



NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety

Actuator Examination Report

August 26, 2022

A. ACCIDENT CEN21LA259

Location: Aspen, Colorado
Date: June 4, 2021
Time: 0954 MDT
Operator: Private
Aircraft: Cessna 560XL
Registration: N615RG

B. PARTICIPANTS or GROUP NAME:

NTSB Investigator-in-Charge:	Joshua Lindberg
NTSB Investigator:	Stephen Stein
Nabtesco Quality Assurance:	Matthew Glugla
Nabtesco Engineering:	Robert Cughan

C. SUMMARY

On June 4, 2021, at 0954 mountain daylight time, a Cessna 560XL airplane, N615RG, was substantially damaged when it was involved in an accident at Aspen-Pitkin County Airport (ASE), Aspen, Colorado. The pilot, co-pilot, and 3 passengers were uninjured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

The pilot stated that the approach was stabilized and normal, and that the landing gear indications were normal with three green lights. During landing and after the deployment of the speed brakes and thrust reversers, an aural landing gear warning was received. The right wing then began to drop and the airplane veered to the right and came to rest on the right side of the runway, resulting in substantial damage to the right wing.

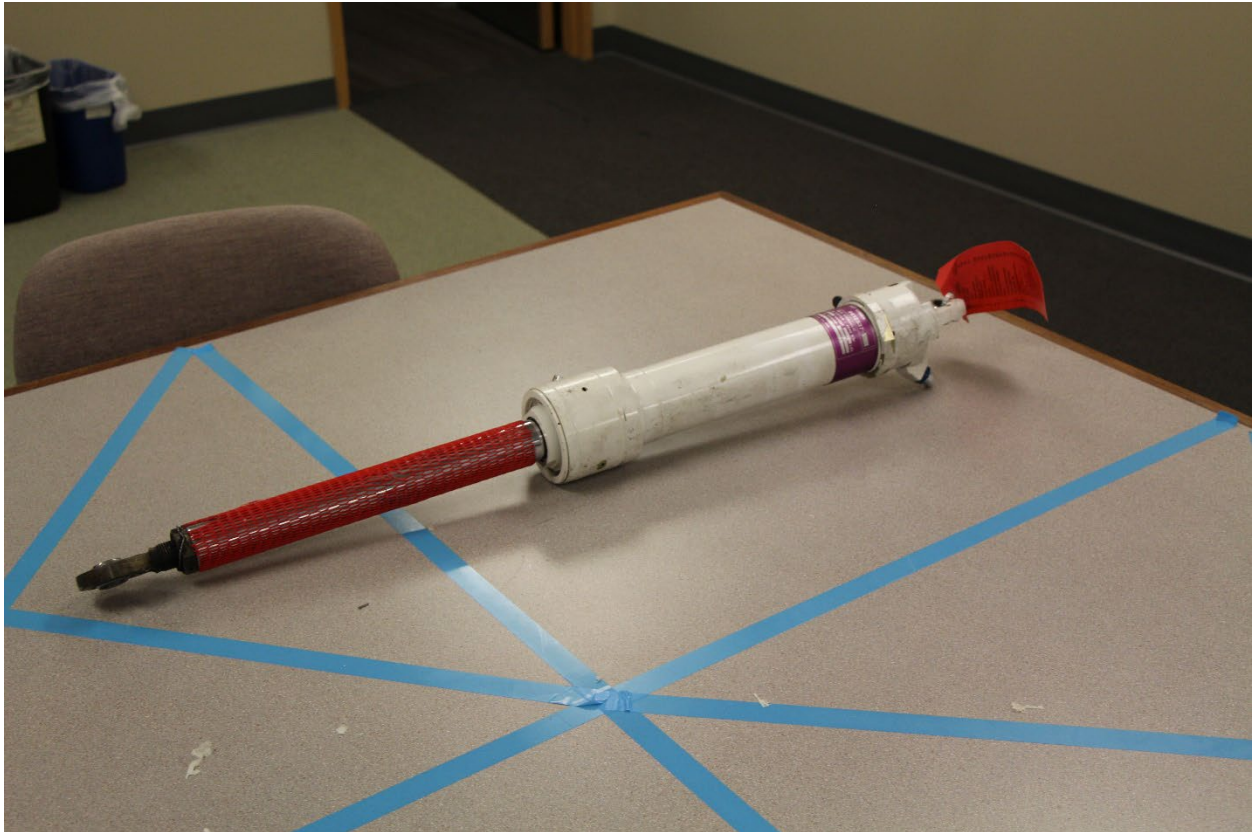
After the accident the right main landing gear was found retracted while the left main landing gear and nose gear were extended. The landing gear handle was found in the UP position. When asked, the crew could not recall manipulating the landing gear handle after the initial gear extension in flight. Figure 1 shows a post-accident view of the cockpit, throttle quadrant, and landing gear handle. The airplane has been retained for further examination and component testing.



Photograph 1: Postaccident view of the cockpit, throttle quadrant, and landing gear handle

D. DETAILS OF THE INVESTIGATION

A functional test and teardown inspection of the right main landing gear hydraulic actuator took place on August 23, 2022 at the Nabtesco Aerospace facility in Kirkland, Washington.

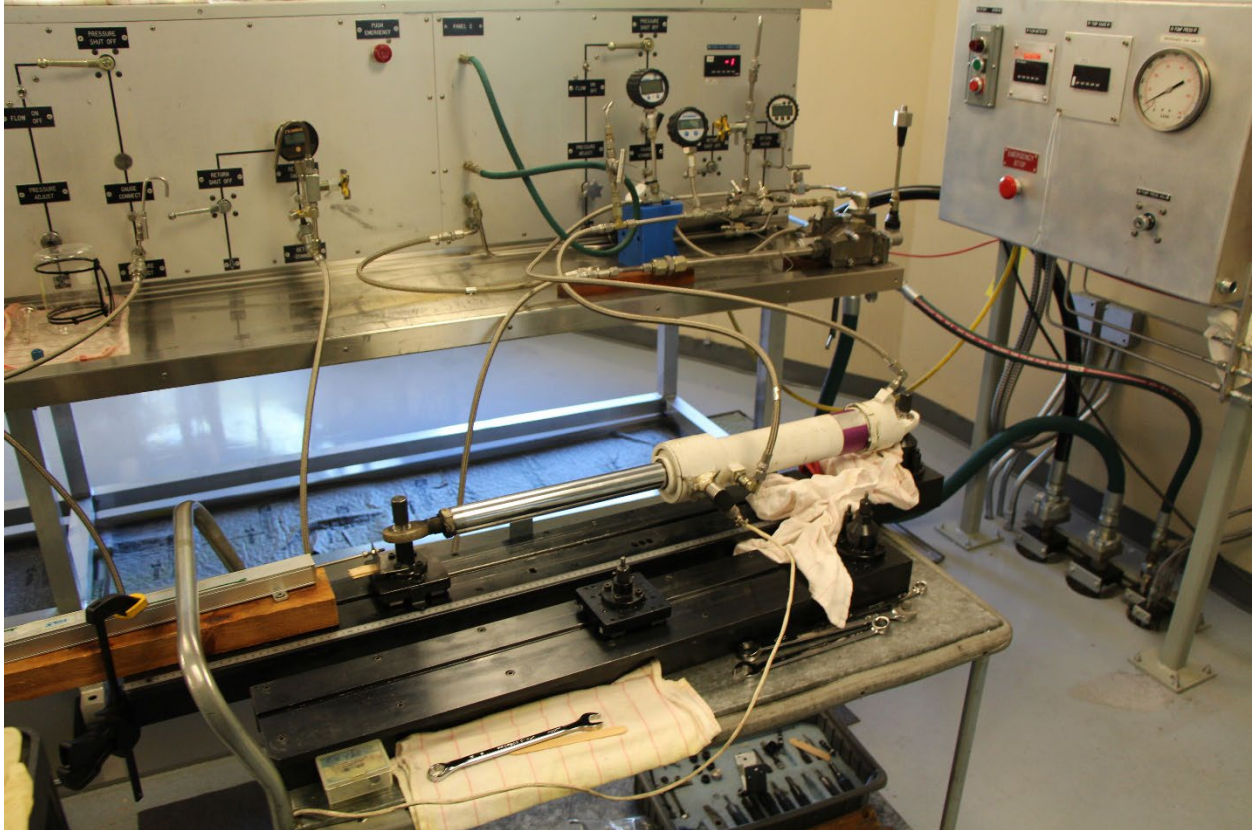


Photograph 2: Hydraulic actuator as received

D.1 Actuator Examination

D.1.1 Functional Test

The hydraulic actuator was placed in a test apparatus in accordance with component maintenance manual (CMM) 32-32-14 rev. 2.



Photograph 3: Hydraulic actuator in test apparatus

The actuator passed most of the CMM tests with exception of two:

1. *Leakage and Operational Test (2.D)*

Test: The test states that no internal leakage should be observed after the first minute.

Result: During the 15 PSIG and 1500 psig tests, one drop was observed at 1500 psig when the actuator was retracted at 15 PSIG and 1500 psig. However, the test was repeated and no leakage was observed at either 15 PSIG or 1500 psig. The technician's handwritten note on the test data sheet shows an "F" next to the 1500 psig internal leakage (see photograph 3). This refers to the initial test, which resulted in a 1 dp (Failed condition) before the test was repeated and passed at 0 dps.

No internal leakage after the first minute	Extend at 15 psig	Actuator		drops
	Extend at 1500 psig	Extended	0	
	Retract at 15 psig	Actuator		
	Retract at 1500 psig	Retracted	✓ 0	drops

Photograph 4: Excerpt from internal leakage test

Test: No external leakage, noise, binding, sticking or other defects should be noted while the actuator is cycled.

Result: A subtle audible sound was heard when the piston was initially extended from the fully retracted position. According to the manufacturer, a subsequent test of another actuator (with the same p/n) revealed the same subtle audible sound when the piston was initially extended from the fully retracted position. The manufacturer reported that they consider this observation to be part of normal operation.

Please refer to the Nabtesco Aerospace, Inc. Test Data Sheet for the test results and to the Actuator Teardown section of this report for observations.

D.1.2 Functional Tests (Textron add-ons)

1.1.3.1 Unlock with elevated back pressure

Back pressures of 150 PSIG and 300 PSIG were applied on the extend side and the tables below indicate the retract pressures necessary to unlock the actuator as detected by the microswitch and first movement of the piston.

150 PSIG Back Pressure (Test no.)	Light (psig)	Piston (psig)
Test 1	287	292
Test 2	284	302
Test 3	283	307

The test setup was rearranged to use independent pressure sources for the extend and retract side due to difficulty calibrating in a 300 psig back pressure. The test at 150 psig back pressure was repeated with new setup and the results were similar.

300 PSIG Back Pressure (Test no.)	Light (psig)	Piston (psig)
Test 1	279	306
Test 2	272	295
Test 3	264	295

To confirm the results, the test was then repeated with 150 PSIG back pressure.

150 PSIG Back Pressure (Test no.)	Light (psig)	Piston (psig)
Test 1	271	295
Test 2	270	305
Test 3	260	290

The investigation noted that similar pressures were required to unlock the actuator with 150 and 300 PSIG applied at the extension port. The part manufacturer stated that the pressure required to indicate an unlocked condition was also required to overcome the spring bias holding the plunger in the locked position. The back pressures tested are of a low enough value that it allows the piston to retract at about the same pressure as the unlocking pressure.

1.1.3.2 Lock with back pressure

A 1,200 psi differential was observed between the 350 PSIG backflow that was applied at the retract port and 1,500 psi at the extended port; however, the microswitch indicator lights did not indicate a locked position during the test while 350 PSIG was applied.

A locked indication was observed at the microswitch indicator lights when the retract pressure was reduced to 40 psig with 1,500 psig applied at the extend port.

1.1.4 Downlock switch rig verification

The switch was rigged at 54° (the CMM limits were 55° +/- 7°). The part manufacturer noted that this is the angle between the centerline of the switch and the centerline of the actuator looking down a on the switch

The 1st and 2nd contacts broke after the nut was turned three-quarters of a full turn

The switch was separated from its threaded attachment after seven full turns

Refer to this report, section D.1.2, for the results of the Textron add-on tests.

Actuator Teardown

The rod end of the piston was placed in a vise and a 1.5 inch wrench with a breaker bar was used to unscrew the rod end with the nut.

The plug was removed from the cylinder and the cylinder lock nut was then removed from the base.

The part manufacturer further noted that the cylinder lock nut was found to be in an un-torqued condition. The lockwire and tamper seal attached to the nut/cylinder head assembly was intact and the nut was not loose while the lockwire was removed. The cylinder lock nut was found loose only after the plug was removed.

The piston was removed from the cylinder along with the spring, plunger, guide and four lock keys. No abnormalities were observed with the piston or associated hardware. All four lock keys were observed in place in the four guide slots when the piston was removed.

The snubber tube exhibited mechanical damage at the cylinder head end, but was otherwise free of any abnormalities. A polished fragment was observed in the cavity of the cylinder head. The snub tube assembly including the spring and lock ring were free of any abnormalities. The snub tube sleeve assembly was removed from the snub tube, but not disassembled, and the spring functioned normally within the sleeve when depressed by hand and the lock ring and plunger were secure at the sleeve.

1. Landing Gear Actuator Tests

Recommended test sites:

Actuators: Nabtesco America, Redmond WA

1.1. **MLG actuator tests** (RH Actuator: 9912537-2, 1550000-2, S/N 0060)

1.1.1. Omitted.

1.1.2. Omitted.

1.1.3. Actuator ATP: Conduct MLG Actuator ATP WP00258 Rev H, with the following additional tests. Record ATP results in ATP data sheets.

1.1.3.1. Unlock with elevated back pressure: After completing ATP test 4.4, conduct an unlock pressure test with back pressure (pressure on the extend side), at 150 psig.

Find the retract pressure necessary to unlock the actuator. Record unlock pressure, repeat 2 times. Increase back pressure to 300 psig and repeat test.

1.1.3.2. Omitted.

1.1.3.3. Lock with back pressure: Starting with the actuator retracted, extend with 300-400 psi back pressure present on the retract side (can be created with extend velocity or a restriction on the retract side). Measure pressure required to lock actuator, and observe lock engagement to verify smooth and consistent lock performance. Record applied back pressure and pressure to unlock. Repeat 2 times.

1.1.4. Downlock switch rig verification: Verify switch rig to factory specifications. Record the number of turns until loss of lock indication for each set of switch contacts. Record how far the switch is threaded into the actuator body by number of turns.

1.2. **MLG actuator tear down and inspection:** Conduct a tear down and measurement inspection of the 1550000-2 MLG actuator.

Hydraulic Components Test Plan Data Sheets	Aircraft: 560-5016	Page 2 of 3
Test Location:	Component: RH MLG Actuator S/N:	Date:

[illegible]

Hydraulic Components Test Plan Data Sheets	Aircraft: 560-5016	Page 3 of 3
Test Location:	Component: RH MLG Actuator S/N:	Date:

Test Paragraph	Test	Results/Notes
Downlock Switch		
1.1.4	Switch rig verification	Switch rigged within specified limits: Y/N: _____ Number of turns until 1 st contact breaks: _____ Number of turns until 2 nd contact breaks: _____ Total number of turns to remove switch: _____
1.3	Omitted	Omitted
RH MLG Actuator Teardown Inspections		
1.2, 1.4	<u>Inspection/measurement completed for:</u> 1550000-2 actuator 1EN329-R downlock switch	<u>In Spec?</u> Y / N: _____ Y / N: _____ (Attach additional sheets as necessary)
	RH MLG Actuator Test witnesses:	