# DATA SUMMARY

## LOCATION

| | |
|---|---|
| Date and time | **Thursday, 22 January 2009; 11:54 local time**[1] |
| Site | **Sabadell Airport (Barcelona)** |

## AIRCRAFT

| | |
|---|---|
| Registration | **EC-DMR** |
| Type and model | **CESSNA F-172-RG** |
| Operator | **Top Fly** |

### Engines

| | |
|---|---|
| Type and model | **LYCOMING O-360-F1A6** |
| Number | **1** |

## CREW

### Pilot in command

| | |
|---|---|
| Age | **31 years old** |
| Licence | **Commercial Pilot License CPL(A)** |
| Total flight hours | **3,300 h** |
| Flight hours on the type | **900 h** |

## INJURIES

| | Fatal | Serious | Minor/None |
|---|---|---|---|
| Crew | | | **2** |
| Passengers | | | |
| Third persons | | | |

## DAMAGE

| | |
|---|---|
| Aircraft | **Significant** |
| Third parties | **None** |

## FLIGHT DATA

| | |
|---|---|
| Operation | **General Aviation – Instruction** |
| Phase of flight | **Landing** |

## REPORT

| | |
|---|---|
| Date of approval | **26 September 2011** |

[1] All times are local. To obtain UTC, subtract one hour from local time.

# 1. FACTUAL INFORMATION

## 1.1. Description of event

The aircraft took off from Sabadell Airport at 08:50 with an instructor and a student onboard to conduct an IFR (Instrument Flight Rules) instructional flight.

They made an ILS approach to the Reus Airport, which proceeded normally. Upon returning to the Sabadell Airport, they entered the traffic circuit to the right of runway 31. When the crew lowered the landing gear, they noticed that the associated indicating light was off. They then verified visually that the right main landing gear leg was not fully extended. After completing both the normal and emergency procedures, they contacted the control tower at 10:22 to inform them of the situation.

They then made an authorized fly-by of the tower, after which the controller confirmed that in fact the gear configuration was not symmetrical.

Finally, and after remaining airborne for an additional hour some distance away from the airport and trying several more times to lower the gear, they decided to return to the airport after reviewing the emergency landing procedure.

They made a second fly-by to have tower personnel confirm the gear position before the instructor finally landed the airplane, turning off the engine and electrical system once the airplane was safely on the ground.


**Figure 1.** Photograph of airplane

During the landing run the instructor kept the airplane's weight on the left wheel. After coming to a nearly full stop, the right wing dropped, its tip resting on the ground and the airplane doing a 180° turn.

The control tower alerted the airport's firefighting service, which reported to the scene after the landing to cover the runway with foam. Both occupants were unharmed and left the aircraft under their own power.

The airplane's right wingtip and horizontal stabilizer, which was also resting on the ground, were damaged. The right main landing gear leg and the nose wheel leg also suffered significant damage.

The post-incident inspection revealed that the actuator for the right gear leg was cracked, as shown in Figure 2, which prevented it from properly performing its function of extending the leg.

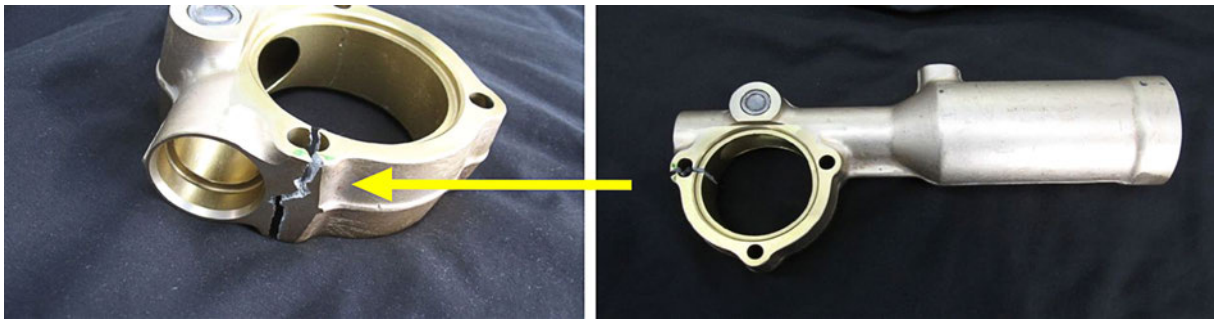

**Figure 2.** Broken actuator

## 1.2. Personnel information

The instructor, who was in the RH seat, had a commercial pilot's license CPL (A), valid since 2001, with multiengine (MEP) and instrument IR(A) ratings. He was also rated as a flight instructor FI(A)[2] and a class instructor CRI(A)[3]. He also had a valid medical certificate. He had a flying experience of 3,300 hours, of which 900 had been on the type.

The student pilot had a student pilot permit SP(A) and was receiving training to obtain a CPL(A) license with an IR(A) rating.

[2] FI(A) Flight instructor rating for PPL(A) licenses on single-engine airplanes.
[3] CRI(A) Class instructor rating for single-pilot multi-engine airplanes.

## 1.3. Aircraft information

### 1.3.1. *General information*

The CESSNA 172 RG, serial number 172RG0547, was manufactured in 1980. It had a valid airworthiness certificate and at the time of the incident had logged 6,619:45 flight hours. It had been used primarily for flight training since 2002.

It had undergone the following maintenance inspections:

| Inspection type | Hours on airplane | Date |
|---|---|---|
| 50 h | 6,007 h | 18-01-2008 |
| 100 h | 6,053 h | 06-02-2008 |
| 50 h | 6,106 h | 11-03-2008 |
| 200 h | 6,151 h | 28-03-2008 |
| 50 h | 6,196 h | 09-04-2008 |
| 100 h | 6,240 h | 25-04-2008 |
| 200 h | 6,291 h | 23-05-2008 |
| 50 h | 6,338 h | 27-06-2008 |
| 100 h | 6,384 h | 15-07-2008 |
| 50 h | 6,431 h | 20-08-2008 |
| 200 h | 6,478 h | 29-09-2008 |
| 50 h | 6,530 h | 25-11-2008 |
| 100 h | 6,580 h | 31-12-2008 |

As reflected in the aircraft maintenance documentation analyzed, the main landing gear had been checked, as required by CESSNA service bulletin 01-2-RG MLGA Rev. 2 of 4 June 2007, during the 50-hour inspection conducted on 9 April 2008 with 6,196 flight hours on the airplane.

That bulletin had been issued to address the need to inspect the main gear actuators for the possible presence of fatigue cracks on the edges of the inner side walls of the actuating ring. The bulletin specifies to replace the actuator or actuator body if any cracks are noted on these parts.

The bulletin notes that if no cracks are found in those actuators with the part numbers listed (which includes the one involved in this incident, 9882015-2), they should be modified and subsequently inspected according to the instructions detailed in the same bulletin.

The modification involves polishing the edge of the 2.28-inch diameter hole on the main landing gear actuator ring using fine-grained sandpaper to achieve a continuous polish starting from the edge of the 1-inch diameter oval hole so as to eliminate any sharp edges or tool marks that can be detected with the finger (see Figure 3).

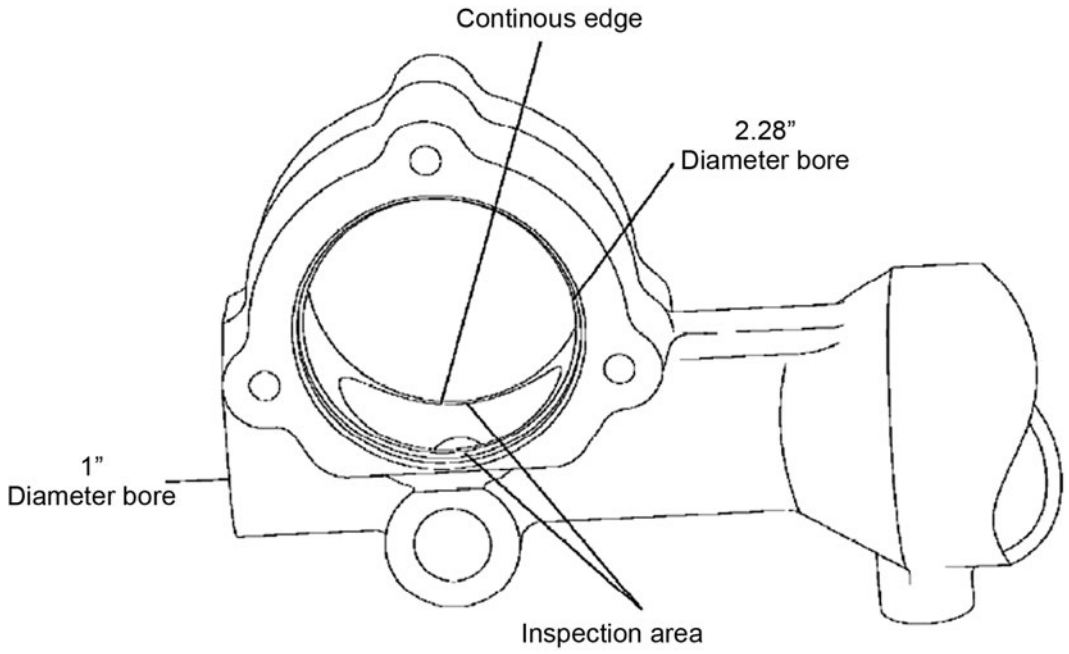


**Figure 3.** Main landing gear actuator inspection

Compliance with the bulletin is mandatory and must be ensured as follows:

- The initial inspection and the checks of actuators with more than 3,000 total hours in service are to be conducted during the next scheduled fuselage maintenance, not to exceed 100 h of operation.
- Subsequent inspections are to be made every 500 h.

Actuators with other part numbers, which are also provided, do not require a modification but must undergo a subsequent inspection.

The bulletin adds that failure to comply could result in damage to the main landing gear actuator.

It also details the areas to inspect, which do not coincide exactly with those areas where the actuator ring in this incident fractured, as well as the inspection method (using liquid penetrants).

### 1.3.2. *Information on main landing gear*

The landing gear works by means of a hydraulic system that interacts with an electrical system which is used to control it and also to provide constant gear position indications. Both the retraction and extension of the gear involve actuators located in each of the three gear legs.

The main gear legs (struts) are attached to a rigid piece (pivot) that, when it rotates, extends or folds the leg. This piece in each leg is in turn joined to an actuator through a toothed circular section that is housed in the actuator ring (the part that broke).

A toothed piston that moves inside the actuator meshes with the circular section, allowing the pivot, and thus the gear leg, to move. See Figures 3 and 4.

Figure 4 shows a close-up of the gearing between the toothed piston and the toothed circular section.

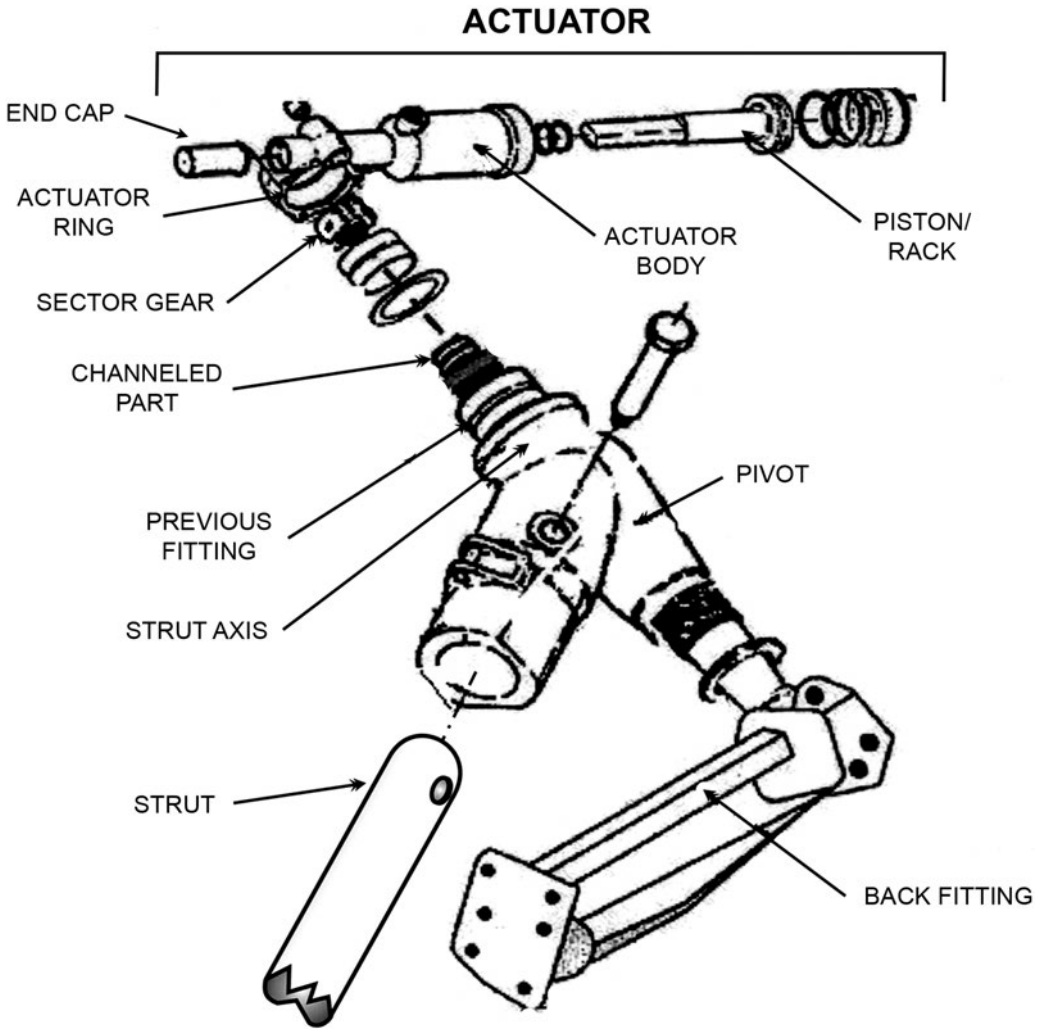


**Figure 4.** Leg actuator and pivot

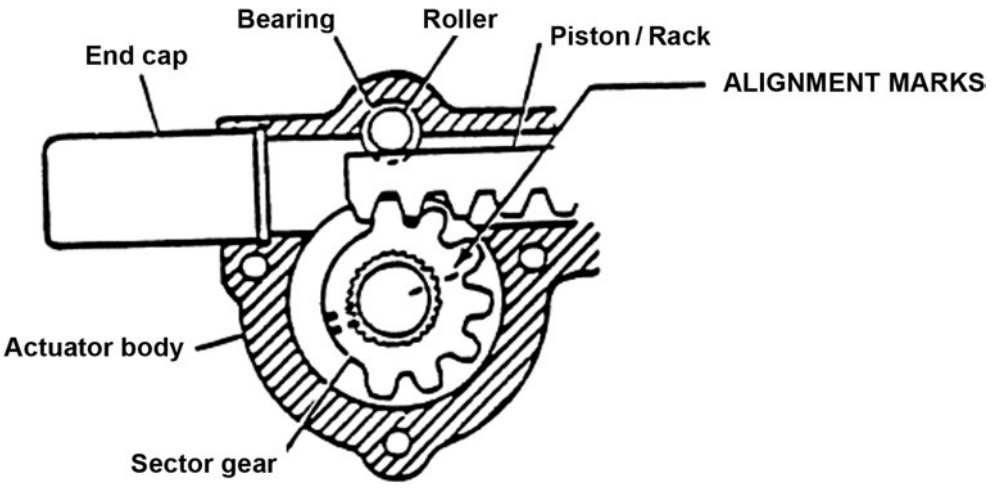


Figure 5. Diagram of the actuator gear

When the gear is down and locked, a green light turns on in the instrument panel. An amber light is on when the gear is in transit.

### 1.3.3. *Maintenance of fractured area*

As specified in the maintenance manual for the 172 RG airplane, in order to maintain the landing gear, it must be first be disconnected from the hydraulic system and then disassembled. The parts must then be inspected as follows:

- Carefully clean all of the parts in solvent.
- Check the surfaces for cleanliness, cracks and wear.
- Inspect the housing, rotating elements, piston, roller and the actuator body for cracks, chips, scratches, marks, wear or any surface irregularity that could affect the normal operation of the actuator.
- Ensure the bearings move freely and do not have any scratches or marks.
- Check the inner gear on the actuator ring.

Any damaged components must be replaced.

### 1.3.4. *Emergency landing with engine power*

The emergencies in the Pilot Operating Handbook do not specifically cover a failure of the landing gear, but they do provide general coverage of the emergency landing, either with or without engine power.

If the engine has power, the items to be performed are as follows:

- Passenger seats in upright position.
- Seatbelts fastened.

- Indicated airspeed: 60 kt.
- Flaps down 20°.
- Select field for full landing.
- Electrical components turned off.
- Flaps down 30° on touch down.
- Doors unlocked.
- Touch down with tail slightly downward.
- Ignition off.
- Mixture cut.
- Brake smoothly.

## 1.4. Tests and research

The leg actuator was sent to a laboratory for analysis.

Three cracks were found in the annular part near the two orifices located where the ring joins the actuator's tubular body.

Cracks A1 and A2 (see Figure 5) were located at one end of the assembly. The walls of the upper hole were cracked through.

Crack B only ran through one of the walls on the inner orifice. Along with this crack, another small crack that was detected on the ring's outer wall that did not penetrate through the thickness of the wall.

The analysis was conducted in three stages. The first involved a visual inspection using instruments that provided up to 30x magnification. The material characteristics were then studied and involved both chemical and micro-structural analyses as well as mechanical tests. Lastly a fractographic analysis was done using macrofractographic and microfractographic observations.

The conclusions were as follows:

- The material from which the piece was manufactured did not exhibit any defects that could have decreased the strength of the actuator material under the conditions involved in the fracture.

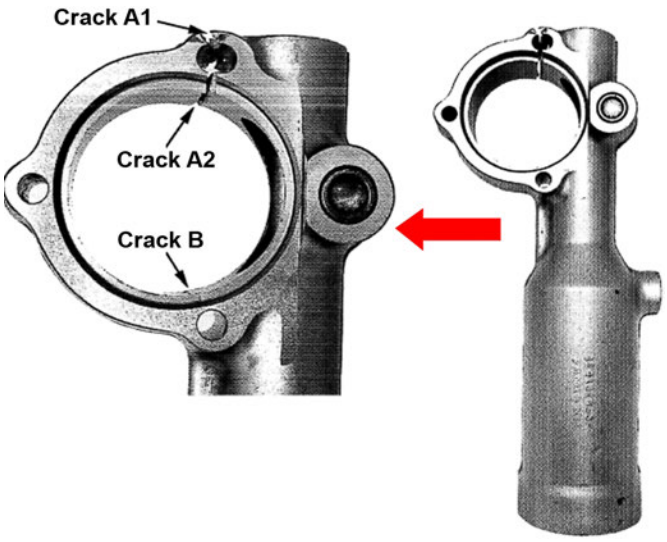


**Figure 6.** Cracks in the actuator

- The fracture mechanism involved was microvoid coalescence, typical of static overload fractures, and which resulted from the effects of a tensile load leading to local circumferential stresses in the annular section of the actuator.

Figures 6 and 7 show the cracks in detail.

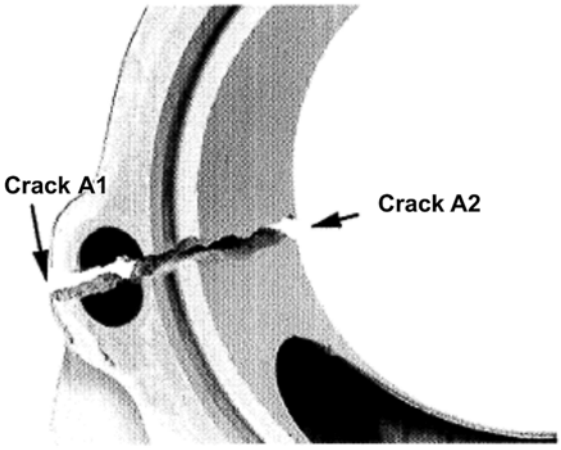


Figure 7. Close-up of cracks A1 and A2

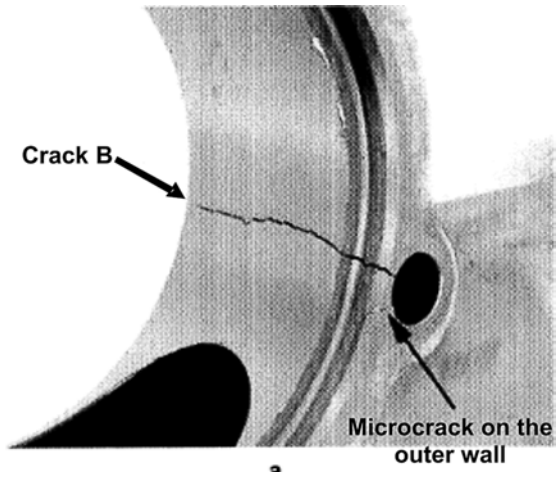


Figure 8. Close-up of crack B

## 1.5. Previous cases recorded by the NTSB on the same piece breaking in other similar aircraft

NTSB informed of the following previous cases of the same piece breaking in other aircraft similar to the incident one, which are summarized in the following board:

| Registration | Date | Place | Cause |
|---|---|---|---|
| N-9451D | 12-11-1997 | San Diego | Actuator overload |
| N-9506D | 15-02-1999 | Lawrenceville | Actuator fatigue |
| N-6231V | 21-08-1999 | Miami | Actuator overload |
| N-6525R | 26-09-2002 | Billings | Actuator fatigue |
| N-6543V | 12-10-2003 | Camarillo | Actuator overload. Not compliance with the Service Bulletin |
| N948SM | 15-09-2004 | Montgomery | Hydraulic liquid line separated from its fitting |
| N-6140R | 31-10-2004 | Kingman | Airplane's landing gear extensión system failure |
| N-522GC | 10-06-2007 | Lantana | Hydraulic liquid line separated from its fitting |
| N-9395B | 08-02-2007 | Daytona Beach | Actuator overload |
| N-6562V | 07-02-2008 | Cahmblee | Nose gear actuator O-ring cracked |
| N-6272R | 10-01-2009 | Carson City | Actuator overload |

## 2. ANALYSIS

The investigation revealed that the instructor had ample experience, which made it possible for him to detect the gear malfunction quickly and to take the measures specified in the flight manual to conduct an emergency landing under power. All proper precautions were taken and the landing was made without injuries to persons and with only minor damage to the aircraft.

The efforts to lower the gear once the fault was detected also relied on the use of proper safety measures. ATC services were instrumental in facilitating the crew's task and in providing support in a safe environment at all times.

With regard to the fracture of the actuator in the leg, it should be noted that the aircraft had been used for pilot training since 2002, as a result of which it had probably been subjected to occasional hard landings leading to high static loads. Another point to consider is that pilot training requires flights without an instructor, which increases the likelihood that landings harder than desired will be made.

The maximum static load that the actuator on the right leg could withstand was probably exceeded on one or several occasions, resulting in stresses that gave rise to the appearance of the cracks that were detected during the investigation. These cracks weakened the area, which structurally was less sound, causing the collapse of the actuator.

## 3. CONCLUSIONS

The accident was caused by the fracture of the actuator in the right main landing gear leg which resulted from a static overload fracture due to local stresses that had formed in the annular region of the actuator.

## 4. RECOMMENDATIONS

None.