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THE CESSNA AIRCRAFT COMPANY
PO BOX 7704
WICHITA, KS 67277

MODEL NO: 650

REPORT NO: HY-GEN-606

ROLL SPOILER PCU
INVESTIGATION 650-7063

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ATP	Acceptance Test Procedure
CMM	Component Maintenance Manual
NTSB	National Transportation Safety Board
PSI	Pounds Per Square Inch
WCSC	Wichita Citation Service Center

1. INTRODUCTION

The purpose of this report is to document findings associated with investigation of the uncommanded roll reported on aircraft 650-7063. The scope of this report is limited to results of bench level component testing and teardown of part number 9914155-19 SN 2641. It is anticipated that additional investigation and reporting is being accomplished by Nabtesco as coordinated with NTSB.

2. 9914155-19 SN 2641 TEST RESULTS

9914155-19 SN 2641 was tested as follows to assess as-received condition by WCSC personnel and witnessed by Cessna Engineering, Product Safety, FAA and Nabtesco representatives. Testing was accomplished at WCSC on Feb 07, 2012. Witnesses included Dennis Bradfield, Dennis Scarberry, Brad Mallory, Marc Morrison, and Stephen Hileman, of Cessna Engineering, Dan Moore Cessna Photographer; Peter Basile of Cessna Product Safety, Bob Cughan, Joseph Caferro, and Mitch Balasu of Nabtesco America, and Paul DeVore, David Fairback, and Christy Eckerman from the FAA. Christy Eckerman brought the incident component and represented the NTSB. Test results indicated unsatisfactory component operation. Planned test procedures were as follows in e-mail to David and Christy. Actual testing is reflected in the commentary that follows.

> David and Christy,
>
> The attached functional test procedure section 4 applies to the subject roll spoiler actuator. I propose testing tomorrow prior to component disassembly as follows:
>
> Per para 4.2 Examination, document received condition by photograph, length, and input arm position.
>
> Per para 4.3 measure input force with and without system pressures per para 4.1.
>
> Skip proof pressure and external leak testing.
>
> Per para 4.6 measure internal leakage.
>
> Per para 4.7 measure time required for full extend, measure time required for full retract, given rapid input arm operation to achieve maximum ram velocity. Actuator to be observed for continuous smooth operation, initial extended, and retracted actuator length to be measured, but not instrumented as shown in ATP figure 2.
>
> Per para 4.8 establish relationship between input arm position and actuator length at extreme position of rod, and of input lever. This will capture operating band and lever overstroke on each end.
>
> Per para 4.9 establish functionality of check valve, observe and record pressure.

Per para 4.10 measure leakage from pressure port to aux port at 800 psi.

This concludes the requirements of the component ATP. I am meeting with the test lab later today to verify that both high and low pressure conditions required for measurement of the input force can be established simultaneously.

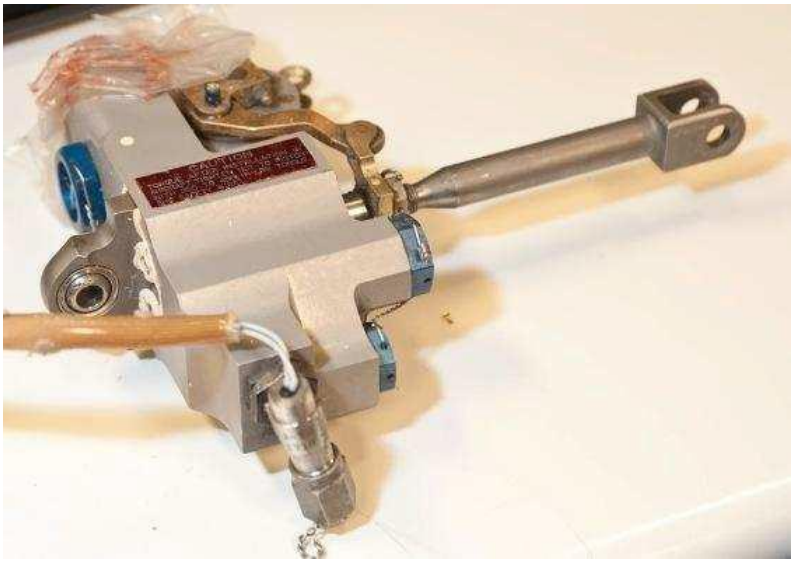
If these test conditions prove satisfactory I propose test be followed by component disassembly and visual inspection. If visual inspection or test results indicate need for additional sub component inspections, I propose it be accomplished by vendor or as coordinated following the tests described in this e-mail.

Please reply confirming this test proposal.

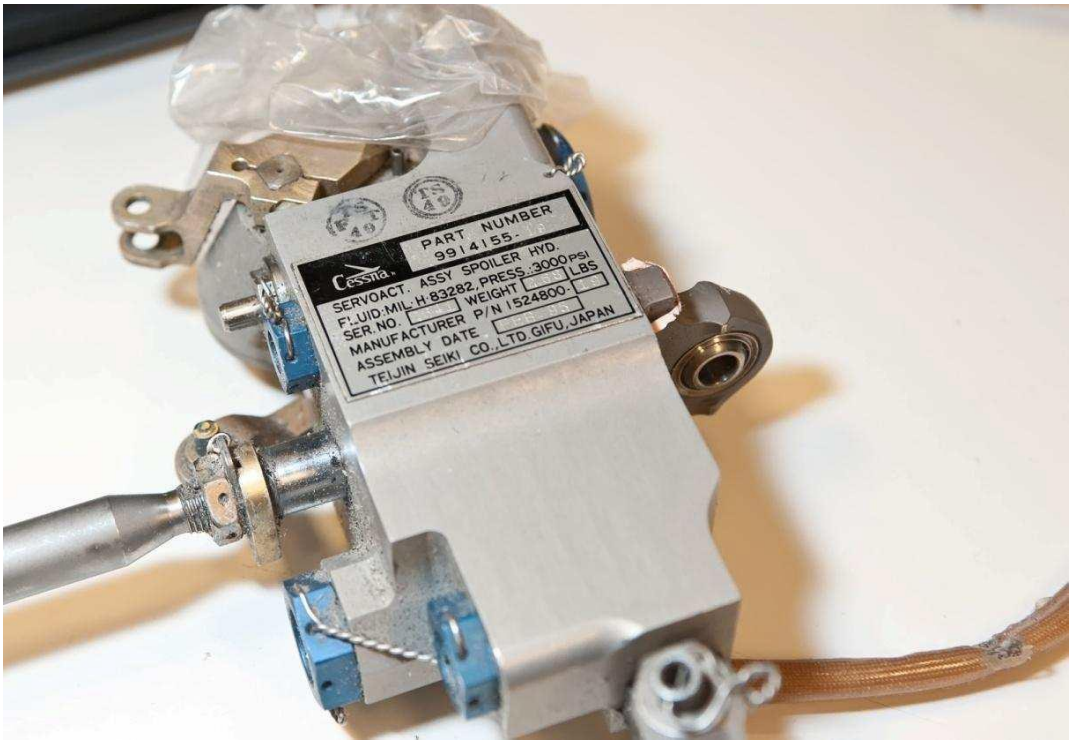
Thanks –Dennis Bradfield

Packaging as received:

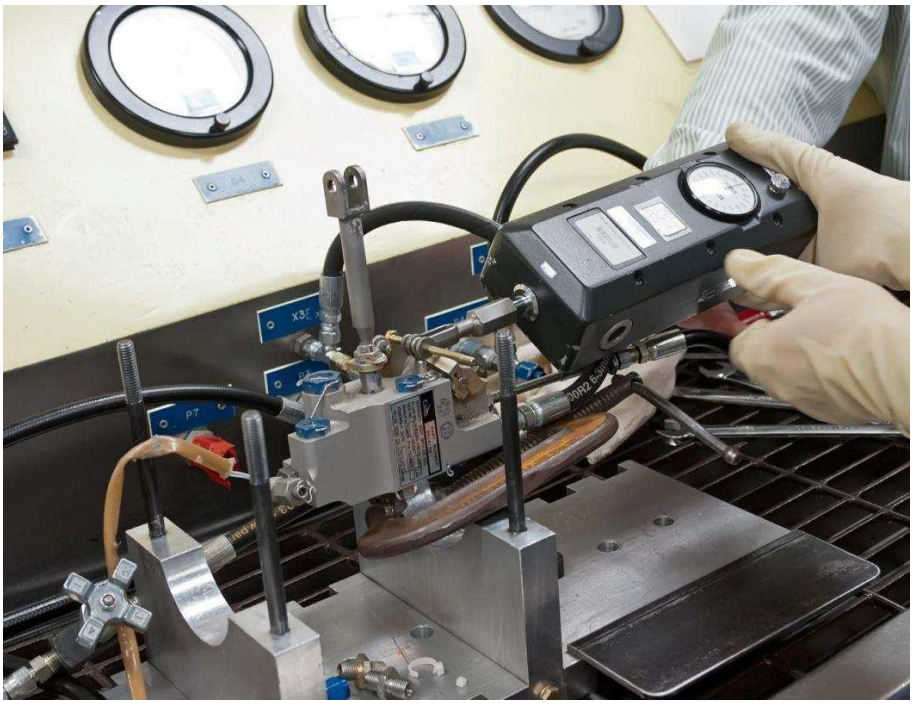
View of feedback link side as received:.



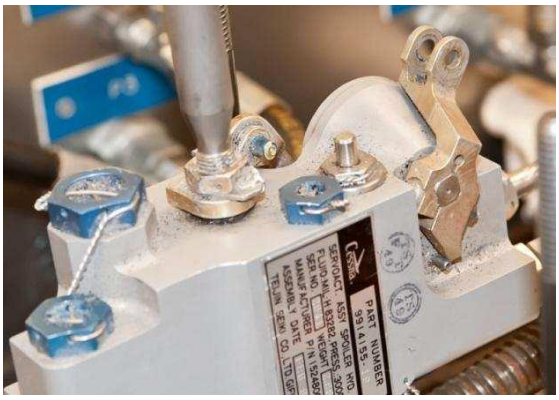
View of input link side as received:



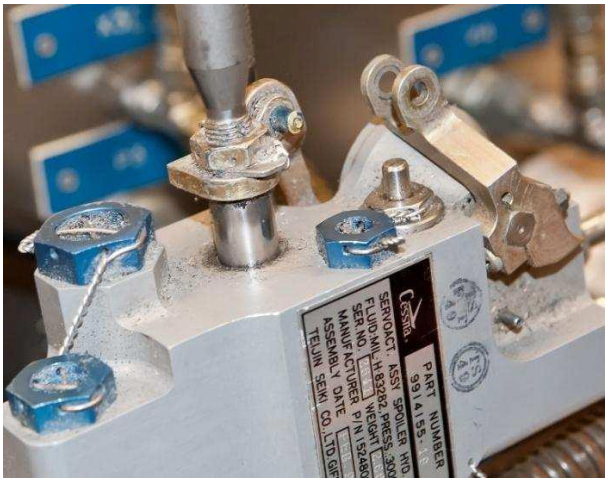
9914155-19 SN 2641 as installed for test at WCSC on 02-07-2012:



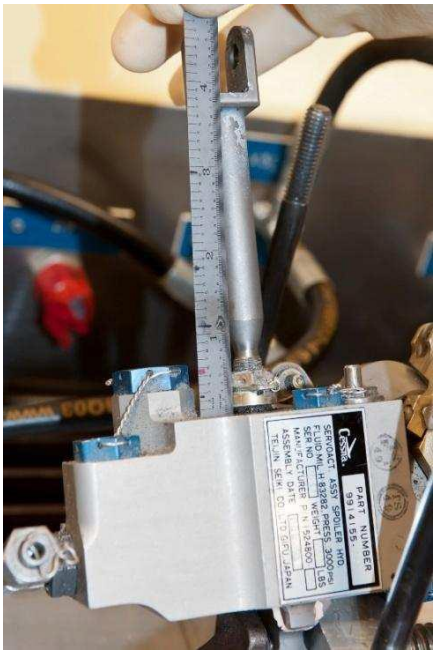
Input lever shown in normally stowed position and held in fully deployed position:




Input lever shown stuck in fully deployed position and stuck in mid position:

Actuator shown in stowed position with scale:



Test results as accomplished at WCSC on 02-07-2012:

Actuator condition as received appeared normal for a component returned from service, rod appeared to be partially extended (7.9 inch length overall, feedback collar 0.55 inches from housing)(note: drawing lists fully extended length as 8.07 inches and fully retracted as 7.34 inches.)

In drip-dry condition as received, operation of input lever resulted in intermittent sticking in mid-stroke position. This was not viewed as indicative of a problem.

Input lever left on to evaluate input torque. Therefore, use fish scale: arm length 1.2 inches, force 0.5 lb on first try, 1.2 lb on second try. (reasonable assessment of input torque but not viewed as best measurement.)

When hydraulic pressure first applied prior to bleeding air from unit, valve was responsive to input when pressure source only at 250 psi. Continued elevation of input pressure to 1000 psi resulted in reduced valve response, slight movement approx 0.3mm. Pressure dropped to 250 psi, unit no longer responds to input lever movement. Seems okay at this point.

Actuated 20 cycles with 3000 psi input pressure to purge air and prepare for measurement of input arm operating torque per normal shop practice.

Needle valve installed in return line to simulate hydraulic system return pressure of approximately 50 psig. (This method builds the backpressure only during actuator operation.)

Using input arm lever of 1.2 inches as before, input forces measured at 6 lbs, 4 lbs, 4.5 lbs, 1.5 lbs. It was determined by second operator that the first 3 values were likely obtained by hitting end of input lever range. The force meter was capturing the maximum force. Final assessment was that input torque seemed reasonable even with back pressure generated as high as 100 to 130 psig.

Zero external leakage identified.

Internal leak check 200 ml in5 minutes (0.01 gpm calculated versus 0.043 gpm max allowed.)

Max rate check: input lever jammed such that manual operation impossible

Reduced pressure, can move but does not freely return

Repeated

Unknown if actuator fully extended.

First input lever jam resulted in input lever stuck in full deploy position with lever against housing.

Second input lever jam resulted in input lever stuck at mid-stroke position.

In both cases pressure was reduced, input lever pushed toward stow position, and actuator retracted, following lever. It was not noted at what pressure motion resumed.

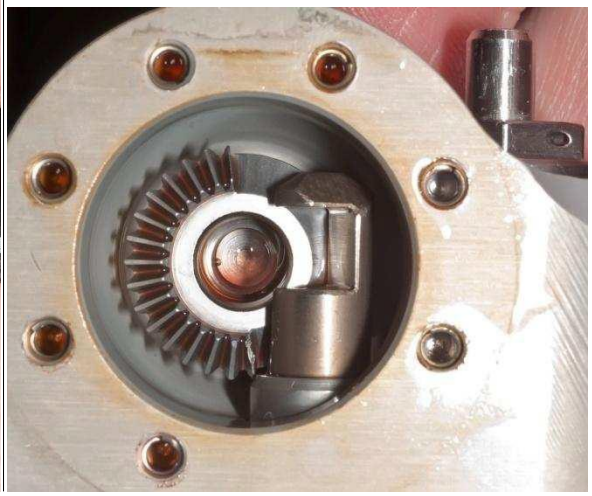
Following these events, at zero input pressure, lever could be operated but it was "sticky".

Group decision was to terminate functional testing and move to disassembly.

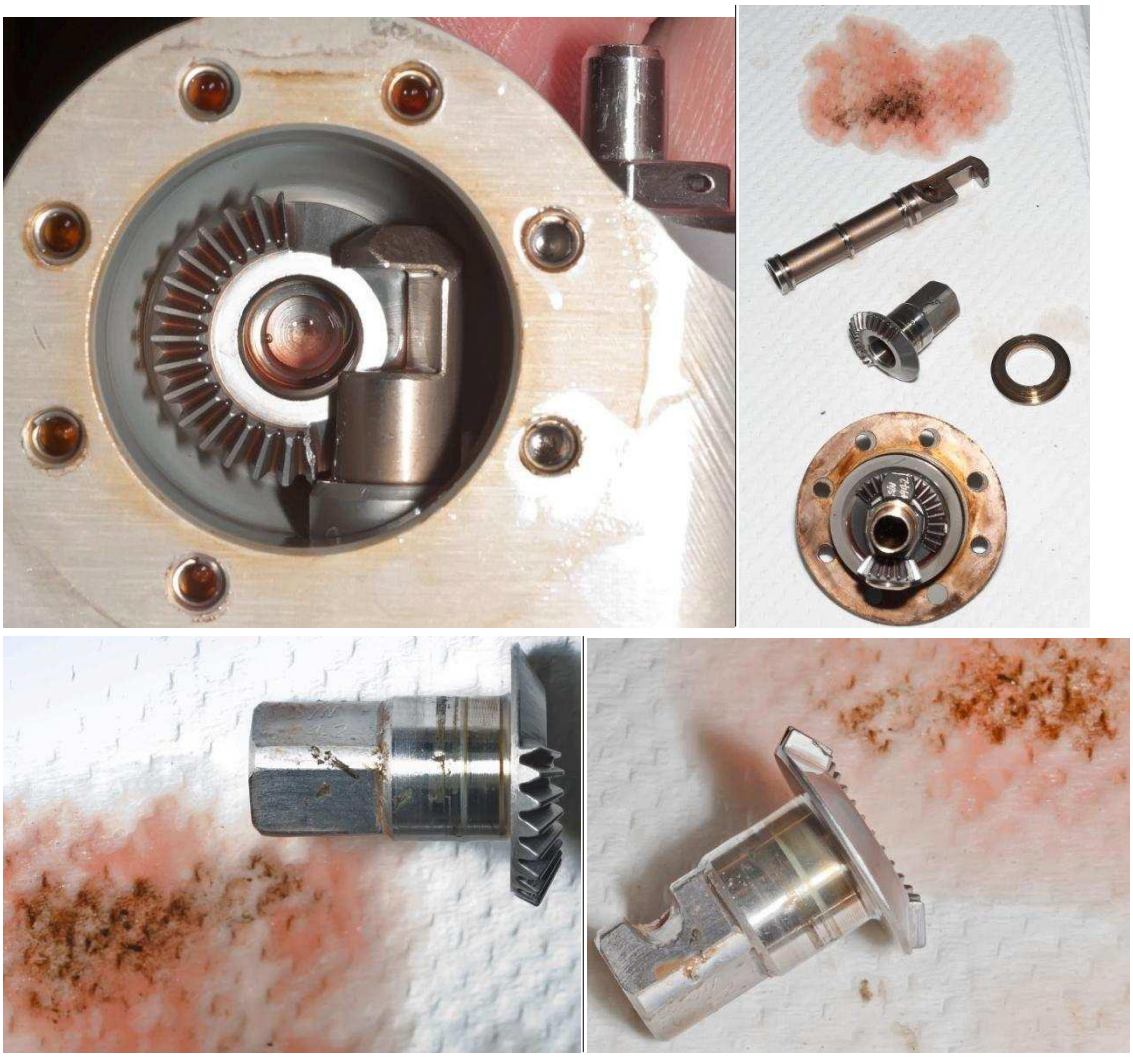
3. COMPONENT DISASSEMBLY

No large contaminants were found during disassembly or from examination of fluid captured during disassembly process as evaluated in Cessna Report 12-359-093 included in this report as section 4.

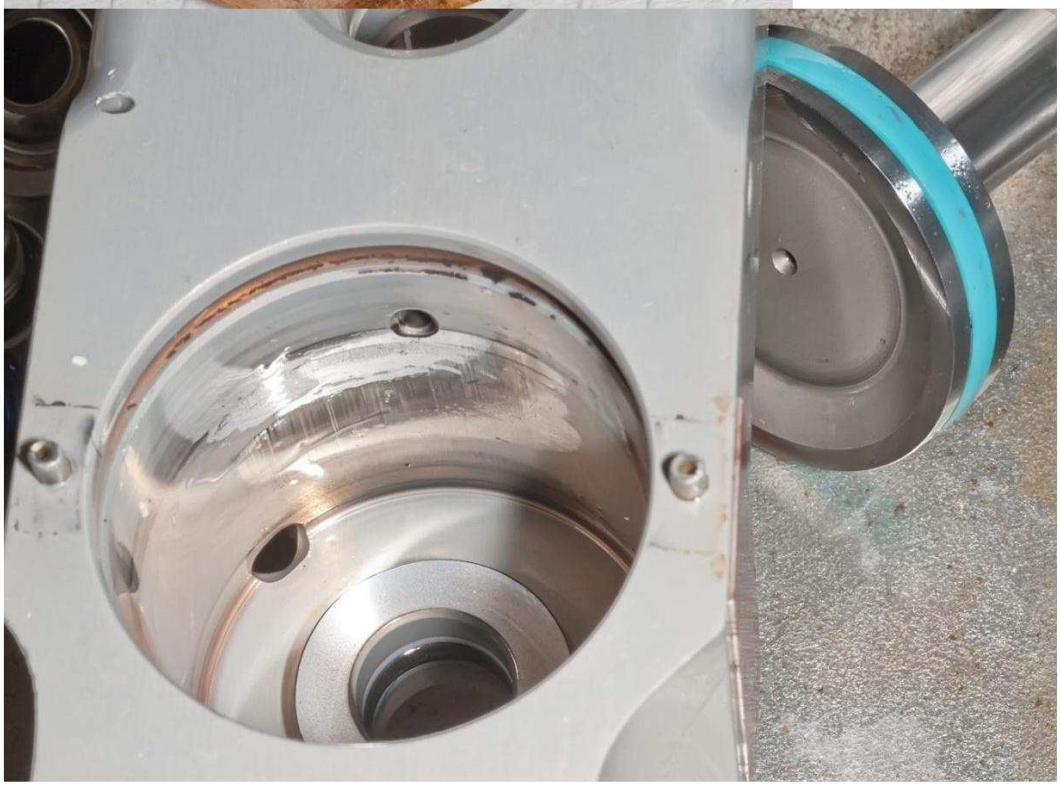
A little chip came out with fluid when medium blue plug was pulled (check valve).



Damage seen on both input and feedback gears at extreme ends of travel, and at opposite ends (when installed damaged gear teeth would likely not be included in normal range of travel.)



Visible contaminant was partially from external seals. It was not viewed as a likely source of valve malfunction at time of teardown.



No visible damage to spool control summing gear or valve assembly.

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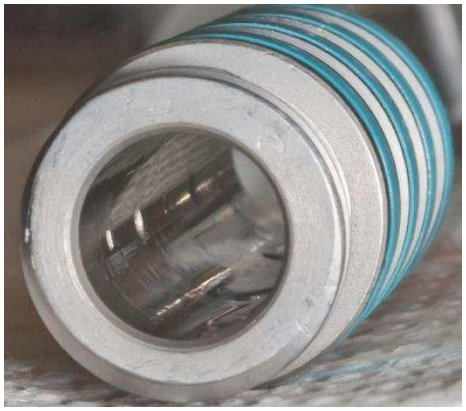

5. CONCLUSION

The roll spoiler actuator 9914155-19 SN 2641 removed from Cessna Model 650-7063 following the accident on 12-28-2011 failed portions of the bench tests conducted on 2-7-2012. The input lever was observed to stick when selected to extend. Finger force on lever was not successful in returning commanded position to the stowed position until after hydraulic pressure was removed from unit. No problems were observed with the ability of the PCU to stow when pressure was applied to the spoiler holddown port (AUX). No obvious cause of input arm jam was identified during component disassembly and observation. Additional investigation by Nabtesco was recommended.

As a follow-on exercise to characterize the behavior of a typical 9914155 actuator, an uncontrolled 9914155-17 assembly was installed on test fixture the following week to compare input lever motion and feel. It was observed that the motion of the input was smooth and continuous with a regular and consistent resistive force, upon application of hand-force to the input lever. (Actual force measurements were not captured.) Actuator output was also smooth and continuous, being directly proportionate to the input motion. This uncontrolled unit functioned and responded as would be expected from a properly functioning unit, serving to contrast with the performance of the unit removed from 650-7063.