AIRCORPS AVIATION

DOCUMENT
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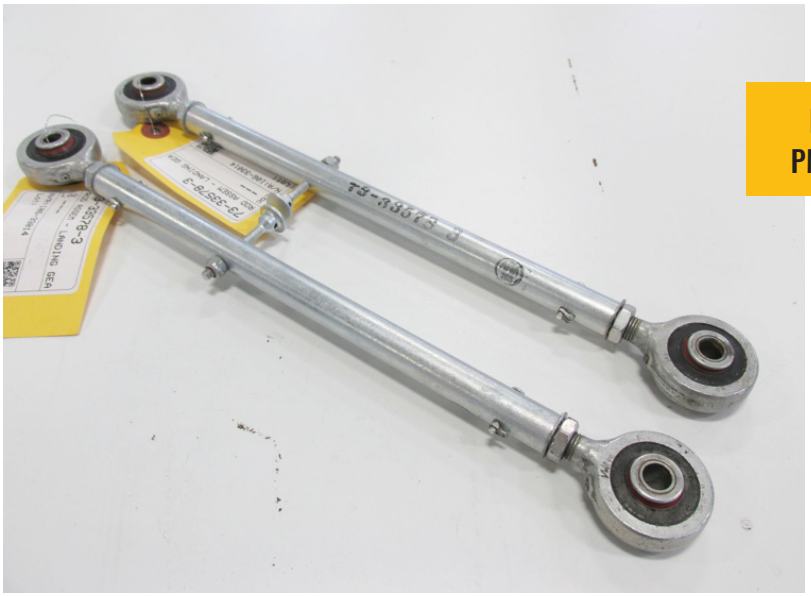
Landing Gear Retraction Rod End Failures & Safety Spring Installation

All P-51 Mustang Variants

Manufacturer	North American Aviation
Aircraft	P-51 Mustang
NAA Part Number	73-33578-3
Rod End Manufacturer P/N	ATE-6N (Schafer)
Proper Description	ROD ASSEM - LANDING GEAR RETRACTING STRUT CONNECTING
Location	One assembly is located in each main landing gear wheel well
Nickname	Gear Links / Landing Gear Rod Ends



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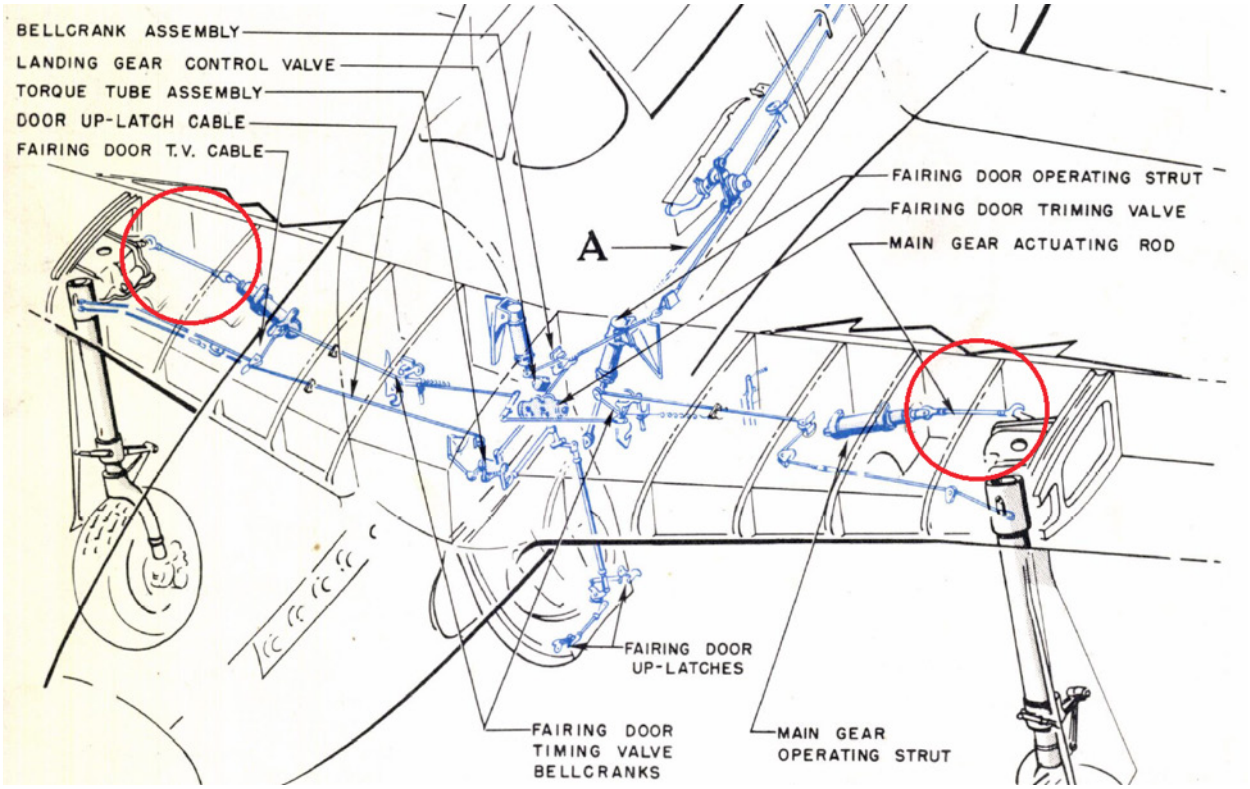
OVERVIEW / EXECUTIVE SUMMARY

Nobody wants to witness or participate in a gear up landing in a Mustang. It can easily be a $1,000,000 repair. And while the most common reason a Mustang ends up on its belly is pilot error, another culprit can be the failure of the landing gear rod end. Fortunately, there are preventative measures and fixes that almost eliminate the likelihood of this failure mode. However, even if an aircraft has been modified, it doesn't totally eliminate the chance of a rod end failure. **AirCorps Aviation in Bemidji MN has compiled a comprehensive explanation of the hardware and failure modes of this critical component, with the belief that it is something every pilot and mechanic involved with a Mustang should thoroughly understand.** Most importantly if you extend the gear on a Mustang and don't get a green light, DON'T recycle the gear.

Read on to learn why...

LOCATION

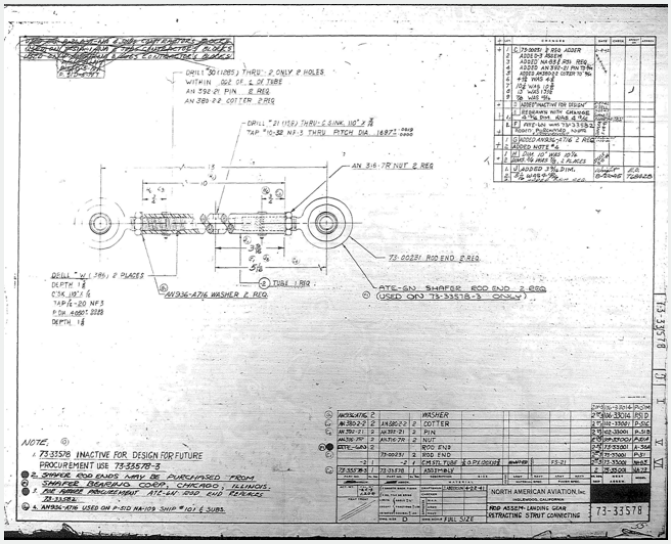
The P-51 Mustang ROD ASSEM - LANDING GEAR RETRACTING STRUT CONNECTING (P/N - 73-33578-3), is located in each landing gear wheel well, between Station 50 and Station 75 of the wing.[1]

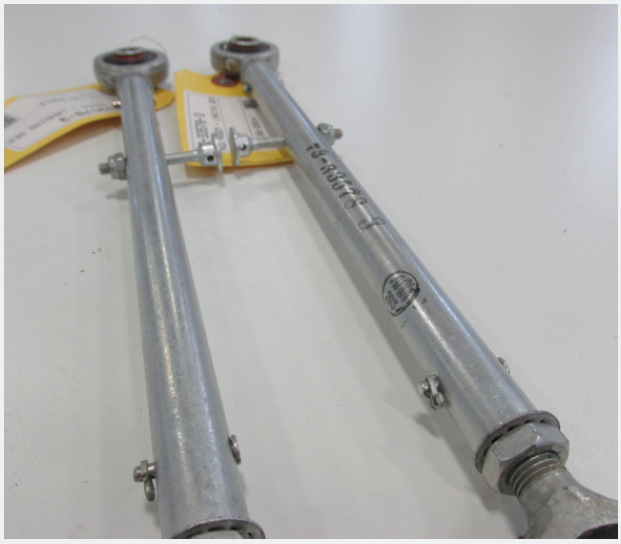


[1]For purposes of length, we will refer to this assembly as installed on a P-51D per Equipment Installation - Landing Gear Wing (P/N 106-33014).

MAKEUP

The 73-33578-3 assembly consists of a .625 OD x .120 wall Chrome Moly steel tube that is threaded on both ends to accept two ATE-6N Rod Ends and attaching hardware. Each end is drilled with a clevis pin inserted to secure the rod ends along with a lock washer and nut. It is also vertically drilled and tapped to mount a special bolt that contacts the landing gear down position indicator switch.





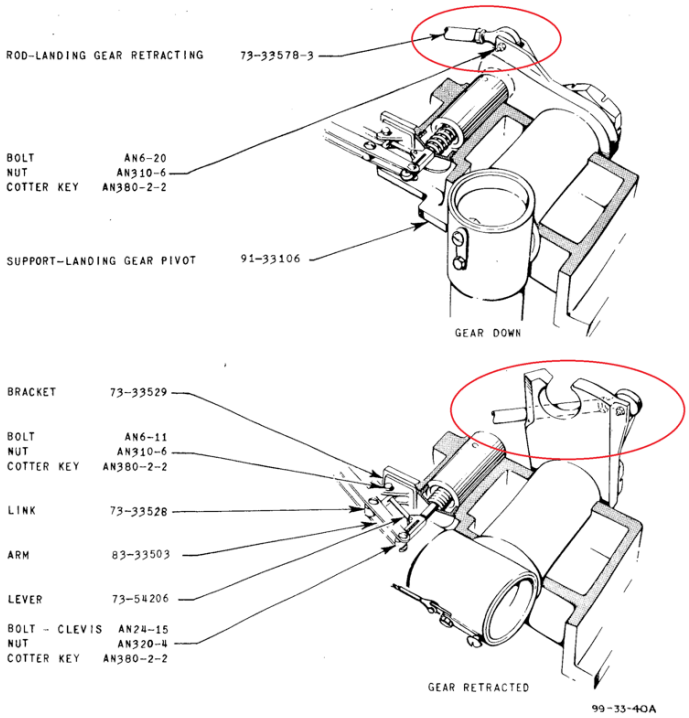


Figure 113—Main Gear Down-position Lock

FUNCTION

The complete rod assembly component can be simply described as providing two major functions:

- Provides the connection between the main landing gear strut and main landing gear, along with transferring hydraulic pressure to extend and retract the landing gear.
- Special bolt 73-54221 contacts the landing gear position indicator switch when in the down position (P/Ns 109-54206 or 109-54226).

CONNECTING PARTS

106-580270 - Strut Assem. Hyd. Landing Gear Operating Complete

to...

67972 - Arm Landing Gear Torque LH (Bendix) - Nicknamed "Porkchop"

106-580270 - Strut Assem. Hyd. Landing Gear Operating Complete

to...

67973 - Arm Landing Gear Torque RH (Bendix) - Nicknamed "Porkchop"

ADJUSTMENT OF LENGTH OF ROD END & CLEVIS END IN RETRACT STRUT

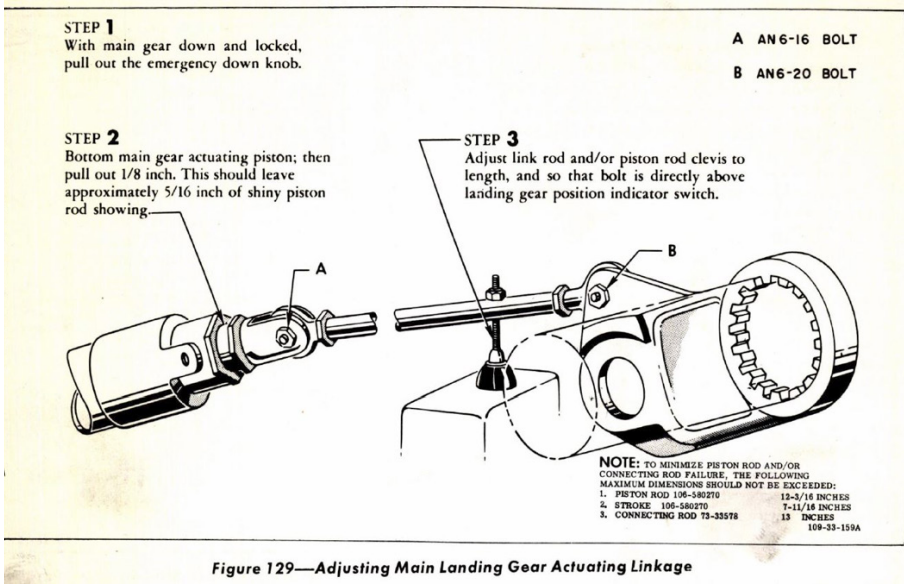


Figure 129—Adjusting Main Landing Gear Actuating Linkage

Because the hydraulic strut never fully bottoms in either direction, the rod assembly is constantly under pressure or tension at both ends of travel. Because of the hinge-like motion of the cycle, misalignment of the bearings will cause additional pressure and tension, and potentially failure of the rod ends.

P-51 LANDING GEAR SYSTEM

The landing gear installation embodies a retractable main gear assembly in each wing panel and a retractable tail gear assembly in the fuselage, each assembly being completely enclosed in the retracted position. All shock struts employ the air-oil combination for cushioning. The positioning of all three landing gear assemblies is controlled simultaneously by one lever on the lower left side of the cockpit.

VARIANTS OF ROD ASSEMBLIES & COMPONENTS

The 73-33578 ROD ASSEM - LANDING GEAR RETRACTING STRUT CONNECTING was originally designed and engineered by North American on April 22, 1941. This design was used on the P-51A, A-36, through the P-51D, including the experimental and lightweight mustang subtypes.

In May 1942 the revised design, P/N 73-33578-3, was drafted for production. This new rod end assembly was indicated by the addition of a the -3 to the part number. Improvements on this rod end assembly from the initial 73-33578 design include the following:

- The rod end 73-33582 was replaced by ATE-6N manufactured by Schafer Bearing Corp.
- Addition of lock washers
- Several minor dimensional adjustments

The original 73-33578 drawing also indicates that the completed assembly is to be finished per army spec FS-21 indicating cadmium plating to prevent corrosion.

INTERCHANGEABILITY

While the 73-33578 and 73-33578-3 are interchangeable, we do not suggest doing so as design improvements were made and prior production lots were deemed inactive for future use.

REMOVAL OF 73-33578 ROD ASSEM - LANDING GEAR RETRACTING STRUT CONNECTING

Use the instructions for landing gear maintenance outlined in Tech Order - T.O. No. 1F-51D-2 (AN 01-60JE-2), Maintenance Instructions for F-51D, F-51M, ZF-51K, and TF-51D, 30-Nov-1956

INSPECTION

This heavily worked and integral component on the P-51 Mustang requires frequent inspection and attention to prevent failure, particularly if operating 70+ year old rod ends.

Some key questions in determining if your 73-33578 rod assemblies need to be inspected / tested / replaced / repaired:

- Does your aircraft have lightweight rod ends? (Identification notes below)
- Have the rod ends and tube recently been inspected?

AirCorps recommends these additional inspections / actions.

- Rod assemblies should be visually checked during pre-flight to verify there are no visible cracks, tube and rod ends are not bent, and Down Indicator Switch Special Bolt is not bent or rotated from alignment with the switch. Know your aircraft so any change will draw your attention.
- Replace any lightweight ATE-6N rod ends with the heavier later variants.
- Magnaflux testing rod ends if performing any landing gear maintenance work.
- Install a take-up spring as a preventative measure to ensure that, upon a failure, the broken rod does not wedge and prevent extension or retraction (Instructions for installation below)
- Thoroughly inspect during each annual inspection

As a reference, the Aircraft Inspection & Maintenance Guide - P-51, 00-20A-2-P-51, 7-Nov-1947 outlines a detailed inspection of the landing gear system that should happen during pre-flight, after flight, daily, and at 25, 50, 100 hour inspections.

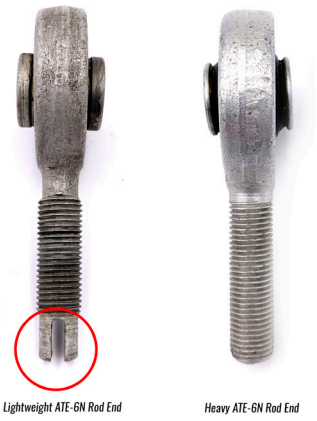
LIGHT AND HEAVY ATE-6N ROD ENDS

The difference between the often referred to light or heavy landing gear retract rod ends can be seen in the neck / transition from the threaded end to the rod end assembly and in the slot that was cut for the AN392-21 pin to hold the rod end in place.

The early or "light" version of the Schafer Bearing Corporation ATE-6 / #A-7462 had a narrower neck in which the diameter reduced in size. This lightweight "Schafer Special Bearing" also had a .125 inch slot cut in the threaded end of the assembly used on 73-33578. The early ATE-6 rod end was slotted and then it was given North American Aviation part number 73-33582 - END - LDG. GR. RETRACTING STRUT CONNECTING ROD. Interestingly, on the 73-33758 drawing in the title block bill of materials draftsmen noted the changes and updated the later assembly 73-33578-3 but never updated the title block on the earlier versions of the rod assembly. The earlier rod end 73-33582 was made inactive for future use on July 14th, 1943 and calling for all future procurement to use Schafer Bearing Corporation P/N ATE-6N / #A-7836.

Lightweight ATE-6N Rod End | Heavy ATE-6N Rod End

Note: Narrowing neck on early style lightweight ends



Lightweight ATE-6N Rod End | Heavy ATE-6N Rod End

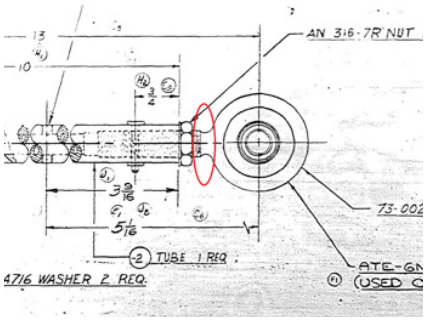
Note: Narrow neck and .125 slot on early style lightweight ends

It is important to note that on the latest revision 73-33578-3 ROD ASSEM. - LANDING GEAR RETRACTING STRUT CONNECTING is to be set assembled to the 13" length and then the threaded end of ATE-6N was drilled for assembly with the AN392-21 pin. Per the assembly drawing, there is no slot cut in the ATE-6N rod end assembly on 73-33578-3. It is important to not be operating with lightweight rod ends, a number of operators have experienced broken rod ends as the result of using lightweight variants. If the rod end on the cylinder end of the rod breaks, the rod will fall and jam on the Sta. 61.5 wing rib. When an extension occurs after the rod breaks the landing gear will extend halfway and stop. With a rod jammed on the rib and a broken rod, the only option will be a gear up landing.

FAILURES - LANDING GEAR RETRACT ROD END FAILURE

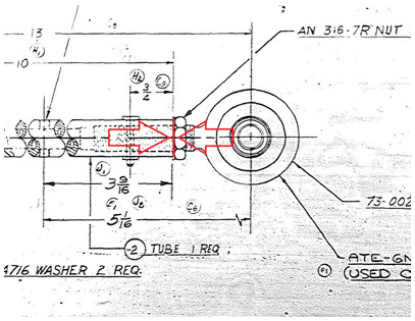
BROKEN LANDING GEAR RETRACT ROD ENDS

How to inspect - visual inspection, magnaflux
Tolerance of damage or wear : Zero
Solutions offered: Replacement of Rod Ends



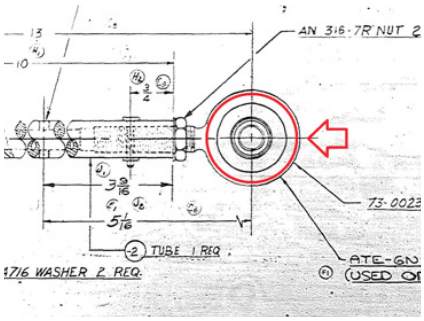
Failure Location # 1

The most common break occurs at the neck of ATE-6N or 73-33582 with the majority of failures occurring at the cylinder (inboard) side of the rod assembly.



Failure Location # 2

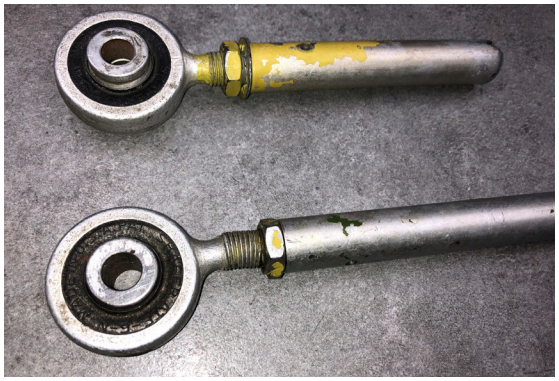
In the threads at the check nut where the ATE-6N or 73-33582 meets the steel tube. Again a majority of breaks occur on the cylinder end.



Failure Location # 3

The least common occurrence we have seen is a blowout of the shell on the ATE-6N or 73-33582. We have only seen this type of failure twice.

Examples of Broken Rod Ends

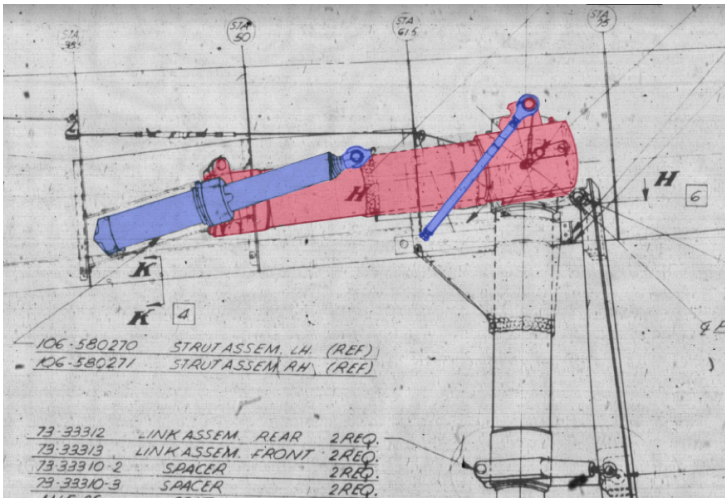


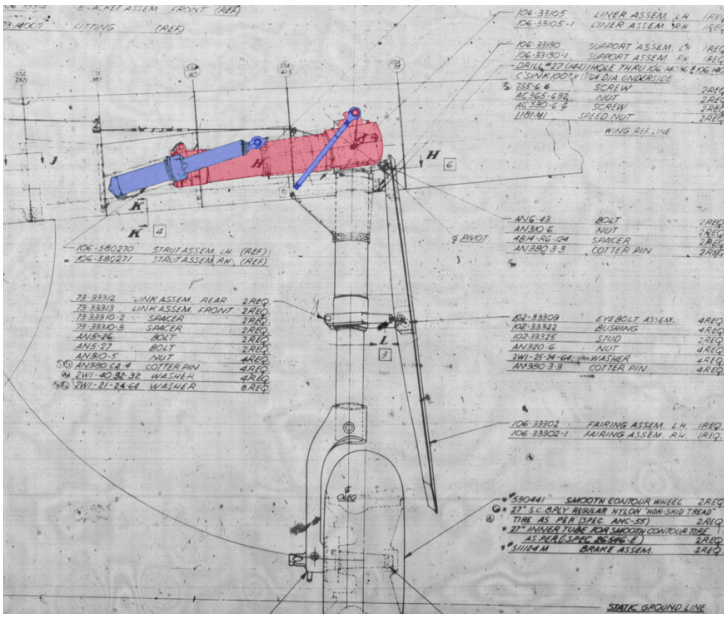
As the images to the left show, this end appears to have been rolled off - meaning the force applied to retract the gear has bent the rod end until failure.

RESULTING FAILURE FROM BROKEN ROD END

With the landing gear retracted, a failure at the cylinder end of 73-33578 Rod Assembly causes the broken rod to fall and wedge on the structural skin of the aircraft and rib at wing station 61.5. If the rod breaks and wedges on the rib, there is nothing a pilot can do to solve the problem in the air.

The rendering below simulates a broken retract rod with the landing gear upper cylinder in the up position indicated in red. The broken rod assembly, separated at the extended cylinder end is colored blue. The majority of the 73-33578 rod assembly will remain attached to the Arm Landing Gear Torque (Nicknamed the Porkchop). The rod assembly will wedge itself between the heavy skin and rib at wing station 61.5 and will prevent the landing gear from fulling extending.





WHY NOT TO RECYCLE THE GEAR

When a failure of either rod end occurs at initial retraction, the pilot will typically observe a brief indication of "Gear Up" followed by a indication of "Gear Unsafe". This is due to the rod releasing the gear position switch in contact with the plunger located on the retract rod after the rod falls from position. If the rod does not jam, the gear will fully extend and a normal landing can be made. As you will not have a safe indication, cycling the gear may present itself as an option. DO NOT CYCLE THE GEAR, this will not solve the issue and will only open the possibility of further jamming in the landing gear system! The landing gear system relies on timing and position of several components and it is high likely more damage will occur.

When a failure occurs in extension, during landing phase of flight, again the pilot will typically observe a "Gear Extended" indication immediately followed by an unsafe light. Typically if an extended indication followed by unsafe indication is observed the landing gear has extended and locked down. Like the failure in retraction, the rod has become misplaced and will no longer contact the rod position switch. Again, DO NOT CYCLE THE GEAR. Have a spotter observe the extension of the gear.

NEVER CHANGE DIRECTION OF YOUR GEAR WITHOUT COMPLETING A CYCLE

Pilot's extending the landing gear and not getting a green gear down light should not recycle the gear. In any situation, regardless of the integrity of the landing gear normal or failed, the pilot should never recycle their landing gear without completing a full cycle. The pilot may decide to do this due to an indication or deviation in intent of flight. The system must always fully complete a cycle before a direction change is made.

If you put gear down and then quickly cycle the gear before letting the complete system cycle, you run the risk of putting the door and landing gear timing system out of sequence & possibly preventing extension of the gear. On the down cycle, the gear drop with no timing of the doors. On the upcycle of landing gear both timing and sequencing is occuring.

This out of sequence failure mode has the potential to prevent extension of the gear and can also disturb airflow to the radiator and oil cooler due to open doors disturbing the airflow. Radio call the tower, someone on the ground, or a wing man for confirmation of landing gear position.

PREVENTATIVE LANDING GEAR ROD ASSEMBLY RETRACT SPRING INSTALLATION

As a preventative measure and safety enhancement, AirCorps recommends the installation of a spring between the retract rod and the extrusion in the gear well on the inboard (cylinder) side of the rod assembly.

Installing Broken Rod End Retract Spring

Parts Required

(2) Landing Gear Retract Rod Take up Spring - 73-33578-tu

(2) AN742D10 or MS21919DG10 Adel Clamp

(4) AN42-B4A Eyebolts or AN5261032R8

(4) AN365-1032A Nuts

Work performed between station 50 & station 61.5 of wing assembly

1. Remove center rivet on back to back stringers (P/N left wing 106-14033-10, -11 & P/N right wing 106-14033-16, -17) - it is important for spring to pull outboard
2. Install AN42-B4 & AN365-1032A through drilled out rivet on stringer
3. Attach AN742D10 or MS21919DG10 Adel clamp and AN365-1032A on inboard (cylinder) side of 73-33578 rod assembly
4. Close Adel clamp with AN42-B4A
5. Connect spring between eyebolts

(see next page for photos)

WHEN PURCHASING

AIRCORPS AVIATION

AirCorps Aviation has PMA approval for 73-33578-3 rod assembly and for the individual parts that make up the assembly.

If you're replacing any parts 73-33578-3 ROD ASSEM – LANDING GEAR RETRACTING STRUT CONNECTING, ensure airworthiness prior to purchasing by inspecting for cracks, straightness, and finish. If swapping out ATE-6N rod ends, operators and maintainers should confirm them to be the heavier variant.

AirCorps can provide parts, perform inspections, answer questions, and assembly services related to this rod assembly as well as overhaul of landing gear, system components, and installations.

AVAILABLE FOR PURCHASE:

ATE-6N – Heavy Rod Ends
Buy Now

73-33578-3-ACP Rod Assembly - Landing Gear Retract Strut Connecting PMA approved **Buy Now**

73-33578-2-ACP Tube - Landing Gear Retract Strut Connecting PMA approved **Buy Now**

ADDITIONAL RELEVANT LANDING GEAR ACTUATING ROD TECH ORDERS & INFO:

AirCorps Library - P-51 Mustang Resources

Aircraft Inspection & Maintenance Guide - P-51, 00-20A-2-P-51, 7-Nov-1947

T.O. 01-60JE-2, Maintenance Instructions for F-51D, F-51M, ZF-51K, and TF-51D, T.O. No. 1F-51D-2 (AN 01-60JE-2), 30-Nov-1956)

Maintenance Instructions - Cavalier Mustang - F-51D, T.0. 1F-51D-2, 27-Sept-1968