BEECHCRAFT PREMIER ACCIDENT INVESTIGATION REPORT

BY K. CERANKOSKY	© Moog Inc	REVISIONS		
DESIGN ENGR. T. SPENCE	REV	DESCRIPTION	DATE	APPROVED
PRODUCT ENGR. K. CERANKOSKY	-	INITIAL RELEASE	10/12/13	KC
MFG. ENG.				
QUALITY J. DAIGLER	A	ADDED ADDITIONAL CLEVIS DAMAGE DETAIL	2/3/2014	KC
RELIABILITY				
LOGISTICS				
CONFIG.				

TABLE OF CONTENTS

1.0 SCOPE:

This report documents the findings on six actuators installed on Beechcraft 390 Premier 1A N777VG involved in an accident on February 20, 2013 detailed in NTSB Identification ERA13MA139. Included in the documented findings will be the position each actuator is believed to have been in at the time of impact.

NOTE: Serial numbers of the actuators discussed were provided by Beechcraft. On units that did not have nameplates as received, the serial numbers were determined through process of elimination or labeled as "Unknown". The "LH" and "RH" markings seen in the included photographs were made by the NTSB; Moog cannot conclude on which side of the aircraft the actuators were installed.

1.1 Document Custodian

Moog East Aurora is the custodian of this document. Any questions regarding the proper interpretation of the requirements of this document shall be referred to them.

2.0 APPLICABLE DOCUMENTS:

The following documents form a part of this document to the extent specified herein:

2.1 Government

ERA13MA139	NTSB Accident Report

3.0 LIFT DUMP ACTUATORS:

The lift dump actuator is a two position hydraulic actuator. The actuator consists of an aluminum manifold with hydraulic extend and retract ports and a single piston. The lift dump actuator controls the inboard spoiler during aircraft landing operations. Hydraulic pressure applied to either side of the piston head commands the piston to full retract or full extend position.

3.1 Lift Dump Actuator Unknown 1

3.1.1 Incoming Visual Inspection

The unit was received in dirty and burnt in some locations. The piston exhibited heat discoloration on exposed length of piston. The nameplate was missing from the manifold. The actuator was received with the aircraft hinge joint connected to the lug end of the manifold. An aircraft hydraulic line was connected to the hydraulic retract port. The rod end had been machined off when removing the actuator from the aircraft. The extended piston length was measured to be 2.1259 inches from the piston gland to the rod end nut.

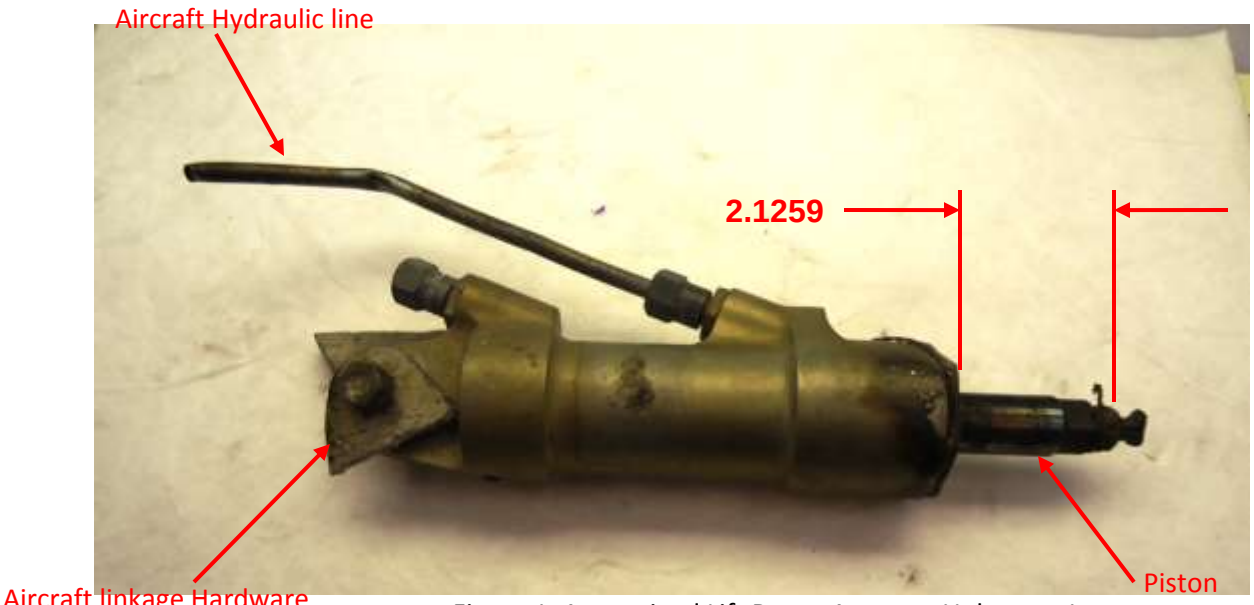

Figure 1. As received Lift Dump Actuator Unknown 1

3.1.2 Disassembly of Unit

The piston gland was untorqued and removed from the manifold. The retaining seals were burnt and crumbled upon removal. A second extended piston length measurement was recorded. The length from the mouth of the manifold to the end of the piston was 2.123 inches. A burr in the manifold bore was observed and prevented the piston from being removed from the manifold through the bore mouth. To remove the piston, the manifold was sectioned to remove the lug end. The manifold was cut approximately 4.48 inches from the bore mouth. The piston was then pressed out of the manifold through the cut end. To better view the burr that prevented the piston from being removed through the bore mouth, the manifold was halved down the centerline. All components were photographed and bagged.

Figure 2. Removed piston gland

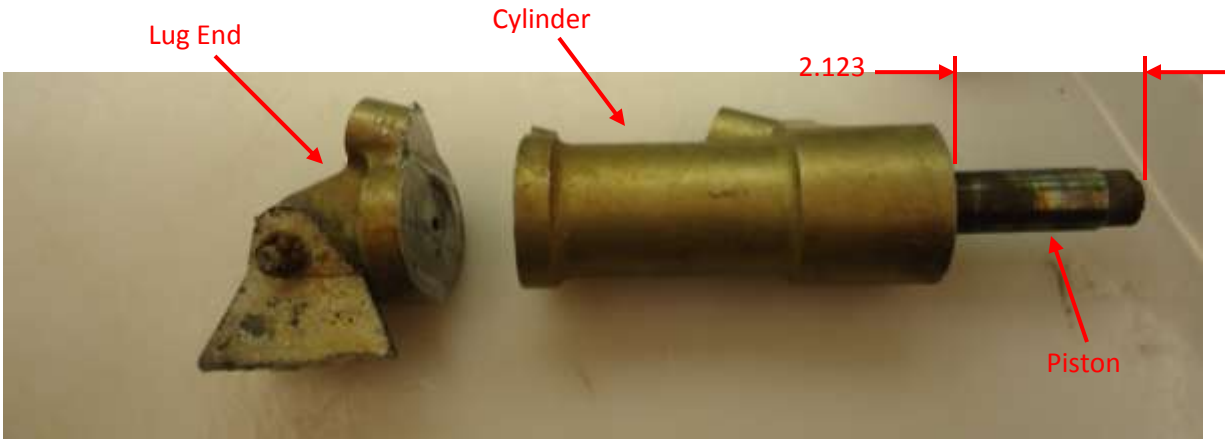

Figure 3. Sectioning of lug end

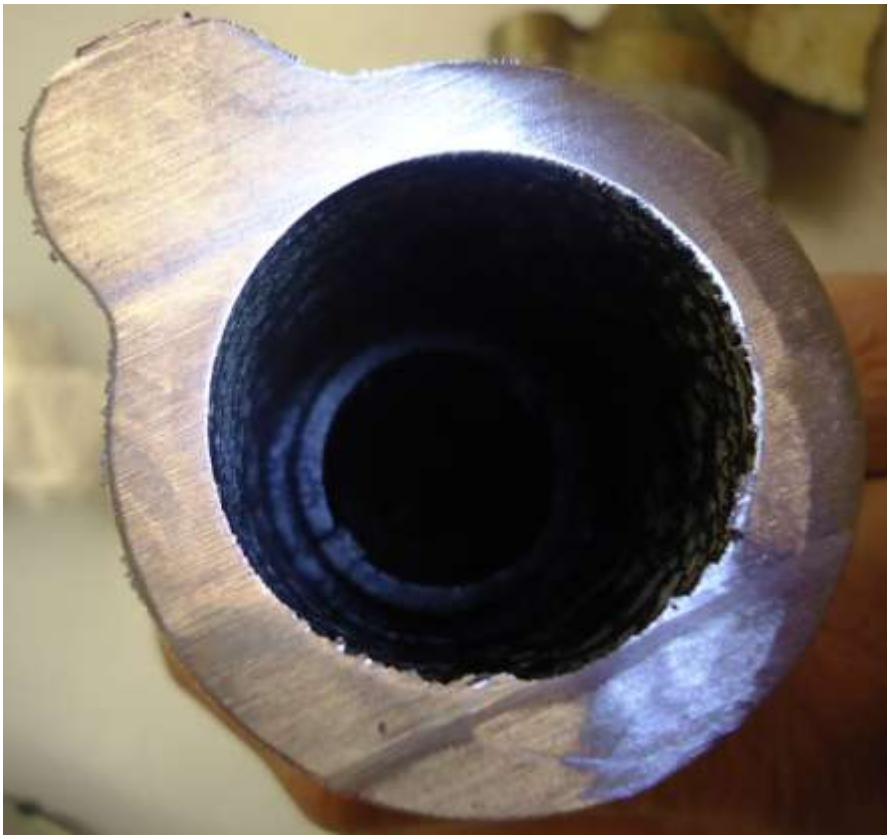

Figure 4. Cylinder bore of actuator

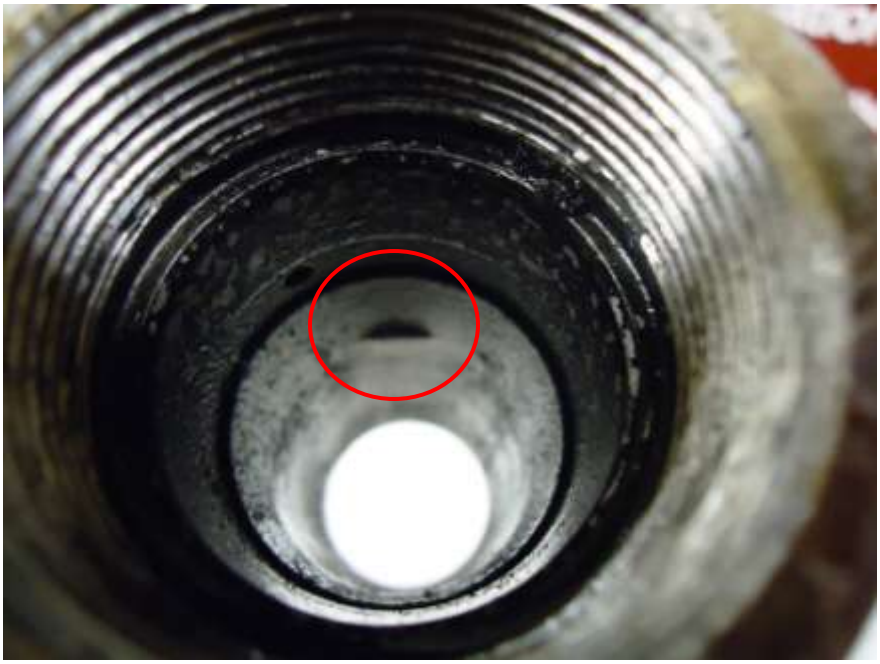

Figure 5. Burr (circled in red) observed preventing piston from being removed through the bore mouth

Figure 6. Sectioned manifold – Half 1

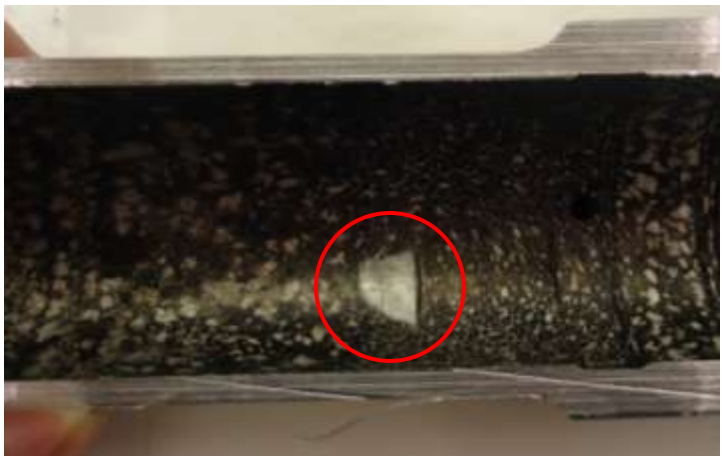

Figure 7. Sectioned manifold – Half 2. Burr and "scuff" mark present.

3.1.3 Findings

The piston gland threads on the manifold and the piston gland were damaged. The last thread on the manifold and gland were crushed, as well as a partial ring burr connected to the last manifold thread. Each half of the manifold showed evidence of burnt oil on the metallic surfaces. A small area of bare metal ("scuff" mark) was present behind the burr (Figure 7) preventing the piston from being removed through the bore mouth. The burr was approximately 2.3245 inches deep from the bore mouth. The scuff mark was approximately .332 inches in length. Based on a nominal extended piston length of 2.580 inches and being measured at 2.123 extended length, the piston was determined to be .457 inches from being in the fully extended position.

Figure 8. Damaged manifold threads (circled in red)

Figure 9. Thread burr seen on manifold threads (borescope image)

Figure 10. Damaged thread on piston gland (circled in red)

3.2 Lift Dump Actuator Unknown 2

3.2.1 Incoming Visual Inspection

The unit was received in with no name plate. The manifold had been severely burnt and melted. The lug end of the manifold was no longer intact. The rod end had been snapped off the piston. The actuator was received in with hydraulic line attached to manifold port. The manifold was observed to be bent and twisted out of round. The hydraulic ports on manifold were bent. The extended piston length was measured to be 2.691 inches from the piston gland to the rod end nut.

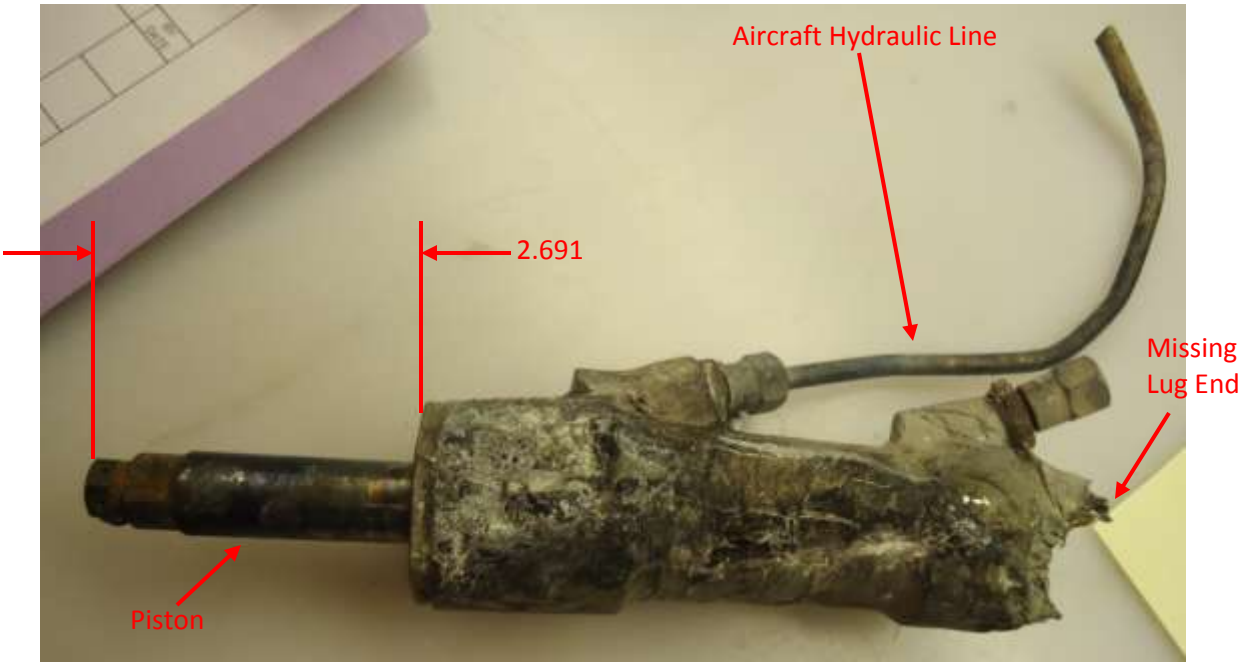

Figure 11. As received Lift Dump Actuator Unknown 2

Figure 12. As received Lift Dump Actuator Unknown 2

3.2.2 Disassembly of Unit

The piston gland could not be untorqued from the manifold. To determine if the piston could be pressed out from the lug end of the manifold, the manifold was sectioned approximately 4.48 inches from the manifold bore mouth. After the lug end was removed, the manifold was observed to be severely out of round and the piston could not be pressed out in that direction. The actuator was then cut down its centerline to view the positions of the internal components. All components were photographed and bagged.

Figure 13. Cylinder bore of manifold after sectioning lug end

3.2.3 Findings

The sectioned halves showed that the manifold had been deformed internally which captured the internal components in the position at time of accident. The sections, as well as a stack-up analysis, show that the piston was .221 inches from bottoming on the piston gland in the fully extended position.

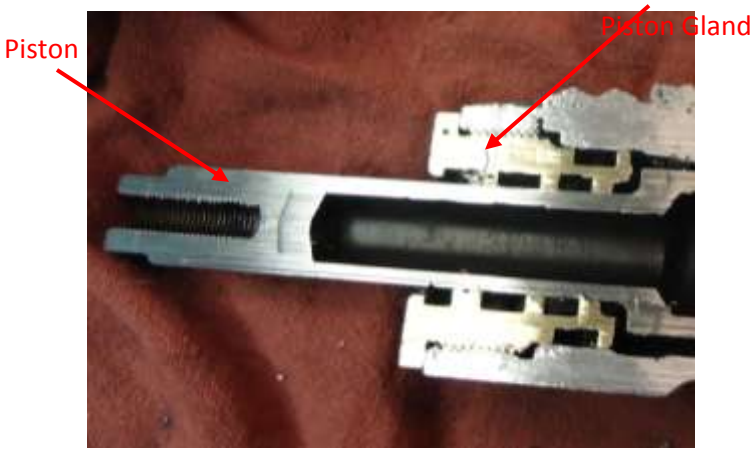

Figure 14. Sectioned half of actuator assembly in fully extended position

Figure 15. Sectioned half of actuator assembly in fully extended position

4.0 BLOW DOWN ACTUATORS:

The blow down actuator assembly is a hydraulic/pneumatic spoiler actuator that consists of a hydraulic actuator extend chamber and a nitrogen charged retract chamber. It includes a nitrogen transducer to measure gas pressure and a slotted rod end which interfaces with aircraft spoiler linkage. The blow down actuator is used as a backup mechanism to ensure spoiler panel retract in cases of uncommanded actuation or hydraulic pressure loss.

4.1 Blow Down Actuator S/N: 0463

4.1.1 Incoming Visual Inspection

This unit was received in with no nameplate or nitrogen caution tags. The nitrogen pressure transducer had been broken off from the manifold. The fill port plug was damaged with material having been displaced. The fluid transfer tube was bent out of nominal alignment. The lug end of the manifold was bent and missing the bearing. The hydraulic pressure port was bent. The piston and clevis were severely bent. The piston was observed to be fractured at the location it exited the piston gland. The piston gland seals were protruding at this point. The clevis was no longer torqued onto the piston, and it was deformed from its manufactured form with gouges in the material. Tiewire was missing in several locations on the actuator. There was no nitrogen charge remaining in the nitrogen retract chamber.

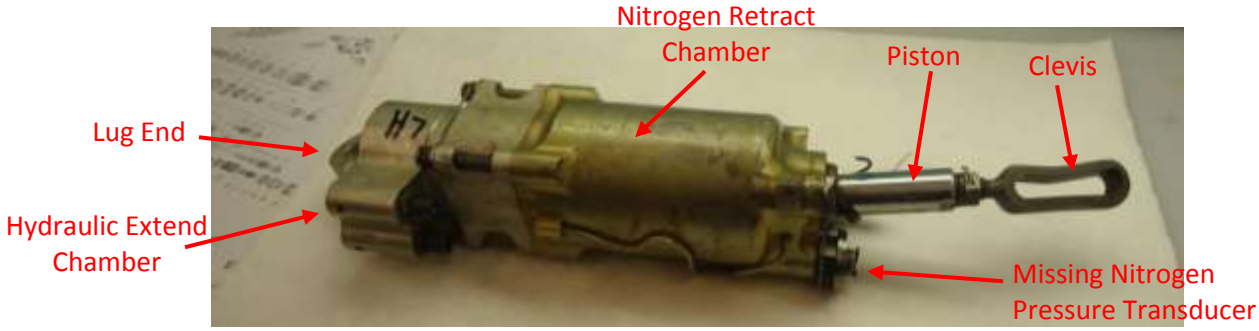

Figure 16. As received Blow Down Actuator S/N: 0463

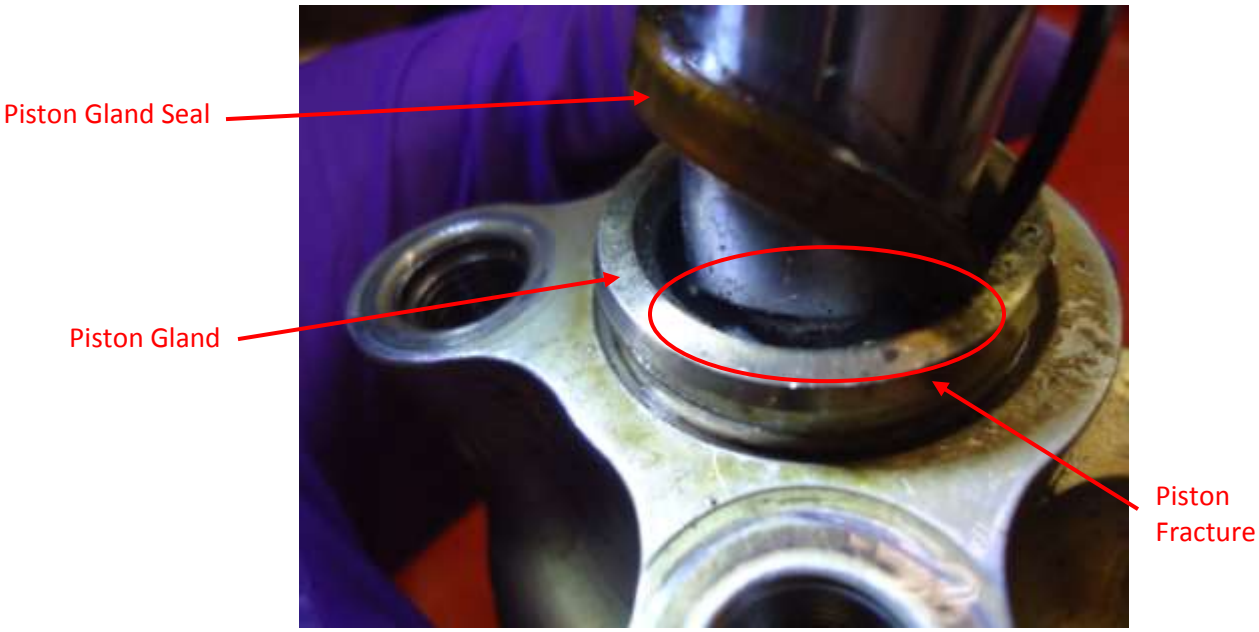

Figure 17. Fractured and bent piston. Gland seals extruding from piston gland.

4.1.2 Disassembly of unit

The hydraulic fill cap, Shrader valve, and remains of the pressure transducer were removed from the actuator assembly. The hydraulic actuator extend chamber was removed from the assembly. Due to the bent and fractured piston, the piston and accumulator assembly could not be removed from the nitrogen retract chamber. The nitrogen retract chamber was sectioned axially down its length to view the positions of the internal components. All components were photographed and bagged. When disassembling the clevis, severe material deformation was noticed on the inner diameter of the outboard end of the clevis. The aircraft bushing found in the S/N: 0459 blow down actuator clevis (see section 4.2) was inserted in the inboard and outboard ends of the clevis of this unit; it could easily be installed in the outboard end, but due to deformation to the inboard end, the bushing could not be inserted in the inboard end.

Figure 18a. Deformed clevis removed from end of piston with gouges present

Figure 18b. Deformed clevis with aircraft bushing installed in outboard end.

Figure 19. Remainder of nitrogen pressure transducer removed from nitrogen retract chamber

Figure 20. Actuator assembly with hydraulic extend chamber removed

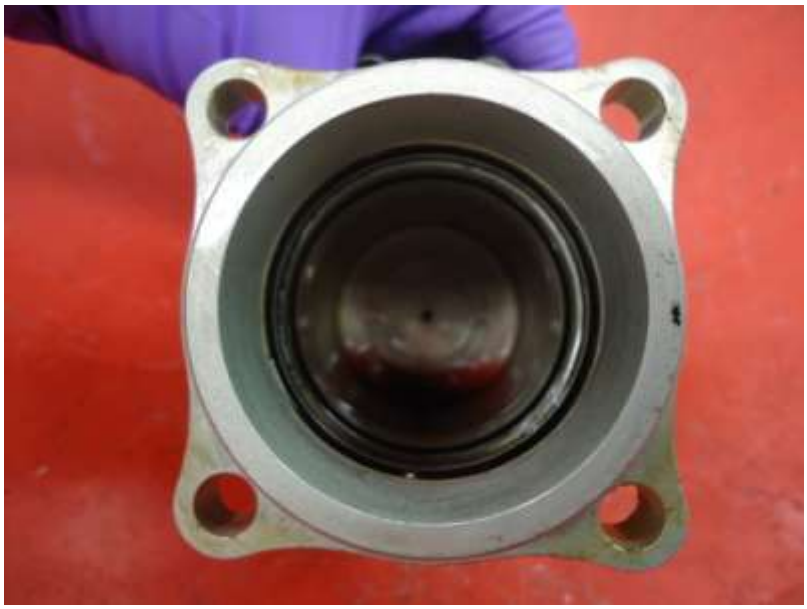

Figure 20. Hydraulic extend chamber

4.1.3 Findings

No indications of position at time of impact were present in the hydraulic extend chamber. The sections of the nitrogen retract chamber showed that the internal components had been fully extended at time of impact.

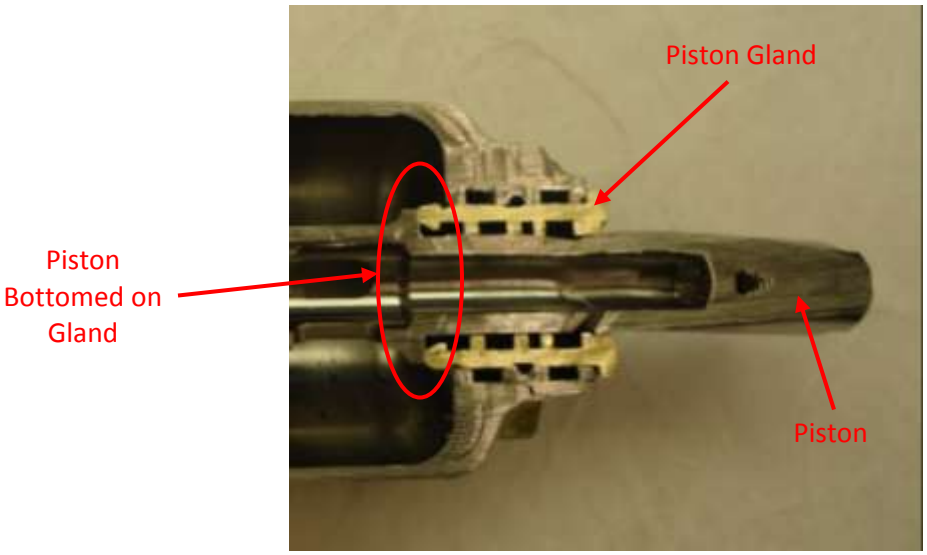

Figure 21. Sectioned actuator assembly in fully extended position

Figure 22. Sectioned actuator piston

Figure 23. Sectioned actuator piston, rotated to show fracture

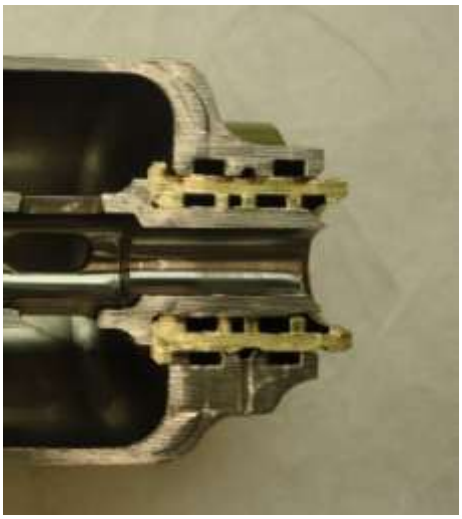

Figure 24. Sectioned actuator assembly in fully extended position

4.2 Blow Down Actuator S/N: 0459

4.2.1 Incoming Visual Inspection

This unit was received in with its nameplate and nitrogen caution tags. The unit showed signs of being burnt and was coated in a tacky residue. The nitrogen pressure transducer housing was dented. Aircraft electrical connector was attached to actuator electrical connector, and the plastic coil was intact on the electrical cable. The piston was fully retracted in the unit. An aircraft bushing was present in the actuator clevis. The nitrogen pressure voltage was checked

to determine if there was nitrogen in the nitrogen retract chamber; the voltage was found to be within the nitrogen charge limits.

Figure 25. As received Blow Down Actuator S/N: 0459

4.2.2 Evaluation Testing

Because a nitrogen charge within operating tolerances was present in the nitrogen retract chamber and no external anomalies suggesting inoperability were observed, the unit was evaluation tested for functionality. All evaluation test values were within acceptance test limits. No components were disassembled from the unit as it was determined to be fully functional.

4.2.3 Findings

No functionality failures were found when the unit was evaluation tested. Since the unit was received in with the piston fully retracted, the actuator operated as designed—when hydraulic pressure was removed, the compressed nitrogen caused the piston to retract.

5.0 ROLL CONTROL ACTUATORS:

The roll control spoiler actuator is a servo-controlled hydraulic actuator. It consists of an aluminum manifold that houses a single piston, an internal linear variable differential transformer (LVDT), an electro-hydraulic servovalve, and a bypass valve. The roll control actuator controls the outboard spoiler panels for roll control, speed brake, and lift dump functions. The LVDT monitors the actuator position and provides feedback to the servovalve. The bypass valve prevents hydraulic over pressure when the actuator is not in use.

5.1 Roll Control Actuator S/N: 0473

5.1.1 Incoming Visual Inspection

This unit was received with its nameplate present. The electrical connector on the unit was missing, as well as a portion of the electrical cable. The plastic coil was intact on the electrical cable. The lug end bearing was tight and could not be rotated by hand. The lug end of the manifold was bent off the actuator centerline. The manifold was damaged in various locations. The extended length of the piston was measured to be 2.5846 inches from the piston gland to the rod end nut. The motorcap of the servovalve was cracked by one of the mounting bolts, and another of the mounting bolts was bent.

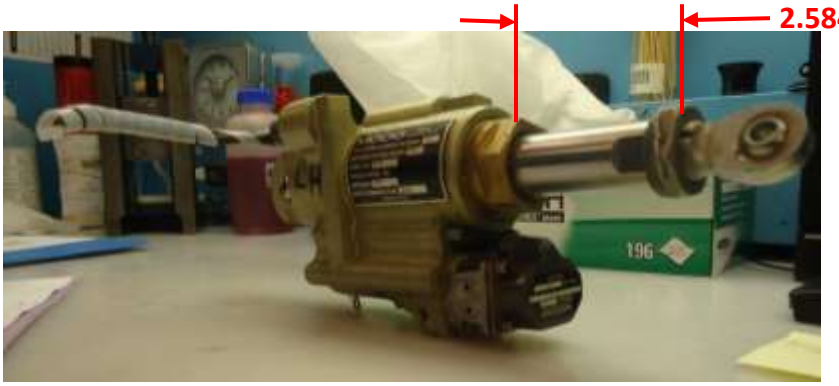

Figure 26. As received Roll Control Actuator S/N: 0473

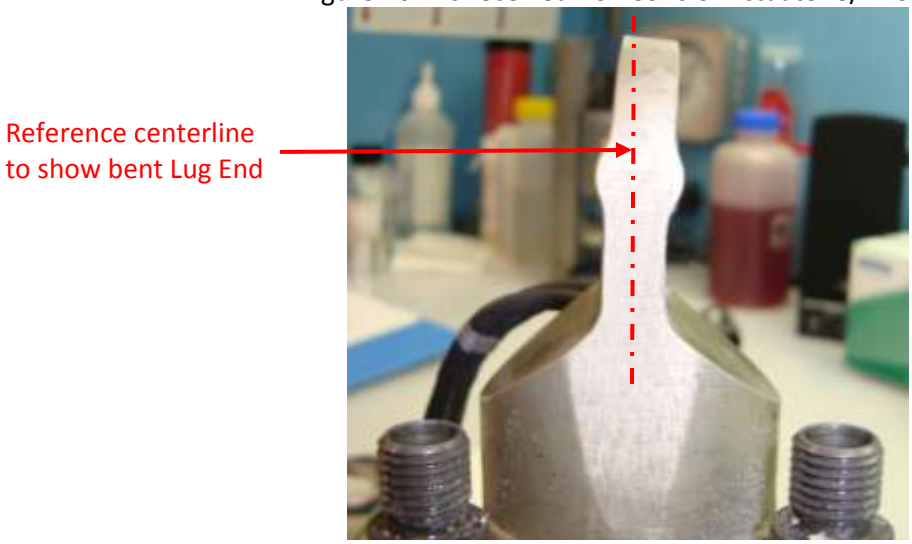

Figure 27. Bent lug end of roll control actuator

Figure 28. Cracked servovalve motorcap

5.1.2 Evaluation Testing

An evaluation test was attempted on this unit, but could not be completed due to leakage out of the servovalve motorcap crack.

5.1.3 Disassembly of Unit

The following components were disassembled from the unit without incident: servovalve and associated components, bypass valve retainer, bypass valve and associated components, piston gland, piston, and LVDT and associated components. While inspecting the manifold under magnification, faint radial scratches were observed. To better view these scratches, the manifold was sectioned down its centerline.

5.1.4 Findings

Since there was leakage out of the servovalve cap, it was determined that there was internal damage to the servovalve causing high internal leakage which prevents hydraulic pressure from reaching the piston. The piston exhibited normal signs of wear within the stroke length. No anomalies were seen on the bypass valve, piston gland, or LVDT. When examining the manifold under 10x magnification, witness marks were observed near the fully extended position. A stack-up analysis shows that the as received piston position was .022 inches from the nominal full extend position.

Figure 29. Actuator piston with normal signs of wear

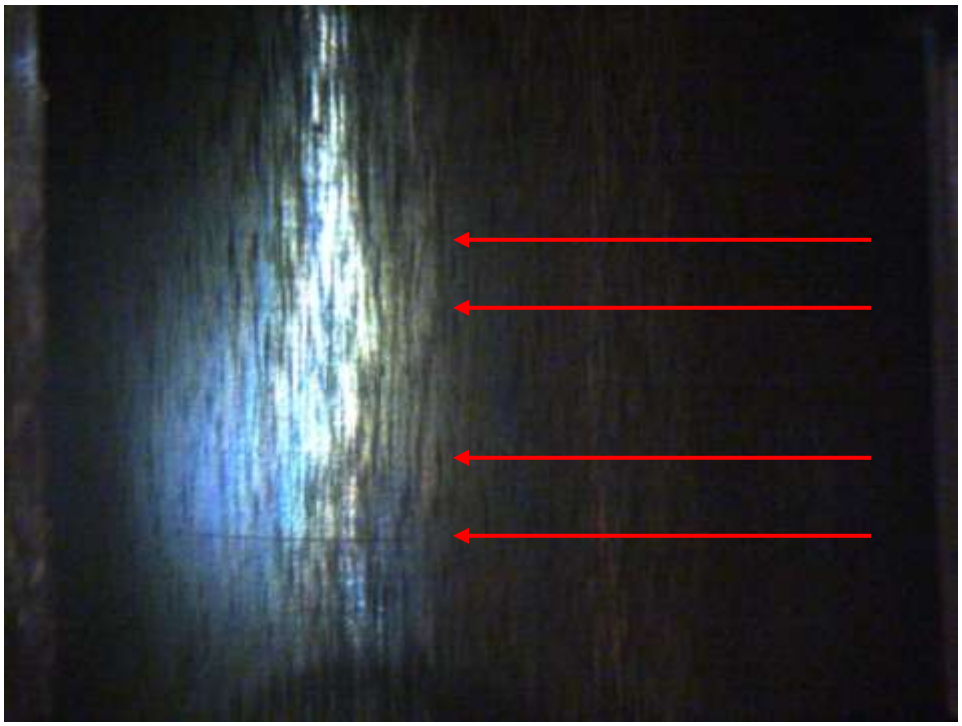

Figure 30. Witness marks observed at 10x magnification on sectioned half of manifold. Marks appear in the fully extended area of the manifold.

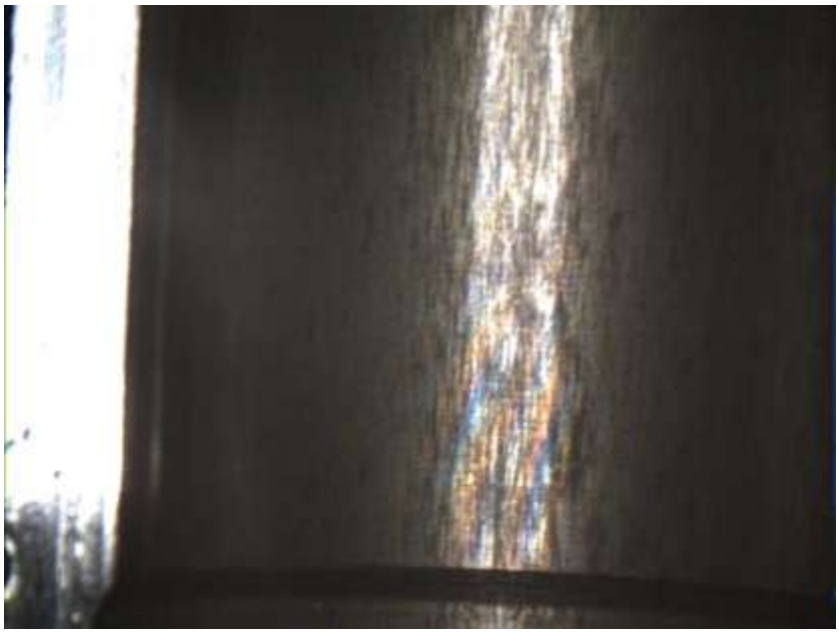

Figure 31. No witness marks observed at 10x magnification on the other sectioned half of the manifold

5.2 Roll Control Actuator S/N: 0469

5.2.1 Incoming Visual Inspection

The unit was received in with its nameplate present. The unit was received in dirty and burnt in some locations. The aircraft connector was attached to the actuator electrical connector, and the plastic coil was intact on the wire cable. Some tiewire was not in the correct direction of pull. The piston rod end bearing was loose. The extended length of the piston was measured to be 2.4057 inches from the piston gland to the rod end nut.

Figure 32. As received Roll Control Actuator S/N: 0469

Figure 33. Residue present on actuator piston

5.2.2 Evaluation Testing

The unit was evaluation tested for functionality due no external anomalies observed. Prior to testing, the residue present on the piston was polished off to avoid introducing contamination into the unit. All evaluation test values were within acceptance test limits, with the exception of dielectric strength and continuity on the servovalve. No components were disassembled from the unit as it was determined to be fully functional.

Figure 34. Residue removed from piston prior to evaluation testing

5.2.3 Findings

No functionality failures were found when the unit was evaluation tested. The stack-up analysis shows that the as received piston position was .201 inches from the nominal full extend position.

6.0 POSITIONS AT TIME OF IMPACT:

Lift Dump Actuator Unknown 1: Through stack-up analysis this unit was determined to have been .457 inches from the nominal full extend piston position as received.

Lift Dump Actuator Unknown 2: The sections and stack-up analysis of this unit showed that the unit was .221 inches from full extend at time of impact. The lift dump is a two position actuator and requires hydraulic pressure to extend or retract the unit. As no hydraulic command was applied to the unit post accident, the actuator could not change position.

Blow Down Actuator S/N: 0463: This actuator was seized in the full extend position due to the impact bending the piston off the centerline, as well as fracturing it. The misalignment prevented the compressed nitrogen from retracting the piston. The fracture provided a leak path for the nitrogen gas out of the nitrogen retract chamber.

Blow Down Actuator S/N: 0459: This unit was tested to be fully functional. As it was received in fully retracted, the actuator operated as designed—when hydraulic pressure was removed, the compressed nitrogen retracted the piston. No conclusions can be made about its position at time of impact.

Roll Control Actuator S/N: 0473: This actuator was determined to be in the full extend position as evidenced by witness marks in the manifold, and a stack-up analysis showing that the piston was .022 inches from nominal full extend. This distance is within the stroke length tolerance.

Roll Control Actuator S/N: 0469: This unit was tested to be fully functional. Through stack-up analysis, the unit was calculated to be .201 inches from the nominal full extend position. This actuator requires a servovalve commanded hydraulic pressure to position the piston, and as no hydraulic pressure was applied post accident, the actuator could not change position.