**CHAPTER 1** : Introduction to Landing Gear

## *Function of a Landing Gear*

1. Support static load of an aircraft on ground or water during maneuver or in static condition.
2. Provide a means of ground maneuvering/taxiing.
3. Absorb the landing shocks.
4. Dampen the vibration.
5. Facilitate aircraft for take-off and landing1
6. Provide aircraft braking and steering functions

## *Types of Landing Gear*

- There are 3 basic types of landing gear that applied to the surfaces, which is water, hard or earthen and snow or ice surfaces.
- Each surface requires a different type configuration of landing gear.
    1. Fixed or rigid type of Landing Gear
    2. Retractable Landing Gear.

## *Fixed or Rigid Landing Gear*

- Mostly used on light low speed aircraft
- Always remains extended
- Simple and low maintenance
- Aircraft that are not practical to be retracted are more suitable to used rigid/fixed type of landing gear.
- It is usually equipped with cowlings or fairings known as:
    1. Spats
    2. Speed Fairings
    3. Wheels Pants.

## *Retractable Landing Gear*

- Landing gear is retracted into the structure ie wing or fuselage compartment known as "Wheel Well" area.
    1. Minimize parasite drag
    2. Results in a better and improved aircraft performance
    3. Normally used on faster aircraft

Note: Extreme care is taken for landing gear because it received rough treatment throughout operation such as frequent landing shocks an irregular contact with ice, dirt and abrasive grit. By regularly washing, lubricating and servicing the landing gear, it guards against corrosion, seizure of mechanical parts and failure of electrical components

## *Wheels Arrangement of Landing Gear*

- Types of wheel arrangement of Landing Gear are:
    1. Single Type LG
    2. Double Type LG
    3. Tandem Type LG (parallel to each other)
    4. Multiple or Bogie Type LG

### Multiple (Bogie/Truck) Landing Gear

- The number of wheel determined by the gross design weight of aircraft and the surfaces on which the loaded aircraft may require when performing landing.

- Advantages of multiple wheel type of landing gear
    1. Multiple wheels spread the aircraft weight over a larger area of load distribution
    2. Providing safety margin in a case of one of the tire burst during take-off or landing.
    3. Extra braking effort or efficiency of braking is accomplish by the number of brake unit attached in each wheel.

- Disadvantages of multiple wheel type landing gear:
    1. More moving parts and therefore require greater amount of maintenance
    2. Tires tends to scrubs during turning maneuver. 3) Larger turning radius required to prevent or reduce tire wear and therefore need a larger space for movement.

## *Landing Gear Arrangement*

- Is determined by the manufacturer.
- Most commonly used arrangement on modern aircraft is the tricycle gear configuration.
- Types of Landing Gear Arrangement are:
    1. Tailwheel (Conventional) Type
    2. Tandem Type
    3. Tricycle Type
- Note:
    - ✓ With higher performance aircraft, drag becomes progressively important and LG is retracted into wings or fuselage during flight.
    - ✓ A retractable LG however increase weight, more complicated and requires additional maintenance.
    - ✓ The retractable tricycle arrangement of the LG is made up of several assemblies and parts.
    - ✓ These consists of air/oil shocks struts, main gear alignment units, supports unit, retraction and safety devices, auxiliary gear protective devices, nose wheel steering system, aircraft wheels tires, tubes and aircraft brake unit/system.

**Tailwheel (conventional) type**

- Main landing gear are located ahead of the C of G with tail wheel acts as auxiliary landing gear.
- Steering the aircraft by means of tail wheel through the application of brake by rudder pedal known as differential braking.
- Extra pilot skills is required to land the aircraft as aircraft tends 'ground loop' and the C of G may swing ahead of main wheel, which may cause abrupt uncontrolled change in direction of aircraft in ground.
- Advantages of Tail / Conventional wheel arrangement:
    1. Using a shorter runaway path because as the tail down attitudes gives a high drag after landing.
- Disadvantages of Tail / Conventional wheel arrangement:
    1. Brake application must be delayed or monitored closely to avoid the tendency to nose –over (nose tilt).
    2. A pilot view is restricted when taxiing and great care during taxiing is required,

**Tandem type**

- Seldom used on civilian aircraft
- May be found on military heavy bombers.
- Main Landing Gear are located in line of the C of G, which is under the fuselage and large wings is supported by out rigger wheels

**Tricycle-type**

- Most widely used.
- Main Landing Gear are located aft or behind of C of G.
- Nose Landing Gear supported the airplane nose and provides steering during ground manuever.
- Nose wheel acts as the steering and the auxiliary gear
- Advantages of tricycle wheel arrangement:
    1. It allows more forceful application of the brake for higher landing speed without nosing over.
    2. It permits better visibility for the pilot during landing and takeoff.
    3. It tends to prevent aircraft 'ground looping' by moving the aircraft C of G forward of the main wheels. Forces acting on the C of G tends to keep the aircraft moving forward on a straight line rather than 'ground looping'.
    *Ground Looping – A sharp, uncontrolled change in direction of the aircraft on ground. Tail wheel type aircraft are highly subjected to 'ground looping' because of its C of G is located forward of the mainwheels.*

***Types of Landing Gear Strut***

- There are 2 types:
    1. Non –Absorbing Landing Gear
    2. Shock Absorbing Landing Gear

**NON-ABSORBING LANDING GEAR**

1. Rigid.
2. Spring Steel.
3. Composite.
4. Bungee Cord.

**Rigid Type (non –absorb)**

- Commonly found on helicopters (skid) and sail planes.
- Rigidly mounted to the aircraft without no specific components to cushion the ground contacts.
- The only way of cushioning is through the flexing of the landing gear or airframe structure itself

**Spring Steel Type (non –absorb)**

- Used flat steel leaf or tubular spring steel.
- On ground contact during landing, the gear flexes and stores the impact energy.
- One end of strut bolted to airframe heavy structure and the axles are bolted to the opposite side.
- Normally used as main gear on light aircraft

**Composite Type (non –absorb)**

- The oleo struts/landing gear is basically made of composite material.
- lightweight and generally used for less excessive types of landing behaviour.
- Usually used on rotorcraft or helicopters. iv. Similar construction to rigid type.

**Bungee Cord Type (non –absorb)**

- Used rubber in the form of rubber doughnut or bungee cord to cushion landing shock
- Bundle of small rubber strands encased in loosely woven cloth tube.
- The structure of the landing gear is usually in the form of steel tubing whenever a rubber cord is used as a shock absorber.
- It is design and installed in such a way that the lever action is applied to tightly wound rubber cord.
- During landing shock, the cord is stretched thus storing the impact energy of landing.
- Stored energy is gradually returned to structure during landing roll
- Take both landing impact and taxi shocks
- Color coded is used to indicate year of manufactured; the color coding is composed of threads that are interwoven in the cotton sheath that bind the rubber together.
- Two spiral threads are used to indicate the year coding and one is used to indicate the quarter of the year and being repeated every 5 years.

| YEAR | COLOR | QUARTER | COLOR |
|---|---|---|---|
| 1995 & 2000 | BLACK | $1^{ST}$ | RED |
| 1996 & 2001 | - | $2^{ND}$ | BLUE |
| 1997 & 2002 | RED | $3^{RD}$ | - |
| 1998 & 2003 | YELLOW | $4^{TH}$ | YELLOW |
| 1999 & 2004 | BLACK | - | - |

- Periodically the bungee cord should be inspected for any aging marks, fraying of the braided sheath, narrowing (necking) of the cord and wear at the point of contact with the structure.
- Regardless of other factors, cord are recommended for replacement for every 5 years of service.

## SHOCK ABSORBING LANDING GEAR

1. Shock-struts / Oleo strut (Absorb)
2. Liquid Spring Type Shock Struts (Absorb)
3. Oleo-pneumatic with separator (Absorb)
4. Oleo-pneumatic without separator (Absorb)

## Shock Struts / Oleo Strut (Absorb)

- Shock absorber commonly known as oleo strut
- Dissipates impact energy of landing by forcing a fluid through restriction.
- The fluid movements generate heat which is dissipated to surrounding atmosphere thus dissipating landing energy.
- Functions of a shock struts:
    1. Absorbs and dissipates landing shocks.
    2. Control re-bound (spring back or recoil) movement.
    3. Providing cushioning effects during taxiing.
    4. Protect aircraft structure from damage
- Servicing Shock-strut / Oleo Strut
    1. To maintain proper strut tube exposures under all operating conditions.
    2. Relieve air pressure from the strut housing chamber by depressing the valve core.
    3. Remove the filler plug, raise the strut to full compression and replenish with a new hydraulic fluid.
    4. Extend and compress the strut several times to remove entrapped air from the housing and to correctly seat seal/packing.
    5. Reinstall filler plug, tightened and inflate the oleo strut.
    6. Rock the airplane several times to determining for correct strut position.
    7. Check for leak
    8. All procedures must be i.a.w. aircraft maintenance manual.

## Liquid Spring Type Shock Struts (Absorb)

- consists of piston type structure and heavy coil spring.
- Spring support the aircraft weight on ground and during taxiing
- Strut absorbs the landing shocks or impact.
- Utilizing the energy stored in compression of a liquid.
- Most liquids are known to be incompressible, but liquid spring type struts uses 'synthetic silicon' base fluid with molecules that are constructed larger than usual.
- Fluid contraction is a problem as fluid volumes changes at low temperature and effecting the oleo performance.
- Can only be pressurized while the aircraft is on jack and the gear should be fully extended.
- Equipped with a gland assembly that prevents leakage of oil.

**Oleo –Pneumatic with Separator (Absorb**)

- Consists of an outer cylinder in which slides a piston tube or inner cylinder.
- Inner cylinder is prevented from rotating by torsion link secure to the outer cylinder.
- Inner cylinder contains a spring-loaded flutter plate which normally covers holes drilled through the head.
- Small holes outside the diameter of the flutter plate acts as a restrictor.
- A floating separator in the inner cylinder separates the oil from the gas (nitrogen).
- Top of the outer cylinder is closed and fitted with oil filler plug.
- Bottom of the lower cylinder is fitted with gas charging valve.

**Oleo –Pneumatic Without Separator (Absorb)**

- The widely used type of shock absorber which does not use a separator to keep the oil separates from the gas.
- Uses a metering pin that can be found in various shapes (depends on the flow rates required) as a replacement of the separator and with an orifice.
- Outer cylinder is fixed rigidly to the airframe structure by mounting assembly.
- Inner cylinder is free to rotate and moved up and down within the outer cylinder.
- Movement is limited by the 'torque link', which connect the inner cylinder to the steering collar that are located at the outer cylinder.
- A difference compared to oleo pneumatic with separator is that the upper chamber in oleo pneumatic without separator is filled with dry air (nitrogen) and the lower chamber is filled with oil.

## *Oleo Pneumatic Shock Struts Construction*

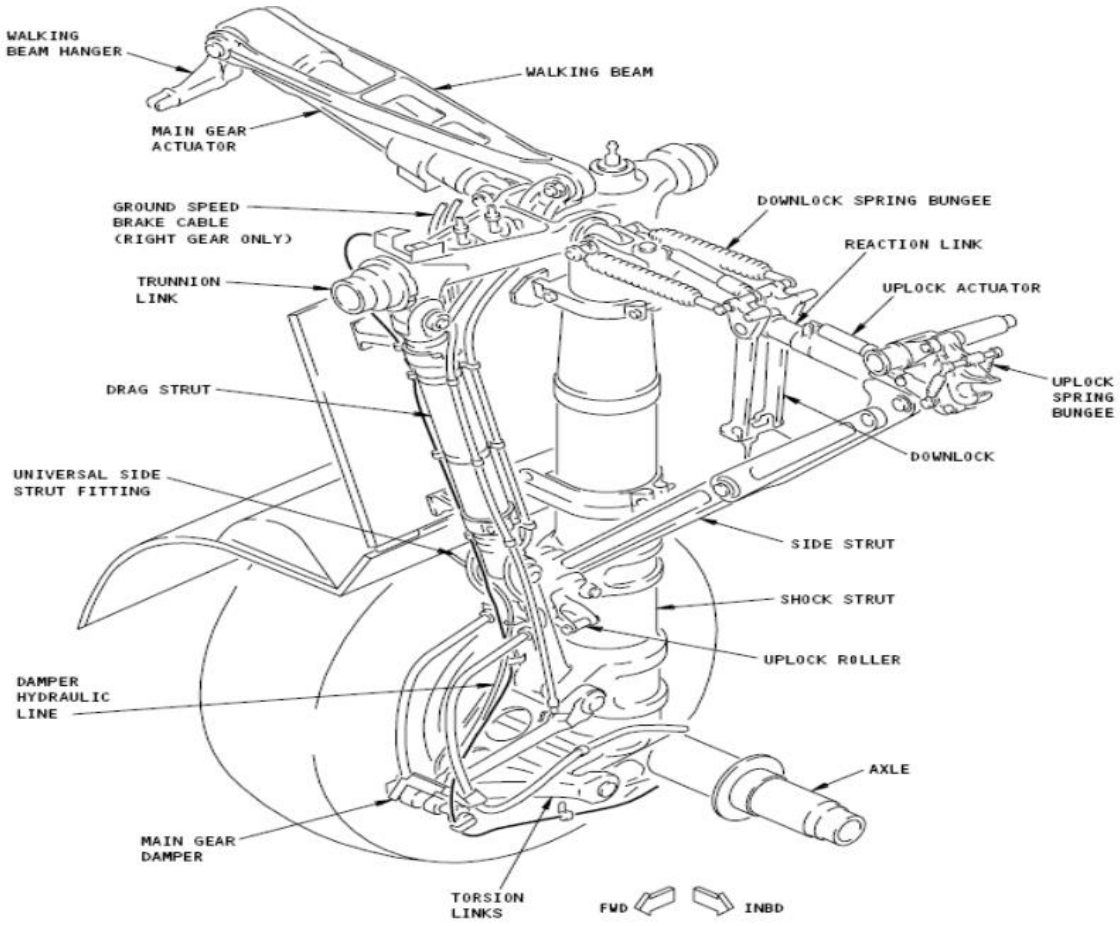
- Uses a compress dry air (nitrogen) and hydraulic fluid (mineral base type) to absorb and dissipate shock loads.
- Shock struts are essentially made up of two telescopic cylinder or tubes with externally closed ends.
- The two-cylinder known as cylinder and piston when assembled will form an upper and lower chamber for the movement of the fluid.
- The lower chamber is always filled with fluid while the upper chamber contains compressed air (nitrogen)
- An orifice is placed between the two chambers (upper & lower) and provides a passage for the fluid into the upper chamber during compression and fluid return during the extension of the struts.
- Metering pin, that is a part of the piston is often used for controlling or governing the rate of fluid flow from the lower chamber into the upper chamber (varies in cross section to provide different rate of flow during compression strokes).
- A packing gland is designed to seal off the sliding joint between the upper and lower telescoping cylinder and are installed in the open end of the outer cylinder.
- A packing gland wiper seals installed in a groove in the lower bearing or gland nut to keep the sliding surface of the piston or inner cylinder from entrance of dirt or grit.
- Entry of foreign matter into the packing gland would results in leakage.
- A leak will result in lost of fluid and nitrogen in the cylinder and could cause oleo 'bottoming' (collapsed).

## *Oleo Pneumatic Operations*

- During compression of the shock struts at landing, the orifice provides a restriction of fluid flow and this reduce the rate of which the piston (located in the inner cylinder) can move into the cylinder.
- This provides a cushioning effect to reduce the shock of landing.
- As the fluid flow through the orifice into the upper chambers, the air in the upper chamber is compressed to the point that the entire weight of the aircraft is supported by the air in the landing gear strut.
- The extension stroke occurs at the end of the compression as the energy stored in the compressed air causes the aircraft to start moving upward in relation to the ground (the compressed air acts as a spring to return the struts to its normal extension).
- The rapid rebound or recoil of struts is dampened by forcing the fluid to return through the restriction of the snubbing device (restricting the rate of fluid flow from upper chamber to lower chamber).
- The compressed air then acts as a shock absorber during the time that the aircraft is taxiing.
- The initial shock of landing is absorbed by the hydraulic fluid. The taxiing static shock is cushioned or dampened by the air/nitrogen gas.
  *Note: For efficiency operation of the shock strut, the proper fluid level and air pressure must be maintained.*

## *Landing Gear Main Components*

1. Torque Links/Torque Arms/Torsion Link (Scissors Assembly)
2. Drag Link/Drag Struts
3. Side Brace Link/ Side Struts
4. Overcenter Link/Downlock Struts/ Jury Struts
5. Trunnion
6. Shock Struts
7. Shimmy Damper
8. Actuator/Jack/Actuating Cylinder
9. Uplock Cylinder/Uplock Actuator
10. Downlock Cylinder/Downlock Actuator
11. Indicator (microswitches/ground safety switch/squat switch)
12. Centering Cam
13. Steering Actuator
14. Landing Gear Door Actuator
15. Emergency Lowering Mechanism




Main Gear Component Location

**1) Torque Links/Torque Arms/Torsion Link (Scissors Assembly)**

- Maintain wheel and axle in a correct aligned position in relation to the strut (misalignment corrected by adding/installing a spacer or shim of different thickness).
- Prevent ram of a piston turning in the struts.
- Restrict the extension of the piston during the extension of the struts.

**2) Drag Link/Drag Struts**

- Stabilizing the landing gear and support the aircraft structure longitudinally.

**3) Side Brace Link/ Side Struts**

- Stabilizing the landing gear and support the aircraft laterally.

**4) Overcenter Link/Downlock Struts/ Jury Struts.**

- Holds the drag link and the side brace in the 'DOWN' and 'LOCKED' position by applying pressure to the center pivot joint in a drag or side brace link.
- Operates hydraulically by bungee cylinder or mechanically by bungee springs.

**5) Trunnion**

- Portion of landing gear outer strut assembly attached to airframe
- Supported at its end by bearing assemblies, which allow the gear to pivot during retraction and extension. The strut formed part of oleo pneumatic shock absorber.

**6) Shock Struts**

- Vertical member of the landing gear assembly that contains the shock absorbing mechanism.

**7) Shimmy Damper**

- Hydraulic snubbing unit that reduces the tendency of the nose or tail wheel oscillate from side to side (rapid oscillation).

**8) Actuator/Jack/Actuating Cylinder**

- Raising and lowering the landing gear. May also be used as a downlock mechanism (continuous application of pressure)

**9) Uplock Cylinder/Uplock Actuator**

- Locking the landing gear in 'UP' and 'LOCKED' position

**10) Downlock Cylinder/Downlock Actuator**

- Locking the landing gear in 'DOWN' and 'LOCKED' position

**11) Indicator (microswitches/ground safety switch/squat switch)**

- Means of providing cockpit indication with regards to the landing gear position, either 'UP' and 'LOCKED','DOWN' and 'LOCKED' or in transition and 'NOT LOCKED'

**12) Centering Cam**

- Aligning the nose wheel before retracted to 'UP' and back to its wheel well compartment.

**13) Steering Actuator**

- Allowing the pilot to control or steer the aircraft by means of NLG wheel assembly for taxiing.

**14) Landing Gear Door Actuator**

- Allowing the opening or closing of landing gear door (main and nose landing gear).

**15) Emergency Lowering Mechanism**

- Providing the means of lowering down the landing gear in the event of normal extension system fails (under FAR 23.729).

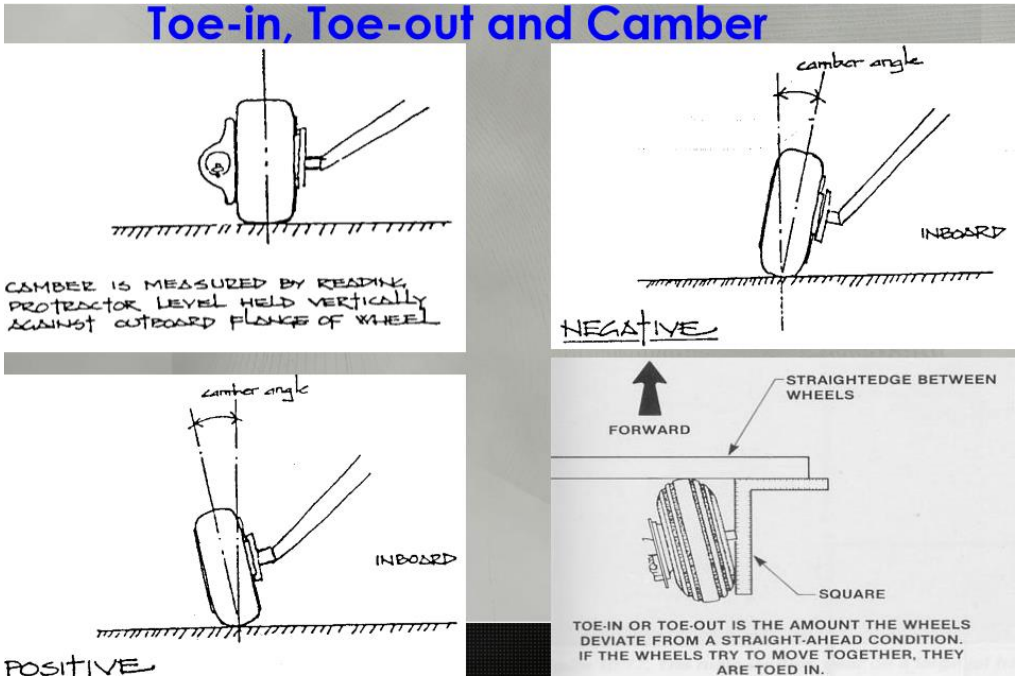
**CHAPTER 2** : Landing Gear Operations

***Alignment of Main Landing Gear***

- Alignment of main landing gear wheel should be checked periodically I.A.W maintenance manual.
- The main function of wheel alignment is to assure proper handling characteristic during taxiing, take-off and landing.
- It is also a method to reduce the tendency of uneven tire wear (more obvious to multiple type wheel arrangement.
- Wheel alignment generally checked for:

1. Camber – The amount of wheel are tilted or inclined from vertical view, if the TOP of the wheel tilts outward the camber is considered as 'positive camber' and if it is tilted inward the camber is considered as 'negative camber'.

2. Toe – The amount wheel deviate from a straight-ahead condition (the amount of wheel angled from the horizontal axis)
    a) Toe In – The wheel tries to move together as the front are closer together than the rear (the extended longitudinal axis of the main landing gear wheel assemblies will intersect forward of the aircraft).
    b) Toe Out – The wheel tries to move further apart as the front of the tire are farther apart than the rear (the extended longitudinal axis of the main landing gear wheel assemblies will intersect aft of the aircraft).



***Oleo Pneumatic Operations***

- Wheel alignment for the 'spring steel' landing gear are achieved by adding or removing shims between the axle and the landing gear struts.
- Wheel alignment for retractable landing gear with oleo pneumatic strut is achieved by adding or removing shims in between the upper torque arm and the lower torque arm link.
- The wheel alignment should be within the tolerance specified in the aircraft maintenance manual

***Retractable Landing Gear***

- Improving aircraft performance by reducing parasite drag on the aircraft.
- The landing gear are being retracted inside the fuselage or wing generally known as 'wheel well' or 'landing gear compartment'.

- Methods of retraction and extension of retractable landing gear:
  1) Mechanical type.
  2) Electrical type.
  3) Hydraulic type.
  4) Pneumatic type.

- Electrical landing gear retraction system has the following features:
  1) A motor for converting electrical energy into rotary motion.
  2) A gear reduction system for decreasing the speed and increasing the force of rotation.
  3) Other gears for changing rotary motion (at a reduced speed) into push pull movement.
  4) Linkage for connecting the push pull movement to the landing gear shock struts.

## *Retractable Landing Gear Operations*

- Retractable Landing Gear are also provided with:
    1. Mechanical locks to ensure that each landing gear is locked securely in the retracted and extended position.
    2. Devices to indicates to the crew the position of each landing gear.
    3. Means by which the landing gear can be extended in the event of hydraulic failure or electrical power source failure.
    4. Means to prevent retraction when the aircraft is on the ground.
    5. Means to guard against landing with the landing gear retracted.

## LOWERING LANDING GEAR

1. To lower the landing gear, the pilot moves the landing gear handle to the GEAR-DOWN position and these events take place.
2. The landing gear handle actuates a switch that turns on the hydraulic pump motor in the power pack so that it turns in the direction shown by the arrows in figure A.
3. Fluid flow through the check valve on the right side of the pump and around the outside of the gears.
4. The output from the pump moves the gear-up check valve piston to the right an unseat the gear-up check valve.
5. The pump output then flows down to the shuttle valve and forces it to the left, opening the passage to the gear-down side of the actuating cylinder.

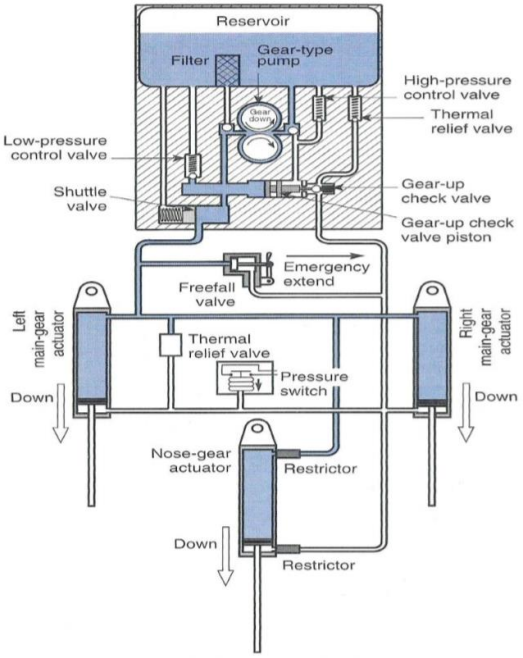


FIGURE A (Lowering)

6. Fluid flow into the down side of the three actuating cylinder and forces the pistons out. The nose gear is much easier to move than the main gears, so the fluid flows into and out of the nose gear actuating cylinder through restrictor.
7. Return fluid from the up side of the actuator flows through the opened gear-up check valve back to the inlet side of the pump.
8. As each gear reaches its down and locked position, the pressure in the gear-down line builds up and fluid is bypassed back into the reservoir through the low-pressure control valve. When all three gears are down and locked, limit switches turn the pump motor off.

## RAISING LANDING GEAR

1. When the aircraft is in the air, the pilot can retract the landing gear by moving the landing gear handle to the GEAR-UP position, these events take place.
2. The landing gear handle actuates a switch that turns on the hydraulic pump motor in the power pack so that it turns in the direction shown in Figure B .
3. Fluid flow through the filter and the check valve on the left side of the pump, around the gears and out the right side, down to the gear-up check valve.
4. The fluid from the pump moves the gear-up check valve piston to the left and unseat the ball and flow to the gear-up side of each of the gear actuating cylinders. The first movement of the piston releases the mechanical down locks and allows the gear to retract.

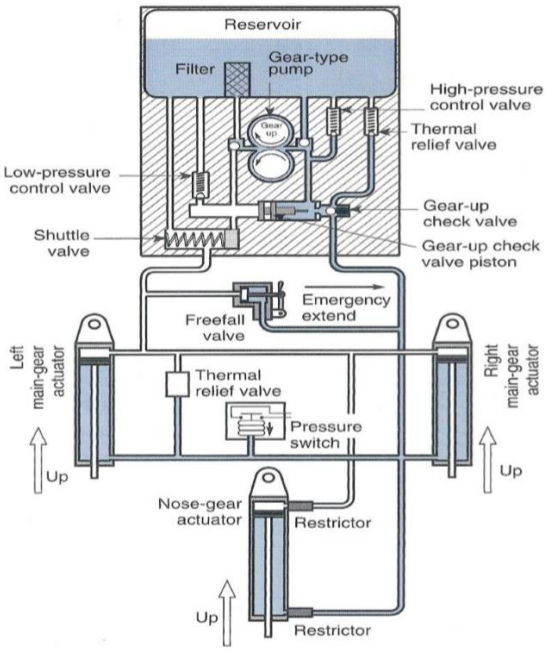


**FIGURE B (Raising)**

5. Fluid return from the geardown side of the actuator past the shuttle valve, which the spring has forced to the right, back into the reservoir.
6. This type of landing gear system does not have any mechanical up locks, but the gear is held retracted by hydraulic pressure. When all three gears are fully retracted, the pressure continues to build up until it reaches a value that opens the pressure switch and shut the hydraulic pump motor 'OFF'.
7. If the pressure in the system leaks down to a specific value, the pressure switch will close and start the pump so it will restore the pressure to the cutout value.

## *Retractable Landing Gear Retraction Methods*

- 4 types of retraction direction on a retractable landing gear:
  1) Rearwards retraction.
  2) Sideward retraction.
  3) Forward retraction.
  4) Upward retraction.

**Rearward retraction**

- Could be used on nose landing gear, tail gear and main gear.
- The disadvantage of this design is that the airflow could not be used as an aid or assisting in emergency extension.
- Require back-up pressure system for emergency extension.

**Sideward retraction**

- Landing gear retracting inboard or outboard.
- Used only on 'main landing' gear application and are not suitable on 'nose landing' gear.
- Fuselage does not allow any nose landing gear or tail wheel gear to be retracted in this direction (small structure, electrical compartment, radar, etc).

**Forward retraction**

- Used generally on both main and nose landing gears.
- Considerable effort required to retract (raise) the landing gear because it is against the airflow during flight.
- Airflow acts as an aids or assisting in emergency extension of the landing gear.

**Upward retraction**

- The gear is retracted upwards into the fuselage known as 'pod' or 'blister'.
- Retracting the landing gear into the wing is not practical due to the size of the landing gear.
- Mainly used on high wing plane aircraft such as 'Lockheed C-130'.

## *Factors that affects retraction direction*

1. Mainplane shape and thickness.
2. Engine placement/location (at empenage, under the wing or inside the fuselage).
3. Landing speed attained.
4. Aircraft design gross weight.
5. Landing gear type (single, double, tandem or multiple).

***Retraction Test***

- Retraction test should be carried out following:
    1) Replacement of a faulty landing gear compartment (valves, switches, actuator, etc).
    2) Adjustment of components related to the retraction system.
    3) After a hard landing or overweight landing occurs.
    4) Whenever incorrect operation is reported or suspected by flight crew or maintenance personnel.

***Checks during Functional Retraction Test***

1. Landing gear for proper operation.
2. Doors for correct operation and fits limits (flushed).
3. Clearance in the wheel well bay with the landing gear retracted and making due allowance for the effects of centrifugal force on the tire diameter (to avoid damaging any hydraulic lines).
4. Permissible retraction and extension time (also timed for 'free fall').
5. Linkages for correct adjustment, proper operation and security
6. Locks, switches, warning devices, electrical and mechanical indicators for correct indication and operation.
7. Freedom from fouling during the retraction or extension especially flexible pipeline.
8. General smooth operation of all landing gear associates mechanism.

**CHAPTER 3** : Landing Gear Locking

***Uplock Mechanism Operation***

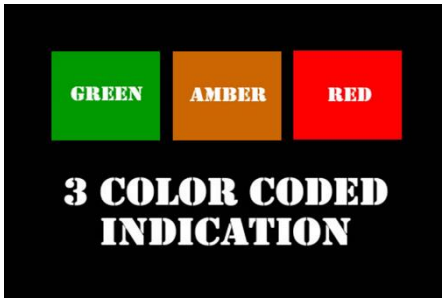
- A mechanical lock, but actuates the releasing of locking by means of fluid (hydraulic) pressure.
- Consisting of a spring-loaded latch attached to the airframe structure, which engages with pin in the landing gear when it is being retracted.
- Fluid pressure is applied simultaneously to the actuator and lock the piston.
- When the lock piston is moved, the pressure applied will automatically releases the latch from the pin and allowing the actuator piston rod to be extended.

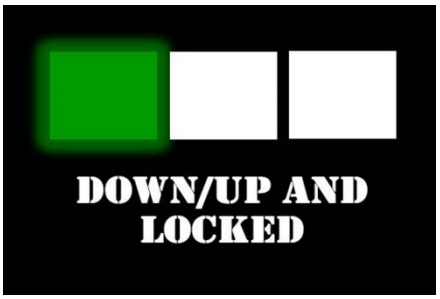
***Emergency Extension System Operation***

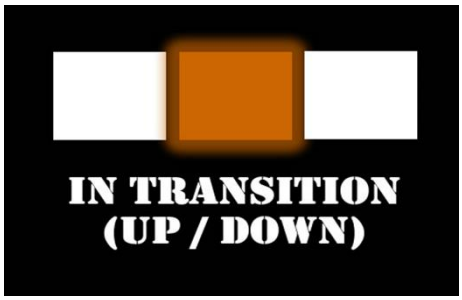
- A means of extension of landing gear and lock it in down position in the event of main operating system fails.
- On some aircraft, the up-lock mechanism is released manually or by means of pneumatic pressure.
- The landing gear is free to fall under its own weight and downlock is engaged by 'spring jack/actuator'.
- On other aircraft, the landing gear is extended by emergency pressure system that often uses alternative pipelines/tubing to the actuator (standby hydraulic system).
- Hydraulic pressure for emergency system may be supplied by means of hydraulic accumulator, hand pump, pneumatic storage cylinder or electrical powered pumps.

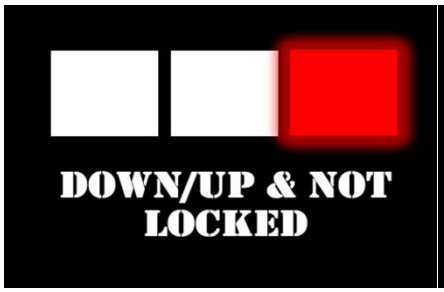
***Landing Gear Positioning Indicator***

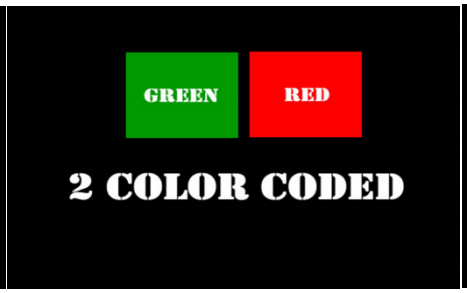
- An electrical indicating system is used to provide visual indication to crew.
- Indicators are usually located in the cockpit or flight compartment.
- 'GREEN' light indicates LG is fully 'DOWN' and 'LOCKED'.
- 'RED' light indicates unsafe condition such as the LG is 'NOT DOWN' and still in 'UNLOCKED' or indicates LG is still in transition from 'UP' to 'DOWN' position or vice-versa.
- 'NO LIGHT' indicates LG is fully 'UP' and 'LOCKED'
- Gear warning devices are incorporated in all retractable LG aircraft and usually consists of a horn or some other aural device and 'RED' warning light (aural and visual warnings).
- The horns blow and the light comes on when the airspeed decreases below the safe figure such as when engine throttle is retarded or set to less than 1/3 (in landing configuration) and the LG is in any position other than 'DOWN' position as required.
- On larger transportation aircraft provision is made for the crew to examine the lock during flight in the event of failure or incorrect operation of the LG indicating system.
- Whenever indicating system is used, it is important that the microswitches are adjusted so that operation of the indicating light coincides with the corresponding position of the LG.

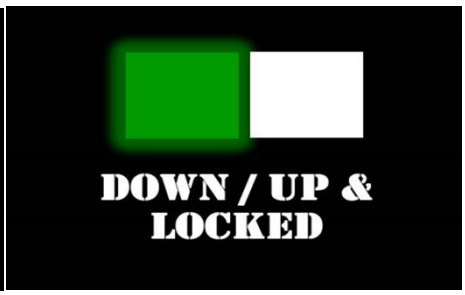


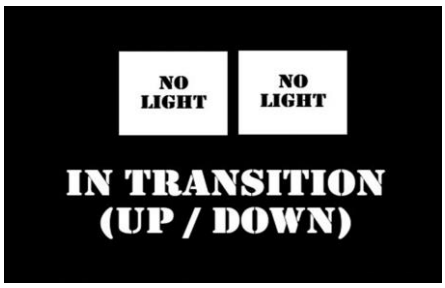



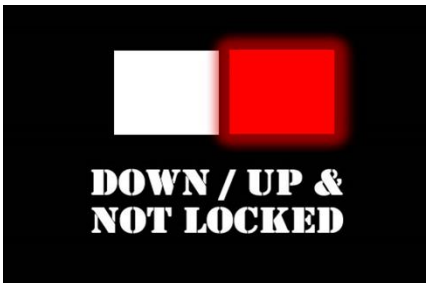




***Safety Features in Landing Gear System***

- The safety lock consists of a spring loader plunger, which retain the selector in the 'DOWN' position.
- It is being released by the operation of a solenoid.
- Electrical power to the solenoid is controlled by a switch mounted on the shock strut.
- When the strut is compressed, the switch is 'OPEN' but as the struts extended after take-off, the switch contacts close and the electrical supply to the solenoid is completed and therefore releasing the selector lever lock and allowing the LG to be selected to 'UP' position.
- A means of overriding the lock such as separated gate switch is provided for emergency use and maintenance purposes.

***Landing Gear Down Lock Mechanism***

1. Hydraulic Downlock
2. Geometric Downlock
3. Mechanical Downlock.

**CHAPTER 4** : Nose Gear Steering System

- Ground steering of a small nose wheel aircraft is accomplished by either a direct linkage to rudder pedals or by means of differential braking (castoring of a nose wheel).

- Free castoring system;
    1) Some light aircraft the nose is free to caster.
    2) This type of nose wheel steering system is controlled by the aircraft brake system.
    3) When the left brake or right brake is pressed or applied, the aircraft will turn in the direction of the applied brake which is left or right direction.
    4) The rate of the turn can be determined or controlled by the amount of pressure applied to the brake.

- Large aircraft is steered by means of hydraulic pressure (NLG down pressure) in the steering cylinders.
- This large cylinder will act as a shimmy damper during take-off and landing but acts as a steering cylinders when aircraft is taxiing.
- Fluid is then directed into and out of these cylinders by the steering control valve that being moved by the application of rudder pedals or a nose wheel steering.
- Nose wheel steering system consists of:
    1) A cockpit control such as wheel, handle, levers or a switch to allow starting and stopping and at the same time to control the action system.
    2) Mechanical (by means of cables), electrical or hydraulic connection for transmitting cockpit control movements to a steering control unit.
    3) A control unit which is usually a metering valve or control valve.
    4) A source of power, which is in most instances the aircraft hydraulic system (NLG down pressure).
    5) Tubing or hydraulic lines for carrying fluid to and from various parts or components of the system.
    6) One or more steering cylinders together with the required linkages for using pressurized fluid to turn the nose gear (either left or right).
    7) A pressuring assembly to keep fluid in each steering that is always under pressure thereby preventing shimmy
    8) A follow up mechanism consisting of gears, cable rods, drum or bell crank for returning the steering control unit to neutral and therefore holding the nose gear at the correct angle of turning.
    9) Safety valves to allow the wheel to trail or swivel in the events of hydraulic failure.
- Power steering hydraulic may be operated by
  - single actuator (equal area)
  - double actuator (unequal area)

**CHAPTER 5** : Nose Wheel Centering System

- The nose wheel must align themselves with the wheel bay once the weight has been removed from them or damage would occur when the undercarriage is retracted.
- Nose gear shock struts are provided with an upper locating cam that are attach to the upper cylinder and mating to the lower locating cam that are attach to the lower cylinder.
- Centering device includes an internal centering cam which is to center the nose wheel as it is being retract into the wheel well.
- During retraction of the nose gear the weight of the aircraft is not supported by the struts.
- The struts are extended by means of gravity and air (nitrogen) pressure within the struts itself.
- As the struts extended, the raise area of the piston strut will contact the slopping area of the fixed centering cam and slides along it.
- In doing so, it will align itself with the centering cam and rotates the nose gear piston into a straight-ahead position.
- A shimmy damper is installed to the NLG to acts as a hydraulic snubbing unit which reduces the tendency of the wheel to oscillates from side to side during ground maneuver or what we called 'shimmy' (a rapid violent side to side swing (oscillation) of a nose or tail wheel while traveling forward at a certain speed along the runaway).

**CHAPTER 6** : Shimmy Damper

- Function: Dampen the rapid oscillation of nose wheel but still allow the wheel to turn by steering system.
- Types of shimmy damper:
  1) Piston Type Shimmy Damper.
  2) Vane Type Shimmy Damper.

***Piston Type Shimmy Damper***

- A simple type shimmy damper consists of a hydraulic cylinder filled with hydraulic fluid and being divided into two chambers by a piston with a bleed hole or an orifice, which restrict the speed at which the piston can be moved in the cylinder.
- Piston rod is fitted to a stationary part of the nose gear while the cylinder is attach to rotating or moving parts of the gear.
- Restricted flow of the fluid has no effects on a normal nose wheel steering but an oppose rapid movement of a piston will prevent shimmy

***Vane Type Shimmy Damper***

- A type of shimmy that are design with a sets of moving vanes and stationary vanes. The moving vanes are mounted on a shaft extended outside of the housing.
- When the shaft turns, the chamber between the vanes changes size and therefore forcing hydraulic fluid from one chamber to another.
- The fluid must flow through restricted orifice, providing dampening effects to any rapid movement of the vanes in the housing. The body or housing is mounted on a stationary part of the NLG and the shaft lever is connected to the movement turning part of the NLG and automatically will move the vane in the shimmy damper.

**Note**: *Shimmy damper will not operates satisfactorily if there is present of air in the cylinder and should be inspected frequently for any oil leaks and effectiveness of its operation.*

***Effects of Nose Landing Gear shimmy***

1. Uneven tire pressure.
2. Uneven tire wear.
3. Incorrect wheel and tire diameter.
4. Incorrect balanced wheel.
5. Unserviceable wheel bearing.
6. Unserviceable bushing on the struts and its attachment.
7. Worn shimmy damper attachment.
8. Wear in the steering linkages.
9. Wear in the torque links attachment and alignment.

***Design features incorporated in LG assembly to eliminates shimmy***

1. Dual wheel arrangement.
2. Twin track wheels.
3. Castoring wheel.
4. Hydraulic steering that acts as a damping unit.

***Steer Damper***

- Hydraulically operated and accomplished the two-separate function of steering and/or eliminates shimmy.
- Basically consists of closed cylinder and containing rotary vane type working chamber (quite similar to vane type shimmy damper) and valving devices.

**CHAPTER 7** : Wheel Assembly

***Aircraft Landing Gear Wheel Assembly***

- Wheel are usually made out of aluminum or magnesium alloy and undergo the process of forging and casting.
- Aluminum alloy wheel are being protected from corrosion by performing anodizing.
- Magnesium alloy wheel are being protected from corrosion by performing chromating.
- After the process of protection is done, the wheel is painted.
- If the protective finish is damage, it must be restored immediately to prevent corrosion.
- Bead seat area is the flat surface on the inside of the rims of an aircraft wheel on which the bead of the tire sits on.
- It is the most critical parts of the wheel because the areas are under high tensile load due to air pressure in the tire and intensify by the landing effects.
- It is rolled to pre-stressed the surfaces with a compressive stress.

**CHAPTER 8** : Wheel Constructions

- There are three types of wheel constructions, which are:
    1. Wheel Base Non-Detachable Flange (Drop Center).
    2. Well Base Removable Flange (Drop Center & Flat Base).
    3. Split or Divided Wheel.

***Wheel Base Non-Detachable Flange (Drop Center)***

- Well base wheel are only fitted on light aircraft and normally used together with tube type tires.
- Similar in construction of removable flange except the flange is fixed.

***Well Base Removable Flange (Drop Center & Flat Base)***

- Made out of one flange integral with hub and the other flange are removable and retain by a locking ring
- When tire is inflated the flange covers the ring and trapping it in the groove and preventing the flange from coming off from the wheel.
- An 'O' ring seal is fitted to provide air tight so tubeless tire can be used with this type of wheel.

***Split or Divided Wheel***

- Made up of two mating halves.
- Connected by bolts passing axially through two parts.
- An 'O' ring is fitted between the two halves when used with tubeless tire.
- As a safety precaution measure in case the bolts that hold the wheel halves together have been damaged or weakened, the tire has to be fully deflated before attempting to dismantle the unit to relieve the strain.

***Description on Wheel Constructions***

- Beads seats area are usually rolled to pre-stress their surfaces to increase its strength against surface tension load
- Inboard wheel half (towards the aircraft) is where the location of bearing cone house, brake drive blocks or keyways, fusible plug….etc.
- Outboard wheel half (away from the aircraft) is where the location of inflation valve housing, bearing cone, wheel cap with bracket to drove the wheel speed sensor of anti-skid system to cover the axle…etc.
- The bearing cup are usually shrink fitted into the hub of the wheel casting and provide the surfaces on which the bearing ride (cup is chilled prior to fit into the cone).
- Removal of the bearing cup required heating of the wheel in a boiling fluid (water) or in an oven with temperature not higher than 2250F for 30 minutes.

***Major Causes of Failure or Rejection of an Aircraft Wheel***

1. Corrosion
2. Loss of bearing lubrication

## *Wheel Bearing*

- Bearing of an aircraft wheel are of the taper roller type.
- It consists of a bearing cone, roller with retaining cage and a bearing cup or outer trace.
- Hub cap is used to keep dirt out of outside bearing while suitable retainer is used to prevent grease from reaching the brake lining.
- Felt seal are provided to prevent dirt from decayed/fouling multiples brakes.
- Bearing should be cleaned and repacked with grease (high melting & low freezing type) either by pressure equipment or by hand periodically I.A.W applicable manufacturer manual.
- The pressure methods (using grease gun for example) is recommended because it is easier, faster and reduce the possibility if contamination and also ensures a more even better distribution within bearing.

  **Note**: *Bearing should be completely dry before packing them with grease. Dry the bearings and the hub area with compressed air and try to exercise caution not to spin the unlubricated bearings*

- Wheel bearing gets contaminated or breaks down from excessive heat and water.
- All wheel bearing should be lubricated at every tire change and as per required by the applicable maintenance manual.
- Wheel bearing, bearing cup, wheel bores and grease retainer should be clean by an appropriate solvent.
- Performing a visual; inspection of bearing. Bearing cup, bearing retainer with 10X magnifying glass and replace all worn, dented, scored or pitted bearing cup

## *Wheel inspection*

- Prior to inspection, wheel to be thoroughly clean with Stoddard solvent or any approved or recommended cleaning solvent
- Eddy current or ultra-sonic flaw detection methods of NDT should be carried out on the bead seat area.
- Magnetic particles inspection to be carried out on wheel attachment bolts, junction of head and shank and the end of threaded portion susceptible to crack and should be inspected carefully.
- Dye penetrate inspection should be carried out on bolts holes.

**CHAPTER 9** : Wheel Bearing Defects

***Bearing Defects and Indications***

**Galling**

- Damage cause by the rubbing of mating surfaces. When localized, high spots rub against each other becomes heated by friction and enough to weld it together. As they continue to move, the welded areas are pulled apart and destroyed some of the surfaces.

**Spalling**

- Damage in which chips are broken from the surface of a case hardened material such as bearing race. Spalling occurs when the bearing race is placed under a load great enough to distort the softer inner part of the metal and cause the hard and brittle surface to crack. Once a crack forms in the surface, chips breaks out.

**Brinelling**

- Damage to the hardened surface of a roller bearing or race caused by excessive radial loads. When the bearing is overloaded, the roller are forced into the race and they leave a small dips or indentation in the race on the surface of the roller.

**Water Stains**

- Black discoloration on bearing races and roller where the surfaces were in contact in the presence of water. This discoloration is an indication of intergranular corrosion within the material.

**Overheating**

- Blue marks of the bearing roller indicate that the bearing has been operated dry or has been subjected to high rotational speed.

**Rust**

- Rough red deposits on any of the rolling surfaces indicates that the bearing has been left unprotected from moisture in the air. Rust leaves pits that ruin the bearing surfaces.

**CHAPTER 10**: Wheel Brakes Systems

- A mechanism to convert kinetic energy to heat energy by friction.
- Brake system are designed to retard or stop the aircraft motion on the ground.
- They are also an aid in controlling the direction of aircraft while it is taxiing and application of brake while the landing gear wheels are being retracted into its wheel well in which provision exist for applying either one or both brakes.
- Brakes can be applied by using the toe pedal attached to the rudder pedals or by a handbrake lever basically for the purpose of parking.
- The greater the toe pedal applied, the greater will be the pressure transmitted to the brakes.

***Two sub-system Composition***

**Brake Actuating Unit**

- A system and components that slows down the aircraft movement and is located at the wheel and converts or changing kinetic energy from the motion of an aircraft into heat energy by means of friction.

**Brake Actuating System**

- Some hydraulic components in the aircraft that allows the pilot to control the amount of friction of a wheel unit produce.

**CHAPTER 11**: Brake Actuation

***Energizing Brakes***

- A brake that uses the momentum of the aircraft to increase its effectiveness by wedging the shoe against the brake drum.
- Are also called 'SERVO' brakes.
- There are 2 types of servo brakes and which is one way or single servo and two way or dual servo.
- In single servo brake/one way servo brakes, the action is effective or energize only when moving in the forward direction of the wheel only.
- In dual servo brake/two way servo brakes, the action is effective or energize may be adjusted to give servo action in either direction which is either forward or backward direction of the wheel.
- This both types are supplied with either single brake shoe or two brake shoe construction.

***Non- Energizing Brakes***

- Most common type of brake used on modern aircraft.
- This type of brake is actuated by hydraulic pressure.
- Amount of braking action depends upon the amount of pressure applied.

**CHAPTER 12**: Energizing Brakes

***Drum Type Brake***

- Similar to those used on automobile.
- In a form of dual/two way servo brakes.
- Used on small aircraft is in a form of single/one way servo brakes.
- Have their shoe lining mounted on a torque plate in such a way, it is the linings are free to move out against the rotating drum.
- When the brakes are applied, two piston in the brakes cylinder will move out and push the lining against a cylindrical cast iron drum that rotates together with the wheel.
- Friction attempts to rotate the lining but they are held in place by the cylinder assembly.
- Rotation of the brake drum wedges the lining tightly against the assembly.
- When hydraulic pressure is release, the retracting spring pulls the lining back from the drum and releases the brakes.
- One of the disadvantage is brake fading, which is the friction produce, heats up the drum and causes the open end of the lining to expand in a bell – mouthed fashion.
- The drum expends away from the linings and the friction decreases.

**CHAPTER 13**: Non- Energizing Brakes

***Single Disk Brake***

- The most popular brake for modern light aircraft.
- This type of brake is actuated by the hydraulic pressure from the master brake cylinder.
- Friction is produce when the rotating disk is squeezed between two brake lining in the caliper.
- There are 2 types of single disk brake:

**Floating disk/Fixed caliper**
The disc is keyed into the wheel and the disc is free to move in and out as the brake is being applied.

**Fixed disk/Floating caliper**
The disc is rigidly attached to the wheel and the caliper is free to moves in and out on two anchor bolts.

***Dual Disk Brake***

- Aircraft that need more braking force, rather than uses a single disc brake, it uses a dual disc brake.
- Similar to a single disc, except that two disc is rotating with the wheel rather than only one disc.
- There is a center carrier with brake lining pucks on both sides between these disc.

## *Expander Tube Brake*

- Use a heavy and flat tube made out of synthetic rubber compound (neoprene) and fabric.
- It is stretched over a circular brake frame between the side flanges.
- Has a nozzle that is connected with the hydraulic fluid line by means of suitable fittings.
- Brake block are made of material similar to that used for molded brake lining.
- The block have notches at each corner to engage with lugs on the brake frame and to prevent movement with the brake drum as it rotates.
- There are grooves across the ends of each blocks and the flat return springs are inserted in these grooves.
- Ends of the spring fit into slots in the side flanges of the brake frame, holding the block firmly against the expander tube and keeping them from dragging when the brake is release.
- Hydraulic fluid expand the tube when the brake is applied thus the expansion of the tube forces the block radially outward against the rotating brake drum.
- The lining provided friction and slows the aircraft movement.
- When the pressure is released, the flat spring (leaf spring) in the ends of the block tends to force the fluid out of the expander tube to pull the block away from contact with the brake drum.
- Used on small airplane as Piper Cub to Boeing B-29 Super Fortress bomber.
- As a reminder, no pressure should be applied when expander tube not restrained by drum brake, dummy brake should be fitted when brake drum is removed for servicing or maintenance purposes.

## *Multiple Disk Brake*

**'Thin Disc' Multiple disc brake**

- Was popular type of brake for heavy aircraft in WWII.
- Provide maximum friction for minimum size and weight and does not fade when the brake gets hot.
- Disadvantages if this type of brake is the tendency of the disc to warp up and causing the brake to drag and need manual adjustment as the disc wore.
- The brake has a series of steel disc called stator that keyed to the axle.
- A rotor or rotating disc that is made out of copper or bronze rotates between each other.
- The disc brake is approximately 1/8 of an inch thick and get very hot when the brake is being used.
- The disc form such solid mass of material that the heat has difficulties of escaping.
- If pilot sets the parking brake moment after using these brakes, the brakes entrap heat will warp the disc.

**'Segmented Rotor' Multiple Disc Brake**

- Is a heavy duty brakes designed for the use with high pressure hydraulic system using power brake control valves or power boost mater cylinder.
- Braking action results from several sets of stationary high friction type of brake lining making contact with rotating (rotor) segments.
- Consisting of rotating disc or rotor that is keyed into the wheel.
- Between the rotors is a stator plate or brake lining that are keyed to the axle.
- Riveted to each side of each stator plate are linings or wear pads that are made out of material that retain its friction characteristic under the condition that are extremely high temperature.
- A pressure plate and a backing plate completes the brake constructions.
- An automatic adjuster is attach to the pressure plate and pushes it back when the hydraulic pressure to the brake is released.
- When pressure is applied to the brake, the pressure plate compressed the return spring on the indicator pin and as the lining wears, the pin is pulled through its friction collar.
- It is a pressed fit, so that as the brake is released, the grip of the friction collar pulls the pressure plate back as much as the adjuster housing will allow.
- Each time brakes are applied, they automatically adjust for the wear of each lining.
- The amount the automatic adjuster pin sticks out of the retainer housing is an indication of the condition of the brake lining.

**'Carbon Disc' Multiple Disc Brake**

- The latest development in aircraft brakes are multiple disc brake that are made out of carbon composite materials.
- The carbon composite brake weight 40% less.
- Able to function in even higher temperature with more reliability than the conventional steel segmented rotor brakes.
- 3 types of carbon fiber reinforcement can be used in carbon disc brake in a process that can take up to 5 months to make each carbon composite.
- Carbon fibers are molded into precise shape and the resulting disc then are baked in special ovens( autoclave), which introduce natural gas.
- Carbon composite posses several unique properties that permits the combining of the overall brake disc function of friction surface, heat sink and structural member into a single unit.
- These unique properties are:
    1. Strength does not decrease at elevated temperatures
    2. When rubbed against itself, can perform excellent as a friction material.
    3. High temperature usage (between 3200F to 3400F).
    4. Good thermal conductivity characteristic that serve to dissipate the heat rapidly.
    5. Less weight compared to steel disc.
    6. Offers reduced maintenance cost (carbon brake disc averagely make approximately between 1200 to 1500 landing a year, but steel brake just approximately 100 landing a year).
    7. Used to be a standard equipment for 'Concorde' aircraft.

**CHAPTER 14**: Brake Actuation Systems

***Independents Brake System***

- Usually found on small aircraft and this systems is a self contained and independent of the aircraft main hydraulic system.
- The system consists of:
    1. A reservoir.
    2. A master cylinder operated by the brake control pedal or hand brake or a handle.
    3. A brake assembly on the wheel.
    4. Fluids line, hoses and fittings.
- Expander tube, shoe or disc brake assemblies may be used with this type of system.
- This system is usually incorporated with a 'compensator port'.

**Compensator Port**

- A small hole between a hydraulic brake master cylinder and the reservoir.
- When the brake pedal is released, this ports uncovered and the pressure on the fluid in the line to the brake master cylinder is the same as the atmosphere pressure.
- When the brake is applied, the master cylinder pistons covers the compensator port and allows pressure in the line to the brake to built up and simultaneously applied the brake.

***Boosted Brake / Power Boost System***

- Used on aircraft that require more braking force than manually applied independent brake master cylinder can produce, yet do not need a complex power brake system.
- Operated by a toggle switch that allows the aircraft hydraulic system to flow to the brake and assist in braking when extra braking load is required.
- Acts as an independents brake system during normal brake pressure requirement and acts as power brake system during high brake load required.
- The boosted brake or powered boost brake operates when pilot depress the brake pedal and when more pressure is needed at the wheel, pilot will pressed harder on the brake.
- The action by the pilot is considered as an additional movement and causes the toggle on the brake master cylinder to depress the spool valve which allows hydraulic system pressure to flow through the center of the spool valve and get behind the piston and help on applying the brakes
- As soon as the pedal released, the spool valves moves back to its original configuration and shutting off the hydraulic pressure to a normal pressure.
- Fluid in the brake line is allowed to return to the reservoir through the system return manifold.

***Power Brake System***

- A system that is being used on large aircraft that requires more fluid and more pressure that can be supplied by independent master cylinder or required a greater displacement and higher pressure.
- The brakes for these aircraft are actuated by pressure supplied from the main hydraulic power system of the aircraft.
- Power brake control valves operated by the pilot will metered the pressure to give pilot the control of the braking action.
- The brake pedal is connected to the power brake control valve through an arrangement of cables, pulley, bell crank and linkages.
- Power brake control valve is also called 'brake metering valves'.
- Power brake control valve direct hydraulic pressure to the brake assemblies when the pilot depress the brake pedal.
- Pressure acting on the spool valve and the spring of the brake control valve creates a return force varies with braking and also providing an artificial feel at the pedal

***De-Booster Valve***

- Hydraulic system pressure is normally too high for effective braking action.
- These system are installed by means of reducing the pressure and increasing the volume of fluid going to the brakes.
- De-Booster is usually installed between the antiskid valve and the wheel cylinder.
- On some large aircraft, de-booster has a lock-out features that allows them to acts or double as a 'hydraulic fuses'.

**CHAPTER 15**: Parking Brake Systems

- Sub-assemblies of an hydraulic brake system. The parking brake control is consists of either pull handle or lever.
- When the brake pedal are depressed and the parking brake lever is pulled, the brake is locked in 'ON' position.
- Depressing the brake pedals again will release the brake (depressing the pedal, is either causing the pressure to build up and automatically unseat the parking brake valve or unload the ratchet type parking lock).
- The setting of a parking brake mechanism while the brake is hot may cause serious damage and the brake should be cool of before attempting to put the parking brake 'ON'.

**CHAPTER 16**: Brake Wear

***Brake Wear Checks***

- Lining wear may be checked by two methods or refer to the applicable maintenance manuals and used as recommended methods by the manufacturers.
- With the brake applied, measure the distance between the face of the brake disc and brake housing. Replace brake lining if the distance has progressed to the maximum specified measurement given in the maintenance manuals.
- With the brake applied, check the position of the automatic adjusting pins. Replace any brake lining if adjusting pin recedes beyond the specified limit inside the adjusting pin nuts.
  **NOTE**: *If any linings or pucks has worn to the thickness that are required to be replace, the entire sets of lining must be replaced. Never mixed the new and the used lining.*

**CHAPTER 17**: Auto-Break

- A system that permits braking at a preset deceleration rate that will be control automatically after touchdown (landing).
- The system will direct the correct amount of pressure to the brakes to achieves the desired rate of deceleration.
- The brake pressure will be decreased automatically to compensate for the deceleration caused by the thrust reverser or speed brakes or both at the same time.
- Anti –skid protection is provided during an autobrake operation.
- Disarming of the autobrake immediately is occur of the following action is taken:
  1. The selector switch of an auto brake is moves to 'DISARM' or 'OFF' position.
  2. Manual braking is used.
  3. Advancing either thrust lever (throttle increasing).
  4. Speed brakes lever to 'DOWN' detent and the speed brake is deployed.
  5. Auto brake system or anti-skid system fault occur/malfunction

**CHAPTER 18**: Emergency Brake System

- To prevent the lost of life or damage to the aircraft if the normal hydraulic brake system fails and the pilot must be able to stop the aircraft.

**Pneudraulic**

- System that separates from the normal hydraulic system. This function operates in a case of hydraulic failure. By means of a pneumatic valve on the instrument panel should the back – up system be operated.

**Hydraulic**

- An alternate hydraulic system incorporated with hand pump or accumulator or auxiliary hydraulic pump.

**CHAPTER 19**: Brake Defects

***Glazed***

- Glass like surface form on the rotating disc when localized overheating occurs, this slick surface does not produce uniform friction and will cause the brake to chatter or squelling

***Brake Fading***

- The decrease in the amount of braking action that occurs with some type of brakes that are applied for a long period of time.
- True fading occurs with overheated drum type brake.
- As the drum is heated, it expends in a bell mounted fashion.
- This will decrease the amount of the drum in contact with the brakes shoes and decreases the braking action.

***Brake Creeping***

- A condition that are similar to brake fading where an internal leaks in the brake master cylinder.
- The brakes are applied but as the pedal is held down on a pressure, the fluid leaks past the piston and the brake slowly released.

***Brake Dragging***

- Brake that does not fully released when the brake pedal is released.
- The brakes are partially applied all the time which cause the lining wear rapidly and heat produced.
- Air in the system also could contribute to dragging brake (When air is expended).

***Spongy Brakes***

- Due to the air presence in the system or deteriorated flexible system hose.

***Brake Grabbing***

- Are usually caused by oil or some form of foreign matter on the disc and lining.
- In addition, worn disc and drum can cause grabbing.

***Excessive Brake Pedal Travel***

- Caused by worn brakes, lack of fluid in brake system, air in system or improperly adjusted mechanical linkages.

**CHAPTER 20**: Brake Bleeding

- Brake bleeding methods:
  1) Gravity or Manuals methods.
  2) Pressure methods.

- Bleeding precautions:
  1. Be certain that bleeding equipment to be used is absolutely clean and is filled with the proper and correct type of hydraulic fluid.
  2. Maintain an adequate supply of fluid during the entire operation. A low fluid supply will allow air to be drawn into the system.
  3. Bleeding should be continued until no more air bubbles are expelled from the system and firm brake pedal is obtained.
  4. After the bleeding operation is completed, checks the reservoir for fluid level. With the brake pressure 'ON', check the entire system for any leaks signs.

**CHAPTER 21**: Anti-Skid System

***Purpose of Anti-Skid System***

1. An electro hydraulic system in the aircraft power brake system that sense deceleration rate of every MLG wheel.
2. If any wheel decelerates to rapidly, indicating an impending skid, pressure to that brake is released and the wheel stop decelerates.
3. Pressure is then re-applied at a slightly lower rate.
4. To assist the pilot in providing optimum braking when aircraft lands.
5. To prevent skidding of aircraft when applying brakes.
6. 4 functions of anti – skid system:
   i. Normal skid control.
   ii. Locked wheel skid control.
   iii. Touchdown protection.
   iv. Fail – safe protection.

***Constructions of Anti-Skid System*** **(3 MAJOR COMPONENTS)**

1. Wheel Speed Sensor.
2. Anti – Skid Control Unit.
3. Anti – Skid Control Valve

**Wheel Speed Sensor**

- To sense the rate of change of wheel deceleration.
- Using the principle of DC / AC generators.
  DC generators ►permanent magnet type.
  AC generators ► variable reluctant type
- Output of the wheel speed sensor is approximately 1 volt for every 10 mph and is fed to an anti – skid control unit.
- Wheel speed sensor is located in every wheel in LG (not installed in NLG).

**Anti – Skid Control Unit**

- Usable electrical output of DC to the anti –skid control valves.
- Produce to regulate brake pressure using a modulator circuit.
- To prevent application of brake pressure prior to touchdown.
- Consists of modulator circuit monitors the current to flapper for the wheel to spin up.
- An amplifier circuit is to maintain a certain amount of pressure in the control valve.
- Skid detector is to compare the wheel deceleration rate to the reference and that is between 15mph – 20mph.

**Anti – Skid Control Valve**

- To control the flow of hydraulic from the control brakes valve to the brake cylinder.
- It has 3 ports which is pressure, return line and brake line.
- Its compromise of 2 stages:
  1st Stage –Electrically stages/servos (torque motor or flapper valve operations).
  2nd Stage – Hydraulically operated by a spool valve (spool valve is used to close/open return line or brake cylinder port).

**CHAPTER 22**: Anti-Skid Operation

## *OPERATION OF ANTI –SKID UNIT*

1. When aircraft is about to land, the locked wheel detector unit sends the signal to control valve, to release the pressure on the wheels.
2. When aircraft lands, the squats switch will remove the release signal to the control valve.
3. Wheel speed sensor will sense a signal to the control valve to apply full pressure to brake.
4. When one of the wheel starts to decelerates greater than reference 20mph and error signal will be fed to the control valve to modulate the brake pressure so that only a small amount of brake pressure applied to the brake while the rest is dumped to the return line.
5. Reason for dumping is to allow the wheel to spin up. The process of applying full pressure braking and release when about to slip goes on until the wheel speed is below 20mph and then the skid detector is disconnected.
6. If an autobrake is incorporated, it will disconnect when wheel speed is less than 20mph.
7. The modulator type of anti –skid system is the best where it provide:
    i. Fastest wheel recovery
    ii. Shortest distance braking capabilities.

## *TESTING OF ANTI –SKID UNIT*

1. Testing is provided by means of test switches or control switches.
2. It also can be tested on the ground and also in flight. If on ground, the light will illuminate once the brake is applied and when in flight there are no light illuminates.
3. Wheel speed sensor produce 1 volt when aircraft speed is 10mph.
4. Reference deceleration is 20mph incorporated in the skid detector by the anti – skid unit.
5. If wheel speed deceleration rate is greater than 20mph (example: initial touchdown is 100mph after a while the speed is 80mph), correction is required by reducing pressure to the brakes (example: some pressure will be fed to the return line).
6. If one of the wheel decelerates less than 10mph, full dumping of pressure to return line is exercise for the wheel to spin up (only on that particular wheel).
7. If all the wheel speed is 20mph or less, the anti – skid unit will automatically de – activated
8. The best anti – skid system use in the new generation aircraft is the 'modulator anti skid' system.
9. Failure of the anti – skid system is indicated by the anti –skid failure 'RED' light.

**CHAPTER 23**: Tires

- Aircraft tire are built to withstand a great deal of punishment, but only by proper care and maintenance that tire can give safe and defendable service (accept a variety of static and dynamic stress dependable in wide range of operation conditions).
- Aircraft tire are design in such a way that it can withstand landing speed up to 250mph and dynamic load of 22 –33 ton of load.
- There are several type of aircraft tire and class as types:
  - ✓ Types I, II, IV and VI (phased out/amend or stop production)
  - ✓ Type III, VII and VIII.
- Table of Types of Tires

| TYPE | DESIGN AND RATING |
|---|---|
| **I** | Smoothly Contour |
| **II** | High Pressure |
| **III** | Low Pressure |
| **IV** | Extra Low Pressure |
| **V** | Not Applicable |
| **VI** | Low Profile |
| **VII** | Extra High Pressure, Low Speed<br>Extra Low Pressure, High Speed |
| **VIII** | Extra High Pressure, Low Profile, Low Speed<br>Extra Low Pressure, Low Profile, High Speed |

***Types III***

- Low pressure and generally used on small aircraft.
- The section width wider in relation to bead diameter to allow lower inflation pressure for improved cushioning and floatation.
- Section width and rim diameter are used to designate the size of the tire.

***Types VII***

- Extra speed (horse power rating) and high load carrying ability.
- Tire designated by outside diameter and width.

***Types VIII***

- High performance and extremely high take –off speed.
- Extra high inflation pressure and have a low-profile configuration tire.

***Advantages and Purposes***

- Provide cushion of air that helps absorbs the shock and roughness of landing and take – off.
- Provide necessary traction for braking purposes and assisting in stopping the aircraft on landing.
- Support the weight of the aircraft while on ground.

**CHAPTER 24**: Tubeless Tires

- Similar in construction to the tube tires except they have a rubber inner liner that is mated to the inside surface of tire.
- The rubber liner helps retain air in the tire.
- The beaded area of the tubeless tire is designed to form a seal with the wheel flange.
- Wear indicator have been built into some of tires as aid in measuring tread wear, and these indicators are holes in the tread area or lands in the bottom of tread grooves.

***Advantages of Tubeless Tire***

1. Air pressure retained longer because inner lining is unstretch.
2. Penetration by sharp object will not cause rapid loss of pressure because lining clings closely to the object and prevent loss of air.
3. More resistant to impact blows because of thicker casing, the lining helping to distribute the stress.
4. Inflation valve creep is eliminated.
5. 10% cooler than the conventional (tube tires) tire.

**CHAPTER 25**: Tire Constructions

***Bead***

- Made of multiple strands of high tensile carbon steel wires embedded in rubber and wrapped in open weave fabric, the beads hold the tire firmly on the rims and serve as an anchor for the fabric plies that are turned up around the bead wires.
- The carcass plies provide form mounting surfaces on the wheel.

***Apex strip***

- An additional rubber formed around the bead to give a contour for anchoring the ply turn – ups.

***Flipper (filler strips)***

- The layers of fabric and rubber insulate the carcass from bead wires and improve the durability.

***Chafers / chafing strips***

- Layers of rubber impregnated woven fabric wrapped around the outside of the beads, provide additional rigidity to the bead and prevent metal wheel rim from chafing the tire that protects the carcass from damage during mounting and de-mounting.
- They insulate the carcass from brake heat and provide a good seal against movements during dynamic operations.
- Tubeless tire have an additional ply of rubber over the chafing strip to function as an air seal.

***Breakers (breakers strip)***

- One or more plies of cord of woven fabric (nylon) impregnated with rubber, used between the tread rubber and they cord to provide extra reinforcement to prevent bruise and damage to the tire (protect casing plies and strengthen tread area).
- Breaker are not part of cord body.

***Bead Toe***

- The inner edge closest to the tire center line.

***Bead Heel***

- The outer bead edge

***Carcass / Cord Body/ Casing Plies***

- Provides basic strength to the tire, consists of multiple layer of nylon with individuals cords arranged parallel to each other and completely encase in rubber (rubberized fabric).
- The cord fabric has a strength in only one direction, each layer of coated fabric constitutes on ply of the cord body.
- Adjacent cord plies in the body are assemble with the cords crossing at nearly right angles at each others.
- This arrangement provides a string and flexible tire that distributes impact shock over wide area.
- The function of the cord body are to give the tire a tensile strength, to resist internal pressure and maintain tire shape.

***Ply rating***

- The rating of an aircraft tire that indicates its relative strength.
- The ply rating does not indicate the actual number of plies of fabric in the tire, rather it indicates the number of plies of cotton fabric needed to produces the same strength as the actual plies.
- Higher the rating, the greater the load a tire could carry.
- Maximum static load an inflation pressure determined ply rating of an aircraft tire.

***Tread***

- Layer of rubber on the outer surface of the tire protects the cord body from abrasion, cut bruises and moisture.
- It is the surface that contact the ground, made of rubber compound for toughness and durability, the tread is patterned in accordance with aircraft operational requirements.
- The circumferential pattern of grooved in the tread are designed to provides good traction under widely varying runway conditions.

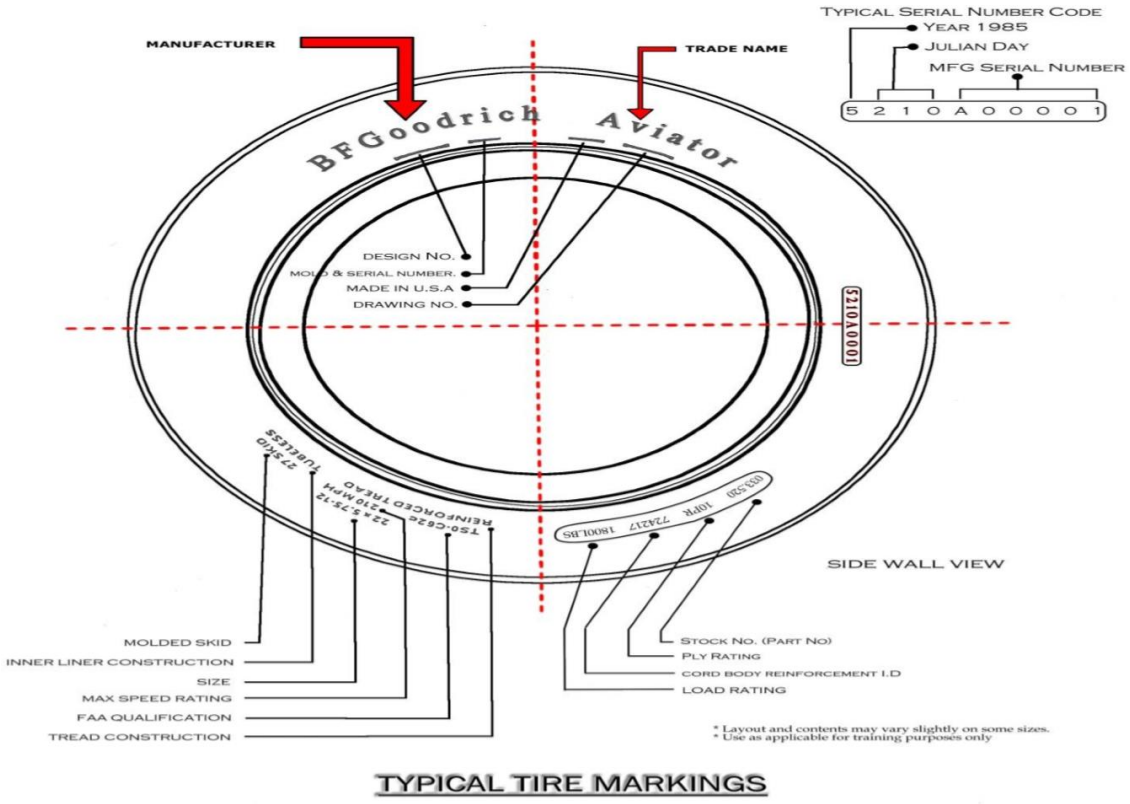
***Sidewall***

- An outer layer of rubber adjoining the tread and extending to the beads, like the treads it protects the cord body from abrasion, cut bruises and moisture.

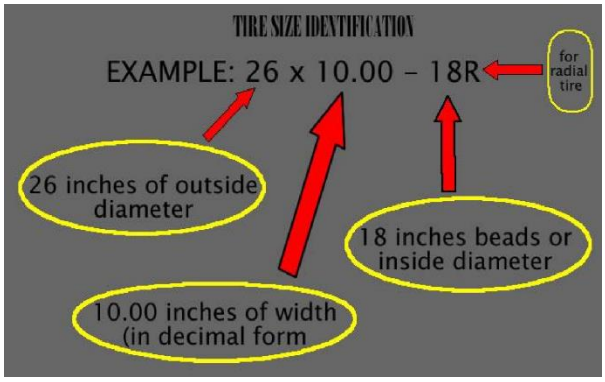
***Inner liner***

- On tubeless tire these inner layer of less permeable (porous) rubber acts a built in tuber, it prevents air from seeping through casing plies.
- For tube tire a thinner rubber liner is used to prevent tube chafing against the inside plies.

**CHAPTER 26**: Tire Sidewall Markings




TYPICAL TIRE MARKINGS




**CHAPTER 27**: Thread Pattern

***Ribbed***

- A very common pattern. Provides a good combination of long tread wear, good grip and directional stability especially on hard runaways.

***Diamond or block pattern (all weather)***

- Widely used and gives good performance on all type of surfaces. Suitable for turf or packed earth airstrip.

***Plain tread***

- Use on some light aircraft and helicopters.

***Twin contact***

- Used on nose wheel in preventing nose wheel shimmy.

***Chined***

- Some nose wheel tires are fitted with a water deflector or chine on the side wall, to deflect water away from rear mounted engines.
- The deflector maybe on one side for twin wheel installation or on both sides for single wheel installation.
- Water dispersing tread having many holes in the crown are sometimes used to help prevent 'aqua planning'

**CHAPTER 28**: Tire Wear

- Patterned tread tires maybe used until the tread is worn to the depth of the pattern.
- Ribbed tires with marker tie bars maybe used until worn to the top of the tie bars.
- Ribbed tires without marker tie bars maybe used until worn to within 2mm (0.080") of the wear indicator grooves.
- Twin contact tire maybe used until center of the crown shows sign of having been contact with the ground.
- Plain tread tires maybe used until either the grey cushion rubber is exposed or when the shades of the casing cords can be seen through the cushion rubber.

**NOTE**: *On tire reinforced treads, several layers of fabric are molded into the treads rubber and will becomes visible during normal use, the treads so exposed should not be confused with the casing cords. These tires are provide within marker tie bars which should be used to assess the wear*

**END OF SUBJECT LANDING GEAR**