



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety

Washington, D.C. 20594

Left Main Landing Gear Actuator Examination Field Notes

January 26, 2011

A. OCCURRENCE

ERA11FA070

Location:	Destin, Florida
Date:	November 23, 2010
Time:	1930 Central Standard Time
Aircraft:	Piper PA-46-350 (Malibu Mirage)
Registration:	N548C
Serial Number:	4636322

B. GROUP

The Investigator-In-Charge (IIC) and participants in the examination from the component manufacturer met at the Triumph Actuation Systems facility in Clemmons, North Carolina on January 26, 2011 for the examination of the left main landing gear actuator that had been removed by the IIC from N548C, the accident airplane. The following participants attended this examination:

IIC:	Shawn Etcher National Transportation Safety Board Ashburn, Virginia
Participant:	Ken Allen Triumph Actuation Systems, LLC Clemmons, North Carolina
Participant:	Gene Hurak Triumph Actuation Systems, LLC Clemmons, North Carolina

C. SUMMARY

On November 23, 2010 about 1930 central standard time, a Piper PA-46-350P (Malibu Mirage), N548C, was substantially damaged when it impacted the water during an approach to the Destin/Ft. Walton Beach Airport (DTS), Destin, Florida. The airplane had departed Lake Front Airport (NEW), New Orleans, Louisiana. Instrument Meteorological conditions prevailed and an instrument flight rules (IFR) flight plan had been filed. The certificated private pilot and two passengers were fatally injured. The

personal flight was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

The IIC met the participants at the Triumph Actuations Systems facility to investigate the left main landing gear actuator from the accident airplane. The component was subjected to a thorough inspection and documentation prior to the unit being tested per the Acceptance Test Procedures (ATP) 1FA10064 Revision "C."

The incoming visual examination determined conformance with respect to envelope, mounting provisions, safety wiring markings, nameplate, and workmanship. The external surface had no damage; however, a small amount of corrosion was noted on the forward faceplate seal, connector pins, and there was evidence of trace amounts of water within the hydraulic fluid. The housing external surfaces were cleaned and the unit was rinsed using new hydraulic fluid in order to prevent contamination to the test stand.



Photo 1. Unit as Received (Courtesy of Triumph Actuation Systems)



Photo 2. Corrosion on scraper faceplate (Courtesy of Triumph Actuation Systems)

The results of the investigation, component documentations, and photographs of the test were distributed to the group members and participants.

D. DETAILS OF INVESTIGATION

Following the external condition examination and documentation the following information was noted:

1. Actuator Unit Label

The unit was identified as a "Frisby Aerospace Hydraulic Actuator," "1500 psi MIL-H-5606 Red Oil." Piper Part Number 10225 1-2 Rev B; Frisby Part Number 1FA10064-1.

2. Testing

After the unit was cleaned and rinsed with fresh hydraulic fluid it was connected to a test stand at 0802 eastern standard time. The connector pins; although exhibiting corrosion, were connected to the test stand position indicator box. There was no continuity or switch indication discrepancies noted.

As part of the test procedure (reference Appendix A) the unit received 2,600 psig for two minutes while in the extended position and then two minutes of 2,600 psig while in the retracted position. No leakage was noted; however, there was a small amount of residual fluid that came from the area around the switch. The fluid was brown in color which was not the same bright red color of the test stand's hydraulic fluid. The switch was wiped clean and no further residual oil or leakage was observed for the remainder of the test.

The unit was retracted and the extension port was open to atmospheric pressure, the supply pressure was slowly increased to between 14.7 and 15.3 psig for six minutes in duration as per the test standards. No leakage was observed from the port.

The unit was retracted and the extend port was open to atmospheric pressure; the supply pressure was slowly increased to 1,600 psig for the five minute requirement per the test standards. No leakage was observed from the port.

The unit, while in the retracted position, was subjected to a slow increase in pressure to 1,600 psig at the retract port. The unit then received eight full cycles. A cycle consisted of beginning at the full retracted position, then to a full extended position, and then back to a full retracted position. No leakage was observed from the piston rod seal and the actuator operated "normally."

The unit was fully extended and locked as indicated by the position indicator box attached to the actuator and supply pressure was slowly applied to the retraction port. The actuator unlocked as indicated by the position indicator box and also by the actuator starting to retract at 700 psig. The test requirements are 200 to 900 psig. This procedure was accomplished five times and the actuator extended "normally" and locked as

indicated by the position indicator box. Sufficient pressure to retract the actuator was applied; the pressure was then fully relieved to simulate a manual extension of the landing gear. The unit was then pulled by hand to the fully extended and locked position by the IIC; the operation was smooth with no binding or anomalies noted. The procedure was completed five times and all five times a fully extended indication and locked position was observed on the position indicator box.

The test was completed at 0846 eastern standard time.

3. Unit Disassembly and Internal Damage

The unit was removed from the test stand to a work station for disassembly. The four screws around the switch were removed to expose the seal. The seal was observed intact and no damage was observed when viewed under a microscope; however, there appeared to be an oil water mixture encrusted on the outside diameter of the plunger surface. The rod end was difficult to remove due to what appeared to be corrosion on the thread, once removed the internal mechanism appeared normal around all seals and the rod was visually checked utilizing a metal straight edge/ruler and was found to have no noticeable deformation. The piston rod dynamic T-seal showed signs of "rolling phenomenon," this is also known in the industry as "pockmarking," which was common on the "dash 1" configuration. Subsequent configurations were "upgraded" with an associated actuator dash number progression. This phenomenon leads to seal breakdown and eventual physical failure with a noticeable fluid leak. This T-seal had not progressed to the point of fluid leaking; however, did exhibit some seal elastomer material breakdown and associated debris at the T-seal groove, with some migration of debris and hydraulic fluid to the adjacent scraper seal area. The scraper seal showed signs of grit/grime build up at the external lip and evidence of T-seal material at the inboard surfaces, but was otherwise intact. This phenomenon is further discussed in Appendix B. The subsequent revisions incorporated an upgraded dynamic rod seal design which prevented this phenomenon from occurring, and are summarized in Appendix B. Other than atheistic reasons the "rolling phenomenon" was not a hazard to safe flight. The chrome finish on the piston rod showed limited areas of what appeared to be "pitting or abrasion" approximately 3.25 inches from the head. "Loose" reassembly of the unit revealed that the area was located immediately under the damaged T-seal when the rod was in the fully extended position. The pitting/abrasion damage was attributed to operation and parking with the rod in the full extended, or gear down, position. Examination of the sealing system which included the rod, scraper, and piston seals were considered "adequate" to provide a leak-free sealing during both static and dynamic conditions.



Photo 3. T-Seal in Groove Showing "Rolling Phenomenon" (Courtesy of Triumph Actuation Systems)

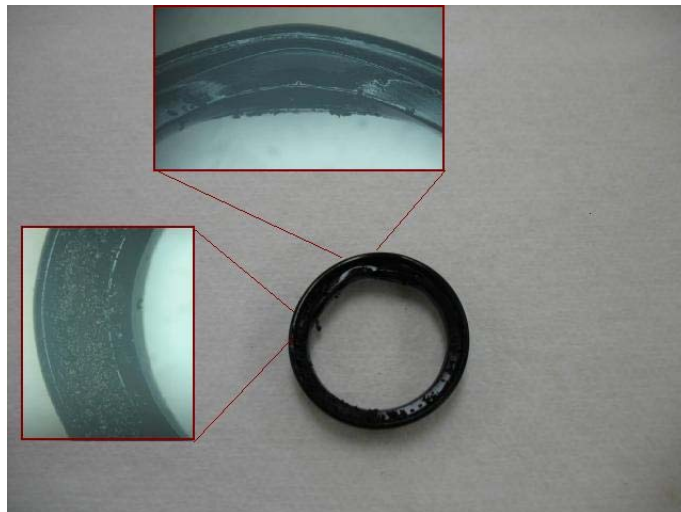


Photo 4. Rod T-Seal As Examined Under a Microscope (Courtesy of Triumph Actuation Systems)

The unit was loosely reassembled for transportation back to the salvage facility.

E. FUTURE INVESTIGATIVE ACTIVITIES

None are planned at this time for this unit. The unit will be returned to the salvage facility to be placed with the accident airplane in preparation for the release of the wreckage by the National Transportation Safety Board IIC.

Appendix A
Acceptance Test Procedures – Results

1-26-11



Frisby Aerospace, LLC
A Triumph Group Company

ATP-1FA10064
Rev. C

ACCEPTANCE TEST DATA SHEETS

For Main Gear Actuator

Frisby P/N 1FA10064 - 1
S/N: FAH 0298
Test Fixture # 1FA10064

Piper P/N: 102551-2
Hydraulic Test Stand # NC TSTND11
Date: 1-26-11

Operator Acceptance Stamp: R&O
4197

Ref. Para. #	Measurement	Max. Accept. Value	Min. Accept. Value	Actual Value	Accepted
4.1	Examination of Product : Per 1FA1006401	----	----	----	Pass
4.2	Proof Pressure	Zero Tolerance	----	----	Ø Leakage
4.3.1	Low Pressure Leakage	Zero leakage from Extend port -1&-2 rod seals: 1 drop -3 rod seals: no excess wetting*	----	----	Ø Leakage
4.3.2	High Pressure Leakage	Zero leakage from Extend port -1&-2 rod seals: 1 drop -3 rod seals: no excess wetting*	----	----	Ø Leakage

THIS DATA IS PROPRIETARY TO FRISBY AEROSPACE. DUPLICATION OR DISCLOSURE TO UNAUTHORIZED PARTIES IS FORBIDDEN WITHOUT WRITTEN PERMISSION

Acceptance Test Data Sheet Page 1 of 2



Frisby Aerospace, LLC
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ATP-1FA10064
Rev. C

Frisby P/N 1FA10064 - 1
S/N: FAH 0298
Test Fixture # 1FA10064

Piper P/N: 102551-2
Hydraulic Test Stand # NCT57ND 11
Date: 1-26-11

R&O
4197

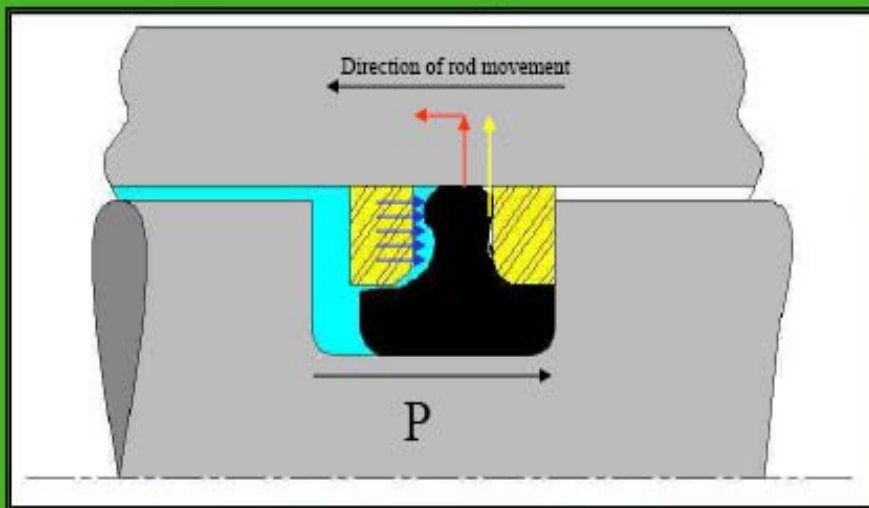
Operator Acceptance Stamp:

Ref. Para. #	Measurement	Max. Accept. Value	Min. Accept. Value	Actual Value	Accepted
4.3.3	Dynamic Rod Seal Leakage	-1&-2 rod seals: 1 drop -3 rod seals: no excess wetting*	---	---	ϕ Leakage
4.4.1	Unlocking Pressure	Cycle for 8 full stroke cycles at 1568 - 1632 psig	900 psig	200 psig	700 psi
4.4.2	Locking Back Pressure	Pressure applied to retract port	---	---	Pass
4.5	Free Fall Operation	49 - 51 psig at Retract Port, engaged with 2 seconds after actuator fully extended. Five (5) Full Stroke Cycles	---	---	Pass

* shall not exhibit leakage in excess of slight wetting of the rod (i.e. insufficient to form a bead of fluid that collects and migrates down the gland face or around the end of the rod)

Appendix B
"Rolling Phenomenon" information

GT Rings - "Pockmarking"



In rod seals when the pressure is applied to the seal, the dynamic contact surface moves in a direction opposing the pressure.

There is a **normal force** providing sealing on the elastomer crown, given by the squeeze and system pressure.

The friction between the elastomer and the dynamic contact surface exerts a **force, μN** , which tries to maintain the status quo between the two.

Opposing this force is the **pressure** in the system, acting on the sidewall of the elastomer crown.

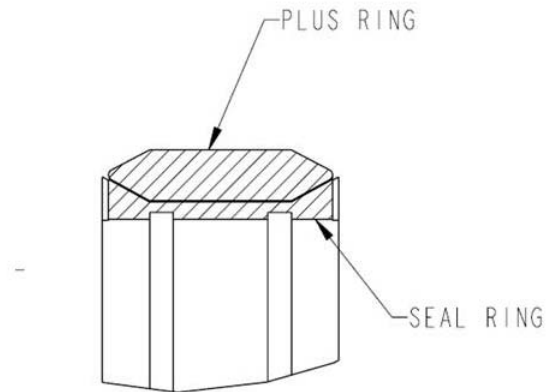
If the force resulting from this pressure is sufficient to negate the friction force then, as in stress plot 2, the stress transition results in a **tensile force** in the crown wall which less than the maximum tensile stress of the elastomer.

However if the **system pressure derived force is not enough to negate the friction force** then, as in stress plots 3, 4 and 5 the stress transition results in a **tensile force** in the crown wall which exceeds the maximum tensile stress of the elastomer. This results in a **tear** in the elastomer which follows the stress planes seen in the stress profiles.

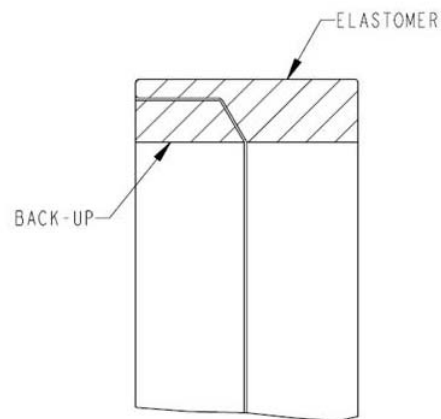
The **tears** result in "pockmarks" being generated and material being removed. This changes the stress profiles in the elastomer, so that the next time tears form they do so in a different place, hence the appearance.

It should be noted that pockmarking damage occurs in the -1 actuator when the following specific conditions are prevalent: 1) rod motion sudden start when the seal is pressurized (during unlock), and 2) exposure of the rod to the environments for significant periods of time (parking), causing the rod surface to dry out and lose lubricity.

The following figures illustrate the upgraded piston rod seal configurations, which are not susceptible to pockmarking.



Cap-type rod seal -2 actuator

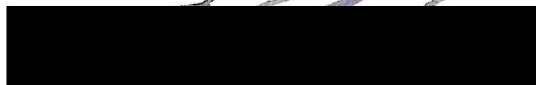


RSR-type rod seal -3 actuator (current design)

Signature of party members at the examination

Submitted by Shawn Echer
Investigator In Charge
National Transportation Safety Board

Signed:



Shawn Echer
National Transportation Safety Board



Ken Allen
Triumph Actuation Systems, LLC



Gene Hurak
Triumph Actuation Systems, LLC