Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Control Cable Terminal - Retirement

AWB 27-001 **Issue** : 7
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1. Applicability

All aircraft flight control cable terminal fittings made from stainless steel specification SAE-AISI 303 Se or SAE-AISI 304, installed on aircraft which are not maintained in accordance with a maintenance program which was developed using MSG-3 methodology.

2. Purpose

While CASA AD/GENERAL/87 currently mandates replacement of all primary flight control assemblies (those used by the pilot for the immediate control of pitch, roll, and yaw[1]), the purpose of this airworthiness bulletin (AWB) is to urge operators and maintainers to consider replacing all flight control cable assemblies having terminal fittings manufactured from stainless steel SAE-AISI 303Se or SAE-AISI 304 before reaching 15 years total time in service.

In addition, operators and maintainers should consider inspecting control cable terminals underneath any rubber sleeves or tape etc. which may be wrapped around the terminal, for corrosion pitting/rust, irrespective of total time in service, and replacing any control cable and terminal assemblies having any signs of corrosion pitting and /or cracked terminals before further flight, as described in section 7 Recommendations of this AWB.

3. Background

Reports of flight control cable terminal fitting separation failures continue to be received in Australia, New Zealand and in the United States. Failure of a flight control cable terminal can result in loss of control.

Investigations have revealed that the failed terminals had been in service for approximately 15 years or more and were typically identified by standard terminal fitting part numbers AN669, MS21260 and NAS650.

Figure 1 – Flight control cable terminal separation

[1] USA Federal Aviation Regulations Part 23.673 – Primary flight controls

It should be noted that these terminal fittings have been incorporated into flight control cable assemblies which can then be identified by different manufacturers part numbers in the aircraft Illustrated Parts Catalogue (IPC).

Terminal fitting separation as described in this AWB is due to chloride stress-corrosion cracking (CSCC) a form of intergranular cracking which does not provide clear visual clues to the full extent of the internal structural damage and can originate from within the terminal (See Figure 7).

This means that even very small corrosion pits, cracks or rust deposits on the surface of the terminal fitting may be indications that the terminal could be very close to failure.

Figure 2 – Flight control cable terminal separation. Note that the failure has occurred outside the safety lockwire hole.

Reported failures in Australia include terminal fittings installed in wings and another in the cabin, and behind the instrument panel (Figure 3). Such locations are generally considered to be free of water, battery gasses and engine exhaust fumes, factors which can contribute to corrosion problems.

Some aircraft manufacturers have revised the Emergency section of the aircraft flight manual (AFM) to introduce a procedure to cope with in-flight elevator control cable failure, describing how to apply elevator trim to control the aircraft using just one cable. Such action confirms that the possibility of an in-flight primary flight control cable separation has become widely recognised as a critical safety issue.

The procedure can be effective if a control cable separation occurs in cruise flight, however, should the ‘up’ elevator control cable separate close to the ground, at the point of applying ‘up’ elevator for take-off (as has occurred) or during the landing flare, there may not be enough time to regain control using trim.

Periodic inspections to monitor rust and/or pitting deposits on the terminal surface are not considered adequate to determine the continuing serviceability of the terminal. In-flight failures indicate that, not only is the initial pitting /cracking generally difficult to detect, but the extent of the associated sub-surface intergranular corrosion is extremely difficult to assess and the rate of crack propagation is unpredictable.

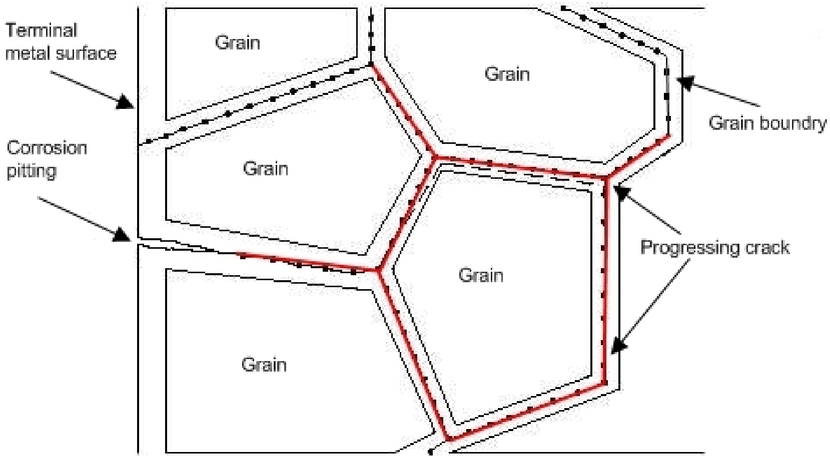

Figure 3 - Intergranular Corrosion Cracking

Adapted from: Corrosion DOE-HDBK-1015/1-93 SPECIALIZED CORROSION Rev. 0 CH-02 Page 33 Figure 14 Intergranular Corrosion Cracking.

The sketch above (Figure 3) shows small surface pitting can be evidence of advanced intergranular corrosion. Rusty stain deposits, when removed usually reveal areas of small pitting.

4. Additional Causes of Corrosion

Corrosion pitting has been found under the rubber sleeves and tape wrapped around the terminal to provide part number identification. During an inspection corrosion was detected at the edge of a rubber sleeve, as shown in Figures 4 and 5, below. When the sleeve was pulled back, the maintainer found severe corrosion under the rubber sleeve. A total of four flap control cable terminals were corroded in one aircraft. These flap control terminals had been in service for approximately 13 years.

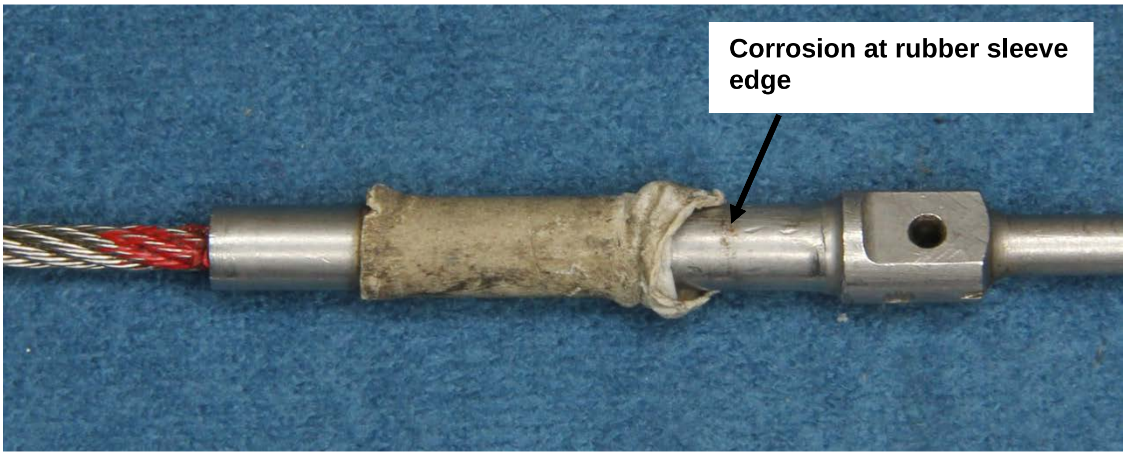

Figure 4 - Control cable terminal section covered in rubber sleeve (Source ATSB Investigation AE-2012-028 Final – 9 April 2013).

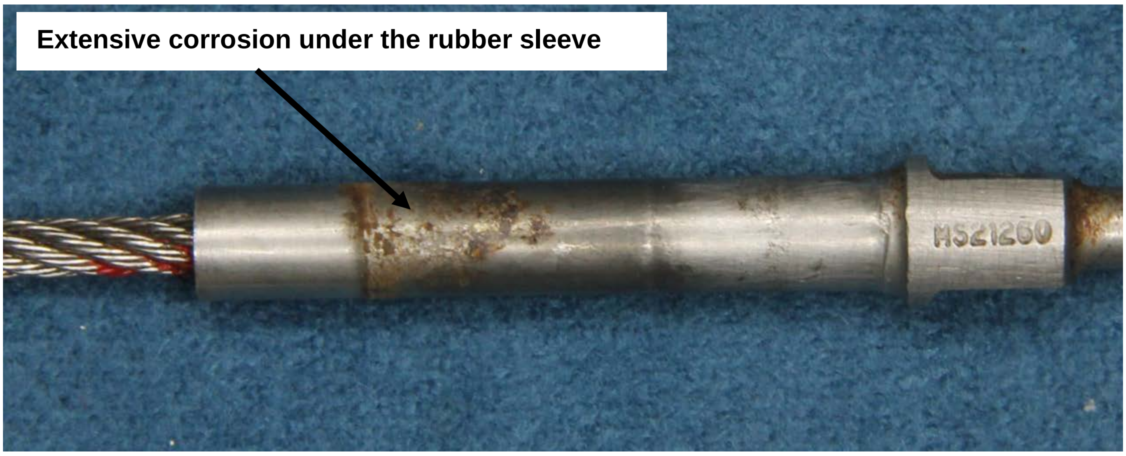

Figure 5 - Control cable terminal shown in figure 5, with the rubber sleeve removed. Note extensive corrosion. (Source: ATSB Investigation AE-2012-028 Final – 9 April 2013).

The corrosion on a rudder cable terminal in Figure 6 was also discovered under rubber tubing sleeve installed by the manufacturer. No less than eleven (11) cases of control cable terminal corrosion were discovered on the one aircraft. The cables had been in service for less than10 years.

Fig. 6. Source: CASA SDR. One of the eleven corroded primary flight control cables on the single aircraft. Corrosion originated from under the rubber sleeve.

Stainless steel's resistance to corrosion is primarily attributed to the existence of a thin chromic oxide film which develops in the presence of oxygen in the atmosphere. Stainless steel must be in continual contact with oxygen in order to develop and maintain the integrity of the film. A breakdown in an area of the oxide film due to lack of oxygen can allow localised corrosion cells to form. The presence of the rubber sleeves or tape over the terminals prevented the chromic oxide film to form, allowing corrosion to develop.

5. Cracking.

A formal investigation by the New Zealand Civil Aviation Authority into a report of stainless steel control cable terminal corrosion, discovered evidence of CSCC originating from the inside of the terminal. Since such cracking can originate from within the terminal, external surface clues such as pitting or cracking may not provide an adequate basis for determining serviceability. This introduces the possibility that a terminal may be close to failure and may even fail with little or no surface indication.

Figure 7 - Internal corrosion - flight control terminal sleeve.

The crack shown in Figure 7 originates from the cable wires (on the left of the picture) swaged in the terminal sleeve. The corrosion has not yet reached the outside surface of the terminal sleeve.

6. References

(i) FAA Special Airworthiness Information Bulletin (SAIB) CE-02-05R1 "…..cracking and corrosion problems currently being experienced with terminals made from SAE AIAI 303 Se stainless steel".

(ii) FAA SAIB CE-11-01 Stabilizers - Horizontal Stabiliser - Turnbuckle (Piper Aircraft Inc.)

(iii) National Transport Safety Board (NTSB) recommendations A-01-06 through A-01-008.

(iv) U.S. Department of Energy DOE-HDBK-1015/1-93 SPECIALIZED CORROSION

(v) FAA AC 43-13-1B chapter 7, section 8, paragraph 7.149d

(vi) NTSB Materials Laboratory Factual Report No. 10-108

(vii) ASM Handbook Committee 1975, Failure Analysis and Prevention, Metals Handbook, 8th ed., Metals Park, Ohio

(viii) USA Federal Aviation Regulations Part 23.673 - Primary flight controls

(ix) CASA Airworthiness Directive AD/GENERAL/87 - Primary Flight Control Cable Assembly Retirement

(x) ATSB Investigation AE-2012-028 Final – 9 April 2013

7. Recommendations

Although CASA AD/GENERAL/87 mandates replacement of primary flight control cables after 15 years' time in service for aircraft not maintained under an MSG 3 maintenance program, CASA recommends 'taking a closer look' at all primary and secondary flight control cable assemblies (the terminals and connecting cable) at the next opportunity, and that operators consider the following actions for all control cables:

a. Visually inspect control cable terminals, irrespective of the total time in service, for the presence of any rubber sleeves, tape or any other material/substance (other than lockwire) that may prevent the chromic oxide film from forming. Such material should be removed and the terminal inspected for corrosion, particularly in the area that was covered by the rubber sleeve or tape. Any sign of corrosion is cause for rejection.

b. Retire all flight control cable assembles with terminals made from stainless steel (SAE-AISI 303Se and SAE-AISI 304) including, but not limited to, terminals manufactured to MS20658 (AN658), MS20667 (AN667), MS20668 (AN668), MS21259 (AN666) and MS21260 (AN669 or NAS650), before reaching 15 years total time in service.

c. Where required by aircraft maintenance documentation, flight control cables should be periodically inspected in accordance with the manufacturer's data and FAA AC 43-13-1B Chapter 7, AIRCRAFT HARDWARE, CONTROL CABLES AND TURNBUCKLES, section 8, paragraph 7.149d. To inspect all surfaces of a cable throughout its entire length for wear and fatigue (broken wires) usually requires that the cable be disconnected and removed, to enable a 10X magnifier to be used.

8. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

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