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CHAPTER 13
LANDING GEAR SYSTEMS

INTRODUCTION

Maintenance on the landing gear, at times, requires maintenance of related systems. This chapter covers the general landing gear systems. Also covered are drop checking procedures, troubleshooting, and the alignment and adjustment of the landing gear.

The systems discussed here are representative. For training purposes, we will use many values for tolerances and pressures to illustrate normal operating conditions. When actually performing the maintenance procedures, you must consult the current applicable technical publications for the exact values to be used.

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to do the following:

1. Identify the various types of landing gear used on fixed-wing and rotary-wing aircraft.
2. Identify operational procedures of landing gear systems.
3. Identify the components of the landing gear system.
4. Recognize the procedures for drop checks, troubleshooting, alignment, removal, and replacement of landing gear systems and components.

LANDING GEAR SYSTEMS

Every aircraft maintained in today’s Navy is equipped with a landing gear system. Most Navy aircraft also use arresting and catapult gear. The landing gear is that portion of the aircraft that supports the weight of the aircraft while it is on the ground. The landing gear contains components that are necessary for taking off and landing the aircraft safely. Some of these components are landing gear struts that absorb landing and taxiing shocks; brakes that are used to stop and, in some cases, steer the aircraft; nosewheel steering for steering the aircraft; and in some cases, nose catapult components that provide the aircraft with carrier deck takeoff capabilities.

FIXED-WING AIRCRAFT

Landing gear systems in fixed-wing aircraft are similar in design. Most aircraft are equipped with the tricycle-type retractable landing gear. Some types of landing gear are actuated in different sequences and directions, but practically all are hydraulically operated and electrically controlled. With a knowledge of basic hydraulics and familiarity with the operation of actuating system components, you should be able to understand the operational and troubleshooting procedures for landing gear systems.

Main Landing Gear

The typical aircraft landing gear assembly consists of two main landing gears and one steerable nose landing gear. As you can see in Figure 13-1, a main gear is installed...
under each wing. Because aircraft are different in size, shape, and construction, every landing gear is specially designed. Although main landing gears are designed differently, all main gear struts are attached to strong members of the wings or fuselage so that the landing shock is distributed throughout the main body of the structure. The main gears are also equipped with brakes that are used to shorten the landing roll of the aircraft and to guide the aircraft during taxiing.

Figure 13-1 — Tricycle landing gear.

Nose Landing Gear

On aircraft with tricycle landing gear, the nose gear is retracted either rearward or forward into the aircraft fuselage. Generally, the nose gear consists of a single shock strut with one or two wheels attached. On most aircraft the nose gear has a steering mechanism for taxiing the aircraft. The mechanism also acts as a shimmy damper to prevent oscillation or shimmy of the nosewheel. Since the nosewheel must be centered before it can be retracted into the wheel well, a centering device aligns the strut and wheel when the weight of the aircraft is off the gear.

ROTARY-WING AIRCRAFT

The landing gear systems on rotary-wing aircraft come in different designs. A helicopter may have a nonretractable landing gear, such as that found on the H-60 helicopter, or it may have a retractable type landing gear like that incorporated on the H-53 helicopter. Some helicopters have a nose landing gear while others have a tail landing gear. The H-53 has a retractable nose landing gear, but the H-60 helicopter uses a tail landing gear. The H-60 tail landing gear is nonretractable.
As you can see, helicopter landing gear systems come in different configurations. The landing gear systems on the helicopters used in the Navy use wheel and brake assemblies. The components used in the landing gear system of a helicopter are very similar to those used in a fixed-wing aircraft landing gear system. In helicopters that use retractable landing gear systems, the components and means of actuation are also similar in design to fixed-wing aircraft. For discussion purposes, we will use the landing gear system of the H-60 helicopter. This helicopter uses a nonretractable main and tail landing gear.

Main Landing Gear

The main landing gear system of the H-60 helicopter consists of nonretractable left and right single wheel landing gear assemblies and the weight-on-wheels system. Each main landing gear assembly is composed of a shock strut, drag beam, axle, wheel, tire, and wheel brake. The left main landing gear assembly also includes a weight-on-wheels sensing switch.

The main landing gear supports the helicopter when it is on the ground, and cushions the helicopter from shock during landing. The weight-on-wheels switch provides helicopter ground or flight status indications for various helicopter systems.

Tail Landing Gear

The H-60 tail landing gear system consists of a dual-wheel landing gear, tail wheel lock system, and tail bumper.

The tail landing gear is a cantilever type with an integral shock strut. The gear is capable of swiveling 360 degrees. It can be locked in the trail position by the tail wheel lock system. A tail recovery assist, secure, and traverse (RAST) probe is mounted on the tail gear.

LANDING GEAR SYSTEMS OPERATION

Landing gear systems on naval aircraft, as stated earlier, are similar in design. Most aircraft equipped with the tricycle-type, retractable landing gear have two systems of operation, normal and emergency.

NORMAL SYSTEM

The normal system of a "typical" landing gear system is described because many components used in different landing gear systems are similar. Figure 13-2 is a schematic that shows the fluid flow in the nose gear up cycle. This system contains a selector valve, flow regulators, priority valves, check valve, actuating cylinders, and the necessary hydraulic tubing that routes hydraulic fluid to and from the required components.

When the landing gear handle is in the UP position, a circuit is completed from the landing gear handle circuit breaker, through the landing gear up switch, to the selector valve. The selector valve is electrically positioned to direct pressure into the landing gear up lines and to vent the down lines to return. Fluid flows from the selector valve, through a flow regulator to the up side of the nose gear cylinder. Fluid also flows through another flow regulator to the down lock cylinder. The down lock cylinder
Figure 13-2 — Nose gear up cycle schematic.
disengages the down lock, and the nose gear cylinder starts to raise the nose gear. As the gear is raised, the nose gear doors are closed by mechanical linkage. When the gear is fully retracted, the up lock mechanism engages the nose gear to lock it in the up position. The up lock mechanism is mechanically actuated through linkage connected to the nose gear. As soon as the down lock mechanism is disengaged and the gear starts to retract, the pilot’s position indicator displays change from a wheel to a barber pole, and the transition light on the landing gear control panel comes on. As soon as the gear is up and locked, the transition light goes out and the position indicator changes from a barber pole to UP, as shown in Figure 13-3. When the landing gear is down and locked, wheels appear on the indicator.

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>REASON FOR INDICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHEELS</td>
<td>NOSE GEAR OR EITHER MAIN GEAR NOT FULL DOWN AND LOCKED</td>
</tr>
<tr>
<td>FLASHING</td>
<td></td>
</tr>
</tbody>
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![WHEELS TRANSITION LIGHT](image)

<table>
<thead>
<tr>
<th>MAIN GEAR POSITION INDICATOR</th>
<th>NOSE GEAR POSITION INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDICATION</td>
<td>REASON FOR INDICATION</td>
</tr>
<tr>
<td>DOWN LEFT NOSE RIGHT</td>
<td>MAIN GEAR FULL DOWN</td>
</tr>
<tr>
<td>UP LEFT NOSE RIGHT</td>
<td>MAIN GEAR FULL UP</td>
</tr>
<tr>
<td>BARBER POLE LEFT NOSE RIGHT</td>
<td>MAIN GEAR IN ANY POSITION OTHER THAN FULL UP OR FULL DOWN</td>
</tr>
</tbody>
</table>

Figure 13-3 — Landing gear warning and position indicator.

EMERGENCY SYSTEMS

If the landing gear fails to extend to the down and locked position, each naval aircraft has an emergency method to extend the landing gear. Emergency extension systems may vary from one aircraft to another. The methods used may be the auxiliary/emergency hydraulic system, the air or nitrogen system, or the mechanical free-fall system. An aircraft may contain a combination of these systems. For example, the main landing gear and the nose gear emergency extension may be operated by the auxiliary/hydraulic system method.

The nitrogen storage bottle system is a one-shot system powered by nitrogen pressure stored in compressed nitrogen bottles. See schematic in Figure 13-4. When the “EMER LG PULL” handle is disengaged from the “LDG GEAR” handle and moved aft to “EMER DOWN”, a crank linked to the handle is raised. The raised crank pulls an actuating cable that operates a lever, opening the spring-loaded emergency release valve. When the release valve opens, nitrogen pressure goes from the CYL port to shuttle valves on the nose gear, main gear, main gear door and tail skid actuating cylinders. Pressure also goes to the landing gear and tail skid dump valves.
Figure 13-4 — Emergency landing gear extension system.
Pneumatic pressure actuates the dump valves to the emergency position. The valves are held in position by a spring-loaded detent. In this position, the uplines between the dump valves and the respective selector valves are blocked off. All landing gear and tail skid system uplines are ported to the combined system reservoir through the respective dump valves. (With the selector valves bypassed, a malfunction in either selector valve cannot prevent emergency extension.) Hydraulic fluid on the up side of each actuating cylinder flows back to the reservoir and allows pneumatic pressure to enter the down side and extend the gear and the tail skid.

Pneumatic pressure applied to each shuttle valve shifts a spool over to block off the hydraulic port. Pressure enters the down port and extends the actuating cylinder, displacing hydraulic fluid on the up side back to the reservoir through the landing gear or tail skid dump valve. (The main gear doors and the main gear shock struts begin to lower at the same time since the hydraulic door timer check valves are bypassed during pneumatic operation however, the doors open fast enough to clear the shock struts since the door cylinders have approximately one-half the stroke of the gear actuating cylinders.)

Once the emergency extension system has been used, the system must be reset before the gear and tail skid can be extended again by either normal or emergency means. With the aircraft on jacks, the “EMER LG PULL” handle is moved from “EMER DOWN” and is engaged with the “LDG GEAR” handle. This seats the emergency release valve and opens the pneumatic extension lines to the atmosphere through the OVBD port of the release valve. Most of the pressurized nitrogen in the lines then flows back through the emergency release valve and is discharged overboard. The reset buttons on the dump valves are then manually pressed, resetting the dump valves to their normal position. In the normal position, the selector valves are connected to the landing gear and tail skid lines.

When aircraft hydraulic power is again available, the “LDG GEAR” handle must be “DN”. This ensures that all actuating cylinders are first pressurized in the down position before attempting to retract the landing gear. Hydraulic pressure in the downlines shifts the shuttle valves to the normal position, shutting off the pneumatic ports. The aircraft hydraulic systems must then be cycled to bleed any remaining nitrogen gas from the fluid lines. Bleeding can be accomplished with several half cycles, prior to fully retracting the gear, with the aircraft on jacks after a blow-down. Following the half cycles, fully actuate the gear hydraulically through eight to ten retract and expand cycles. The bottle must then be recharged to operating pressure.

**LANDING GEAR COMPONENTS**

Various mechanical and hydraulic components make up a landing gear system. The components discussed here are representative of those found on most naval aircraft.

**LANDING GEAR DOOR LATCHES**

Landing gear hydraulic system maintenance is similar to the other types of hydraulic system maintenance. This system is inspected for internal and external leakage as well as proper operation during inspections. While performing operational checks, you must inspect the complete landing gear installation for adjustments, clearances, and sequence of operation.

The adjustment of latches is one of your prime concerns. A latch is used in hydraulic systems as a device designed to hold a unit in a certain designated position after the
unit has traveled through a part of its cycle. For example, when the landing gear is retracted in some landing gear systems, each gear is held in the up position by a latch. The same holds true when the landing gear is extended. Latches are also used to hold the landing gear doors in the open or closed positions.

There are many variations in designs of latches. All latches are designed to accomplish the same thing. They must operate automatically, at the proper time, and hold the unit in the desired position.

The main landing gear forward door is held closed by two door latches. As shown in Figure 13-5, one latch is installed near the front of the door and the other near the rear of the door. To lock the door securely, both locks must grip and hold the door tightly against the aircraft structure. The principal components of each latch mechanism, shown in Figure 13-5, are a hydraulic latch cylinder, a latch hook, a spring-loaded linkage, and a sector. The latch cylinder is connected hydraulically with the landing gear control system and mechanically, through linkage, with the latch hook. When hydraulic pressure is applied, the cylinder operates the linkage to engage or disengage the hook with or from the latch roller on the door. In the gear-down sequence, the hook is disengaged by the spring load on the linkage. In the gear-up sequence, spring action is reversed when the closing door is in contact with the latch hook, and the cylinder operates the linkage to engage the hook with the latch roller. Cables on the landing gear emergency extension system are connected to the sector to permit emergency release of the latch rollers. An up-lock switch is installed on, and actuated by, each latch to provide main-gear-up indication in the cockpit.

Figure 13-5 — Main gear door latch mechanisms.

With the gear up and the door latched, inspect the latch roller for proper clearance. See View B of Figure 13-6. On this installation, the required clearance is 1/8 inch ±3/32 inch.
If the roller is not within tolerance, it may be adjusted by loosening its mounting bolts and raising or lowering the latch roller support. This can be done because of the elongated holes and serrated locking surfaces of the latch roller support and serrated plate. See View A of Figure 13-6.

LANDING GEAR DOORS

When installing new landing gear doors, you have to trim each door for a specific installation to obtain the required clearances. The amount of material to be trimmed is determined by retracting the landing gear (with the door linkage disconnected), and then releasing the hydraulic pressure. The up lock rollers on the doors are then removed to allow the doors to be closed, and yet not become locked in the closed position. With the landing gear doors held in the closed position, each door's edge is marked where trimming is needed to maintain the specified clearances. The doors are then opened and the excess amount of material trimmed off. After you have completed the trimming and checked the doors for proper clearances, the landing gear is lowered and the door linkage and up lock rollers are installed.

The distance the landing gear doors open or close depends upon the length of door linkage and adjustment of doorstops. Maintenance instruction manuals (MIMs) specify the length of door linkages and adjustment of stops or other procedures whereby correct adjustments may be made. On some models of aircraft that incorporate forward and aft landing gear doors, the doors are adjusted separately, and in some cases, they are "pulled" or "warped" into a desired shape.
Landing gear doors have specific allowable clearances that must be maintained between doors and the aircraft structure or other landing gear doors. These required clearances can be maintained by adjusting the door hinges and connecting links and trimming excess material from the door if necessary.

On some installations, door hinges are adjusted by placing the serrated hinge and serrated washers in the proper position and torquing the mounting bolts, which allows linear adjustments. Figure 13-7 shows this type of mounting. The amount of linear adjustment is controlled by the length of the elongated bolt hole in the door hinge.

SHOCK STRUTS

Shock struts are self-contained hydraulic units. They carry the burden of supporting the aircraft on the ground and protecting the aircraft structure by absorbing and dissipating the tremendous shock of landing. Shock struts must be inspected and serviced regularly for them to function efficiently. This is one of your important responsibilities.

Each landing gear is equipped with a shock strut. In addition to the landing gear shock struts, carrier aircraft are equipped with a shock strut on the arresting gear. The shock strut's primary purpose is to reduce arresting hook bounce during carrier landings.

Because of the many different designs of shock struts, only information of a general nature will be included in this chapter. For specific information on a particular installation, you should refer to the applicable aircraft MIM or accessories manual.

A typical pneumatic/hydraulic shock strut (metering pin type) is shown in Figure 13-8. It uses compressed air or nitrogen combined with hydraulic fluid to absorb and dissipate shock, and it is often referred to as the "air-oil" type strut. This particular strut is designed for use on the main landing gear.

The shock strut is essentially two telescoping cylinders or tubes, with externally closed ends. When assembled, the two cylinders, known as cylinder and piston, form an upper and lower chamber for movement of the fluid. The lower chamber is always filled with fluid, while the upper chamber contains compressed air or nitrogen. An orifice (small opening) is placed between the two chambers. The fluid passes through this orifice into the upper chamber during compression, and returns during extension of the strut.

Most shock struts employ a metering pin similar to that shown in Figure 13-8 to control the rate of fluid flow from the lower chamber into the upper chamber. During the compression stroke, the rate of fluid flow is not constant, but is controlled automatically by the variable shape of the metering pin as it passes through the orifice.
On some types of shock struts now in service, a metering tube replaces the metering pin, but shock strut operation is the same. An example of this type of shock strut is shown in Figure 13-9.

Some shock struts are equipped with a dampening or snubbing device, which consists of a recoil valve on the piston or recoil tube. The purpose of the snubbing device is to reduce the rebound during the extension stroke and to prevent a too rapid extension of the shock strut, which would result in a sharp impact at the end of the stroke.

The majority of shock struts are equipped with an axle that is attached to the lower cylinder to provide for tire and wheel installation. Shock struts not

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**Figure 13-8 — Landing gear shock strut (metering pin type).**

equipped with axles have provisions on the end of the lower cylinder for ready installation of the axle assembly. Suitable connections are also provided on all shock struts to permit attachment to the aircraft.

A fitting, which consists of a fluid filler inlet and a high-pressure air valve, is located near the upper end of each shock strut to provide a means of filling the strut with hydraulic fluid and inflating it with air or nitrogen.

A packing gland designed to seal the sliding joint between the upper and lower telescoping cylinders is installed in the open end of the outer cylinder. A

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**Figure 13-9 — Landing gear shock strut (metering tube)**
packing gland wiper ring is also installed in a groove in the lower bearing or gland nut on most shock struts to keep the sliding surface of the piston or inner cylinder free from dirt, mud, ice, and snow. Entry of foreign matter into the packing gland will result in leaks. The majority of shock struts are equipped with torque arms attached to the upper and lower cylinders to maintain correct alignment of the wheel.

This type of NLG shock strut cylinder and piston assembly is a forward retracting, cantilevered, dual chamber air and oil (oleo) shock strut. NLG cylinder and piston assembly supports the items listed: nose wheels, nosewheel steering power unit, launch bar assembly, launch bar power unit, repeatable release holdback adapter, AOA approach light assembly, landing/taxi light assembly. NLG cylinder and piston assembly absorbs shock loads and maintains NLG tire and runway compliance during landing, takeoff, and taxiing. It absorbs compression and tip back forces during launch.

Nosewheel steering forces are mechanically transmitted by the NLG cylinder and piston assembly to the nosewheels. A towbar may be inserted into the NLG axles, allowing ground equipment to position the aircraft. See Figure 13-10.

All shock struts are provided with an instruction plate that gives, in a condensed form, instructions relative to the filling of the strut with fluid and inflation of the strut. The instruction plate also specifies the correct type of hydraulic fluid to use in the strut. The plate is attached near the high-pressure air valve. It is of the utmost importance that you always consult the applicable aircraft MIMs and familiarize yourself with the instructions on the plate prior to servicing a shock strut with hydraulic fluid and nitrogen or air.

Figure 13-11 shows the inner construction of a shock strut and the movement of the fluid during compression and extension of the strut. The compression stroke of the shock strut begins as the aircraft hits the ground. The center of mass of the aircraft continues to move downward, compressing the strut and sliding the inner cylinder into the outer cylinder. The metering pin is forced through the orifice, and by its variable shape, controls the rate of fluid flow at all points of the compression stroke. In this manner, the greatest possible amount of heat is dissipated through the walls of the shock strut. At the end of the downward stroke, the compressed air or nitrogen is further compressed, limiting the compression stroke of the strut. If there is an insufficient amount of fluid and/or air or nitrogen in the strut, the compression stroke will not be limited, and the strut will "bottom" out, resulting in severe shock and possible damage to the aircraft.
The extension stroke occurs at the end of the compression stroke, as the energy stored in the compressed air or nitrogen causes the aircraft to start moving upward in relation to the ground and wheels. At this instant, the compressed air or nitrogen acts as a spring to return the strut to normal. At this point, a snubbing or dampening effect is produced by forcing the fluid to return through the restrictions of the snubbing device (recoil valve). If this extension were not snubbed, the aircraft would rebound rapidly and tend to oscillate up and down because of the action of the compressed air. A sleeve, spacer, or bumper ring incorporated in the strut limits the extension stroke.

**MECHANICAL LINKAGE**

The landing gear drag brace, shown in Figure 13-12 consists of an upper and lower brace that is hinged at the center to permit the brace to jackknife during retraction of the gear. The upper brace pivots on a trunnion attached to the wheel well overhead. The lower brace is connected to the lower portion of the shock strut outer cylinder.

On the drag brace shown in Figure 13-12, a locking mechanism is used where the lower and upper drag braces meet. Usually in this type of installation, the locking mechanism is adjusted so that it is allowed to be positioned slightly overcentered. You must be able to inspect and adjust landing gear braces and locking mechanisms as specified in the applicable MIM.

To adjust the drag brace shown in Figure 13-12, you would first remove the cotter pin and nut (not shown) from the lock arm shaft. With the drag brace in the full extended position, rotate the eccentric bushings that are located
on each end of the lock arm shaft.

Both bushings must be rotated together to ensure that the high point of the eccentricity is the same on both bushings. Failure to do this may result in damage to the equipment or sluggish operation. The bushings may be rotated in either direction until the end of the lock arm shaft, shown as point "A" in Figure 13-12, is a distance of 0.003 inch to 0.015 inch from the striker. This clearance is checked with a feeler gauge.

Other portions of the drag brace are nonadjustable, except for the length of its down lock cylinder. Figure 13-12 indicates the cylinder should be adjusted to a length of 12 3/8 inches. In the design of drag braces, the tendency has been directed toward lessening the adjustment requirements. In some installations, drag braces are manufactured to exact dimensions and do not require adjustments.

LANDING GEAR SYSTEMS MAINTENANCE

Mandatory drop checks are required for all landing gear maintenance procedures that involve the removal and replacement of components, breaking of hydraulic lines or fittings, and any adjustments to gear or door linkages. Conditional maintenance requirements cards call for a drop check whenever the aircraft experiences a "hard landing." In addition, regular drop checks are required as part of the aircraft periodic inspection, even if there has been no reported discrepancy.

DROP CHECK PROCEDURES

All drop check operations should be performed as specified in the applicable maintenance instructions manual (MIM). These procedures should be thorough enough to ensure that the system is free of leaks and the operational integrity of the system has been restored following maintenance. Operational checks cover three distinct areas. They are the operation of the landing gear and doors, the operation of the landing gear position indicator and warning system, and the operation of the landing gear emergency system.

The first step in the drop check procedures is to place the aircraft on jacks, shown in Figure 13-13.

Further preparation includes connection of a hydraulic test stand and external electrical power, removal of landing gear maintenance safety locks, and the proper placement of the landing gear control handle.

As the operational procedure begins, check to make sure that the landing gear doors do not close in the path of the retracting main struts. This condition will be obvious (with hydraulic and electrical power on the aircraft) if the landing gear doors do not remain in the full open position when the landing gear control handle is placed in the UP position. Placing the landing gear control handle momentarily to the UP and DOWN positions several times will correct this condition by removing air from the wheel door cylinders.

Regulate the hydraulic test stand to operate at a flow of 4 gpm, (gallons per minute) and slowly increase hydraulic pressure. The landing gear down lockpins should start to retract. They should be fully retracted when the pressure reaches 1,800 psi, and then all gear assemblies should start to retract.

When the nose gear nears the up position, be sure the fairing doors are cammed to the closed position, and then check all gear doors to be sure they are closed and locked when the position indicator indicates the up-and-locked condition. Move the landing gear handle down and check to see that the wheel fairing doors open and gear
NOTE
Some aircraft require resetting of the landing gear dump valves before recycling the landing gear. Refer to the applicable MIMs.

Figure 13-13 — Performing drop check procedures.

When you check the emergency extension of the gear, first retract the gear normally, secure external hydraulic pressure, place the landing gear handle in the down position, and then pull and hold the emergency extension handle fully aft. Visually check that all gear assemblies are down and locked by observing the landing gear position indicator in the cockpit, and then release the emergency extension handle. It may be necessary to manually push the gear assemblies to the down-and-locked position. The force required to push the main gear to the locked position should not exceed 20 pounds applied to the axle hub. The force required to push the nose gear to the locked position should not exceed 10 pounds applied at the center line of the axle hub. Make at least one complete normal cycle of the landing gear, and then remove external power and aircraft from jacks.
TROUBLESHOOTING

Troubleshooting of the landing gear system, like all hydraulic systems, requires that you understand the theory of operation of the particular system and the function and sequence of operation for each component.

Troubleshooting steps provided in the MIM are normally aligned with the sequence of events or steps in the operational checkouts. They provide an efficient means of isolating the malfunction. The MIM requires that each step in the operational checkouts be performed in sequence. If trouble occurs during the procedure, it must be corrected before proceeding with the next step. These troubleshooting aids provide a logical cause for many anticipated landing gear malfunctions, including procedures for isolating and remedying the problem. Refer to the system schematic for the particular system and accompanying maintenance instructions, in addition to sound reasoning, to pinpoint the cause for a malfunction in an efficient manner.

Some landing gear malfunctions are related to improper maintenance practices, with the lack of proper lubrication being the predominant malpractice. A review of past discrepancies and previous corrective actions may also aid in analyzing malfunctions.

Occasionally, discrepancies that are reported as a result of flight are difficult or even impossible to duplicate on the deck. However, too many discrepancies signed off with "Could not duplicate system checks 4.0," or similar corrective actions, show up as repeat malfunctions or as the cause of accidents. Every effort should be made to locate a sound logical cause for a reported malfunction by thoroughly checking the system, each component, linkages, clearance, and associated indicating systems. All phases of the operational checkouts must be verified by a quality assurance inspector.

Detecting internal leakage of components may require the use of special equipment, such as the ultrasonic leak detection translator or simple isolation of components by disconnecting lines, applying pressure, and measuring for allowable leakage limits.

ALIGNMENT AND ADJUSTMENT

Improper rigging or adjustment of landing gear linkages results in a significant number of unsafe or hung landing gear discrepancies. Most landing gear, when in an overcenter and locked position (up or down), requires very little interference or binding to prevent its initial movement.

Alignment of newly installed landing gear assemblies or individual components should be in strict accordance with the procedures outlined in the applicable MIM. Complete assemblies are aligned in a specified sequence, with designated steps throughout the sequence that require quality assurance verification before proceeding to the next step. Landing gear doors may have to be deactivated or disconnected to check for proper up lock actuation and gear up clearances. Complete alignment includes down-and-locked adjustment, up-and-locked adjustment, and proper door operation. Verification of the emergency landing gear system operation is normally required in verifying the landing gear system. Some MIMs cover the emergency system as a separate procedure, but a complete operational checkout should include the emergency backup system.
RECOIL STRUT MAINTENANCE

According to current maintenance directives, maintenance of recoil struts (including minor repair and miscellaneous parts replacement) should be confined to work that can be performed with only partial disassembly of the equipment. Instructions for major or complete overhaul are covered in overhaul instructions manuals for recoil struts, and such work is performed by specialized shops.

LOWER STRUT AND GLAND SEAL REPLACEMENT

On most aircraft the piston O-rings and delta rings can be replaced at the organizational level of maintenance while the strut is installed on the aircraft. Procedures for replacing the seals in a main gear recoil strut at the organizational level of maintenance consist of jacking the aircraft in accordance with the applicable MIM. Remove the wheel and brake assemblies so that handling of the lower strut is easier. Remove the cap from the strut filler valve and release the nitrogen pressure from the strut by opening the valve swivel nut counterclockwise. Remove the necessary wire bundles, hydraulic lines, etc., that form a connection between the upper cylinder and lower piston of the strut. Remove the up and down lines from the gear actuating cylinder. Connect a hand pump or check and fill stand lines so that the strut may be retracted to an angle that will allow the piston to be withdrawn from the cylinder. Cap any loose lines or fittings to prevent contamination. On some aircraft, you will have to use a spring compressor or some other means to release tension on the gear down lock mechanism so that the gear can be partially retracted.

With the strut cylinder secured in the partially retracted position and all pressure released from the strut, the upper and lower torque arms can be disconnected. Cut the lockwire and remove the lock screws from the gland nut. Figure 13-14 shows a main gear recoil strut piston. Refer to Figure 13-14 while you read the following seal replacement material.

With the piston supported, the collar or gland nut is unscrewed and the piston withdrawn from the cylinder. Pour the hydraulic fluid into a suitable container, and place the piston/axle assembly in a clean work area. Inspect the hydraulic fluid for evidence of rubber or metal particles that might indicate wear conditions within the strut.

Remove the pin retainer and three pins from the piston head; then remove the piston head and the recoil valve. On some aircraft the retaining pins are press fitted while on others they are screwed in. Remove the metering pin assembly, follower, thrust bearing assembly, adapter, delta ring, and other removable parts in the order in which they are installed on the piston assembly, as shown in Figure 13-14.

The cylinder walls, piston head, adapter, follower, and bearings should be inspected for excessive wear and sharp edges. Minor nicks, scratches, or sharp edges can be
polished out with a crocus cloth (steel parts) or aluminum oxide abrasive cloth (aluminum parts).

Coat all seals and backup rings with hydraulic fluid and install in the reverse order of the disassembly sequence. Ensure that the adapter, follower, and recoil valve are facing in the right direction on the piston assembly. Once the piston assembly is reassembled, quality assurance should check for proper reassembly before inserting it into the cylinder.

The inner surface of the cylinder and the outer surface of the piston are coated with hydraulic fluid, and the piston is immediately installed in the cylinder. The gland nut is tightened and the lock screws installed and safety wired. The torque arms are reconnected and the strut lowered to its normal extended position. All linkage, hydraulic lines, wire bundles, and the brake and wheel assemblies are installed in the reverse order of their removal. The strut is serviced as required by the applicable MIM or maintenance requirements card.

Proper servicing is very important. Not all struts are serviced in the standard manner. Consult the appropriate MIM to prevent improper servicing and subsequent landing gear or structural failure. All linkage on the lower strut that was disturbed must be lubricated, the brakes bled, and the brakes and the landing gear systems operationally tested.

STRUT REMOVAL AND REPLACEMENT

To remove a strut assembly, first jack the aircraft according to instructions furnished in the applicable MIM. To reduce the weight and allow for easier handling, remove the wheel (with tire and brake assembly).

Figure 13-14 — Main gear recoil strut piston.

CAUTION

Before removing a wheel assembly from an aircraft, deflate the tire completely. To ensure positive removal of all pressure from the tire, you should remove the valve core and attach a "deflated tire" tag to the valve stem after deflating the tire.
Remove all attached fairings and door connecting rods. Disconnect and cap the hydraulic brake lines and fittings. Disconnect electrical connections at the cannon plugs, and remove wiring from clamps as necessary. Retain all removed hardware in a cloth bag.

Disconnect the drag brace by partially pulling the upper torque arm pin. After disconnecting the drag brace, reinstall the pin and nut to retain the torque arm.

The side brace is generally removed with the strut assembly. It should be disconnected at its upper end by removing the nut and pin. After the side brace is disconnected, reinstall the pin.

If equipped with a shrink rod, disconnect the shrink rod from the strut, not from the aircraft. This is accomplished by removing the rod fitting bolt at the bottom of the rod. When the shrink rod is disconnected, the nut and bolt should be reinstalled in the fitting for safekeeping.

Support the recoil strut and partially pull the crossbolt at the top of the strut to disengage it from the support structure. Lower the strut and reinstall the bolt and nut.

Installation essentially reverses the removal procedures. With the aircraft still on jacks, carefully move the top of the recoil strut into place to engage the support structure fitting. Install the crossbolt, washer, nut, and cotter pin. Connect the shrink rod to the shrink rod fitting. Connect the side brace to the support structure fitting. Partially pull the upper torque arm pin and connect the drag brace. Reinstall the pin, tongued washer, nut, and cotter pin.

Assemble the brake and wheel to the strut axle, bleed the brake, and service the strut as specified in the aircraft MIM. Ensure that the air valve is safety wired before charging the strut with nitrogen. After the strut has been serviced with hydraulic fluid and nitrogen, tighten the air valve to the specified torque value required by the MIM. Replace all removed fairings, doors, hydraulic lines, and electrical connections. Lubricate all reinstalled linkages, and check the landing gear for proper operation.

**SERVICING, BLEEDING, AND INSPECTING SHOCK STRUTS**

For efficient operation of shock struts, the proper fluid level and pneumatic pressure must be maintained. Before you check the fluid level, you should consult the aircraft MIM. Deflating a strut can be a dangerous operation unless the servicing personnel are thoroughly familiar with high-pressure air valves and observe all the necessary safety precautions.

**Servicing**

The high-pressure air valve shown in Figure 13-15 is used on most naval aircraft. This air valve is used on struts, accumulators, and various other components that must be serviced with high-pressure air or nitrogen. The following procedures for deflating a typical shock strut, servicing with hydraulic fluid, and
Some aircraft must be placed on jacks with their struts completely extended for servicing. See Figure 13-16. For specific aircraft, consult the appropriate aircraft MIM.

1. Position the aircraft so that the shock struts are in the normal ground operating position. Ensure that personnel, workstands, and other obstacles are clear of the aircraft.

**NOTE**

Some aircraft must be placed on jacks with their struts completely extended for servicing.
2. Remove the cap from the air valve, as shown in View A of Figure 13-16.

3. Release the air pressure in the strut by slowly turning the air valve swivel nut counterclockwise approximately 2 turns. This action can normally be accomplished with the use of a combination wrench.

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**WARNING**

When loosening the swivel nut, ensure that the 3/4-inch hex body nut is either lockwired in place or held tightly with a wrench. If the swivel nut is loosened before the air pressure has been released, serious injury may result to personnel.

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4. Ensure that the shock strut compresses as the air or nitrogen pressure is released. In some cases, it may be necessary to rock the aircraft after deflating to ensure complete compressing of the strut.

5. When the strut is fully compressed, the air valve assembly may be removed by breaking the safety wire and turning the 3/4-inch body nut counterclockwise.

6. Use the type of hydraulic fluid specified on the shock strut inspection plate to fill the strut to the level of the air valve opening. Figure 13-17 shows the instruction plate found on one type of aircraft main landing gear strut. Improper oil level in the strut chamber will decrease the shock absorbing capabilities of the strut and could cause the strut to bottom out during landing. This would damage the strut and/or wing structure.

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**NOTE**

The instruction plate may be found on the strut or on the wheel door near the strut.

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7. Reinstall the air valve assembly, using a new O-ring packing. Torque the air valve body hex nut from 100 inch-pounds to 110 inch-pounds, as shown in View B of Figure 13-16.

8. Lockwire the air valve assembly to the strut, using the holes provided in the body nut.

9. Inflate the strut, using a regulated high-pressure source of nitrogen or dry air. Under no circumstances should any type of bottle gas other than nitrogen or compressed air be used to inflate shock struts. The amount a strut is inflated depends upon the specific aircraft strut being serviced. One manufacturer may use a strut inflation chart, such as the one shown in View D of Figure 13-16. The strut is measured as indicated at dimension "A." This measurement, in inches, is then located on the bottom of the inflation chart. For example, locate the measurement of 1.75 inches on the chart. From this point, vertically trace an imaginary line until it intersects the curved line. At this point of intersection, horizontally trace a second imaginary line to the left edge of the chart. The figure...
indicated at this point (550 psi) is the required pressure for that particular extension of the strut.

All aircraft struts are not measured from the same points. View E of Figure 13-16 shows another location where strut extension is measured. The proper procedure to use will always be found on the instruction plate attached to the shock strut. If these instructions are not legible, consult the applicable MIM.

If the strut's chamber is underpressurized, the strut may not overcome normal O-ring friction during extension on takeoff. This condition could prevent the strut from fully extending, thus the torque scissors limit switch would not actuate to close the electrical circuit to retract the gear. It would also cause the strut to bottom during taxiing and landing operations.

If the strut's chamber is overpressurized, the additional pressure will tend to keep the strut pressurized after takeoff. On those aircraft that use shrink mechanisms, the shrink mechanisms may be overloaded or stall the strut actuator as the gear retracts. If the gear retracts in the wing without shrinking, due to the failure of the shrink mechanism, damage to both the wing and landing gear may result.

10. Tighten the air valve swivel hex nut to a recommended torque of 50 to 70 inch-pounds.

11. Remove the high-pressure air-line chuck and install the valve cap fingertight.

Because some aircraft struts require special servicing procedures, the General Information and Servicing section of the applicable MIM should always be checked before servicing the shock struts of any aircraft.

**Bleeding**

If the fluid level of a shock strut has become extremely low or, if for any other reason, air is trapped in the strut cylinder, it may be necessary to bleed the strut during the servicing operation. Bleeding is performed with the aircraft placed on jacks. In this position, the shock struts can be extended and compressed during the filling operation, expelling all of the entrapped air. As mentioned earlier, certain aircraft must be placed on jacks for routine servicing of the shock struts. The following is a typical bleeding procedure.

1. Construct a bleed hose that contains a fitting suitable for making an airtight connection to the shock strut filler opening. The hose should be long enough to reach from the shock strut filler opening to the deck when the aircraft is on jacks.
2. Jack the entire aircraft until all shock struts are fully extended.
3. Release the air or nitrogen pressure in the strut to be bled, as previously described in this chapter.
4. Remove the air filler valve assembly.
5. Fill the strut to the level of the filler port with hydraulic fluid.
6. Attach the bleed hose to the filler port, and insert the opposite end of the hose into a quantity of clean hydraulic fluid.
7. Place an exerciser jack or other suitable single-base jack under the shock strut jacking point. See view C of figure 13-15. Compress and extend the strut fully (by raising and lowering the jack) until the flow of air bubbles from the strut has completely stopped.

**NOTE**
Compress the strut slowly and allow it to extend by its own weight.

8. Remove the exerciser jack, and then lower and remove all other jacks.
9. Remove the bleed hose from the shock strut.
10. Install the air filler valve and inflate the strut.

**Inspection**

Shock struts should be inspected regularly for leakage of fluid and for proper extension. Exposed portions of the strut pistons should be cleaned in the same manner as actuating cylinder pistons during preflight and postflight inspections. Exposed pistons should be inspected closely for scoring and corrosion. Excessive leakage of fluid can usually be stopped by deflating the strut and tightening the packing gland nut. If leakage still persists after tightening the packing gland nut and reinflating the strut, the strut must be disassembled and the packings replaced.

The tools shown in *Figure 13-18* are typical of the tools used during disassembly and assembly of landing gear shock struts. Normally, each tool is designed

![Figure 13-18 — Landing gear shock strut tools.](image-url)
for, and should be used only on, one type of installation. When using wrenches, you must take care to maintain the lugs of the wrenches in their respective positions. Slippage of the wrench, when under torquing conditions, may cause damage to aircraft parts, the tool, or even injury to personnel. NEVER place extension handles of any type on these tools to increase the applied force.

These tools, like other special tools, should be kept where they will not be subjected to rough handling, which could cause mushroomed or deformed surfaces, making them useless for aircraft repair.

**INTERMEDIATE MAINTENANCE REPAIR AND SEAL REPLACEMENT**

Repair of recoil struts at the intermediate level of maintenance is restricted to seal replacement and replacement of parts listed in the "Intermediate Maintenance Section" of the aircraft MIM or the appropriate 03 manual. The following paragraphs provide information on the disassembly, cleaning, inspection, parts replacement, reassembly, and bench testing of a strut at the intermediate level.

**Disassembly**

Disassemble the strut assembly in the order of the key index numbers assigned to the exploded view illustration provided in the appropriate 03 series accessories manual or the "Intermediate Maintenance Section" of the applicable MIM.

![WARNING]

Before beginning disassembly, make sure that all pressure has been exhausted from the strut. Do not disassemble the inner and outer cylinder until all the pressure has been released from the strut. Disassembly of the strut before releasing all pressure could lead to serious personnel injury or loss of life.

Remove the complete air valve assembly by breaking the lockwire and unscrewing the 3/4-inch hex nut. Turn the strut over and drain the hydraulic fluid. Disconnect the torque arms (scissors). Break the lockwire and unscrew the packing nut at the bottom of the outer cylinder. Carefully withdraw the inner cylinder from the outer cylinder. Pull the metering pin and bulkhead from the inner cylinder with a smooth controlled force. Tag or keep parts together to expedite reassembly.

**Cleaning**

Thoroughly clean all parts of the recoil strut assembly, using MIL-PRF-680 dry-cleaning solvent (spray or dip) or a similar cleaning solvent. Dry thoroughly with clean, dry, compressed air, paying particular attention to all recesses and internal passages. Use the cleaning solvent in a well-ventilated area. Avoid prolonged inhalation of fumes. Keep solvent away from open flames.
Cleaned parts that normally come in contact with fluid during operation of the strut should be coated with hydraulic fluid. Depending on local conditions, it may be desirable to also coat external highly machined surfaces.

Wipe the lower bearing clean with a clean, lint-free cloth dampened with hydraulic fluid. Do not touch machined surfaces with your bare hands. Do not use compressed air to dry bearings. Clean the bearings with new cleaning solvent and dry with a lint-free cloth.

**Inspection**

Perform a thorough visual inspection of the disassembled parts for serviceability. Packing grooves and surrounding areas should be inspected for scratches, burrs, nicks, or other roughness that might cut packings on installation or cause seal failure during strut operation. Inspect machined surfaces for mars, abrasions, gouges, grooves, scores, scratches, and corrosion. If any parts are suspected of having cracks, the part should be inspected using one of the nondestructive methods of testing.

Check all threaded parts for distorted or mutilated threads. Inspect plated surfaces for blistering, flaking, wear, or other defects.

Within the limits of practicability, check all holes for concentricity and taper, using an internal micrometer, hole gauges, plug gauges, or similar equipment. Check the angle between the piston and the axle. Check to ensure that the brake flange is perpendicular to the axle. Inspect all ports, bores, and passages for cleanliness. Place bearings next to a sensitive compass to check for residual magnetism.

Bearings should be inspected for obvious damage, Brinelling (shallow indentations in the raceway), or corrosion. Rotate bearing races and check for roughness, binding, or looseness. Bearing retainers must be checked for cracks, warpage, and corrosion. Refer to the tables furnished in the applicable accessories manual or the "Intermediate Maintenance Section" of the appropriate MIM for service limits established for critical areas.

**Repair or Replacement**

Repair or replace all parts that show evidence of excessive wear, scoring, or corrosion. Replace all parts that show wear beyond the dimensions specified in the inspection standards tables found in most 03 manuals or MIMs.

Each time the strut is disassembled, all preformed and special packings should be replaced, although they may appear to be serviceable.

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**NOTE**

Never work on machined surfaces with metallic tools.
Always use brass O-ring tools for checking scratches and removing or replacing seals and gaskets.

Blend out minor scratches, nicks, and burrs from machined surfaces of steel parts with a crocus cloth. Use aluminum oxide abrasive cloth to polish aluminum parts. The smoothness of the repaired area must be equal to or smoother than the finish of the surrounding area. Do not attempt to remove normal wear marks from the sliding surface of the piston.
Areas with damaged paint or other protective finishes must be restored to a serviceable condition.

If any bushings require replacement, the mating bushing must also be replaced.

**Reassembly**

Reassemble the strut assembly in essentially the reverse order of disassembly. Exercise adequate precautions to ensure that dirt, dust, grit, or other foreign matter does not enter the strut during assembly. Contamination of parts can cause a definite failure. Guarding against contamination cannot be overemphasized.

Observe the torque values specified in the 03 manual or MIM. Where a specific torque value is not specified for a threaded part, tighten the part according to the standard torque values provided in the *Structural Hardware Manual*, NAVAIR 01-1A-8. Some structural repair manuals and maintenance instructions manuals also contain this information. On some parts, such as the strut gland nut, tightening should conform to acceptable shop practices and common sense, unless otherwise specified.

Lightly coat all preformed packings with hydraulic fluid. After all seals and parts are properly installed, the piston head is tightened and the retaining pins installed and staked into place. The piston assembly is inserted into the outer cylinder, and the gland nut is tightened to a snug fit, backed off two key slots, and locked in place. If the gland nut is too tight, it will result in binding of the thrust bearing. Two lock plates, positioned 180 degrees apart on the collar and gland nut, are secured with screws and lockwired to hold the gland nut in place. Use the double twist method of applying the lockwire so that tension of the wire tends to tighten the nut.

**Bench Testing**

With the strut fully compressed and in the vertical position, service the strut with hydraulic fluid. Install the air valve on the strut and torque to 100-110 inch-pounds. Place the strut fully extended in a horizontal or vertical position and inflate with oil-free dry nitrogen to the normally extended pressure specified in the MIM or 03 manual. Ensure that the strut shows no leakage after a 1-hour interval.

If the strut fails the bench test, it is tagged to show the portion of the test that failed. Then it is deflated, flushed with preservative hydraulic fluid, and forwarded to the next higher level of maintenance.

If the strut passes the bench test and is not to be installed on an aircraft immediately, flush with preservative hydraulic fluid before sending it to supply.
If any parts other than those listed as replaceable at the intermediate level of maintenance are faulty, tag the strut and forward it to the next higher level of maintenance. The VIDS/MAF is closed out to account for man-hours expended in attempting repairs before the strut is declared beyond the capability of maintenance (BCM). If a Quality Deficiency Report (QDR) form was attached to the strut by the removing organizational maintenance activity, complete the QDR and submit it according to the instructions provided in COMNAVAIRFORINST 4790.2 (series).

Any unusual failure or strut malfunction should be reported by the submission of a QDR so that failure trend patterns or isolated instances may be reviewed for possible higher echelon action. Forward the No. 4 copy of the MAF and the hard copy of the QDR with the strut to the next higher level of maintenance.
Review Questions

13-1. A landing gear system is operated and controlled by what means?

A. Electrically controlled and pneumatically operated
B. Electrically operated and hydraulically controlled
C. Hydraulically controlled and pneumatically controlled
D. Hydraulically operated and electrically controlled

13-2. What does a typical fixed-wing aircraft landing gear configuration consist of?

A. One main landing gear and two steerable nose landing gears
B. Two main landing gears and one steerable nose landing gear
C. Two main landing gears and one steerable tail landing gear
D. Two main landing gears and two steerable nose landing gears

13-3. In what direction does the nose landing gear of a fixed-wing aircraft retract?

A. Either forward or rearward into the fuselage
B. Forward into the fuselage only
C. Forward on the down stroke and rearward on the up stroke
D. Rearward into the fuselage only

13-4. During normal operation, what component disengages the down lock, allowing the nose landing gear cylinder to raise the nose gear?

A. The down lock cylinder
B. The down lock switch
C. The up lock cylinder
D. The up lock switch

13-5. During normal operation, what component closes the nose landing gear doors?

A. Hydraulic actuator
B. Mechanical linkage
C. Over center actuator
D. Pneumatically operated

13-6. What is indicated in the pilot's position indicator when the landing gear is in transition from gear down to gear up?

A. Barber poles
B. Flashing green light
C. The word DOWN
D. The word UP
13-7. What component is used to hold the doors of a landing gear system in the closed position?

A. Hydraulic actuator  
B. Latches  
C. Main landing gear tire  
D. Mechanical linkage

13-8. What are the principal components of a latch mechanism?

A. Elongated holes, serrated plate, hook cylinder, and latch support  
B. Hydraulic latch cylinder, latch hook, spring-loaded linkage, and a sector  
C. Hydraulic latch hook, latch cylinder, spring-loaded linkage, and a sector  
D. Latch roller support, plate, latch hook, spring-loaded linkage, and a sector

13-9. What component provides a main gear up-and-locked indication on the pilot's cockpit indicators?

A. Barber poles  
B. Poppet valve  
C. Transition light  
D. Up lock switch

13-10. All drop checks should be performed in accordance with what manual?

A. COMNAVAIRFORINST 4790.2 (series)  
B. NATOPS manual  
C. NAVAIR 01-1A-17 manual  
D. The applicable maintenance instruction manual (MIM)

13-11. What is the first step in performing a drop check?

A. Connect hydraulic test stand and electrical power  
B. Place landing gear handle in the UP position  
C. Place the aircraft on jacks  
D. Remove landing gear safety locks

13-12. What is the maximum pressure required to retract and lock a landing gear during a drop check?

A. 1800 psi at 3 gallons per minute (gpm)  
B. 1800 psi at 4 gallons per minute (gpm)  
C. 3000 psi at 3 gallons per minute (gpm)  
D. 3000 psi at 4 gallons per minute (gpm)