension leakage and continuity)		O	O	O
15. Check magneto points for proper clearance (Maintain clearance at .018 ± .006)		O	O	O
16. Check magneto for oil seal leakage		O	O	O
17. Check breaker felts for proper lubrication		O	O	O
18. Check distributor block for cracks, burned areas or corrosion and height of contact springs			O	O
19. Check magnetos to engine timing		O	O	O
20. Overhaul or replace magnetos (See Note 3)				O
21. Remove air filters and tap gently to remove dirt particles (Replace as required)	O	O	O	O
22. Clean fuel injector inlet line strainer (Clean injector nozzles as required) (Clean with acetone only)	O	O	O	O
23. Check condition of injector alternate air doors and boxes	O	O	O	O
24. Remove induction air box valve and inspect for evidence of excessive wear or cracks. Replace defective parts (See Note 7)		O	O	O
25. Inspect fuel injector attachments for loose hardware (See Note 8)		O	O	O
26. Check intake seals for leaks and clamps for tightness		O	O	O
27. Inspect all air inlet duct hoses (Replace as required)		O	O	O
28. Inspect condition of flexible fuel lines		O	O	O
29. Replace flexible fuel lines (See Note 3)				O
30. Check fuel system for leaks		O	O	O
31. Check fuel pumps for operation (Engine driven and electric)		O	O	O
32. Overhaul or replace fuel pumps (Engine driven and electric) (See Note 3)				O
33. Check vacuum pumps and lines		O	O	O
34. Overhaul or replace vacuum pumps (See Note 3)				O
35. Check throttle, alternate air, mixture and propeller governor controls for travel and operating condition		O	O	O
NOTE: Visually inspect the exhaust system per Piper Service Bulletin No. 373A at each 25 hours of operation. (See Note 10.)				
36. Inspect exhaust stacks, connections and gaskets for cracks and loose mounting (Replace gaskets as required)	O	O	O	O
37. Inspect muffler, heat exchange, baffles and "augmentor" tube (See Note 6)	O	O	O	O
38. Check breather tubes for obstructions and security		O	O	O
39. Check crankcase for cracks, leaks and security of seam bolts		O	O	O
40. Check engine mounts for cracks and loose mountings		O	O	O
41. Check engine baffles for cracks and loose mounting		O	O	O
42. Check rubber engine mount bushings for deterioration (Replace as required)		O	O	O
43. Check fire wall seals		O	O	O
44. Check condition and tension of alternator drive belt		O	O	O
45. Check condition of alternator and starter		O	O	O
46. Check fluid in brake reservoir (Fill as required)	O	O	O	O
47. Inspect all lines, air ducts, electrical leads and engine attachments for security, proper routing, chafing, cracks, deterioration and correct installation	O	O	O	O
48. Lubricate all controls		O	O	O
49. Overhaul or replace propeller governor (See Note 3)				O
50. Complete overhaul of engine or replace with factory rebuilt (See Note 3)				O
51. Reinstall engine cowl	O	O	O	O

NOTES:

1. Both the annual and 100 hour inspections are complete inspections of the airplane, identical in scope, while both the 500 and 1000 hour inspections are extensions of the annual or 100 hour inspection, which require a more detailed examination of the airplane, and overhaul or replacement of some major components. Inspection must be accomplished by persons authorized by the FAA.
2. Intervals between oil changes can be increased as much as 100% on engines equipped with full flow (cartridge type) oil filters - provided the element is replaced each 50 hours of operation.
3. Replace or overhaul as required or at engine overhaul. (For engine overhaul, refer to Lycoming Service Instructions No. 1009.)
4. Replace flexible oil lines as required, but no later than 1000 hours of service.
5. Refer to Piper Service Letter No. 597 for flap control cable attachment bolt use.
6. Refer to Piper Service Bulletin No. 373A for exhaust system inspection.
7. Refer to Piper Service Bulletin No. 358.
8. Torque all attachment nuts to 135 to 150 inch-pounds. Seat "Pal" nuts finger tight against plain nuts and then tighten an additional 1/3 to 1/2 turn.
9. Inspect rudder trim tab for "free play;" must not exceed .125 inches. Refer to Service Manual for procedure, Section V. Refer to Piper Service Bulletin No. 390A.
10. Compliance with Piper Service Letter No. 673 eliminates repetitive inspection requirements of Piper Service Bulletin No. 373A and FAA Airworthiness Directive No. 73-14-2.
11. Piper Service Letter No. 704 should be complied with.

FIGURE 16–2 Inspection checklist for a light airplane. *(Piper Aircraft Corp.)*

Nature of Inspection	50	100	500	1000
C. CABIN GROUP				
1. Inspect cabin entrance, doors and windows for damage and operation		O	O	O
2. Check upholstery for tears		O	O	O
3. Check seats, seat belts, security brackets and bolts		O	O	O
4. Check trim operation		O	O	O
5. Check operation and condition of rudder pedals		O	O	O
6. Check parking brake handle and toe brakes for operation and cylinder leaks		O	O	O
7. Check control wheels, column, pulleys and cables		O	O	O
8. Check flap control cable attachment bolt per Note 5		O	O	O
9. Check landing, navigation, cabin and instrument lights		O	O	O
10. Check instruments, lines and attachments	O	O	O	O
11. Check manifold pressure gauge filters (2); replace as required		O	O	O
12. Check gyro operated instruments and electric turn and bank (Overhaul or replace as required)		O	O	O
13. Replace filters in gyro horizon and directional gyro or replace central air filter		O	O	O
14. Clean or replace vacuum regulator filter		O	O	O
15. Check altimeter (Calibrate altimeter system in accordance with FAR 91.170, if appropriate)		O	O	O
16. Perform pitot-static tests, if appropriate (Refer to FAR 91.170)		O	O	O
17. Check operation of fuel selector valves		O	O	O
18. Check operation of fuel drains (See Note 11)		O	O	O
19. Check condition of heater controls and ducts		O	O	O
20. Check condition and operation of air vents		O	O	O
D. FUSELAGE AND EMPENNAGE GROUP				
1. Remove inspection plates and panels		O	O	O
2. Check baggage doors, latches and hinges		O	O	O
3. Check battery, box and cables (Check at least every 30 days. Flush box as required and fill battery per instructions on box)	O	O	O	O
4. Check electronic installation		O	O	O
5. Check bulkheads and stringers for damage		O	O	O
6. Check antenna mounts and electric wiring		O	O	O
7. Check hydraulic pump fluid level (Fill as required)	O	O	O	O
8. Check hydraulic pump lines for damage and leaks		O	O	O
9. Check fuel lines, valves and gauges for damage and operation		O	O	O
10. Check security of all lines		O	O	O
11. Check vertical fin and rudder surfaces for damage		O	O	O
12. Check rudder hinges, horn and attachments for damage and operation		O	O	O
13. Check vertical fin attachments		O	O	O
14. Check ELT installation and condition of battery and antenna		O	O	O
15. Check rudder, tab hinge bolts for excess wear (Replace as required)		O	O	O
16. Check rudder trim mechanism (See Note 9)		O	O	O
17. Check stabilator surfaces for damage		O	O	O
18. Check stabilator, tab hinges, horn and attachments for damage and operation		O	O	O

Nature of Inspection	50	100	500	1000
19. Check stabilator attachments		O	O	O
20. Check stabilator and tab hinge bolts and bearings for excess wear (Replace as required)		O	O	O
21. Check stabilator trim mechanism (Check tab free play) (Refer to Section V)		O	O	O
22. Check aileron, rudder, stabilator, stabilator trim cables, turnbuckles, guides and pulleys for safety, damage and operation	O	O	O	O
23. Inspect all control cables, air ducts, electrical leads and attaching parts for security, routing, chafing, deterioration, wear and correct installation		O	O	O
24. Clean and lubricate stabilator trim drum screw			O	O
25. Clean and lubricate all exterior needle bearings				O
26. Lubricate per Lubrication Chart	O	O	O	O
27. Check rotating beacon for security and operation		O	O	O
28. Check condition and security of Autopilot bridle cable and clamps		O	O	O
29. Reinstall inspection plates and panels		O	O	O
E. WING GROUP				
1. Remove inspection plates and fairings		O	O	O
2. Check surfaces and tips for damage, loose rivets, and condition of walk-way		O	O	O
3. Check aileron hinges and attachments		O	O	O
4. Check aileron cables, pulleys and bellcranks for damage and operation		O	O	O
5. Check flaps and attachments for damage and operation		O	O	O
6. Check condition of bolts used with hinges (Replace as required)				O
7. Lubricate per Lubrication Chart	O	O	O	O
8. Check wing attachment bolts and brackets		O	O	O
9. Inspect all control cables, air ducts, electrical leads, lines and attaching parts for security, routing, chafing, deterioration, wear and correct installation		O	O	O
10. Check fuel tanks and lines for leaks and water		O	O	O
11. Remove, drain and clean fuel gascolator bowls (Drain and clean at least every 90 days)		O	O	O
12. Fuel tanks marked for capacity		O	O	O
13. Fuel tanks marked for minimum octane rating		O	O	O
14. Check fuel tank vents (Refer to Piper Service Bulletin No. 382)		O	O	O
15. Reinstall inspection plates and fairings		O	O	O

NOTES:

1. Both the annual and 100 hour inspections are complete inspections of the airplane, identical in scope, while both the 500 and 1000 hour inspections are extensions of the annual or 100 hour inspection, which require a more detailed examination of the airplane, and overhaul or replacement of some major components. Inspection must be accomplished by persons authorized by the FAA.
2. Intervals between oil changes can be increased as much as 100% on engines equipped with full flow (cartridge type) oil filters - provided the element is replaced each 50 hours of operation.
3. Replace or overhaul as required or at engine overhaul. (For engine overhaul, refer to Lycoming Service Instructions No. 1009.)
4. Replace flexible oil lines as required, but no later than 1000 hours of service.
5. Refer to Piper Service Letter No. 597 for flap control cable attachment bolt use.
6. Refer to Piper Service Bulletin No. 373A for exhaust system inspection.
7. Refer to Piper Service Bulletin No. 358.
8. Torque all attachment nuts to 135 to 150 inch-pounds. Seat "Pal" nuts finger tight against plain nuts and then tighten an additional 1/3 to 1/2 turn.
9. Inspect rudder trim tab for "free play;" must not exceed .125 inches. Refer to Service Manual for procedure, Section V. Refer to Piper Service Bulletin No. 390A.
10. Compliance with Piper Service Letter No. 673 eliminates repetitive inspection requirements of Piper Service Bulletin No. 373A and FAA Airworthiness Directive No. 73-14-2.
11. Piper Service Letter No. 704 should be complied with.

FIGURE 16–2 Continued.

Nature of Inspection	Inspection Time 50	100	500	1000
F. LANDING GEAR GROUP				
1. Check oleo struts for proper extension (Check for proper fluid level as required)	O	O	O	O
2. Check nose gear steering control and travel		O	O	O
3. Check wheel alignment		O	O	O
4. Put airplane on jacks (Refer to Section II)		O	O	O
5. Check tires for cuts, uneven or excessive wear and slippage		O	O	O
6. Remove wheels, clean, check and repack bearings		O	O	O
7. Check wheels for cracks, corrosion and broken bolts		O	O	O
8. Check tire pressure (N-31 psi/M-50 psi)	O	O	O	O
9. Check brake lining and disc		O	O	O
10. Check brake backing plates		O	O	O
11. Check brake lines and retaining clamps		O	O	O
12. Check condition of center spring		O	O	O
13. Check gear forks for damage		O	O	O
14. Check oleo struts for fluid leaks and scoring		O	O	O
15. Check gear struts, attachments, torque links, retraction links and bolts for condition and security		O	O	O
16. Check downlocks for operation and adjustment		O	O	O
17. Check torque link bolts and bushings (Rebush as required)			O	O
18. Check drag end side brace link bolts (Replace as required)				O
19. Check gear doors and attachments		O	O	O
20. Check gear warning horn and light for operation		O	O	O
21. Check hydraulic fluid level in pump reservoir		O	O	O
22. Retract gear - check operation		O	O	O
23. Retract gear - check doors for clearance and operation		O	O	O
24. Check operation of squat switch		O	O	O
25. Check downlock switches, up-switches and electrical leads for security		O	O	O
26. Lubricate per Lubrication Chart	O	O	O	O
27. Remove airplane from jacks		O	O	O

Nature of Inspection	Inspection Time 50	100	500	1000
G. OPERATIONAL INSPECTION				
1. Check fuel pumps, fuel tank selector and crossfeed operation	O	O	O	O
2. Check fuel quantity and pressure or flow gauges	O	O	O	O
3. Check oil pressure and temperatures	O	O	O	O
4. Check alternator output	O	O	O	O
5. Check manifold pressure	O	O	O	O
6. Check alternate air	O	O	O	O
7. Check parking brake and toe brakes	O	O	O	O
8. Check vacuum gauge	O	O	O	O
9. Check gyros for noise and roughness	O	O	O	O
10. Check cabin heater operation	O	O	O	O
11. Check magneto switch operation	O	O	O	O
12. Check magneto RPM variation	O	O	O	O
13. Check throttle and mixture operation	O	O	O	O
14. Check propeller smoothness	O	O	O	O
15. Check constant speed propeller action	O	O	O	O
16. Check engine idle	O	O	O	O
17. Check electronic equipment operation	O	O	O	O
18. Check operation of controls	O	O	O	O
19. Check operation of flaps	O	O	O	O
H. GENERAL				
1. Aircraft conforms to FAA Specifications	O	O	O	O
2. All FAA Airworthiness Directives complied with	O	O	O	O
3. All Manufacturers Service Letters and Bulletins complied with	O	O	O	O
4. Check for proper Flight Manual	O	O	O	O
5. Aircraft papers in proper order	O	O	O	O

NOTES:

1. Both the annual and 100 hour inspections are complete inspections of the airplane, identical in scope, while both the 500 and 1000 hour inspections are extensions of the annual or 100 hour inspection, which require a more detailed examination of the airplane, and overhaul or replacement of some major components. Inspection must be accomplished by persons authorized by the FAA.
2. Intervals between oil changes can be increased as much as 100% on engines equipped with full flow (cartridge type) oil filters - provided the element is replaced each 50 hours of operation.
3. Replace or overhaul as required or at engine overhaul. (For engine overhaul, refer to Lycoming Service Instructions No. 1009.)
4. Replace flexible oil lines as required, but no later than 1000-hours of service.
5. Refer to Piper Service Letter No. 597 for flap control cable attachment bolt use.
6. Refer to Piper Service Bulletin No. 373A for exhaust system inspection.
7. Refer to Piper Service Bulletin No. 358.
8. Torque all attachment nuts to 135 to 150 inch-pounds. Seat "Pal" nuts finger tight against plain nuts and then tighten an additional 1/3 to 1/2 turn.
9. Inspect rudder trim tab for "free play;" must not exceed .125 inches. Refer to Service Manual for procedure, Section V. Refer to Piper Service Bulletin No. 390A.
10. Compliance with Piper Service Letter No. 673 eliminates repetitive inspection requirements of Piper Service Bulletin No. 373A and FAA Airworthiness Directive No. 73-14-2.
11. Piper Service Letter No. 704 should be complied with.

FIGURE 16–2 Continued.

Walk-Around Inspections

To keep an aircraft in proper operating condition and to locate defects that arise between major inspections, manufacturers recommend various types of walk-around and preflight inspections. Frequent minor inspections of airliners are conducted by flight engineers or maintenance personnel. The inspections are usually conducted at every stop at which time permits (see Figure 16- 5). For example, the inspector might carry a flashlight and check the interior of the tailpipe for the condition of the turbines and thrust reversers. The inspector further might check the tires, look for fluid leaks, and examine the fuselage and control surfaces for wrinkles and any other condition that indicates deterioration or damage.

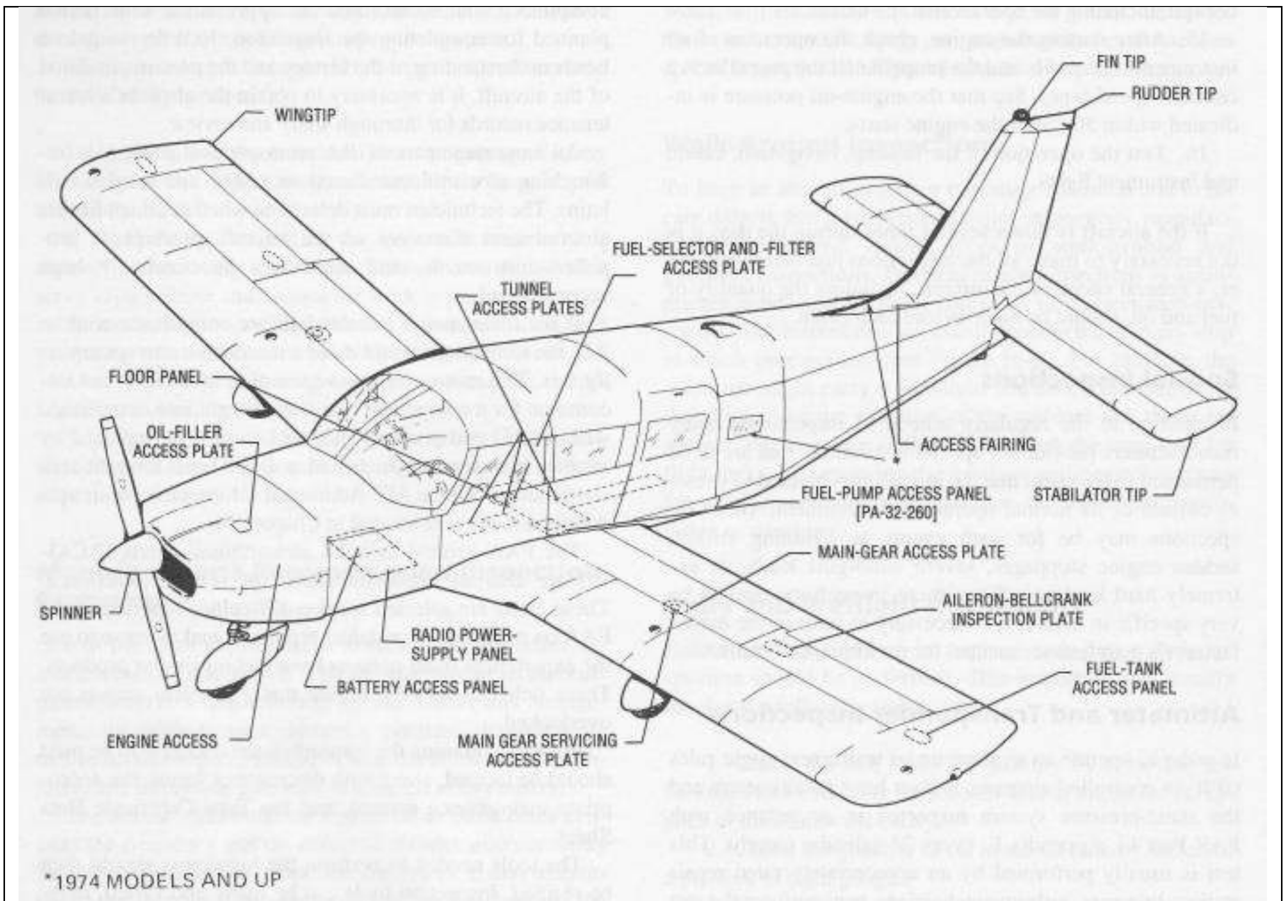


FIGURE 16–6 Access plates and panels.

Daily and Preflight Inspections

Before the first flight of an airplane each day, a daily inspection should be performed. This inspection will usually involve the following instructions:

1. Check the fuel tanks for quantity by removing the fuel caps and observing the level of fuel in the tanks. A dipstick is sometimes necessary.

2. Check the quantity of oil in the oil tank by means of a dipstick or sight gauge.

3. Drain a small amount of fuel from each of the fuel drains and strainers. This is to ensure that sediment and water are removed from the tanks.

4. Check the inflation of all tires.

5. Check the extension of the shock struts to ensure that they are properly inflated.

6. Check the engine compartment for loose wires and fittings. Visually inspect spark-plug leads, nuts, air ducts, exhaust pipes, controls, and accessories. Check for oil leaks.

7. Examine the propeller blades for grooves, cuts, and evidence of any other damage.

8. With the ignition switch off, turn the propeller by hand at least two revolutions and note any unusual noises or other indications of malfunction. Stand clear of the propeller's plane of rotation.

9. Inspect the hinges and the control attachments for all control surfaces. Test each control for freedom of movement.

10. Visually inspect the exterior of the aircraft for damage, loose parts, or any other unsatisfactory condition. Check for fluid leaks.

11. Inspect the windshield, windows, and doors for damage. Check the door or doors for proper latching and locking.

12. Inspect the interior of the cabin and cockpit, including the seat belts, the seats, and any loose parts on the floor.

13. Test the operation of all controls from within the cockpit, including the operation of the brakes.

14. After starting the engine, check the operation of all instruments, the radio, and the propeller (if the propeller is a constant-speed type). See that the engine-oil pressure is indicated within 30 s after the engine starts.

15. Test the operation of the landing, navigation, cabin, and instrument lights. If the aircraft is flown several times during the day, it is not necessary to make all the inspections just listed; however, a general check of the aircraft, including the quantity of fuel and oil, should be made before each flight.

Al-Najaf Technical Institute
Aeronautical Technologies Department
Year Two
Subject: - Aircraft Maintenance

Lecturer Notes by Dr. Essam Al-Zaini

Source 1: - Aviation Maintenance Technician Handbook—Airframe Volume 1, 2012, U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION

Source 2: - Part 66 Cat. B1 Module 7 MAINTENANCE PRACTICES Volume 1

Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 3 Aircraft Oxygen System

3.1 INTRODUCTION

The airplane utilizes an **1800 psi** high-pressure oxygen system which provides the pilot and co-pilot with a diluter-demand type of oxygen supply.

Provisions leave also been made through a shutoff valve for future incorporation of a low-pressure (17 to 42 psi), continuous flow supply system for the passenger compartment. Installation of an automatic continuous flow regulator and wall outlets located as required and according to compartment arrangement is required to complete the passenger compartment oxygen system. (This is a function of the furnishing agency).

The usual installation consists of a plug-in type of outlet at each seat with disposable masks. One or two outlets, (including a therapeutic outlet), are in the lavatory.

The therapeutic_ outlet flow is rated at several times the normal flow and is utilized in case passenger illness or respiratory problems arise. Unless the cabin installation includes special types of outlets and masks with built-in demand type regulators, standard plug-in masks used will cause oxygen to flow only when plugged in.

This flow is at a continuous rate, regardless of whether the mask is on or not provided the supply and cabin shutoff valves in the cockpit are both on. Removing the mask plug will shut off the flow at that outlet.

Major components of the oxygen system installed in the basic production airplane are listed in the following table.

Unit	No. Per Airplane	Location
Filler Valve	1	Nose wheel well, left side
Oxygen Cylinder	1	Forward of cockpit
Diluter-Demand Regulator	2	One each in the aft section of pilot's and co-pilot's side consoles
Pressure Gage	1	Pilot's outboard skirt panel.
Flow Indicator	2	One on the pilot's outboard skirt panel adjacent to the pressure gage, and one on the co-pilot's outboard skirt panel adjacent to the normal hydraulic pressure gage.

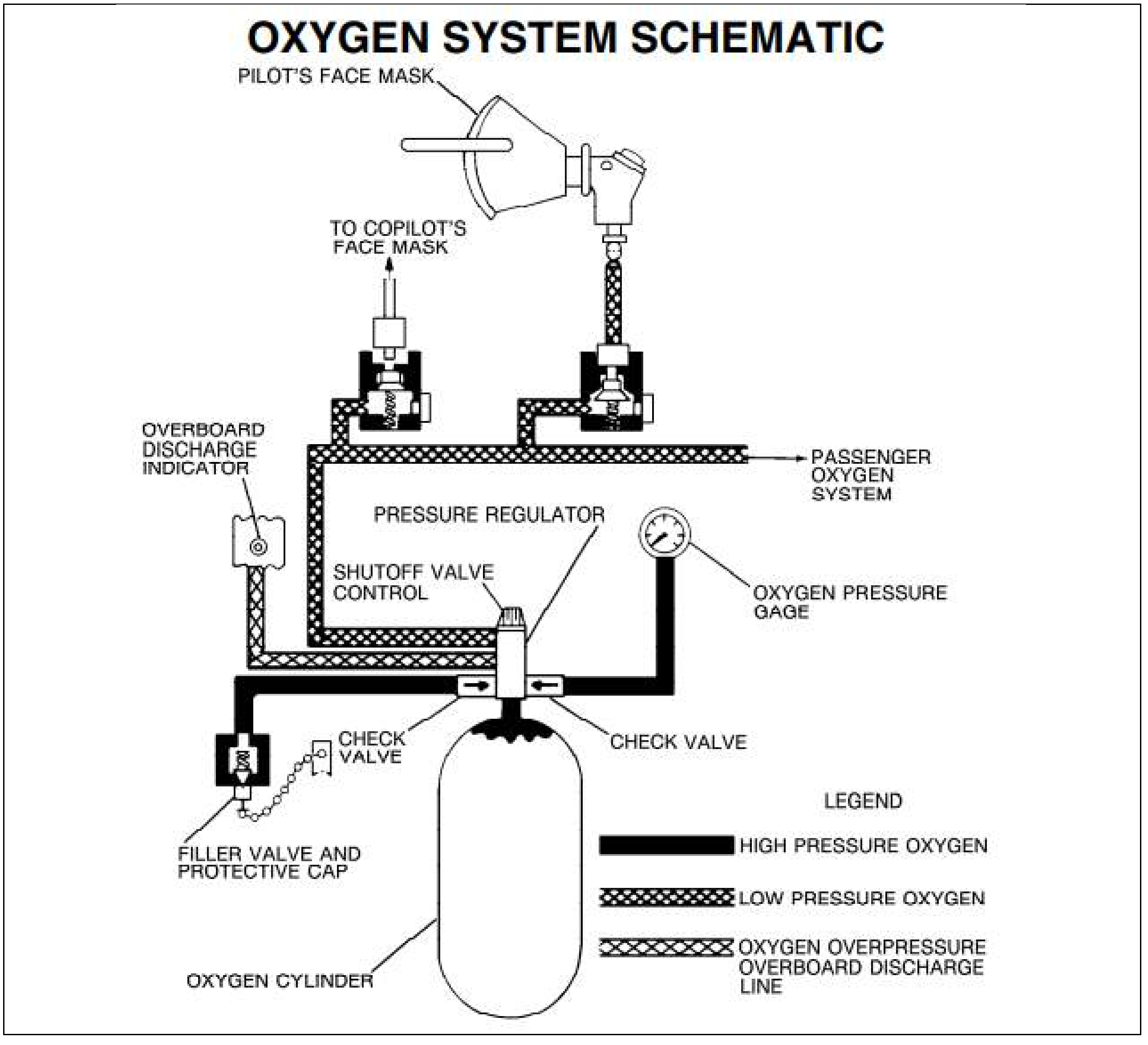
Unit	No. Per Airplane	Location
Cabin Shutoff Valve	1	Aft section of co-pilot's side console adjacent to the diluter demand regulator.
Oxygen Supply Shutoff Valve	1	Lower left skirt of pilot's panel.

The oxygen supply from the oxygen cylinder is routed with a common rigid tubing outlet line through a **cockpit oxygen shutoff valve** to each **diluter-demand regulator**. **The oxygen supply shutoff valve** acts as an internal master shutoff for the entire aircraft oxygen supply - both passenger and crew. The oxygen supply shutoff valve should remain closed at all times until oxygen is required in flight.

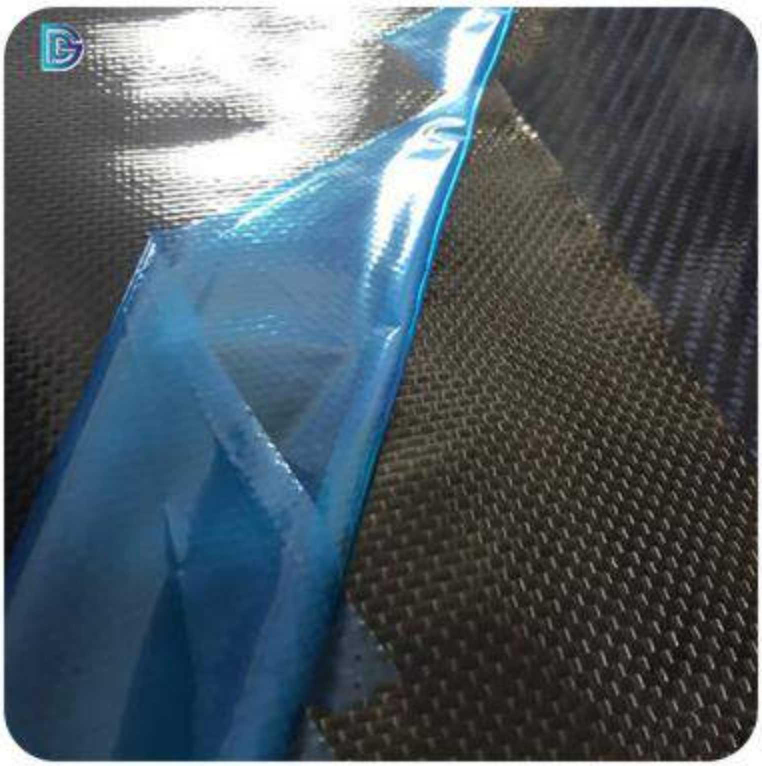
NOTE: The cabin shutoff valve will stop all oxygen flow to the passengers when closed, but will not affect the crew supply

Flexible hoses attached to each regulator provide the oxygen mask connections for each flight crew member. **A 0 to 2000 psi** oxygen cylinder pressure gage located on the pilot's outboard skirt panel indicates the available oxygen supply in the system. Oxygen is routed from the gage to the crew distribution system, and also to the passenger distribution system.

NOTE: Do not attempt to read cylinder pressure gage until after the oxygen supply shutoff valve is open, since the gage is downstream of the valve. Opening the valve slowly will bring cylinder pressure into the gage and the rest of the system, and this is the only way to check the cylinder pressure. (See figure 1.)



A fully charged, **49 or 76 (optional) cubic foot cylinder**, located in the nose compartment, provides ample oxygen for normal flight requirements and an emergency descent. The light weight bottle is made of **Kevlar, impregnated with epoxy resin** which is wound longitudinally and circumferentially over a seamless aluminum liner.



The cylinder must not be allowed to become completely discharged, since there is a possibility of contamination due to negative pressures which can occur with temperature changes. **A completely discharged container must therefore be treated as if the pressure regulator has been damaged, and reconditioned.**

A **blinker type flow indicator** is connected to each diluter-demand regulator to provide a visual indication of the proper operation of the regulator. A tee fitting connects one outlet of the oxygen supply shutoff valve to the diluter-demand regulator on the co-pilot's console and the cabin shutoff valve.

3.2 SERVICING OXYGEN SYSTEM

Service Oxygen Cylinder

The oxygen cylinder is located in the nose section on the left side.

(1) Maximum pressure for the oxygen cylinder is 1800 PSI at 15°C (59°F), 1700 PSI at - 1°C (30°F), or 1970 PSI at 43°C) (110,'F.) .

NOTE: The minimum amount of oxygen required for the flight crew is 1000 PSI at 15°C (59°F). (Standard Day)

(2) Replace oxygen cylinder if pressure becomes less than 50 PSI.
(3) Recharge cylinder through filler valve located on the left side of the nose wheel well.

NOTE: It is recommended that oxygen cylinder pressure not be permitted to get below 100 PSI.

To recharge oxygen cylinder using the oxygen filler valve on the left Side, forward in the nose wheel well, proceed as follows:

WARNING: USE ONLY AVIATOR'S GASEOUS BREATHING OXYGEN. MILITARY SPECIFICATION MIL-0-27210 TO SERVICE OXYGEN CYLINDER. KEEP ALL LUBRICANTS CLEAR OF OXYGEN.

(1) Aircraft 1 through 200 including 322 and 323, not having ASC 200A incorporated:

(a) In cockpit, ensure that the pilot's and copilot's regulator red emergency knob is fully closed; and that the CABIN SHUTOFF VALVE (copilot's side console-aft) is CLOSED.

(b) Open the oxygen shutoff valve on the pilot's outboard skirt panel. The oxygen cylinder pressure gage on the same panel should indicate cylinder pressure.

(c) Gain access to oxygen filler valve in forward, left side of nose wheel well by opening clamshell doors, using procedure outlined in Section 12 0.

WARNING: BEFORE WORKING IN ANY WHEEL WELL, ENSURE THAT ALL LANDING GEAR AND LANDING GEAR DOOR SAFETY DEVICES ARE IN STALLED.

(d) In the nose wheel well, remove the cap from the oxygen filler valve. Clean any dirt and contamination from the valve.

(e) On external oxygen filler equipment (must be capable of supplying 1800 PSI at 15°C [59°F] with shutoff valve on unit) crack external filler rig shutoff valve to blow rig line clear of dirt and contamination before connection to aircraft. Close valve.

(f) In nose wheel well, connect external oxygen filler equipment to oxygen filler valve.

(g) With a man in the cockpit to observe cylinder pressure gage, slowly open external equipment rig shutoff valve and fill cylinder until gage reads the proper level as predetermined by Table A.

(h) Close the external oxygen filler equipment shutoff valve when the correct pressure is reached.

(i) In the cockpit close the oxygen supply shutoff valve.

(j) Disconnect the external equipment supply line from the filler valve.

(k) Test the filler valve opening for leaks with MIL-L-25576 Leak-Tec formula OX16 or solution conforming to MIL-L-25576. Wipe off solution after test is completed.

Table A

Initial Temperature (F)	Filling Pressure (PSIG)
0	1595
10	1630
20	1665
30	1700
40	1730
50	1765
60	1800
70	1835
80	1865
90	1900
100	1935
110	1970
120	2000

(0°C × 9/5) + 32 = 32°F

NOTE: Initial temperature refers to ambient temperature before filling. Filling pressure refers to pressure to which cylinders must be filled.

(1) Replace cap on filler valve and tighten to a low torque. Cap keeps connection clean, and ensures against leaks. Therefore, it must be replaced.

NOTE: The filter valve has an allowable leak rate of 0.5 liter per minute. It is therefore necessary to replace the cap on the valve to prevent leakage.

(2) Aircraft 1 through 200 including 322 and 323 having ASC 200A incorporated

(a) In cockpit, ensure that the pilot's and copilot's regulator red emergency knob is fully closed: and the CABIN SHUTOFF VALVE (copilot's side console-aft) and the OXYGEN SUPPLY SHUTOFF VALVE on the pilot's outboard panel are CLOSED

WARNING: COMPARTMENT INTERIOR, FILLER VALVE AND CONNECTION MUST BE COMPLETELY FREE OF CONTAMINATION

(b) Open the oxygen servicing compartment access door and remove the oxygen filler valve cap from the valve
(c) On external oxygen filler equipment (must be capable of supplying1800 PSI at 15° C (59° F) with shutoff valve on unit) crack external filler rig shutoff valve to blow rig line clear of dirt and contamination before connection to aircraft. Close valve.
(d) Connect external rig to oxygen filler valve.
(e) While observing OXYGEN CYLINDER PRESSURE GAGE, adjacent to the oxygen filler valve slowly open external rig shutoff valve and fill cylinder until CYLINDER GAGE reads proper level as determined from Table A of this page.
(f) Close external rig shutoff valve when correct pressure is reached.
(g) Disconnect external rig supply line from filler valve
(h) Check filler valve opening for leaks with Leak-Tec formula OX16 or solution conforming to MIL-L-25576. Wipe off solution after test for leak is completed.
(i) Replace cap on filler valve and tighten to a low torque. Cap keeps connection clean, and ensures against leaks, therefore, it must be replaced.

NOTE: The filler valve has an allowable leak rate of 0.5 liter per minute. It is therefore necessary to replace the cap on the valve to prevent leakage.

(j) Close access door.

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Source 1: - Aviation Maintenance Technician Handbook—Airframe Volume 1, 2012, U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION

Source 2: - Part 66 Cat. B1 Module 7 MAINTENANCE PRACTICES Volume 1

Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 4 Aircraft Air-conditioning System

4.1 INTRODUCTION

There are two types of air conditioning systems commonly used on aircraft. **Air cycle** air conditioning is used on most turbine-powered aircraft. It makes use of engine bleed air or APU pneumatic air during the conditioning process. **Vapor cycle** air conditioning systems are often used on reciprocating aircraft. This type system is similar to that found in homes and automobiles. Note that some turbine-powered aircraft also use vapor cycle air conditioning.

4.1.1 Air Cycle Air Conditioning

Air cycle air conditioning prepares engine bleed air to pressurize the aircraft cabin. The temperature and quantity of the air must be controlled to maintain a comfortable cabin environment at all altitudes and on the ground. The air cycle system is often called the air conditioning package or pack. It is usually located in the lower half of the fuselage or in the tail section of turbine-powered aircraft. [Figure 1]

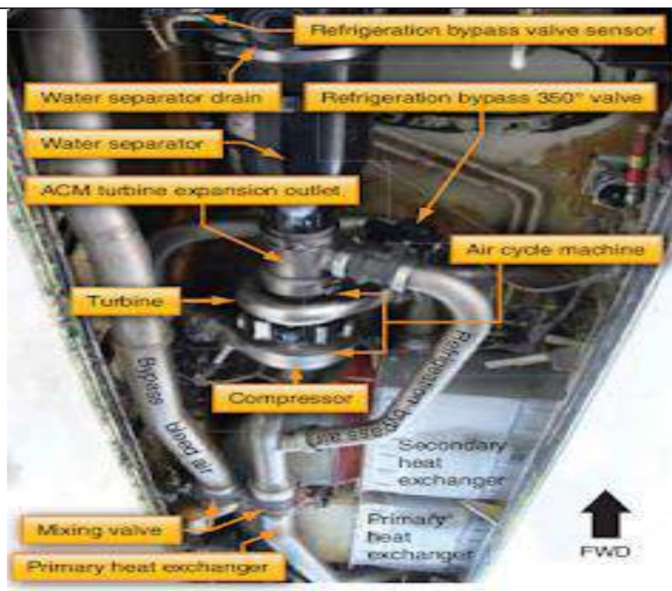

Figure 1. Boeing 737 air cycle system. The photo is taken looking up into the air conditioning bay located in the lower fuselage on each side of the aircraft

Air Cycle Air Conditioning System Operation

Even with the frigid temperatures experienced at high altitudes, bleed air is too hot to be used in the cabin without being cooled. It is let into the air cycle system and routed through a heat exchanger where ram air cools the bleed air. This cooled bleed air is directed into an air cycle machine. There, it is compressed before flowing through a secondary heat exchange that cools the air again with ram air. The bleed air then flows back into the air cycle machine where it drives an expansion turbine and cools even further. Water is then removed and the air is mixed with bypassed bleed air for final temperature adjustment. It is sent to the cabin through the air distribution system. By examining the operation of each component in the air cycle process, a better understanding can be developed of how bleed air is conditioned for cabin use. Refer to Figure 2, which diagrams the air cycle air conditioning system of the Boeing 737.

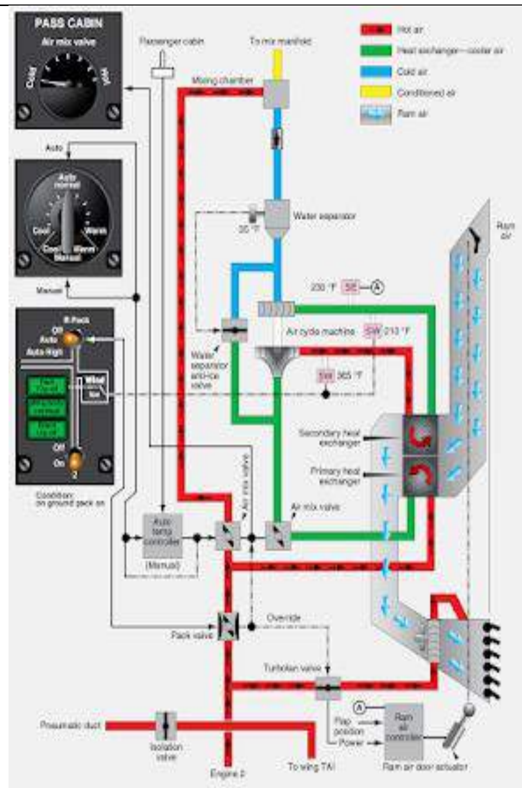

Figure 2.The air cycle air conditioning system on a Boeing 737

Pneumatic System Supply

The air cycle air conditioning system is supplied with air by the **aircraft pneumatic system**. In turn, the pneumatic system is supplied by bleed air tap-offs on each engine compressor section or from the APU (Auxiliary Pneumatic Unit) supply Figure (3). An external pneumatic air supply source may also be connected while the aircraft is stationary on the ground. In normal flight operations, a pneumatic manifold is supplied by the engine bleed air through the use of valves, regulators, and ducting. The air conditioning packs are supplied by this manifold as are other critical airframe systems, such as the anti-ice and hydraulic pressurization system.

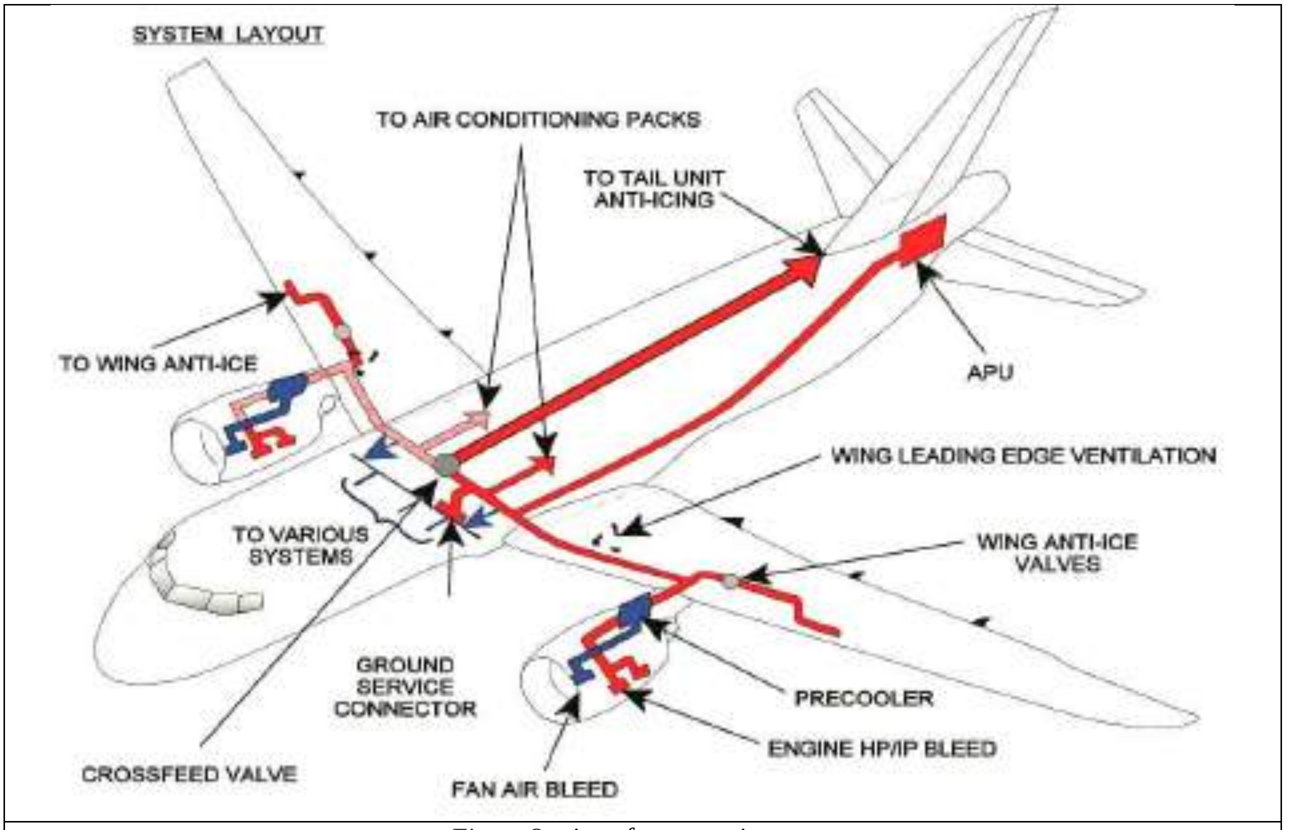

Figure 3. aircraft pneumatic system

Air Cycle Air Conditioning System Component Operation

1. Pack Valve

The pack valve is the valve that regulates bleed air from the pneumatic manifold into the air cycle air conditioning system. It is controlled with a switch from the air conditioning panel in the cockpit. Many pack valves are electrically controlled and pneumatically operated. Also known as the supply shutoff valve, the pack valve opens, closes, and modulates to allow the air cycle air conditioning system to be supplied with a designed volume of hot, pressurized air. [Figure 4] When an overheat or other abnormal condition requires that the air conditioning package be shut down, a signal is sent to the pack valve to close.

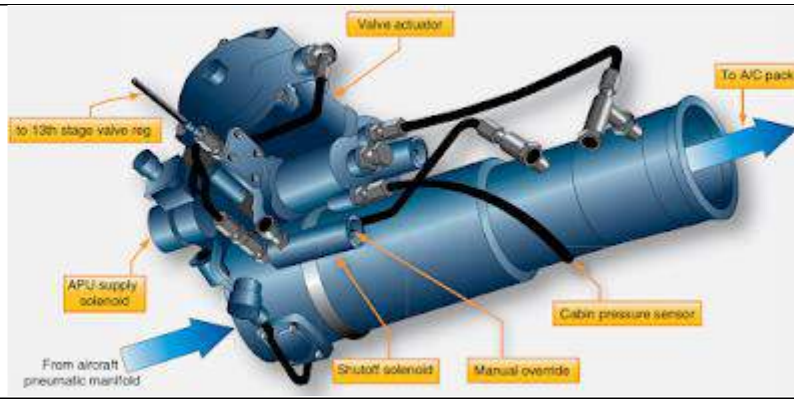

Figure 4. This pack valve drawing illustrates the complexity of the valve, which opens, closes, and modulates. It is manually actuated from the cockpit and automatically responds to supply and air cycle system parameter inputs

2. Bleed Air Bypass

A means for bypassing some of the pneumatic air supplied to the air cycle air conditioning system around the system is present on all aircraft. This warm bypassed air must be mixed with the cold air produced by the air cycle system so the air delivered to the cabin is a comfortable temperature. It simultaneously controls the flow of bypassed air and air to be cooled to meet the requirements of the auto temperature controller. It can also be controlled manually with the cabin temperature selector in manual mode. Other air cycle systems may refer to the valve that controls the air bypassed around the air cycle cooling system as a temperature control valve, trim air pressure regulating valve, or something similar.

3. Primary Heat Exchanger

Generally, the warm air dedicated to pass through the air cycle system first passes through a primary heat exchanger. It acts similarly to the radiator in an automobile. A controlled flow of ram air is ducted over and through the exchanger, which reduces the temperature of the air inside the system. [Figure 5] A fan draws air through the ram air duct when the aircraft is on the ground so that the heat exchange is possible when the aircraft is stationary. In flight, ram air doors are modulated to increase or decrease ram air flow to the exchanger according to the position of the wing flaps. During slow flight, when the flaps are extended, the doors are open. At higher speeds, with the flaps retracted, the doors move toward the closed position reducing the amount of ram air to the exchanger. Similar operation is accomplished with a valve on smaller aircraft. [Figure 6].

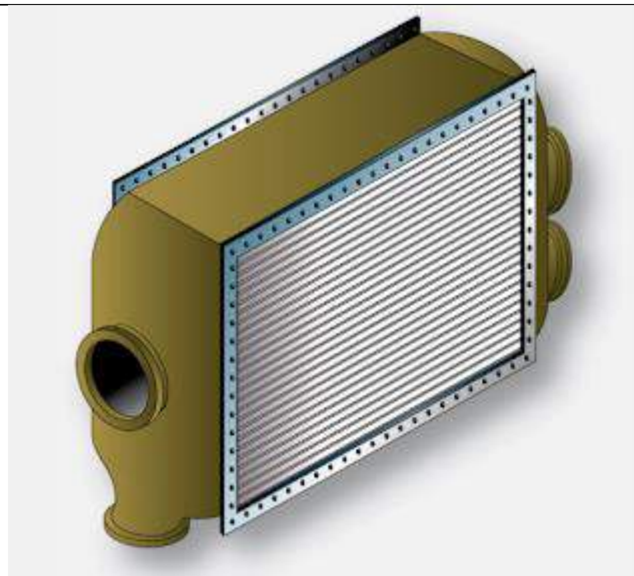

Figure 5. The primary and secondary heat exchangers in an air cycle air conditioning system are of similar construction. They both cool bleed air when ram air passes over the exchanger coils and fins

Figure 6. A ram air door controls the flow of air through the primary and secondary heat exchangers

4. Refrigeration Turbine Unit or Air Cycle Machine and Secondary Heat Exchanger

The heart of the air cycle air conditioning system is the **refrigeration turbine unit**, also known as the **air cycle machine (ACM).** It is comprised of a compressor that is driven by a turbine on a common shaft. System air flows from the primary heat exchanger into the compressor side of the ACM. As the air is compressed, its temperature rises. It is then sent to a secondary heat exchanger, similar to the primary heat exchanger located in the ram air duct. The elevated temperature of the ACM compressed air facilitates an easy exchange of heat energy to the ram air. The cooled system air, still under pressure from the continuous system air flow and the ACM compressor, exits the secondary heat exchanger. It is directed into the turbine side of the ACM. The steep blade pitch angle of the ACM turbine extracts more energy from the air as it passes through and drives the turbine. Once through, the air is allowed to expand at the ACM outlet, cooling even further. The combined energy loss from the air first driving the turbine and then expanding at the turbine outlet lowers the system air temperature to near freezing. [Figure 7].

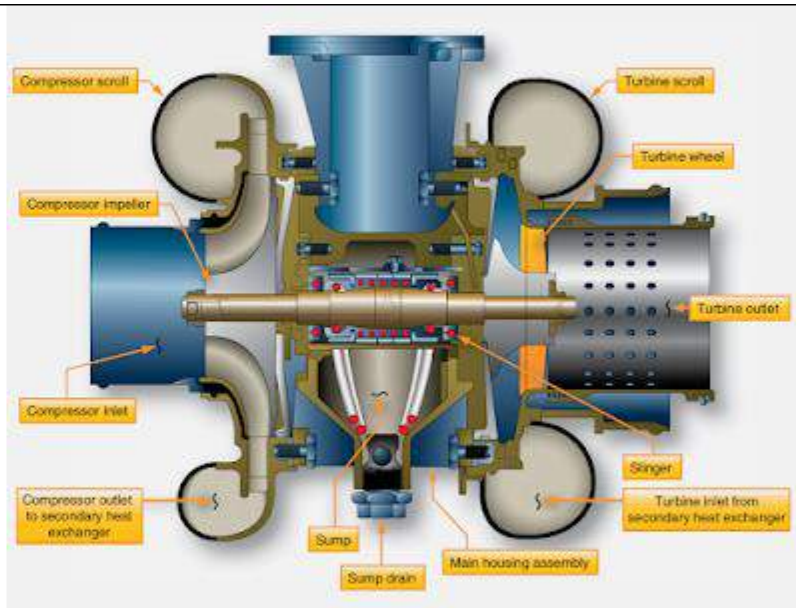

Figure 7. A cutaway diagram of an air cycle machine. The main housing supports the single shaft to which the compressor and turbine are attached. Oil lubricates and cools the shaft bearings

5. Water Separator

The cool air from the air cycle machine can no longer hold the quantity of water it could when it was warm. A water separator is used to remove the water from the saturated air before it is sent to the aircraft cabin. The separator operates with no moving parts. Foggy air from the ACM enters and is forced through a fiberglass sock that condenses and coalesces the mist into larger water drops. The convoluted interior structure of the separator swirls the air and water. The water collects on the sides of the separator and drains down and out of the unit, while the dry air passes through [Figure 8].

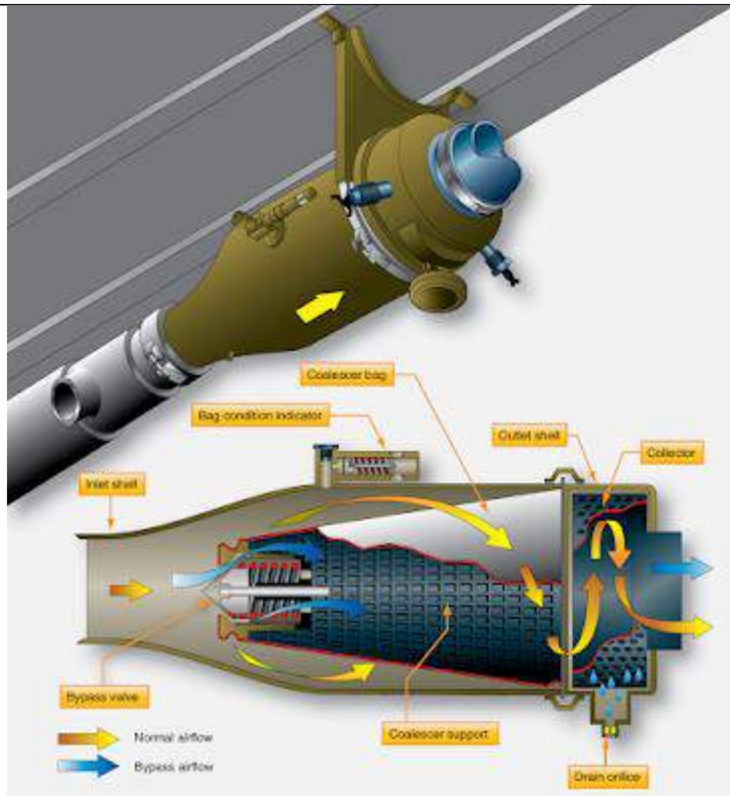

Figure 8. A water separator coalesces and removes water by swirling the air/water mixture from ACM expansion turbine. Centrifugal force sends the water to the walls of the collector where it drains from the unit

6. Refrigeration Bypass Valve

As mentioned, air exiting the ACM turbine expands and cools. It becomes so cold, it could freeze the water in the water separator, thus inhibiting or blocking airflow. A temperature sensor in the separator controls a refrigeration bypass valve designed to keep the air flowing through the water separator above freezing temperature. The valve is also identified by other names such as a temperature control valve, 35° valve, anti-ice valve, and similar. It bypasses warm air around the ACM when opened. The air is introduced into the expansion ducting, just upstream of the water separator, where it heats the air just enough to keep it from freezing. Thus, the refrigeration bypass valve regulates the temperature of the ACM discharge air so it does not freeze when passing through the water separator.

7. *Cabin Temperature Control System*

Most cabin temperature control systems operate in a similar manner. Temperature is monitored in the cabin, cockpit, conditioned air ducts, and distribution air ducts. These values are input into a temperature controller, or temperature control regulator, normally located in the electronics bay. A temperature selector in the cockpit can be adjusted to input the desired temperature. [Figure 9] The temperature controller compares the actual temperature signals received from the various sensors with the desired temperature input. Circuit logic for the selected mode processes these input signals. An output signal is sent to a valve in the air cycle air conditioning system. This valve has different names depending on the aircraft manufacturer and design of the environmental control systems (i.e., mixing valve, temperature control valve, trim air valve). It mixes warm bleed air that bypassed the air cycle cooling process with the cold air produced by it. By modulating the valve in response to the signal from the temperature controller, air of the selected temperature is sent to the cabin through the air distribution system.

Figure 9. Typical temperature selectors on a transport category aircraft temperature control panel in the cockpit (left) and a business jet (right). On large aircraft, temperature selectors may be located on control panels located in a particular cabin air distribution zone

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Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 5 Aircraft Anti-Icing and de-icing System

5.1 INTRODUCTION

Generally, anti-icing systems prevent the formation of ice (aircraft surfaces) while the de-icing systems remove the ice after it is formed.

Anti-icing fluid prevents the accumulation of frost, ice, or snow on a clean airplane surface for a certain period of time called holdover time. **SAE Type II, III, or IV** fluids are normally used for anti-icing because they are thickened to provide longer holdover times than Type I fluids. They are most effective when applied unheated and undiluted to a clean airplane surface.

In addition to deicing or anti-icing the airplane, the fluids must also flow off the airplane during takeoff and not cause unacceptable performance effects. Fluid manufacturers can ensure acceptable aerodynamic characteristics by subjecting fluids to the aerodynamic acceptance test contained in the SAE standards.

Standard Practices

Procedure

Make sure that all loose snow is removed from the aircraft before you do the de-icing/antiicing procedures.

WARNING: FOR SUFFICIENT HOLDOVER TIME, MAKE SURE THE FREEZING POINT OF THE DE-ICING/ANTI-ICING MIXTURE IS LESS THAN THE AIRCRAFT AND AMBIENT TEMPERATURES.

THE HOLDOVER TIME WILL ALSO DECREASE DURING THE CONDITIONS THAT FOLLOW:

- **THERE ARE STRONG WINDS**
- **THERE IS PRECIPITATION**
- **THE AMBIENT TEMPERATURE DECREASES**
- **THERE ARE WINDS CAUSED BY OTHER AIRCRAFT ENGINES**

Obey the precautions and standard practices that follow when you do the de-icing/anti-icing procedures:

(a) The APU should be shut down for all anti-icing/de-icing operations.

(b) If it is necessary to operate the engines or the APU while you do the de-icing/anti-icing procedures, obey the precautions that follow:

1. Make sure that the engines are at idle speed.
2. Make sure that all bleed air valves are closed.
3. Make sure that all the external lights in the de-icing/anti-icing area are off.
4. Make sure the valves for the air conditioning unit are off.
5. Adjust the rudder to the full left position, this prevents the rudder from directing fluid into the APU inlet.

WARNING: DO NOT LET DE-ICING FLUID GO INTO THE APU. DE-ICING FLUID IN THE APU CAN CAUSE THE APU SPEED TO BE OUT OF CONTROL. YOU CAN CAUSE INJURY TO PERSONNEL AND DAMAGE TO THE APU.

(c) Do not point the spray of de-icing/anti-icing fluid directly into the areas that follow:

1. Windshields
2. Side windows
3. Passenger compartment windows
4. Door and window seals
5. Pitot/static probes
6. Total air temperature (TAT)
7. probes Angle of attack (AOA) sensors
8. Static pressure ports
9. Antennas
10. Winglets
11. Engine intake and exhaust ports
12. Engine thrust reversers
13. Fuel drains
14. Wheels and brakes
15. Waste water and condensation drains Ram air intake
16. Auxiliary power unit (APU)
17. Inlet and exhaust areas
18. Emergency door handles.
19. Landing gear
20. Bleed-air overboard exhausts

(d) If the aircraft is moved from a warm hangar during freezing precipitation, do one of the steps that follows:

NOTE: Freezing precipitation will melt when it touches the warm surfaces, and then freeze to the surface when it becomes cold.

1. Do the anti-icing procedure before the aircraft is moved out of the warm hangar.
2. Let the aircraft temperature decrease below freezing, before it is moved out of the hangar.

(e) If you use warm water to remove the ice and frost, do the steps that follow:

1. Do the procedure in a warm hanger.
2. If anti-icing fluid is not applied, then keep the aircraft in the warm hanger until it is dry

(f) If possible, increase the temperature of the de-icing fluid and water mixture to 180 to 200 °F (82.3 to 93.4 °C), at the source.

(g) Do not use a continuous flow of de-icing fluid directly at one location on the aircraft surfaces.

(h) Apply the fluid at a low angle to prevent damage to the aircraft surfaces.

(i) Do not use more than 10 psi (68.9 kPa) of pressure to blow the ice and snow off the surfaces.

(j) To apply the fluid across a large area of snow or ice, use a light to moderate spray.

(k) Do not spray the fluid into the wind.

(I) Apply the de-icing/anti-icing fluid from the highest to the lowest areas.

(m) Apply the spray as near to the surface as possible.

(n) The effect of the de-icing/anti-icing will decrease with the conditions that follow:

- High winds
- Winds caused by other aircraft engines
- Wet snow
- High precipitation
- Aircraft skin temperature
- Fuel temperature in areas near the skin
- Sun light

(O) If there is continuous precipitation, do the steps that follow:

1. Do the 2-step de-icing/anti-icing procedure.
2. Do the de-icing/anti-icing procedure as close to flight time as possible.
3. Make sure that there is no ice, snow, and unwanted material in the engine intake area.
4. During freezing fog conditions, examine the rear of the fan blades for ice and frost before the engines start.

5. During wet snow conditions, do the steps that follow:

For short term parking of the aircraft in an open area during cold weather, do the steps that follow:

(a) Do the pre-takeoff inspection as soon to the departure time as possible.
NOTE: If at night, make sure that sufficient light is available to do the inspection of the aircraft.

(b) Do a visual inspection of the aircraft components and areas that follow:

- Make sure that the pitot static tubes are clear of snow, frost, ice, and unwanted material.
- Make sure that the static pressure ports are clear of snow, frost, ice, and unwanted material.
- Make sure that all the doors are clear of are clear of snow, frost, ice, and unwanted material.
- Make sure that the TAT and the AOA are clear of snow, frost, ice, and unwanted material.
- Make sure that the windshields are clear of snow, frost, ice, and unwanted material.
- Make sure that all the flight control surfaces and their travel areas are clear of snow, frost, ice, and unwanted material.
- Make sure that the main and nose landing gears and bays are clear of snow, frost, ice, and unwanted material.
- Make sure that the engine intakes and exhausts are clear of snow, frost, ice, and unwanted material.
- Make sure that all inlets, exhausts, and drains are clear of snow, frost, ice, and unwanted material.

(c) If necessary, do the de-icing/anti-icing procedure again, until all the snow, frost, and ice is removed from the critical aircraft components and areas.

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Chapter 6 Aircraft Fuel System

6.1 INTRODUCTION

The fuel system is designed to provide an uninterrupted flow of clean fuel from the fuel tanks to the engine. The fuel must be available to the engine under all conditions of engine power, altitude, attitude, and during all approved flight maneuvers. Two common classifications apply to fuel systems in small aircraft: gravity-feed and fuel-pump systems.

- **Gravity-Feed System**

The gravity-feed system utilizes the force of gravity to transfer the fuel from the tanks to the engine. For example, on high-wing airplanes, the fuel tanks are installed in the wings. This places the fuel tanks above the carburetor, and the fuel is gravity fed through the system and into the carburetor. If the design of the aircraft is such that gravity cannot be used to transfer fuel, fuel pumps are installed. For example, on low-wing airplanes, the fuel tanks in the wings are located below the carburetor. [Figure 7-30].

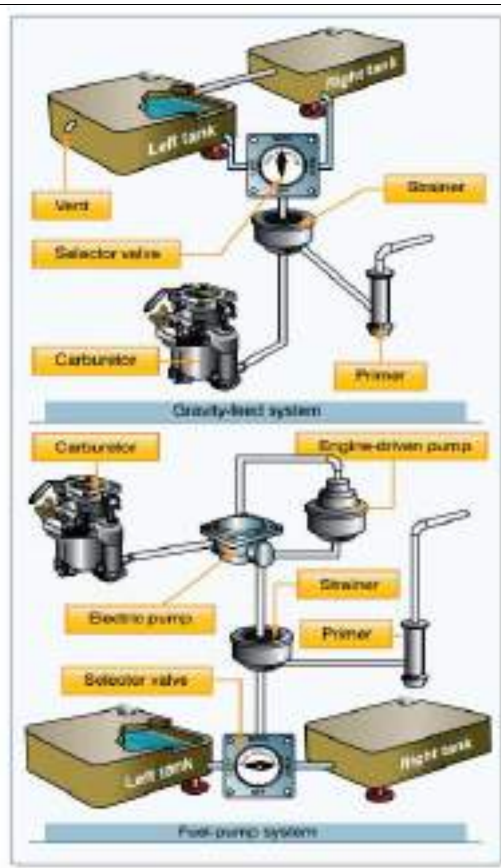

Figure 7-30. *Gravity-feed and fuel-pump systems.*

- **Fuel-Pump System**

Aircraft with fuel-pump systems have two fuel pumps. The main pump system is engine driven with an electricallydriven auxiliary pump provided for use in engine starting and in the event the engine pump fails. The auxiliary pump, also known as a boost pump, provides added reliability to the fuel system. The electrically-driven auxiliary pump is controlled by a switch in the flight deck.

- **Fuel Primer**

Both gravity-feed and fuel-pump systems may incorporate a fuel primer into the system. The fuel primer is used to draw fuel from the tanks to vaporize fuel directly into the cylinders prior to starting the engine. During cold weather, when engines are difficult to start, the fuel primer helps because there is not enough heat available to vaporize the fuel in the carburetor.

- **Fuel Tanks**

The fuel tanks, normally located inside the wings of an airplane, have a filler opening on top of the wing through which they can be filled. A filler cap covers this opening. The tanks are vented to the outside to maintain atmospheric pressure inside the tank. They may be vented through the filler cap or through a tube extending through the surface of the wing. Fuel tanks also include an overflow drain that may stand alone or be collocated with the fuel tank vent. This allows fuel to expand with increases in temperature without damage to the tank itself. If the tanks have been filled on a hot day, it is not unusual to see fuel coming from the overflow drain.

- **Fuel Gauges**

The fuel quantity gauges indicate the amount of fuel measured by a sensing unit in each fuel tank and is displayed in gallons or pounds. Aircraft certification rules require accuracy in fuel gauges only when they read “empty.” Any reading other than “empty” should be verified. Do not depend solely on the accuracy of the fuel quantity gauges. Always visually check the fuel level in each tank during the preflight inspection, and then compare it with the corresponding fuel quantity indication.

If a fuel pump is installed in the fuel system, a fuel pressure gauge is also included. This gauge indicates the pressure in the fuel lines.

- **Fuel Selectors**

The fuel selector valve allows selection of fuel from various tanks. A common type of selector valve contains four positions: LEFT, RIGHT, BOTH, and OFF. Selecting the LEFT or RIGHT position allows fuel to feed only from the respective tank, while selecting the BOTH position feeds fuel from both tanks. The LEFT or RIGHT position may be used to balance the amount of fuel remaining in each wing tank. [Figure 7-31].

Figure 7-31. *Fuel selector valve.*

Regardless of the type of fuel selector in use, fuel consumption should be monitored closely to ensure that a tank does not run completely out of fuel. Running a fuel tank dry does not only cause the engine to stop, but running for prolonged periods on one tank causes an unbalanced fuel load between tanks.

Running a tank completely dry may allow air to enter the fuel system and cause vapor lock, which makes it difficult to restart the engine. On fuel-injected engines, the fuel becomes so hot it vaporizes in the fuel line, not allowing fuel to reach the cylinders.

- **Fuel Strainers, Sumps, and Drains**

After leaving the fuel tank and before it enters the carburetor, the fuel passes through a strainer that removes any moisture and other sediments in the system. Since these contaminants are heavier than aviation fuel, they settle in a sump at the bottom of the strainer assembly. A sump is a low point in a fuel system and/or fuel tank. The fuel system may contain a sump, a fuel strainer, and fuel tank drains, which may be collocated.

The fuel strainer should be drained before each flight. Fuel samples should be drained and checked visually for water and contaminants. Water in the sump is hazardous because in cold weather the water can freeze and block fuel lines. In warm weather, it can flow into the carburetor and stop the engine. If water is present in the sump, more water in the fuel tanks is probable, and they should be drained until there is no evidence of water. Never take off until all water and contaminants have been removed from the engine fuel system.

Fuel Grades

Fuel for aircraft with turbine engines is classified as JET A, JET A-1, and JET B. Jet fuel is basically kerosene and has a distinctive kerosene smell. Since use of the correct fuel is critical, dyes "color the fuel itself" are added to help identify the type and grade of fuel. [Figure 7-32].

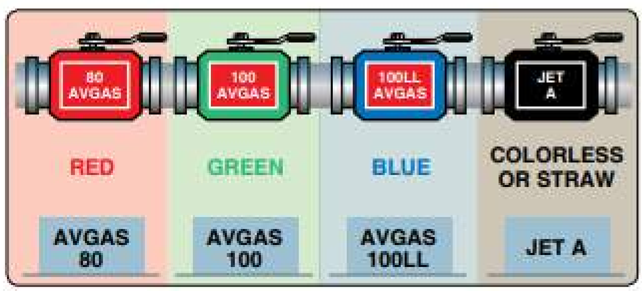

Figure 7-32. *Aviation fuel color-coding system.*

In addition to the color of the fuel itself, the color-coding system extends to decals and various airport fuels handling equipment. For example, all AVGAS is identified by name, using white letters on a red background. In contrast, turbine fuels are identified by white letters on a black background.

Fuel Contamination

Accidents attributed to power plant failure from fuel contamination have often been traced to:

- Inadequate preflight inspection by the pilot
- Servicing aircraft with improperly filtered fuel from small tanks or drums
- Storing aircraft with partially filled fuel tanks
- Lack of proper maintenance

Fuel should be drained from the fuel strainer quick drain and from each fuel tank sump into a transparent container and then checked for dirt and water. When the fuel strainer is being drained, water in the tank may not appear until all the fuel has been drained from the lines leading to the tank. This indicates that water remains in the tank and is not forcing the fuel out of the fuel lines leading to the fuel strainer. Therefore, drain enough fuel from the fuel strainer to be certain that fuel is being drained from the tank. The amount depends on the length of fuel line from the tank to the drain. If water or other contaminants are found in the first sample, drain further samples until no trace appears.

Fuel System Icing

Ice formation in the aircraft fuel system results from the presence of water in the fuel system. This water may be undissolved or dissolved. One condition of undissolved water is entrained water that consists of minute water particles suspended in the fuel. This may occur as a result of mechanical agitation of free water or conversion of dissolved water through temperature reduction.

Prevention Procedures

The use of anti-icing additives for some aircraft has been approved as a means of preventing problems with water and ice in AVGAS. Some laboratory and flight testing indicates that the use of hexylene glycol, certain methanol derivatives, and ethylene glycol monomethyl ether (EGME) in small concentrations inhibit fuel system icing. These tests indicate that the use of EGME at a maximum **0.15 percent** by volume concentration substantially inhibits fuel system icing under most operating conditions.

Refueling Procedures

Static electricity is formed by the friction of air passing over the surfaces of an aircraft in flight and by the flow of fuel through the hose and nozzle during refueling. Nylon, Dacron, or wool clothing is especially prone to accumulate and discharge static electricity from the person to the funnel or nozzle. To guard against the possibility of static electricity igniting fuel fumes, a ground wire should be attached to the aircraft before the fuel cap is removed from the tank. Because both the aircraft and re-fueler have different static charges, bonding both components to each other is critical. By bonding both components to each other, the static differential charge is equalized. The refueling nozzle should be bonded to the aircraft before refueling begins and should remain bonded throughout the refueling process. When a fuel truck is used, it should be grounded prior to the fuel nozzle contacting the aircraft.

If fueling from drums or cans is necessary, proper bonding and grounding connections are important. Drums should be placed near grounding posts, and the following sequence of connections observed:

1. Drum to ground
2. Ground to aircraft
3. Drum to aircraft or nozzle to aircraft before removing the fuel cap

When disconnecting, reverse the order

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Chapter 7 Aircraft Hydraulic System

7.1 INTRODUCTION

Hydraulic systems in aircraft provide a means for the operation of aircraft components. The operation of landing gear, laps, light control surfaces, and brakes is largely accomplished with hydraulic power systems. Hydraulic system complexity varies from small aircraft that require fluid only for manual operation of the wheel brakes to large transport aircraft where the systems are large and complex.

- **Hydraulic Fluid**

Hydraulic system liquids are used primarily to transmit and distribute forces to various units to be actuated. Liquids are able to do this because they are almost incompressible.
Manufacturers of hydraulic devices usually specify the type of liquid best suited for use with their equipment in view of the working conditions, the service required, temperatures expected inside and outside the systems, pressures the liquid must withstand, the possibilities of corrosion, and other conditions that must be considered. If incompressibility and fluidity were the only qualities required, any liquid that is not too thick could be used in a hydraulic system. But a satisfactory liquid for a particular installation must possess a number of other properties. Some of the properties and characteristics that must be considered when selecting a satisfactory liquid for a particular system are discussed below.

1. Viscosity: - One of the most important properties of any hydraulic fluid is its viscosity. Viscosity is internal resistance to flow. A liquid such as gasoline that has a low viscosity lows easily, while a liquid such as tar that has a high viscosity lows slowly. Viscosity increases as temperature decreases. A satisfactory liquid for a given hydraulic system must have enough body to give a good seal at pumps, valves, and pistons, but it must not be so thick that it offers resistance to low, leading to power loss and higher operating temperatures. These factors add to the load and to excessive wear of parts. A fluid that is too thin also leads to rapid wear of moving parts or of parts that have heavy loads. The instruments used to measure the viscosity of a liquid are known as viscometers.

2. Chemical Stability: - Chemical stability is another property that is exceedingly important in selecting a hydraulic liquid. It is the liquid's ability to resist oxidation and deterioration for long periods. All liquids tend to undergo unfavorable chemical changes under severe operating conditions. This is the case, for example, when a system operates for a considerable period of time at high temperatures. Excessive temperatures have a great effect on the life of a liquid. It should be noted that the temperature of the liquid in the

reservoir of an operating hydraulic system does not always represent a true state of operating conditions.

3. Flash Point: - Flash point is the temperature at which a liquid gives off vapor in sufficient quantity to ignite momentarily or flash when a flame is applied. A high flash point is desirable for hydraulic liquids because it indicates good resistance to combustion and a low degree of evaporation at normal temperatures.

4. Fire Point: - Fire point is the temperature at which a substance gives off vapor in sufficient quantity to ignite and continue to burn when exposed to a spark or flame. Like flash point, a high fire point is required of desirable hydraulic liquids.

- **Types of Hydraulic Fluids**

To assure proper system operation and to avoid damage to nonmetallic components of the hydraulic system, the correct fluid must be used. When adding fluid to a system, use the type specified in the aircraft manufacturer's maintenance manual or on the instruction plate affixed to the reservoir or unit being serviced.

The three principal categories of hydraulic fluids are:
1. Minerals
2. Polyalphaoleins
3. Phosphate esters

When servicing a hydraulic system, the technician must be certain to use the correct category of replacement fluid.

- **Hydraulic Fluid Contamination**

Two general contaminants are:

1. Abrasives, including such particles as core sand, weld spatter, machining chips, and rust.
2. Nonabrasives, including those resulting from oil oxidation and soft particles worn or shredded from seals and other organic components.

- **Contamination Check**

Whenever it is suspected that a hydraulic system has become contaminated or the system has been operated at temperatures in excess of the specified maximum, a check of the system should be made. The filters in most hydraulic systems are designed to remove most foreign particles that are visible to the naked eye. Hydraulic liquid that appears clean to the naked eye may be contaminated to the point that it is unit for use. Thus, visual inspection of the hydraulic liquid does not determine the total amount of contamination in the system.

Assignment is required – oral presentation
Contamination Check
Hydraulic Sampling Schedule
Sampling Procedure
Hydraulic System Flushing
Health and Handling

Basic Hydraulic Systems

Regardless of its function and design, every hydraulic system has a minimum number of basic components in addition to a means through which the fluid is transmitted. A basic system consists of a pump, reservoir, directional valve, check valve, pressure relieve valve, selector valve, actuator, and filter. [Figure 12-2]

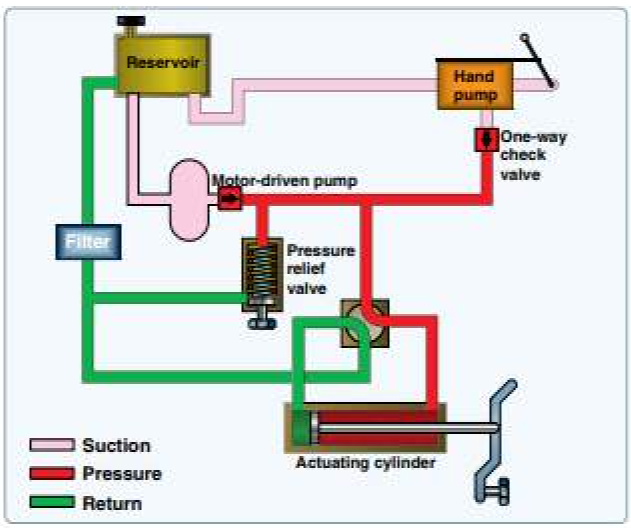


Figure 12-2. *Basic hydraulic system.*

- **Open Center Hydraulic Systems**

An open center system is one having fluid flow, but no pressure in the system when the actuating mechanisms are idle. The pump circulates the fluid from the reservoir, through the selector valves, and back to the reservoir. [Figure 12-3] The open center system may employ any number of subsystems, with a selector valve for each subsystem. Unlike the closed center system, the selector valves of the open center system are always connected in series with each other. In this arrangement, the system pressure line goes through each selector valve. Fluid is always allowed free passage through each selector valve and back to the reservoir until one of the selector valves is positioned to operate a mechanism.

When one of the selector valves is positioned to operate an actuating device, fluid is directed from the pump through one of the working lines to the actuator. [Figure 12-3B] With the selector valve in this position, the flow of fluid through the valve to the reservoir is blocked. The pressure builds up in the system to overcome the resistance and moves the piston of the actuating cylinder; fluid from the opposite end of the actuator returns to the selector valve and lows back to the reservoir. Operation of the system following actuation of the component depends on the type of selector valve being used.

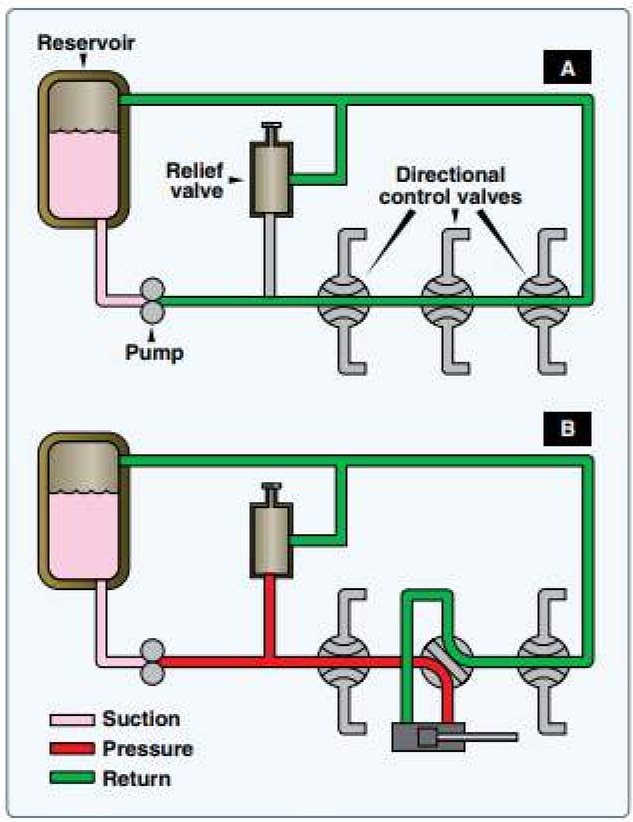


Figure 12-3. *Open center hydraulic system.*

- **Closed-Center Hydraulic Systems**

In the closed-center system, the fluid is under pressure whenever the power pump is operating. The three actuators are arranged in parallel and actuating units B and C are operating at the same time, while actuating unit A is not operating. This system differs from the open-center system in that the selector or directional control valves are arranged in parallel and not in series. The means of controlling pump pressure varies in the closed-center system. If a constant delivery pump is used, the system pressure is regulated by a pressure regulator. A relief valve acts as a backup safety device in case the regulator fails.

Hydraulic System Components

Figure 12-6 is a typical example of a hydraulic system in a large commercial aircraft. The following sections discuss the components of such system in more detail.

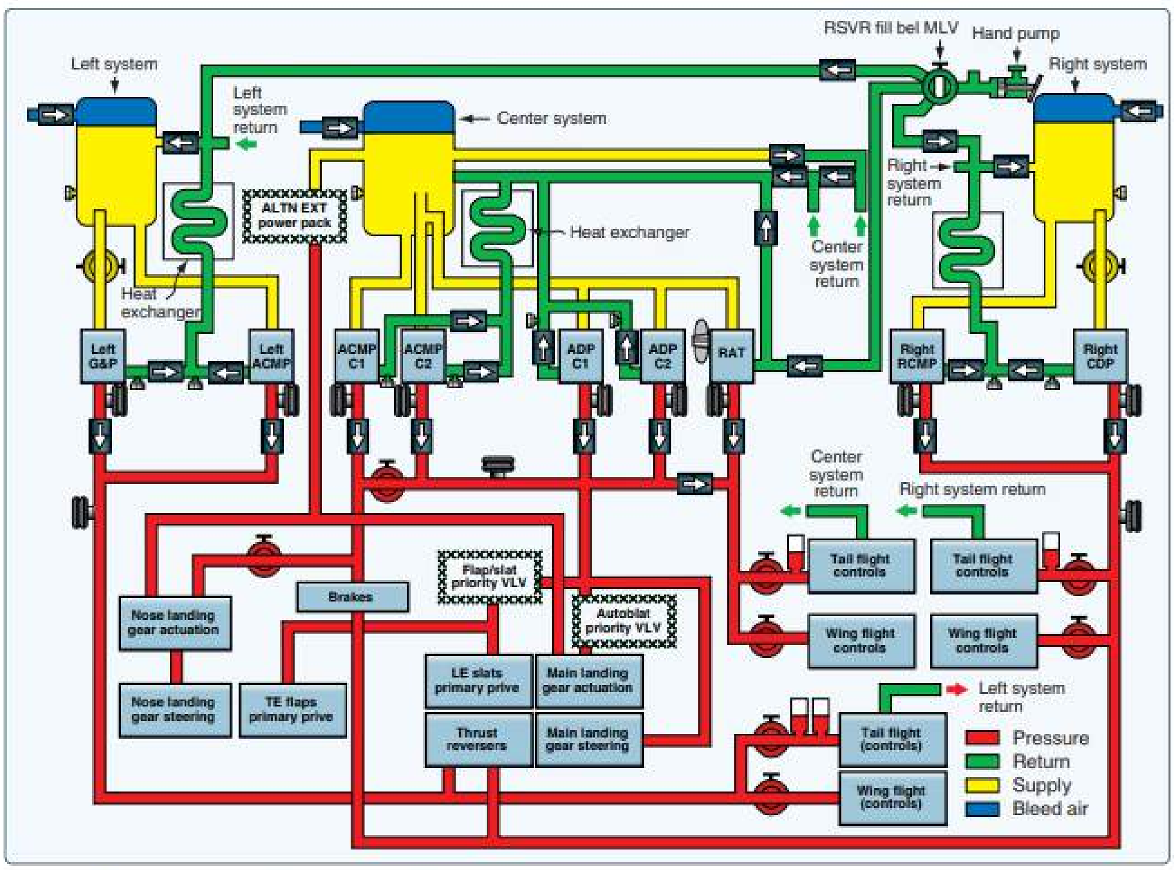


Figure 12-6. *Large commercial aircraft hydraulic system.*

- **Reservoirs**

The reservoir is a tank in which an adequate supply of fluid for the system is stored. Fluid lows from the reservoir to the pump, where it is forced through the system and eventually returned to the reservoir. The reservoir not only supplies the operating needs of the system, but it also replenishes fluid lost through leakage. Furthermore, the reservoir serves as an overflow basin for excess fluid forced out of the system by thermal expansion (the increase of fluid volume caused by temperature changes), the accumulators, and by piston and rod displacement.

The reservoir also furnishes a place for the fluid to purge itself of air bubbles that may enter the system. Foreign matter picked up in the system may also be separated from the fluid in the reservoir or as it flows through line filters. Reservoirs are either pressurized or nonpressurized.

Nonpressurized Reservoirs: - Nonpressurized reservoirs are used in aircraft that are not designed for violent maneuvers, do not fly at high altitudes, or in which the reservoir is located in the pressurized area of the aircraft. High altitude in this situation means an altitude where atmospheric pressure is inadequate to maintain sufficient low of fluid to the hydraulic pumps. Most nonpressurized reservoirs are constructed in a cylindrical shape. The outer housing is manufactured from a strong corrosion-resistant metal. Filter elements are normally installed within the reservoir to clean returning system hydraulic fluid. A typical nonpressurized reservoir is shown in Figure 12-8. This reservoir consists of a welded body and cover assembly clamped together. Gaskets are incorporated to seal against leakage between assemblies.

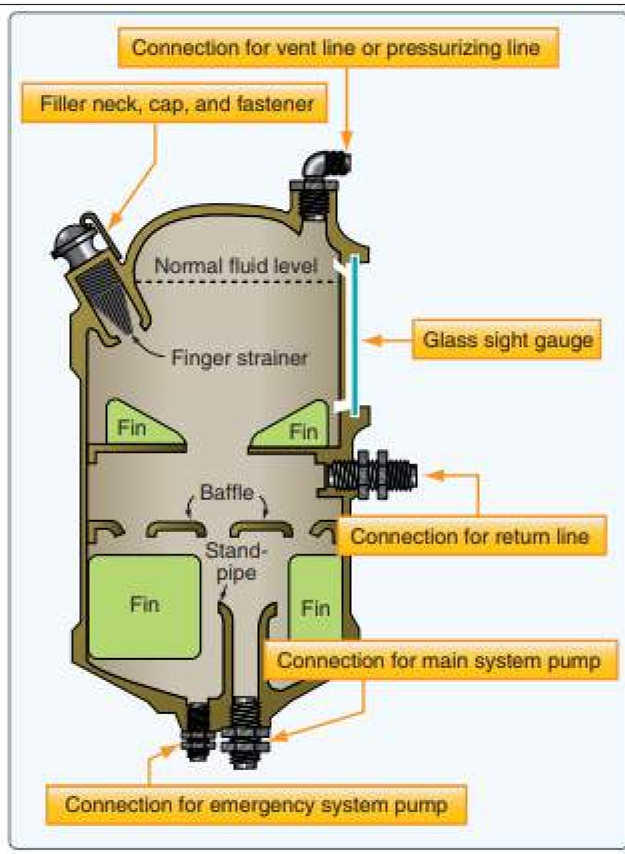


Figure 12-8. *Nonpressurized reservoir.*

Pressurized Reservoirs: - Reservoirs on aircraft designed for high-altitude light are usually pressurized. Pressurizing assures a positive low of fluid to the pump at high altitudes when low atmospheric pressures are encountered. On some aircraft, the reservoir is pressurized by bleed air taken from the compressor section of the engine. On others, the reservoir may be pressurized by hydraulic system pressure. Air-pressurized reservoirs are used in many commercial transport-type aircraft. [Figures 12-9 and 12-10] Pressurization of the reservoir is required because the reservoirs are often located in wheel wells or other nonpressurized areas of the aircraft and at high altitude there is not enough atmospheric pressure to move the fluid to the pump inlet. Engine bleed air is used to pressurize the reservoir. The reservoirs are typically cylindrical in shape.

Figure 12-9. *Air-pressurized reservoir.*

Figure 12-10. *Components of an air-pressurized reservoir.*

The following components are installed on a typical reservoir:

- Reservoir pressure relief valve—prevents over pressurization of the reservoir. Valve opens at a preset value.
- Sight glasses (low and overfull)—provides visual indication for light crews and maintenance personnel that the reservoir needs to be serviced.
- Reservoir sample valve—used to draw a sample of hydraulic fluid for testing.
- Reservoir drain valve—used to drain the fluids out of the reservoir for maintenance operation.
- Reservoir temperature transducer—provides hydraulic fluid temperature information for the light deck.
- Reservoir quantity transmitter—transmits fluid quantity to the light deck so that the light crew can monitor fluid quantity during light.

Assignment is required – oral presentation
Reservoir Servicing

- **Filters**

A filter is a screening or straining device used to clean the hydraulic fluid, preventing foreign particles and contaminating substances from remaining in the system. [Figure 12-15] If such objectionable material were not removed, the entire hydraulic system of the aircraft could fail through the breakdown or malfunctioning of a single unit of the system.

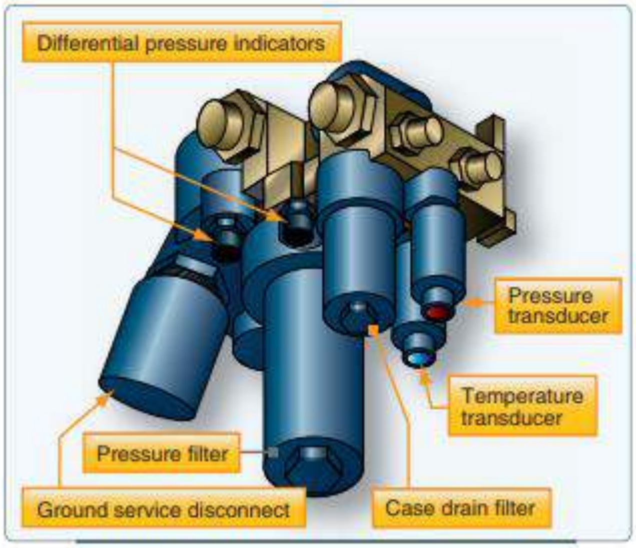


Figure 12-15. *Filter module components.*

The hydraulic fluid holds in suspension tiny particles of metal that are deposited during the normal wear of selector valves, pumps, and other system components. Such minute particles of metal may damage the units and parts through which they pass if they are not removed by a filter. Since tolerances within the hydraulic system components are quite small, it is apparent that the reliability and efficiency of the entire system depends upon adequate filtering.

Filters may be located within the reservoir, in the pressure line, in the return line, or in any other location the designer of the system decides that they are needed to safeguard the hydraulic system against impurities. Modern design often uses a filter module that contains several filters and other components. [Figure 12-16]

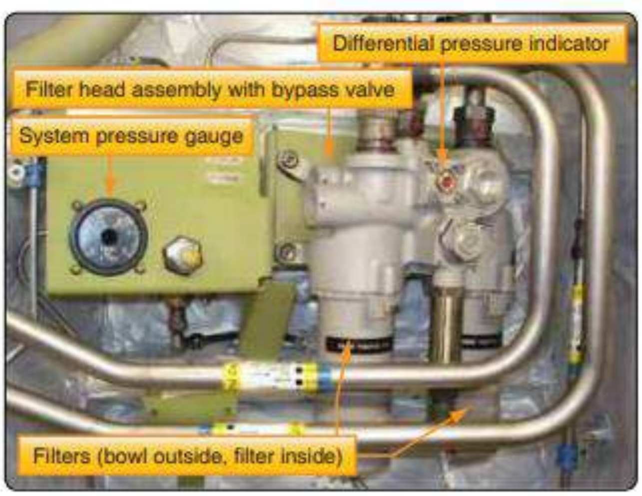


Figure 12-16. *A transport category filter module with two filters.*

Assignment is required – oral presentation
Maintenance of Filters

- **Pumps**

All aircraft hydraulic systems have one or more power-driven pumps and may have a hand pump as an additional unit when the engine-driven pump is inoperative. Power-driven pumps are the primary source of energy and may be either engine driven, electric motor driven, or air driven. As a general rule, electrical motor pumps are installed for use in emergencies or during ground operations.

Hand Pump: - The hydraulic hand pump is used in some older aircraft for the operation of hydraulic subsystems and in a few newer aircraft systems as a backup unit. Hand pumps are generally installed for testing purposes, as well as for use in emergencies. Hand pumps are also installed to service the reservoirs from a single refilling station. The single refilling station reduces the chances for the introduction of fluid contamination. Several types of hand pumps are used: **single action**, **double action**, **and rotary**. Figure 12-20 shows a rotary hand pump in a hydraulic system.

Figure 12-20. *Rotary hand pump.*

Power-Driven Pumps: - Modern aircraft use a combination of engine-driven power pumps, electrical-driven power pumps, air-driven power pumps, power transfer units (PTU), and pumps driven by a RAT. For example, large aircraft, such as the Airbus A380, have two hydraulic systems, eight engine-driven pumps, and three electrical driven pumps. The Boeing 777 has three hydraulic systems with two engine driven pumps, four electrical driven pumps, two air driven pumps, and a hydraulic pump motor driven by the RAT. [Figure 12-21 and 12-22]

Figure 12-21. *Engine-driven pump.*

Figure 12-22. *Electrically-driven pump.*

Assignment is required – oral presentation
Classification of Pumps

- **Valves**

There are three types of valves used in the aircraft hydraulic system; 1. Flow Control Valves, 2. Pressure Control Valves, and 3. Shuttle Valves

1. Flow Control Valves

Flow control valves control the speed and/or direction of fluid low in the hydraulic system. They provide for the operation of various components when desired and the speed at which the component operates. Examples of low control valves include: **selector valves, check valves, sequence valves, priority valves, shuttle valves, quick disconnect valves, and hydraulic fuses.**

Assignment is required – oral presentation

Provide a brief definition of the above indicated types of flow control valves

2. Pressure Control Valves

The safe and efficient operation of fluid power systems, system components, and related equipment requires a means of controlling pressure. There are many types of automatic pressure control valves. Some of them are an escape for pressure that exceeds a set pressure; some only reduce the pressure to a lower pressure system or subsystem; and some keep the pressure in a system within a required range.

3. Shuttle Valves

In certain fluid power systems, the supply of fluid to a subsystem must be from more than one source to meet system requirements. In some systems, an emergency system is provided as a source of pressure in the event of normal system failure. The emergency system usually actuates only essential components. The main purpose of the shuttle valve is to isolate the normal system from an alternate or emergency system.

- **Accumulators**

The accumulator is a steel sphere divided into two chambers by a synthetic rubber diaphragm. The upper chamber contains fluid at system pressure, while the lower chamber is charged with nitrogen or air. Cylindrical types are also used in highpressure hydraulic systems. Many aircraft have several accumulators in the hydraulic system. There may be a main system accumulator and an emergency system accumulator. There may also be auxiliary accumulators located in various sub-systems.

The function of an accumulator is to:

1. Dampen pressure surges in the hydraulic system caused by actuation of a unit and the effort of the pump to maintain pressure at a preset level.

2. Aid or supplement the power pump when several units are operating at once by supplying extra power from its accumulated, or stored, power.
3. Store power for the limited operation of a hydraulic unit when the pump is not operating.
4. Supply fluid under pressure to compensate for small internal or external (not desired) leaks that would cause the system to cycle continuously by action of the pressure switches continually kicking in.

Types of Accumulators There are two general types of accumulators used in aircraft hydraulic systems: spherical and cylindrical.

Al-Najaf Technical Institute
Aeronautical Technologies Department
Year Two
Subject: - Aircraft Maintenance

Lecturer Notes by Dr. Essam Al-Zaini

Source 1: - Aviation Maintenance Technician Handbook—Airframe Volume 1, 2012, U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION

Source 2: - Part 66 Cat. B1 Module 7 MAINTENANCE PRACTICES Volume 1

Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 8 Aircraft Landing Gear System

8.1 Introduction to the Aircraft Landing Gears

The landing gear supports the aircraft during landing and while it is on the ground. Simple aircraft that fly at low speeds generally have fixed gear. This means the gear is stationary and does not retract for flight. Faster, more complex aircraft have **retractable** landing gear. **After takeoff, the landing gear is retracted into the fuselage or wings and out of the airstream. This is important because extended gear create significant parasite drag which reduces performance.** ***Parasite dr*****ag is caused by the friction of the air flowing over the gear**. **It increases with speed.**

On very light, slow aircraft, the extra weight that accompanies a retractable landing gear is more of a detriment than the drag caused by the fixed gear. *Figure 1-82* shows examples of fixed and retractable gear.

Figure 1-82. *Landing gear can be fixed (top) or retractable (bottom).*

Landing gear must be strong enough to withstand the forces of landing when the aircraft is fully loaded. **In addition to strength, a major design goal is to have the gear assembly be as light as possible. To accomplish this, landing gear are made from a wide range of materials**

including steel, aluminum, and magnesium. Wheels and tires are designed specifically for aviation use and have unique operating characteristics.

Main wheel assemblies usually have a braking system. To aid with the potentially high impact of landing, most landing gear have a means of either **absorbing shock** or **accepting shock** and distributing it so that the structure is not damaged.

8.2 Landing Gears Maintenance

The most important job in the maintenance of the aircraft landing gear system is thorough **accurate inspections**. To properly perform inspections, all surfaces should be cleaned to ensure that no trouble spots are undetected.

During all inspections and visits to the wheel wells, ensure all ground safety locks are installed.

1. Check **emergency control handles** and systems for proper position and condition.
2. Inspect landing gear wheels for cleanliness, corrosion, and cracks.
3. Check wheel tie bolts for looseness.
4. Check tires for wear, cuts, deterioration, presence of grease or oil, alignment of slippage marks, and proper inflation.
5. Inspect landing gear mechanism for condition, operation, and proper adjustment.
6. Lubricate the landing gear, including the nose wheel steering. Check steering system cables for wear, broken strands, alignment, and safety.
7. Inspect landing gear shock struts for such conditions as cracks, corrosion, breaks, and security. Where applicable, check brake clearances and wear.

8.2.1 Lubrication

Various types of lubricant are required to lubricate points of friction and wear on landing gear. Specific products to be used are given by the manufacturer in the maintenance manual. Lubrication may be accomplished by hand or with a grease gun. Follow manufacturer's instructions. Before applying grease to pressure grease fitting, be sure the fitting is wiped clean of dirt and debris, as well as old hardened grease. Dust and sand mixed with grease produce a very destructive abrasive compound. Wipe off all excess grease while greasing the gear. The piston rods of all exposed strut cylinders and actuating cylinders should be clean at all times.

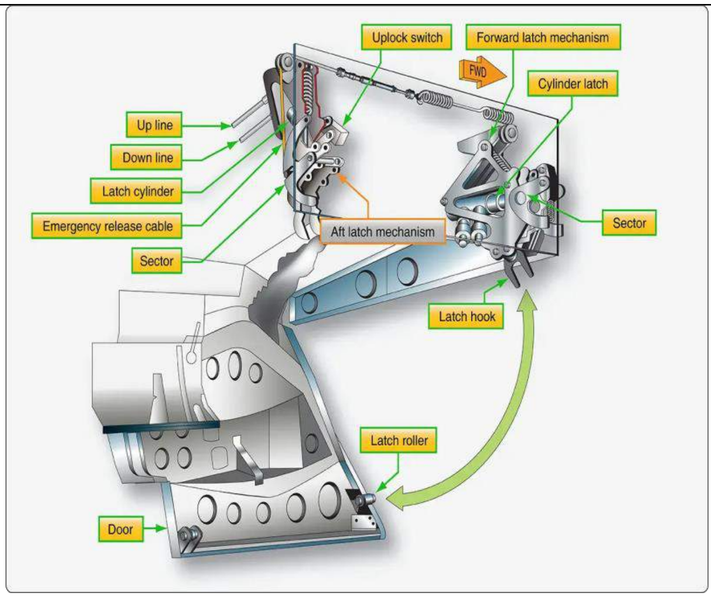
Periodically, wheel bearings must be removed, cleaned, inspected, and lubricated. When cleaning a wheel bearing, use the recommended cleaning solvent. Do not use gasoline or jet fuel. Dry the bearing by directing a blast of dry air between the rollers. Do not direct the air so that it spins the bearing as without lubrication, this could cause the bearing to fly apart resulting in injury. When inspecting the bearing, check for defects that would render it unserviceable, such as cracks, flaking, broken bearing surfaces, roughness due to impact pressure or surface wear, corrosion or pitting, discoloration from excessive heat, cracked or broken bearing cages, and scored or loose bearing cups or cones that would affect proper seating on the axle or wheel. If any discrepancies are found, replace the bearing with a serviceable unit. Bearings should be lubricated immediately after cleaning and inspection to prevent corrosion.

To lubricate a tapered roller bearing, use a bearing lubrication tool or place a small amount of the approved grease on the palm of the hand. Grasp the bearing with the other hands and press the larger diameter side of the bearing into the grease to force it completely through the space between the bearing rollers and the cone. Gradually turn the bearing so that all of the rollers have been completely packed with grease.

8.2.2 Adjusting Landing Gear Latches

The adjustment of various latches is a primary concern to the aircraft technician. Latches are generally used in landing gear systems to hold the gear up or down and/or to hold the gear doors open or closed. Despite numerous variations, all latches are designed to do the same thing. They must operate automatically at the proper time, and they must hold the unit in the desired position. A typical landing gear door latch is examined below. Many gear up latches operate similarly. Clearances and dimensional measurements of rollers, shafts, bushings, pins, bolts, etc., are common.

On this particular aircraft, the landing gear door is held closed by two latches. To have the door locked securely, both latches must grip and hold the door tightly against the aircraft structure. The principle components of each latch mechanism are shown in Figure below. They are a hydraulic latch cylinder, a latch hook, a spring loaded crank-and-lever linkage with sector, and the latch hook.



8.2.3 Gear Door Clearances

Landing gear doors have specific allowable clearances between the doors and the aircraft structure that must be maintained. Adjustments are typically made at the hinge installations or to the connecting links that support and move the door.

The distance landing gear doors open or close may depend upon the length of the door linkage. Rod end adjustments are common to fit the door. Adjustments to door stops are also a possibility. The manufacturer's maintenance manual specifies the length of the linkages and gives procedure for adjusting the stops. Follow all specified procedures that are accomplished with the aircraft on jacks and the gear retracted.

Doors that are too tight can cause structural damage. Doors that are too loose catch wind in flight, which could cause wear and potential failure, as well as parasite drag.

8.2.4 Drag and Side Brace Adjustment

Each landing gear has specific adjustments and tolerances per the manufacturer that permit the gear to function as intended. A common geometry used to lock a landing gear in the down position involves a collapsible side brace that is extended and held in an over-center position through the use of a locking link. Springs and actuators may also contribute to the motion of the linkage. Adjustments and tests are needed to ensure proper operation.

8.3 Landing Gear Retraction Test

The proper functioning of a landing gear system and components can be checked by performing a landing gear **retraction test**. This is also known as swinging the gear. The aircraft is properly supported on jacks for this check, and the landing gear should be cleaned and lubricated if needed. The gear is then raised and lowered as though the aircraft were in flight while a close visual inspection is performed. All parts of the system should be observed for security and proper operation. The emergency back-up extension system should be checked whenever swinging the gear.

Retraction tests are performed at various times, such as during annual inspection. Any time a landing gear component is replaced that could affect the correct functioning of the landing gear system, a retraction test should follow when adjustments to landing gear linkages or components that affect gear system performance are made. It may be necessary to swing the gear after a hard or overweight landing.

The following is a list of general inspection items to be performed while swinging the gear:

- **Check the landing gear for proper extension and retraction.**
- **Check all switches, lights, and warning devices for proper operation.**
- **Check the landing gear doors for clearance and freedom from binding.**
- **Check landing gear linkage for proper operation, adjustment, and general condition.**
- **Check the alternate/emergency extension or retraction systems for proper operation.**
- **Investigate any unusual sounds, such as those caused by rubbing, binding, chafing, or vibration.**

Al-Najaf Technical Institute
Aeronautical Technologies Department
Year Two
Subject: - Aircraft Maintenance
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Source 1: - Aviation Maintenance Technician Handbook—Airframe Volume 1, 2012, U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION

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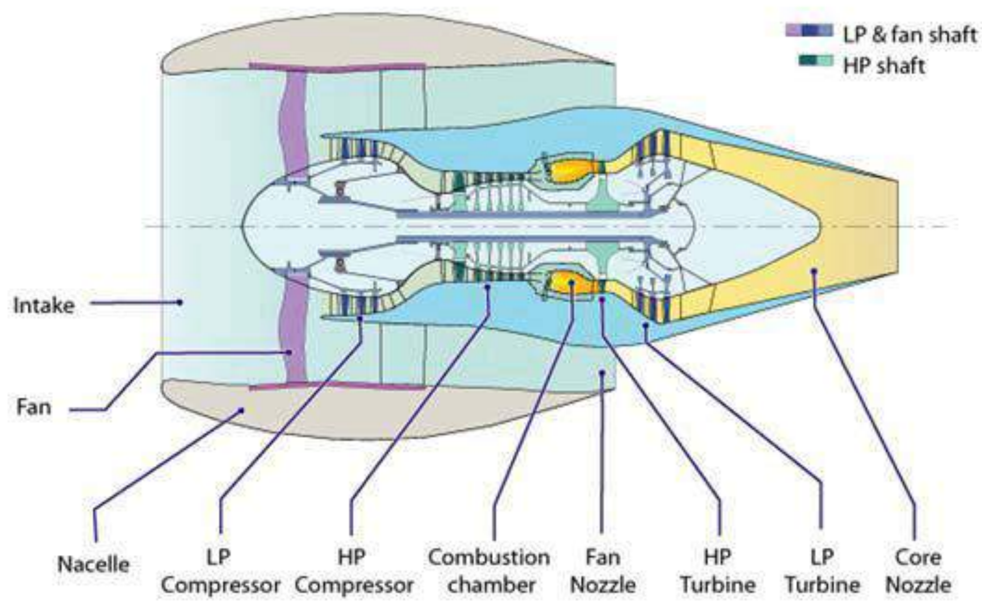
Source 3:- APPENDIX D Scope and Detail of Items (as Applicable to the Particular Aircraft) to Be Included in Annual and I 00-Hour Inspections

Chapter 9 Aircraft Engine Maintenance

9.1 Introduction the Aircraft Engine

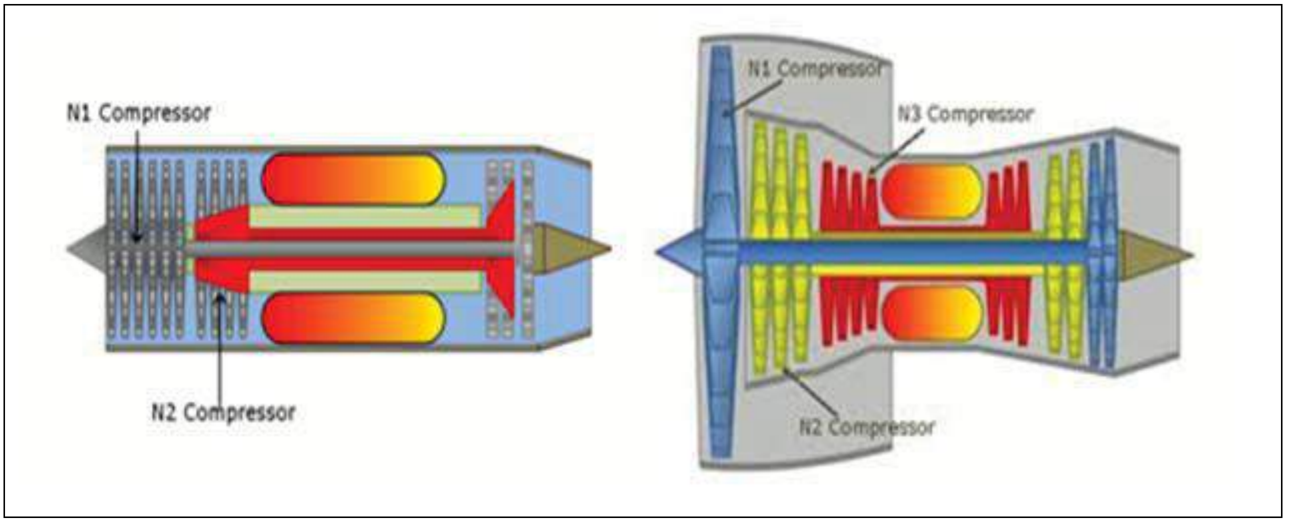
Aircraft turbine engines used on today's commercial jet aircraft are classified as turbofans – **Figure below**. Relative to their turbojet predecessor turbofans develop much higher takeoff thrust, are much more fuel efficient, and considerably quieter in operation.



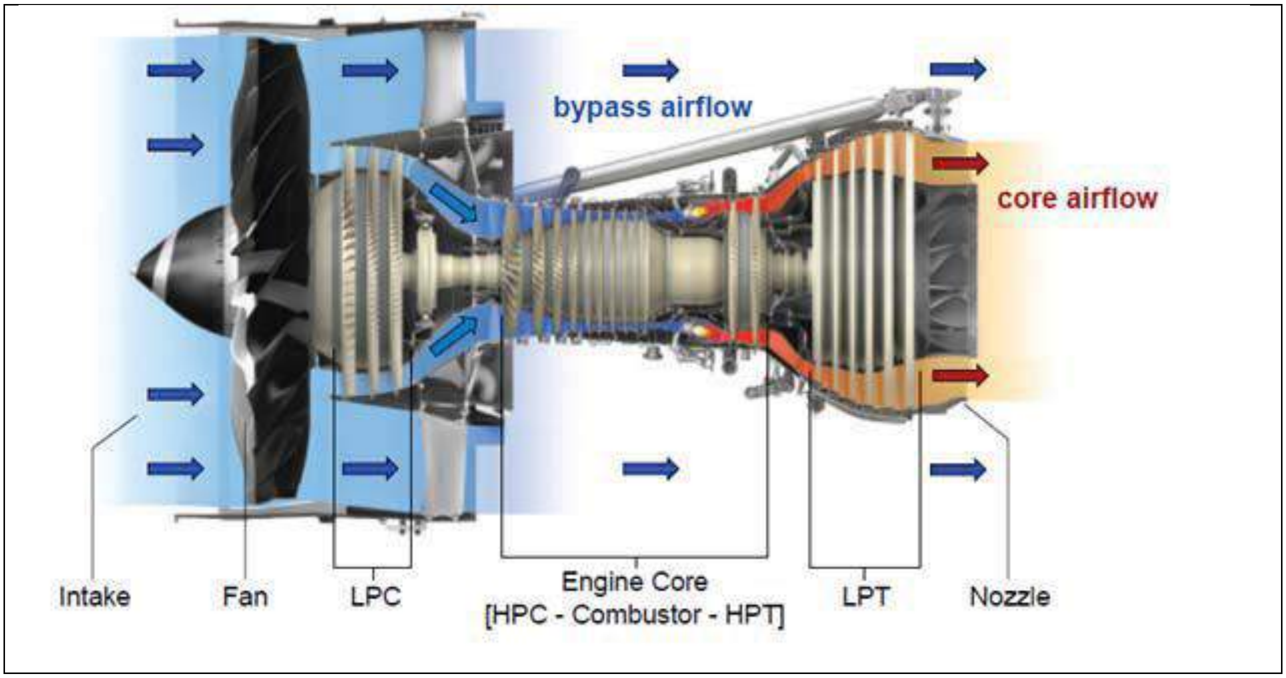
All turbofan engines currently in use are axial flow engines, meaning that the compression phase within the core is done axially (parallel to the axis of the engine) as the air flows through the compressor. The compressor is composed of several rows of airfoils that alternate among rotor blades and stator blades. Rotor blades are connected to the rotating shaft whereas stator blades are fixed and do not rotate.

In a turbofan engine a large portion of the inlet air accelerated by the fan is bypassed around the core of the engine. The fan, in effect, is taking on the role of a propeller by generating supplemental thrust. The remaining portion of the inlet air continues into the core engine where it is compressed and mixed with fuel in the combustor. The resulting high temperature exhaust gas is used to turn (power) the turbine and generate thrust. A turbofan, therefore, generates a portion of its thrust from the core engine and most of its thrust from the fan.

Conventional turbofan engine design is based on either a twin-spool or triple-spool configuration – **Figure below. In a twin spool configuration the low pressure compressor is driven by the low pressure turbine, and the high-pressure compressor is driven by the high-pressure turbine. A triple-spool turbofan generally includes an additional (intermediate) compressor and turbine**. Each spool generally rotates at different speeds in order to maintain high efficiency in all stages of compression.



Thrust growth on turbofans is usually obtained by increasing fan airflow, which is commonly achieved by increasing its bypass ratio. The **bypass ratio** is the ratio of the air that goes around the engine to the air that goes through the core – **Figure below**. In high bypass engines, the core engine primarily acts as a gas generator providing high energy gas flow to drive the fan turbine. The fan alone produces anywhere from 50% - 85% of the total engine thrust depending on the engine model. In addition, high bypass engines burns fuel far more economically relative to lower bypass ratio engines.

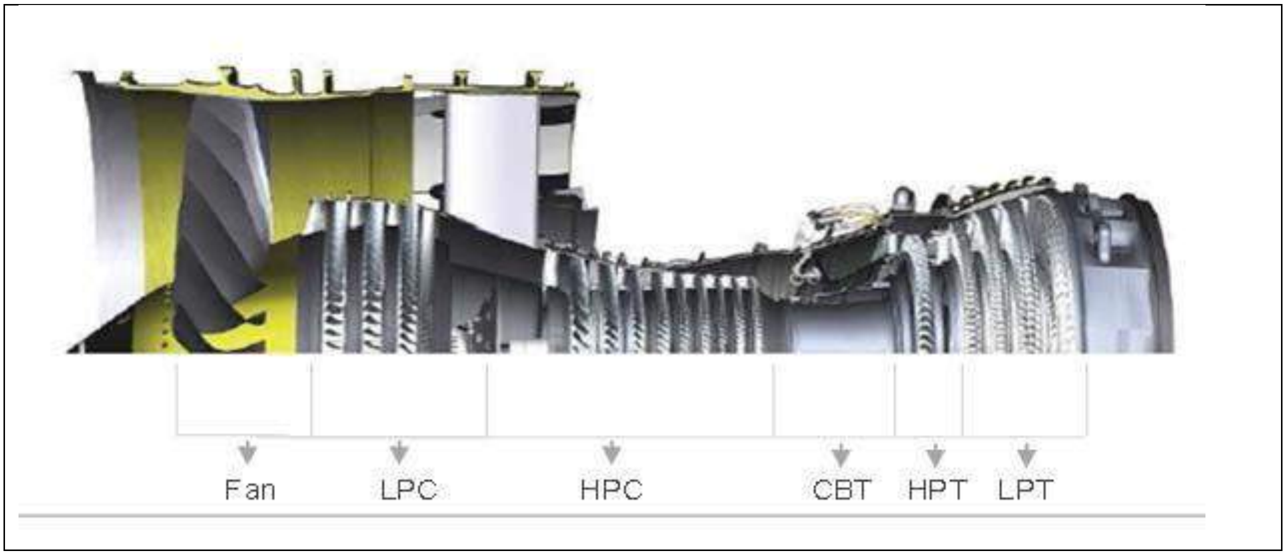


Increasing the bypass ratio tends to increase core thermal efficiency as well as improve fuel efficiency. High bypass ratios are also correlated with lower noise, since the large flow of air surrounding the jet exhaust from the engine core helps to buffer the noise produced by the latter.

9.2 ENGINE MODULE DESIGN CHARCTERISTICS

Today's engines are built from a number of individual assemblies known as **modules**, each of which has its individual identity, service history and inspection thresholds. Any of the constituent modules can be replaced as an entire unit during a shop visit. **Key benefits gained from a modular construction are: a.) Decreased turn-time, and b.) Reduced spare engine holdings.**

Figure below illustrates a modular architecture of a conventional twin-spool turbofan engine. Turbofans that are based on triple-spool design architecture also include an Intermediate Pressure Compressor (IPC) module and an Intermediate Pressure Turbine (IPT) module. A brief description of each of the major modules is summarized below.



1 Fan / Low Pressure Compressor (LPC) - The Fan / LPC module is the first component on the engine. The key components of the fan module consist of the fan blades, fan disk, and compressor case. Today’s fan blades are generally made of titanium, however a number of newer generation models also use high strength composites.

2 High Pressure Compressor (HPC) - The HPC module is made up of a series of rotor and stator assemblies whose main function is to raise the pressure of the air supplied to the combustor. The rotor assembly key components are the axially mounted compressor blades, while the stator assembly key components are the compressor vanes.

3 Combustor - The combustor is where fuel is added to the cycle to create thermal energy. Most of today’s modern turbofan engines employ an annular combustion system. The key components of a combustor consist of the inner & outer casings, fuel nozzles, and the high pressure nozzle guide vanes.

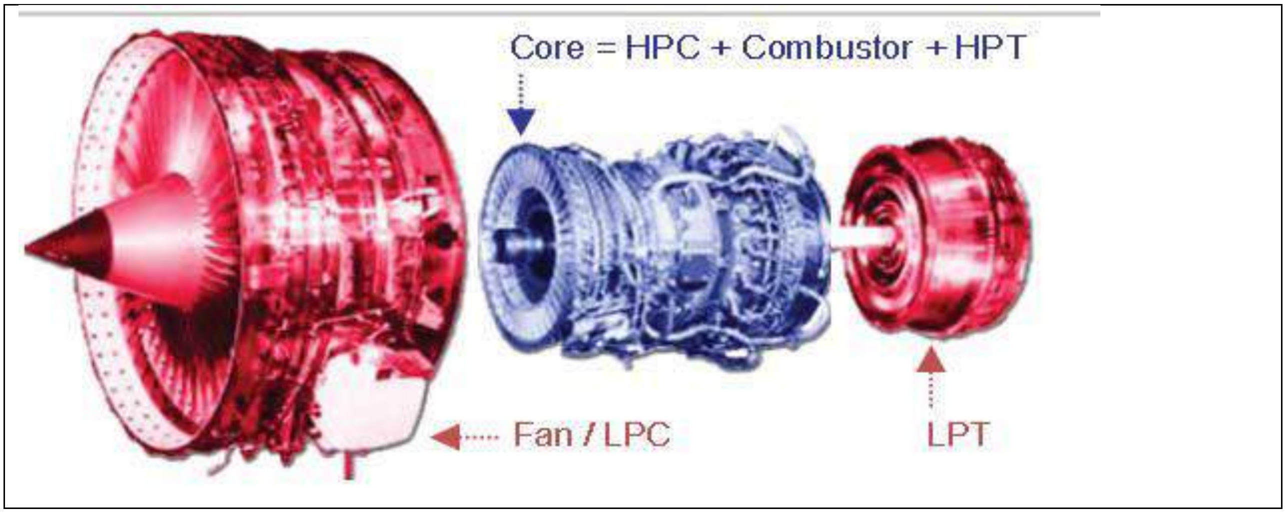
4 High Pressure Turbine (HPT) - The HPT module is aft of the compressor rear frame and forward of the LPT stator case. The HPT module is made up of the HPT rotor and nozzle guide vane assemblies, which act to extract the combustion thermal energy for driving the high-pressure compressor and accessory gearbox.

5 Low Pressure Turbine (LPT) - The LPT module is downstream of the HPT module. LPT components include the LPT rotors, LPT nozzle stator case and turbine rear frame. The LPT extracts the remaining combustion thermal energy to drive the fan and low-pressure compressor rotor assembly.

6 Accessory Drive - The accessory drive section is usually attached to the engine core or fan case. The accessory drive transfers mechanical energy from the engine to drive the basic engine & aircraft accessories (e.g. generators and hydraulic pumps) mounted to the accessory gearbox.

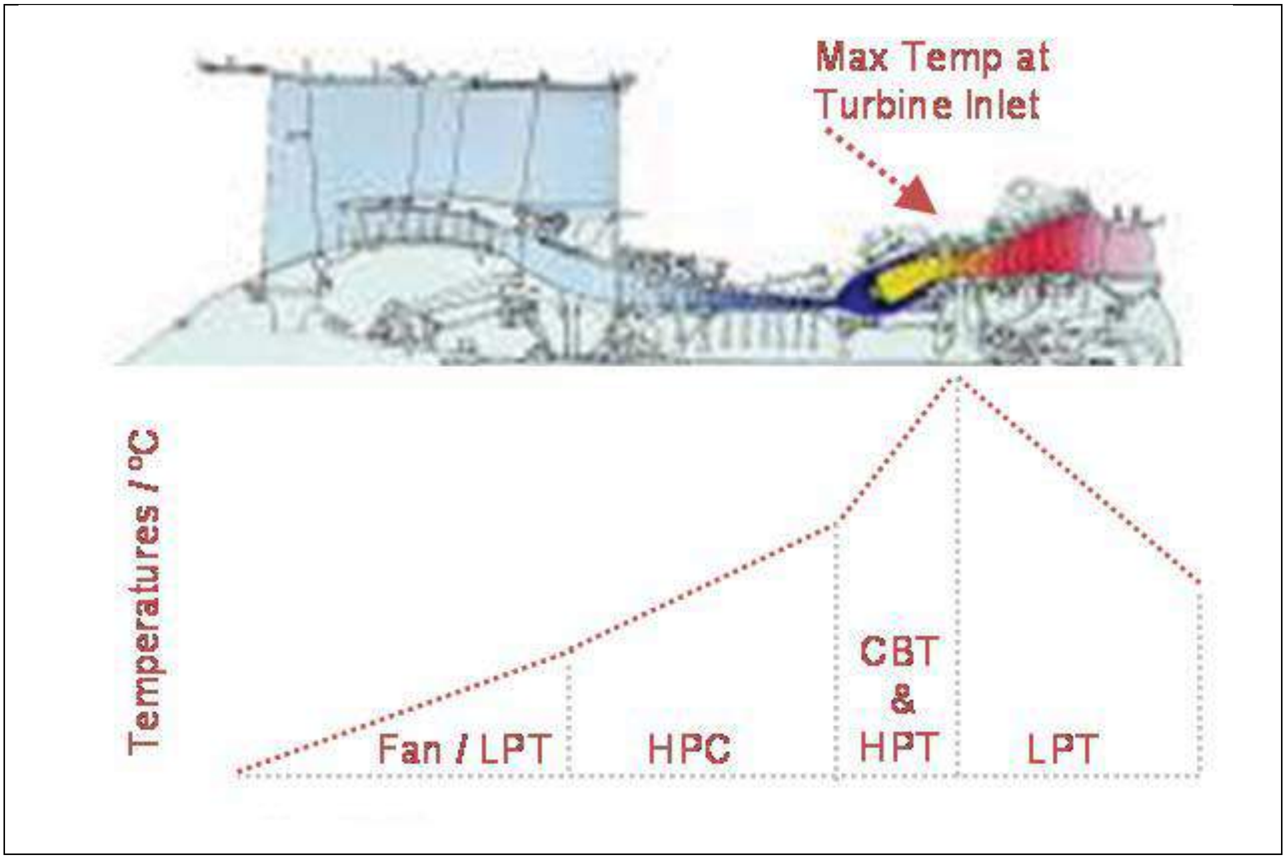
9.3 Engine's core section

An engine's core section, also referred to as the hot section, consists of the HPC, combustor, and HPT – **Figure below**. During operation it is this section that will be subject to most demanding conditions with respect to **temperature, pressure, and rotational speed**. It will therefore be this assembly of the engine that will deteriorate fastest, and core refurbishment will more likely need to be performed at every shop visit to regain lost performance.



9.4 ENGINE OPERATING TEMPERATURES

High thermal efficiency is dependent on high turbine entry temperatures. **Figure below** shows the temperature rise through the engine gas flow path. **Today's engines can experience turbine inlet temperatures in excess of 1,500°C**. To put this into perspective, at approximately 1,500°C components in the turbine are operating eight times hotter than a typical domestic oven.

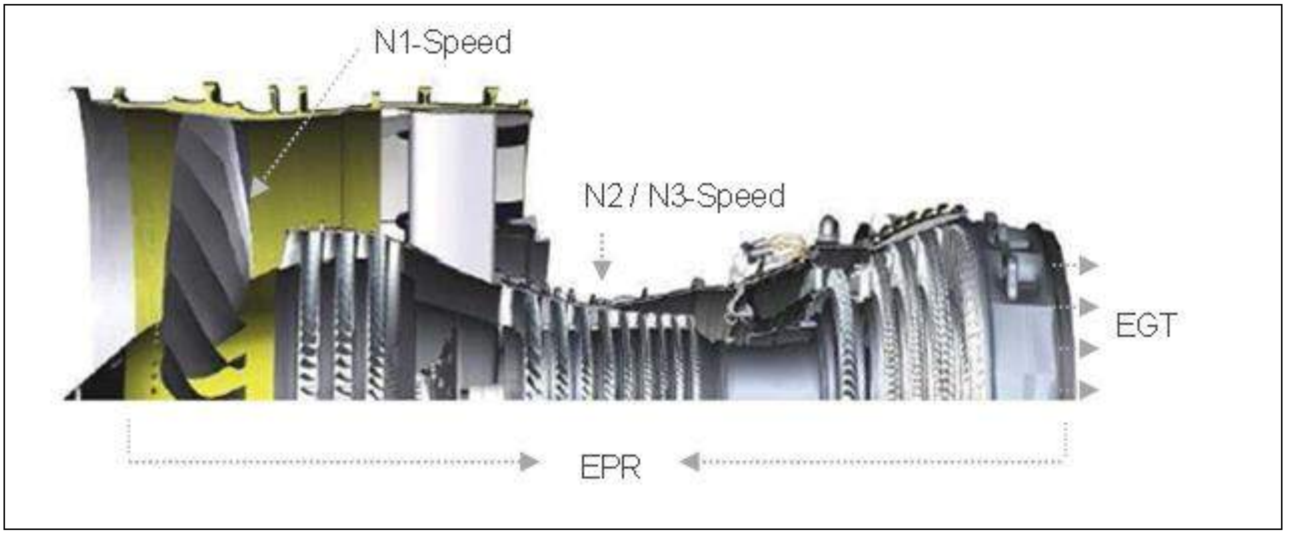


The **primary limitation** to higher turbine inlet temperatures is the availability of **exotic materials** that can withstand these higher temperatures. The general trend is that raising the turbine inlet temperature increases the specific thrust of the engines with a small increase in fuel consumption rate.

The combination of a higher overall pressure ratio and turbine inlet temperature improves thermal efficiency. This, together with a lower specific thrust (better propulsive efficiency), leads to a lower specific fuel consumption.

9.5 ENGINE KEY OPERATING PARAMETERS

The primary engine operating parameters are illustrated in **Figure below**, and consist of **fan speed (N1-speed) and Exhaust Gas Temperature (EGT)**. **Fan speed is commonly used for thrust indication whereas EGT is a common condition (or health) monitoring parameter**. **Some engine models also make use of Engine Pressure Ratio (EPR) and N2/N3-speed for thrust monitoring**. The following is a brief discussion of each of these performance parameters.



1. Engine Pressure Ratio (EPR) - is defined to be the total pressure ratio across the engine, and is computed by taking the ratio of the total pressure at the exhaust (or turbine exit) to total pressure at the front of the fan/compressor. This is used by some engine manufacturers to measure engine thrust.

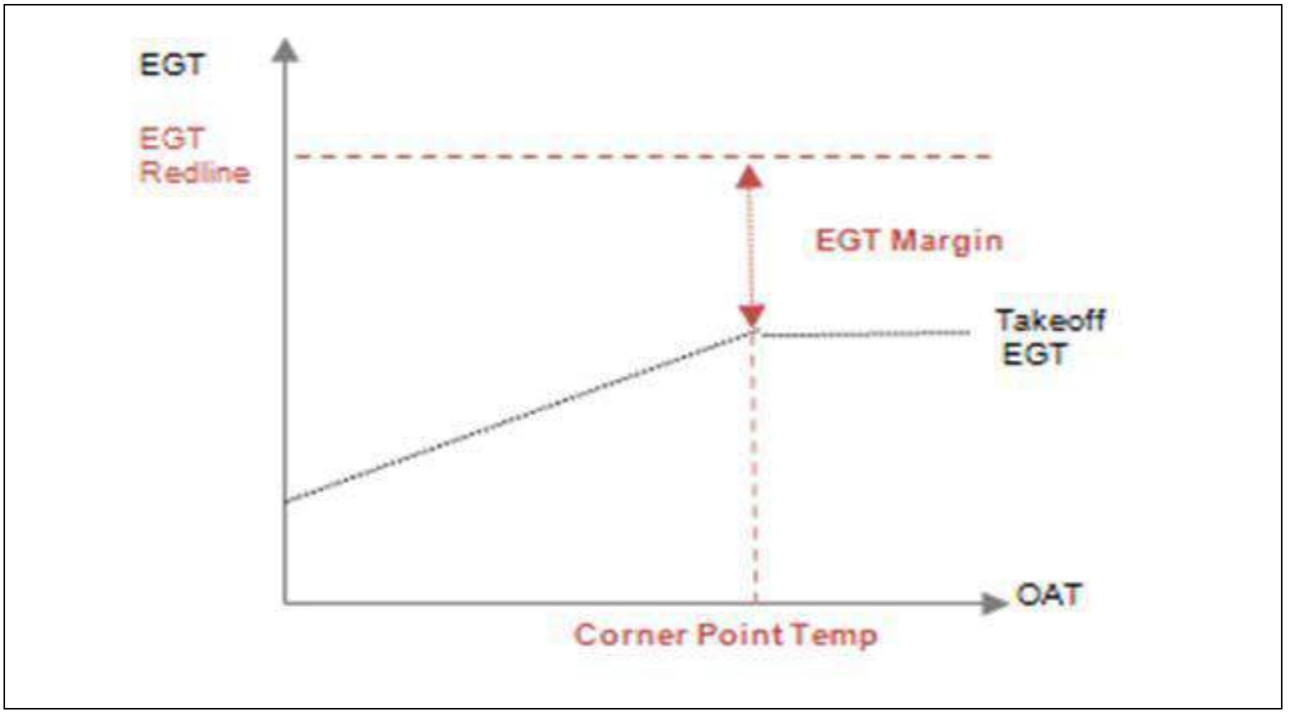
2. N1-speed - N1-speed is the rotation speed of the fan (or low pressure compressor depending on the engine type) and is typically presented as percentage of design RPM. **Rapidly fluctuating N1 or EPR can be a sign of an engine stall** (***It is commonly applied to the phenomenon whereby an engine abruptly ceases operating and stops turning. It might be due to not getting enough air, energy, fuel, or electric spark, fuel starvation, a mechanical failure, or in response to a sudden increase in engine load***)**, whereas as low EPR or N1-speed can be a sign of a flameout (*In aviation, a flameout (or flame-out) is the run-down of a jet engine or other turbine engine due to the extinction of the flame in its combustor*)**. N1-speed is also a primary parameter used to measure thrust. N2-speed (or N3-speed if the engine is a three spool configuration) is the rotation of the high or intermediate pressure compressor and is also presented as percentage of its design RPM. **Rapidly fluctuating N2/N3-speed can be a sign of an engine stall.**

3. Exhaust Gas Temperature (EGT) - expressed in degrees Celsius, is the temperature at the engine exhaust and a measure of an engine's efficiency in producing its design level thrust; the higher the EGT the more wear and deterioration affect an engine. High EGT can be an indication of degraded engine performance. An exceedance in EGT limits can lead to immediate damages of engine parts and/or a life reduction of engine parts. With this in mind it then becomes absolutely important to keep the EGT as low as possible for as long as possible.

4. EGT Margin - Normally EGT reaches its peak during take-off, or just after lift-off. The difference between the maximum permissible EGT (red-line) and the peak EGT during takeoff is called the **EGT Margin – Figure below**.

EGT margin is expressed mathematically as follows:

EGT Margin = EGT Redline – EGT Gauge Reading



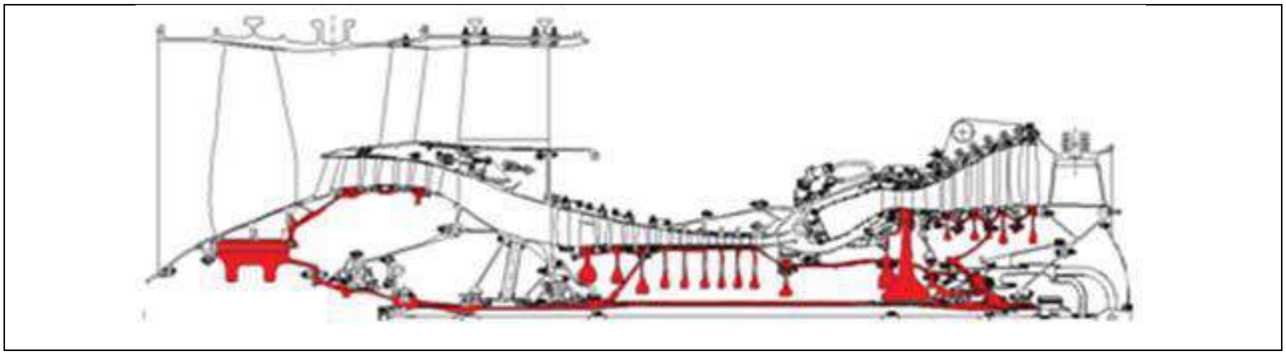
In general, EGT margins are at their highest levels when the engines are new or just following refurbishment. Theoretically an engine can remain in operation until its EGT margin has reduced to zero. EGT margin is also sensitive to changes in Outside Air Temperatures (OAT). As the OAT increases so does EGT for a given thrust setting. This is because most engine power management systems are designed to maintain constant take-off thrust with rising OAT.

The rise in EGT is traditionally linear up to the design **corner point temperature** at which point the EGT becomes controlling. The corner point temperature is where the EGT is highest when operating at maximum thrust conditions. **Operating at a higher OAT beyond the corner point**

temperature is possible, however the thrust must be reduced (de-rated) to avoid an EGT redline exceedance.

9.6 ENGINE LIFE LIMITED PARTS (LLPs)

Within engine modules are certain parts that cannot be contained if they fail, and as such are governed by the number of flight cycles operated. These parts are known as critical **Life-Limited Parts (LLP)** and generally consist of **disks, seals, spools, and shafts** – **Figure below**.



In most cases, the declared lives of LLPs are between 15,000 - 30,000 cycles, and a complete set will represent a high proportion (greater than 20%) of the overall cost of an engine. If the engine is operated over a long-range network, LLPs may never need to be replaced over the life of the engine. Over short-range routes however, LLPs may need to be replaced two or three times and, consequently, contribute a relatively high cost.

Certain LLPs can have shorter lives imposed on them by airworthiness directives (ADs) or other technical issues such as a decrease in fatigue characteristics or strength capability. Additionally, some engine manufacturers certify ultimate lives of LLPs at the time they certify an engine model. Other manufacturers certify the lives of LLPs as experience is accumulated. In these scenarios ultimate lives are reached after one or several life extensions.

The term stub-life is used to represent the engines shortest life remaining of all LLPs installed in a specific engine. Not all stub-lives are consumed during operation, and quite often the range of life remaining on an individual LLP at the time of replacement can vary from 3 to 15 percent of total cyclic life. Invariably, a considerable amount of value can be wasted when LLPs are replaced.

A number of engine models also contain **static LLPs.** Although these parts are not classified to be critical rotating parts they do fall under the category of parts whose failure could create a hazard to the aircraft. Such parts often consist of **coverings and mounts**.

9.7 Engine On-Condition Monitoring

In order to monitor the performance of an engine, regular detailed measurements are taken of the engine's operating speed, temperature, pressure, fuel flow and vibration levels. The measurements are tracked by special software in order to identify deteriorating trends. By closely monitoring these trends it is possible to identify a potential problem with the engine and rectify the problem before it becomes serious.

One means to monitor the physical condition of internal engine parts is through use of a **borescope.** Borescopes are easy-to-use optical diagnosis instruments that view, magnify and illuminate hard-to-reach areas. They are used to inspect the internal parts of the engine for defects such as cracks, stress fractures and corrosion.

The most commonly used form of the borescope is the video borescope, which consists of a handheld unit and a long, flexible, fiber-optic cable as shown in **Figure below.** Current borescope technology now allows for the accurate measurement of voids and defects such that the serviceability of an engine can be determined immediately by the inspector.