Australian Government
Australian Transport Safety Bureau

Aircraft control cable terminal fittings – ATSB technical examination

Investigation

ATSB Transport Safety Report
Aviation External Investigation
AE-2012-028
Final – 9 April 2013

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

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Safety summary

What happened

Sample cable terminal fitting

The Australian Transport Safety Bureau (ATSB) was requested by the Civil Aviation Safety Authority (CASA) to assist in the examination of a number of aircraft flight control cable terminal fittings, to identify if they had been affected by stress corrosion cracking (SCC). The terminals had been manufactured from SAE-AISI 303 Se stainless steel (part numbers AN669 and MS21260) and were installed on Piper, Cessna and Beech aircraft. SCC is an environmental failure mechanism resulting from a combination of a susceptible material, applied (or residual) stress and a corrosive environment.

What the ATSB found

While several of the 54 submitted cable terminals showed evidence of surface pitting corrosion, none revealed any evidence of SCC when examined visually and using non-destructive testing techniques.

During the course of the ATSB examinations, CASA received fractured cable terminals from a Piper PA32 and an amateur built aircraft; these fittings were also submitted for examination. The failure mechanism in both cases was confirmed as SCC that had initiated on the external terminal surfaces. The ATSB was also advised of the additional failure of a terminal that was investigated by the New Zealand Civil Aviation Authority. The failure mechanism was also confirmed as SCC, however the cracking had initiated from the internal surface of the swaged terminal sleeve where it was in contact with the wire cable.

What's been done as a result

A number of actions have been taken in Australia and internationally to address the issue of SCC in control cable terminals manufactured from SAE-AISI 303 Se. The latest CASA airworthiness bulletin (AWB 27-001 Revision 3) updated owners on the potential for SCC of flight control cable terminals and urged operators to consider replacing the cables before they reach 15 years in service. A recent Federal Aviation Administration Airworthiness Directive (AD-2013-02-13) required the inspection of the stabilator control system on certain Piper aircraft and replacement of parts as necessary. CASA has also initiated a project that is seeking to amend Civil Aviation Order 100.5, *'General requirements in respect of maintenance of Australian Aircraft',* to mandate a recurring inspection of terminals manufactured from SAE-AISI 303 Se which have a total time in service of 15 years or greater.

Safety message

The ATSB encourages owners, operators and maintainers of aircraft that may be fitted with cable terminals with part numbers AN669 and MS21260, to familiarise themselves with the issues surrounding terminal fitting corrosion and the associated risks to continued airworthiness. Personnel should familiarise themselves with CASA Airworthiness bulletin, AWB 27-001 and the US National Transportation Safety Board Safety Recommendations A-01-6 through -8 released on April 16, 2001. Both documents highlight the risk to continued safe operation associated with SCC of flight control cable terminals and provide a comprehensive background on the failure mechanism and experiences. The ATSB urges operators to consider replacement of the cables in line with the regulators guidelines, as experience has shown that inspection alone is not a complete defence against SCC failures.

Contents

Introduction

The Australian Transport Safety Bureau (ATSB) was requested by the Civil Aviation Safety Authority (CASA) to assist in the examination of a number of aircraft flight control cable terminals considered to be at risk of stress corrosion cracking (SCC). The terminals had been manufactured from SAE-AISI 303 Se austenitic stainless steel and similar terminals were installed on Piper, Cessna and Beech aircraft.

The terminals (Figure 1) were designed so that one end could be swaged[1] onto a wire rope cable, while the opposite end contained threads that were inserted into a turnbuckle for tensioning the cable. The terminals contained a hole through the centre wrenching flats for securing the assembly with lock wire.

Figure 1: Sample of cable terminals submitted to the ATSB

Stress-corrosion cracking

Stress-corrosion cracking occurs when a component made from a susceptible material is placed under a sustained tensile stress and subjected to a corrosive environment. The cracking propagates as a function of time exposed to the stress and the aggressiveness of the corrosive environment. Growth of cracking is continuous while the stress and environmental conditions are present, and is not related to time in flight. The stress can be residual, (i.e. from the manufacturing processes), or be applied during service (from cable tensions), and the most damaging environment for an austenitic stainless steel terminal would be when in operation in warm, humid, salty air. Austenitic stainless steels, such as the 3xx series, and in particular the free machining grades with sulphur additives (including the 303 Se grade), have been shown to be especially susceptible to chloride stress corrosion cracking, and are potentially at greater risk of failure.

CASA released Airworthiness Bulletin (AWB) 27-001 Issue 2 on 31 October 2011, which recommended removal of all flight control cable terminals before they reach a calendar age of 15 years. That recommendation was based on reported failures in Australia[2] and the USA, and the National Transportation Safety Board (NTSB) recommendations (A-01-6 through -8) issued on April 16, 2001. The NTSB recommendations were issued following reports of six aircraft on which flight control terminals had fractured, and a further four aircraft where cracking had been detected. From the terminals examined, the NTSB determined that about 18 to 20 years exposure to the most damaging conditions was required for the terminals to progress to fracture.

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[1] Swaging is a mechanical process where the fitting is compressed around the cable creating a permanent joint

[2] ATSB Investigation number 200501905, Beech Aircraft V35A, VH-FEW, 30 April 2005. This report referred to four control cable terminal failures in Australia between 1995 and 2004 and 10 failed or cracked terminals in the USA.

The AWB urged operators to consider replacement of the terminals after 15 years, as it was considered that, due to the nature of the SCC mechanism, inspection for pitting on the terminal surface was inadequate to determine the extent of corrosion that may exist beneath the surface.

At the time of the release of Revision 2 of the AWB, CASA began an examination of a large population of control cable terminals to identify if any of the selected terminals had sustained SCC, and to assess the potential risk to the Australian fleet. A number of cable assemblies[3] were sourced from a maintenance organisation in north-western Victoria and were believed to have been in service for greater than 30 years. The cables and terminals had been removed during routine maintenance from a number of different types of aircraft, and from different flight control systems.

The AWB was updated as Revision 3 on 5 June 2012, with an added description of a terminal that had cracked from the internal surface of the swaged section, at the interface with the wire cable.

CASA supplied a select number of the cables and terminals to the ATSB that were considered to be suspect following their preliminary low-powered visual examinations (5x, 10x) in accordance with the manufacturers guidelines on in-situ examination.

Scope of the examination

- Visual examination, including stereobinocular examination, of the submitted control cableterminals to identify suspect components.
- Scanning electron microscope (SEM) examination on a select number of control cable terminals considered to exhibit corrosion.
- Non-destructive inspection (fluorescent penetrant) of all submitted control cable terminals to detect the presence of surface breaking discontinuities.
- Sectioning and microscopy of selected control cable terminals to determine presence and/or extent of SCC.

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[3] A control cable assembly includes the control cable, control cable terminal fitting and turnbuckle

Context

Visual examination

CASA initially supplied the ATSB with 13 corroded terminals that they had deemed to be the most concerning examples, following their own preliminary examination. The terminals were identified with a variety of information such as aircraft registration and/or aircraft type and terminal location (such as aileron or elevator). Further samples, also identified as exhibiting potential SCC, were submitted at a later date.

Slight differences were observed in the design of the terminals received, but they were essentially the same component. The primary difference was in the centre section that included a hole for safety wire installation; one population exhibited a hexagonal form (Figure 1 bottom) while the other exhibited a rounded mid-section with wrench flats (Figure 1 top). The terminals also exhibited three different manufacturing markings which included ‘bell’, ‘F’ or ‘OO’ (Figure 2).

Figure 2: Manufacturer markings observed on the submitted terminals (from left to right; bell, F and OO)

The terminals marked with an ‘F’ were all of the type with the hexagonal centre section, while the ‘bell’ and ‘OO’ samples were round. Additionally, all the ‘bell’ and ‘OO’ items were identified as part number AN669, while approximately half the ‘F’ terminals were part number AN669 with the other half being part number MS21260[4]. The two part numbers were consistent with those identified in the CASA AWB.

A number of the terminals exhibited general discolouration and areas of accumulated corrosion product across the surfaces, while some appeared to be in relatively good condition, with bright shiny surfaces, and no evidence of any significant corrosion.

The wrench flats and centre sections of some of the terminals showed a rough, discoloured appearance, and appeared to have progressed to mild pitting corrosion in a number of cases (Figure 3 & 4).

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[4] Military Standard MS21260M with Amendment 5, *Terminal, wire rope, swaging, stud,* 14 January 2010. AN669 was an Air Force-Navy Aeronautical standard that preceded MS21260. It was cancelled on 25 November 1963.

Figure 3: Discolouration / corrosion (arrowed) and rough surface finished on the wrench flats of an 'F' terminal.

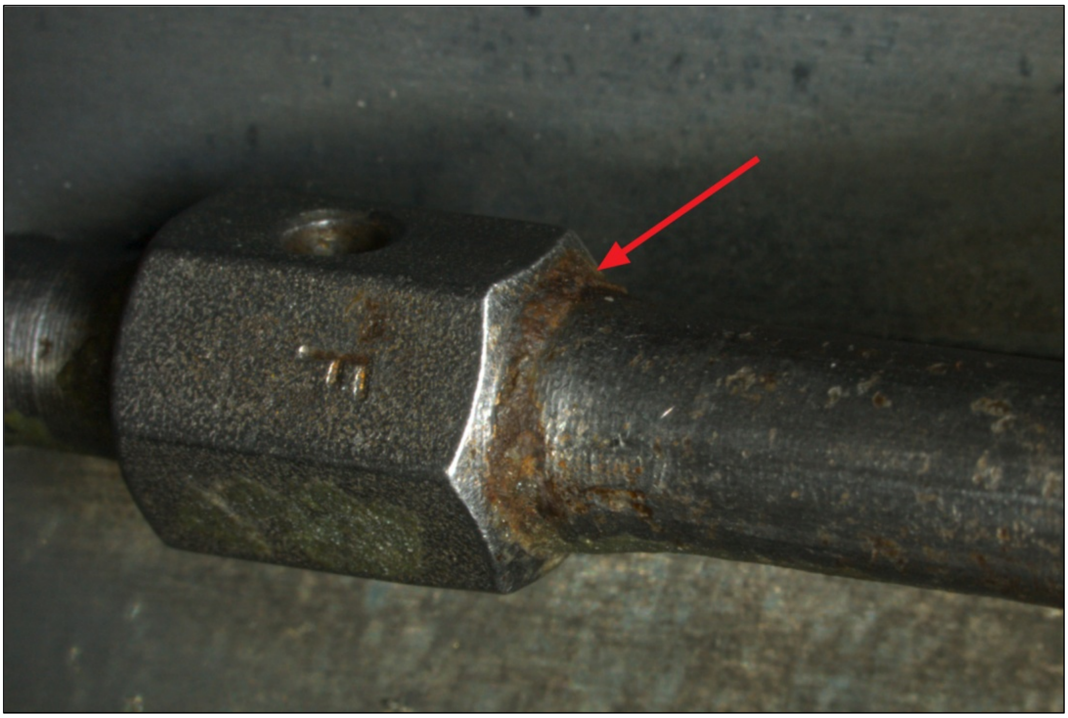

Figure 4: 'OO' terminal with discolouration and rough/pitted surface on the centre section.

Following initial examination using a stereobinocular microscope up to approximately 40x magnification, eight samples were identified as having potential pitting corrosion (details in Table 1), however after some additional cleaning only four were selected for further examination (highlighted in blue).

Table 1: Details of the terminals that exhibited evidence of possible corrosion. Samples highlighted in blue were subject to further examination

Sample number	Details
1	‘F’ MS21260-S4R[5], R/H carry through
2	‘F’ MS21260-S4L
3	‘F’ AN669-S4R
4	‘bell’ MS21260, PA28R-201, aileron direct
5	‘OO’(?) MS21260
6	‘F’ AN669-S4R, C172 elevator
7	‘bell’ MS21260-L4RH, Beech A36 , elevator cable forward up pulley
8	‘bell’ MS21260-S4LH, PA28R-201, LH aileron direct cable

Sample 4 had a localised orange/brown deposit on the surface (Figure 5). Removal of the deposit showed that the surface of the terminal underneath was stained (Figure 6) and further cleaning with an abrasive cloth revealed the presence of widespread small corrosion pits (Figure 7). No evidence of cracking was observed on any of the submitted cables.

Figure 5: Deposit on the surface of sample 4; a ‘bell’ MS21260 terminal

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[5] The dash numbers provided specific information on the terminal including left or right hand thread, wire rope diameter, minimum breaking strength, and cross sectional area.

Figure 6: Surface of sample 4 following removal of deposit in Figure 5

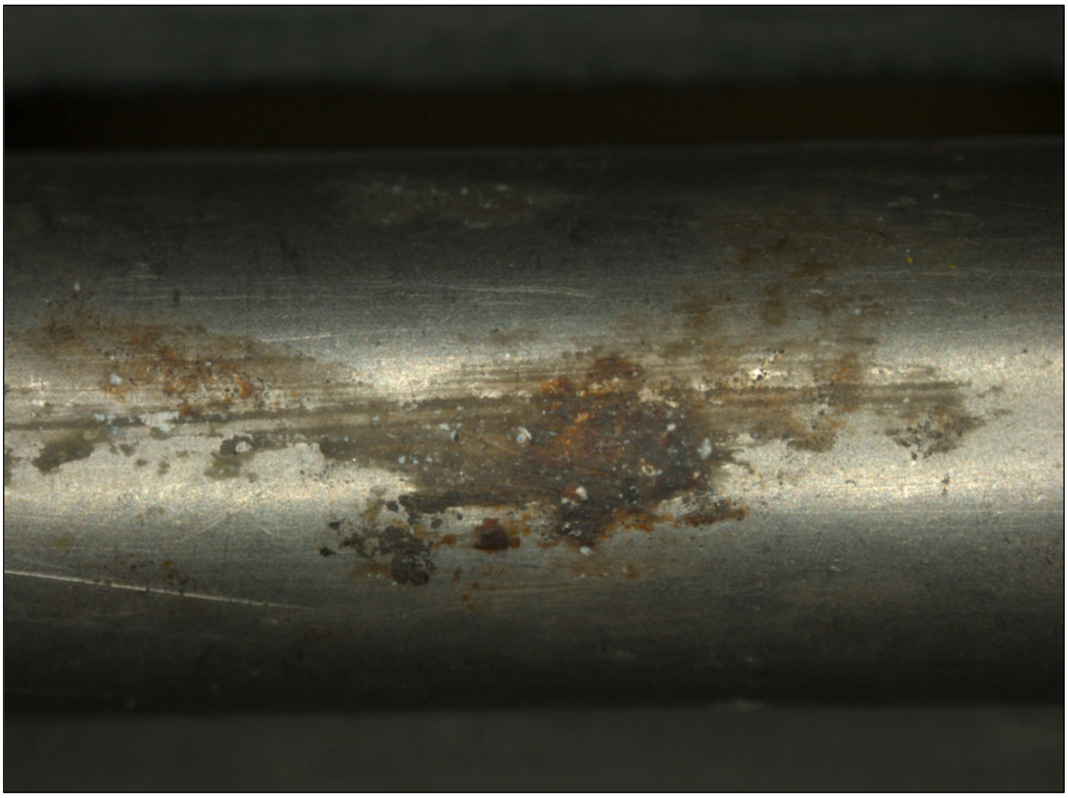
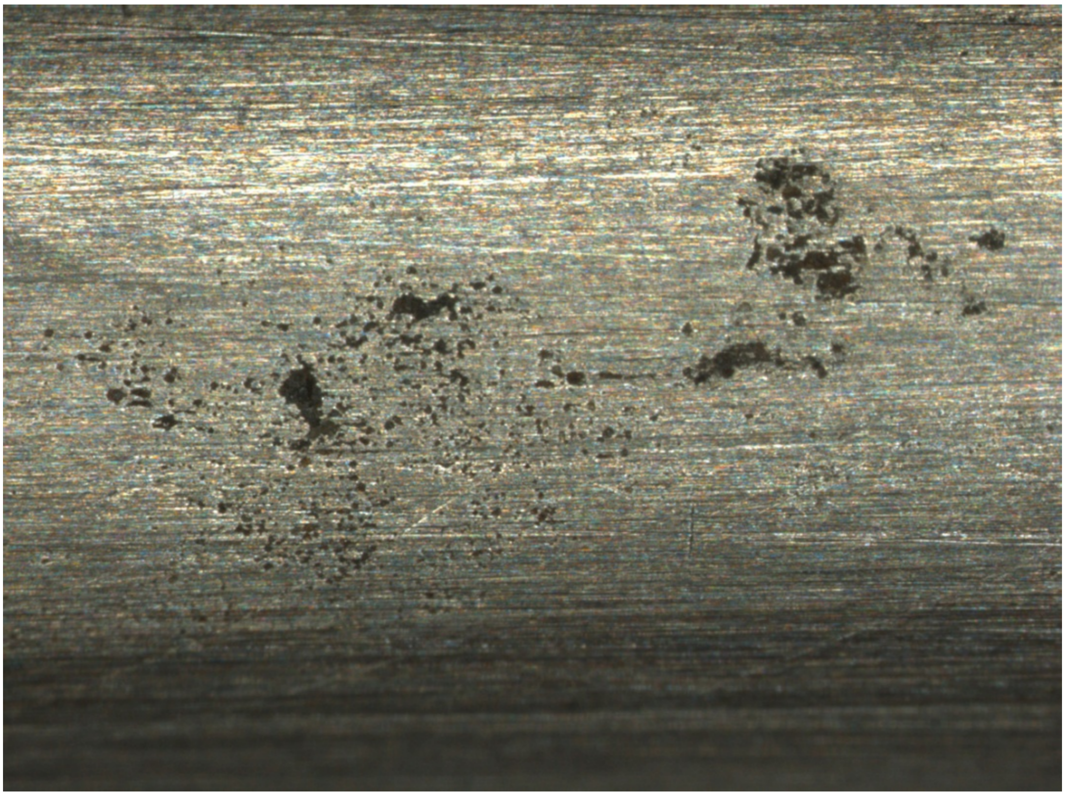


Figure 7: Pitting observed on sample 4 in area shown in Figure 6 after cleaning



Non-destructive inspection

All terminal samples were examined using a fluorescent dye penetrant inspection technique. While circumferential linear indications were identified at the radius between the wrench flats and the shank of the terminal on some samples, closer inspection revealed the indications to be associated with surface features most likely stemming from the manufacturing process (i.e. tool marks).

Scanning electron microscopy

Examination of the four selected samples in Table 1 using the scanning electron microscope (SEM) confirmed the presence of widespread shallow pits (Figure 8). The use of energy dispersive x-ray spectroscopy (EDS) confirmed the base alloy type as a 303 Se stainless steel, and identified the presence of chlorides within and around the pits (Figure 9).

Figure 8: Magnified view of the widespread pitting on sample 4 as shown in Figure 7

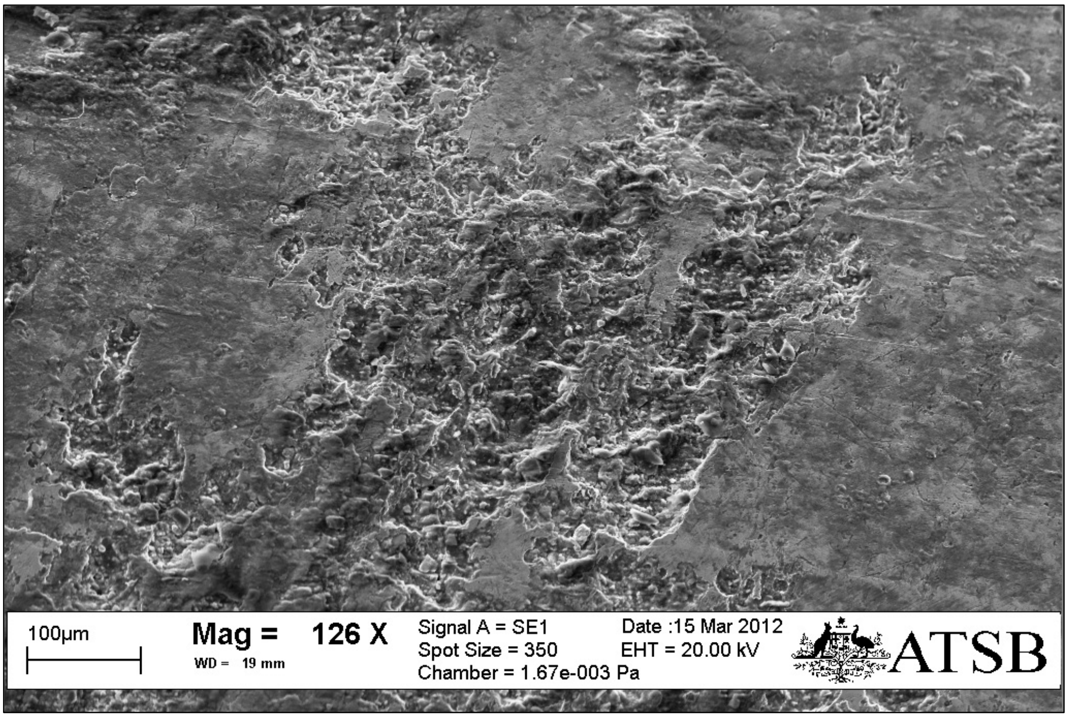
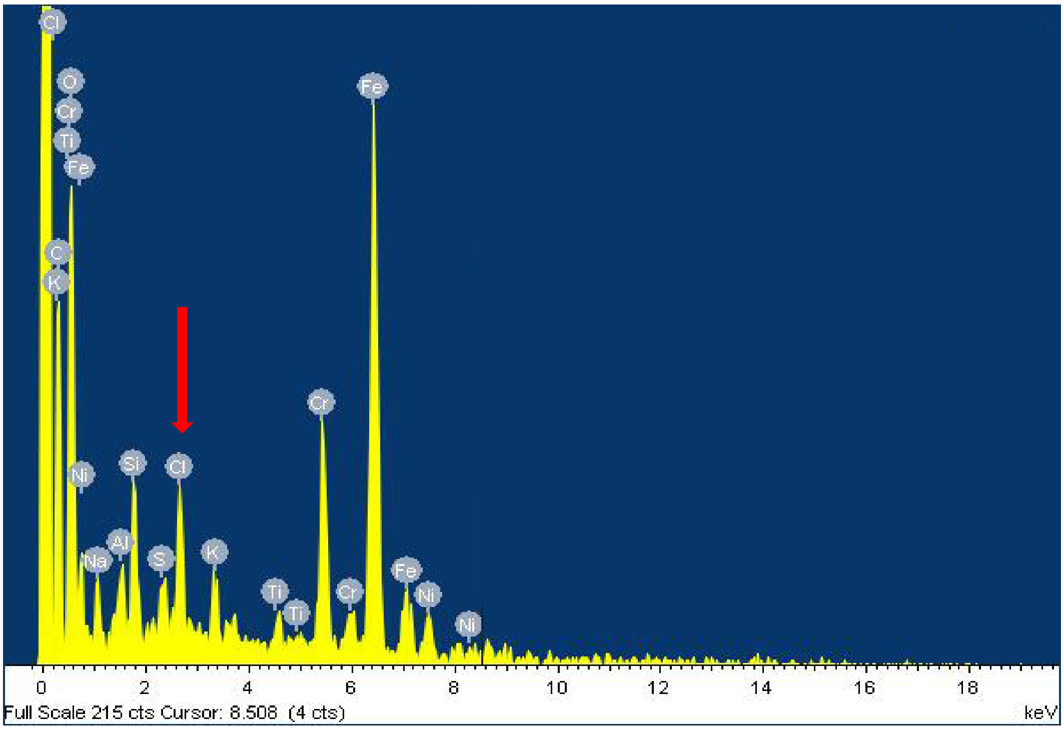


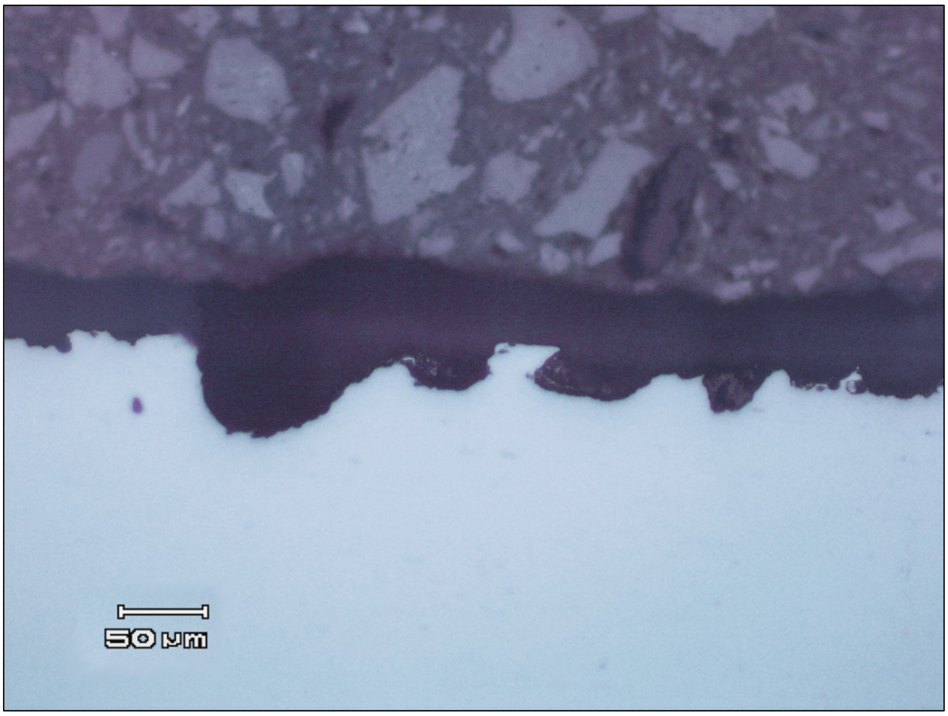
Figure 9: Energy dispersive X-ray spectrum of the corrosion product (chloride peak arrowed)



Microstructural examination

A cross section was removed from sample 4 and prepared for microstructural examination. The polished cross section confirmed the presence of a large number of wide, shallow pits along the sample length. The nature of the pits was consistent with chloride pitting in stainless steel (Figure 10). There was no observed evidence of any associated cracking from the pits or other features consistent with stress corrosion cracking.

Figure 10: Surface pitting observed during the microstructural examination



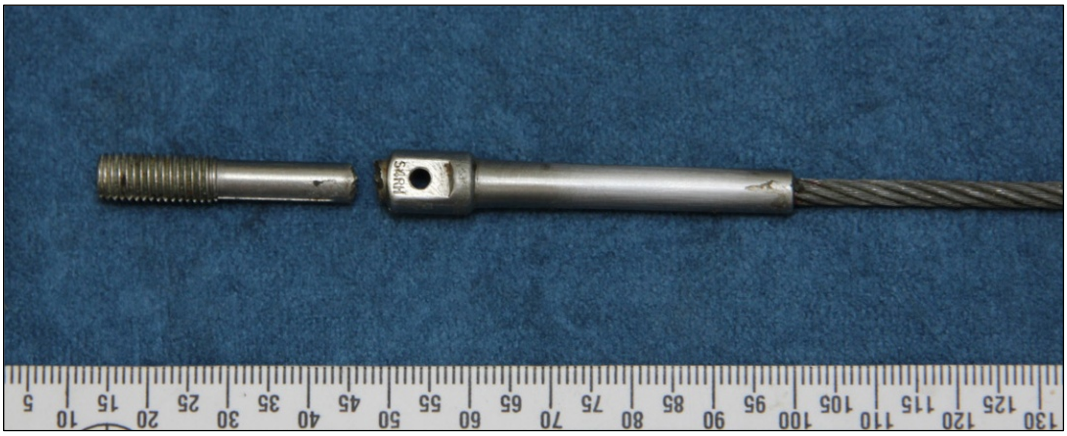
Failed terminals

Piper PA-32

During the investigation, CASA were advised of a terminal failure in the ‘up’ elevator cable of a Piper PA-32 aircraft. The cable and terminal fitting was submitted to the ATSB for examination, along with the other assemblies that were fitted to the aircraft. It was reported that the terminals had most likely been in service for the life of the aircraft, which was around 35 years.

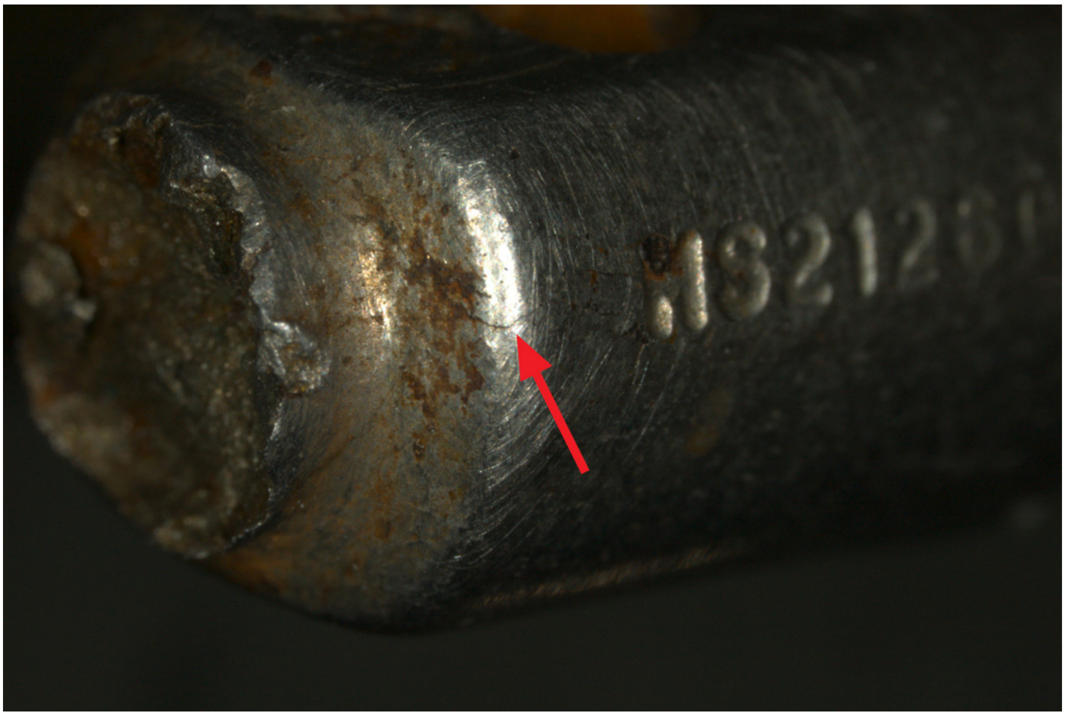
The terminal had fractured through the shank on the threaded end in the region adjacent to the wrench flats (Figure 11). The terminal had the ‘bell’ manufacturer’s mark and was part number MS21260.

Figure 11: Failed terminal submitted to the ATSB



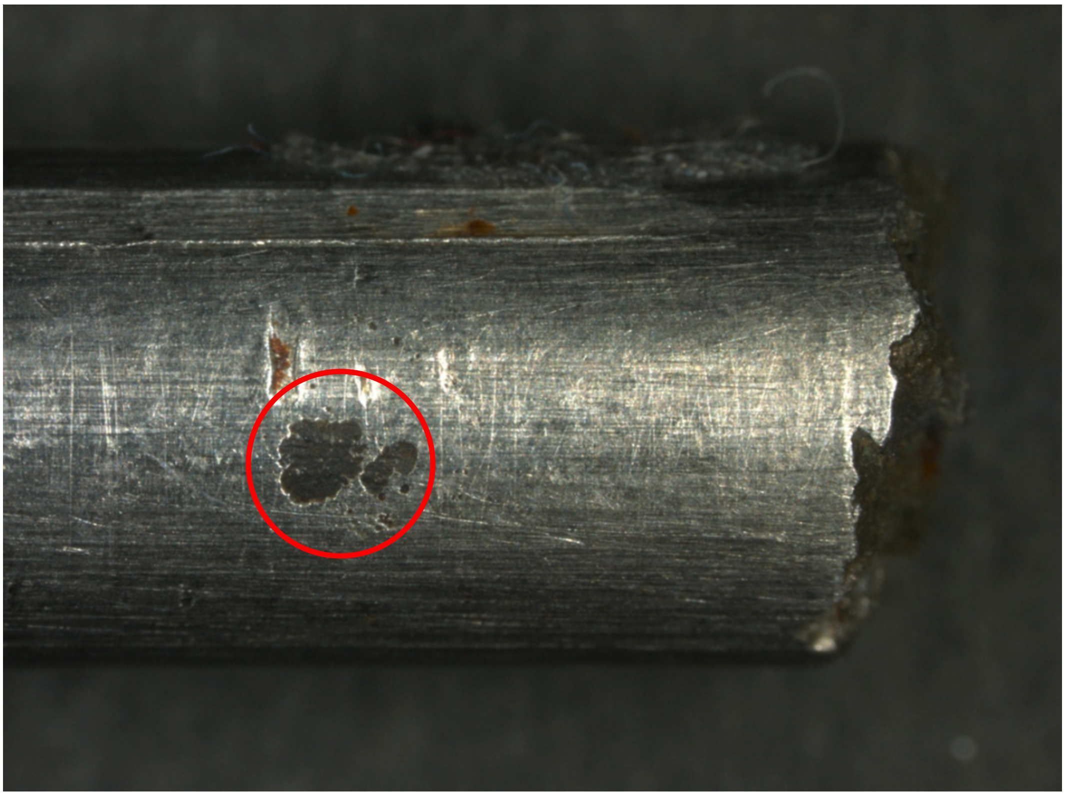
The fracture surface and surrounding area was discoloured, and exhibited a rough appearance. The appearance of the fracture face, together with branched, secondary cracking extending from the primary fracture face into the wrench flats (Figure 12) was indicative of a stress corrosion cracking failure mechanism.

Figure 12: Widespread discolouration and secondary cracking (arrowed) on failed terminal



An area of discolouration was observed on the shank on the threaded side of the fracture, approximately 3mm from the fracture face (Figure 13). Closer examination revealed shallow pits, similar to those observed on the previously submitted samples.

Figure 13: Failed terminal showed similar pitting (circled) to the previously inspected samples

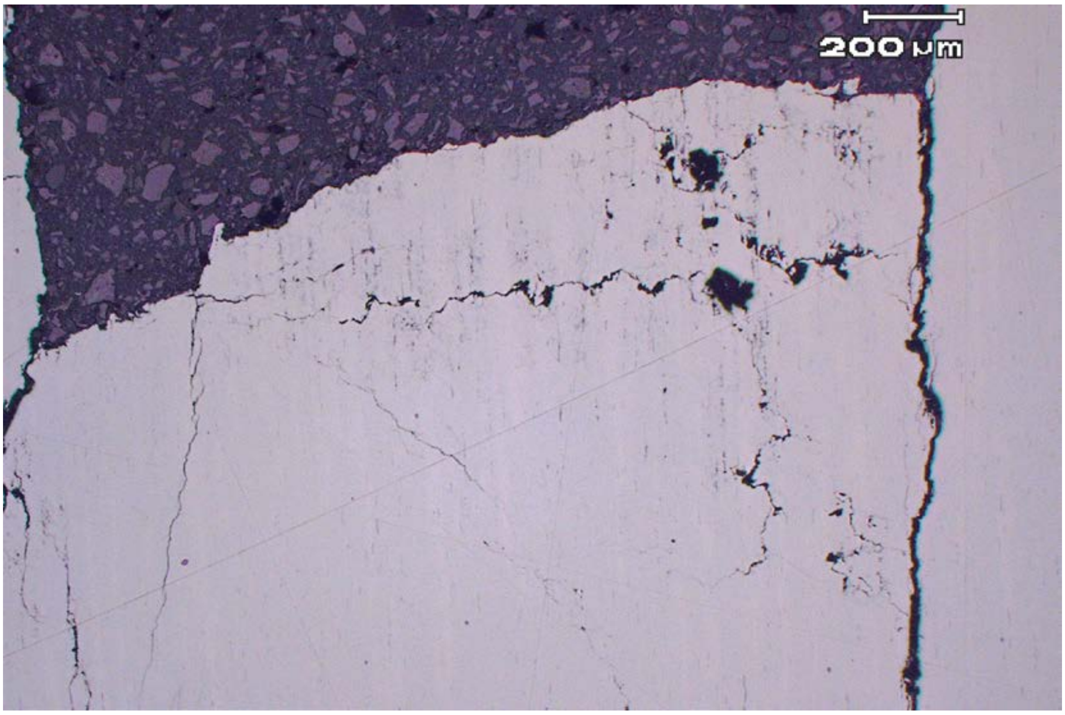


Minicab GY-201

CASA received a service difficulty report on 6 August 2012 regarding a failed aileron control cable terminal on an amateur built aircraft (Minicab GY-201) that was identified during an inspection in accordance with AWB 27-001 Revision 3. The terminal was part number AN669, exhibited the ‘F’ manufacturing symbol and had probably been in service since the aircraft was manufactured in 1980. The terminal had fractured but had remained connected by the lock wire. The surfaces in the region of the failure were heavily discoloured and the fracture surface had a rough appearance (Figure 14). Significant pitting corrosion was observed on the external surfaces and the internal surfaces of the lock wire hole and swaged end. One half of the terminal (the side containing the wrench flats) was sectioned for metallographic examination perpendicular to the fracture. The polished cross section revealed an extensive network of highly branched cracks. The cracks were predominantly transgranular in nature, and extended both longitudinally through the sample from the primary fracture surface, and horizontally from the external surfaces (Figure 15). These features confirmed that the mode of failure was SCC. Cracking from the lock wire hole surface and from the internal swaged surface was also observed.

Figure 14: Failed terminal from Minicab GY-201 aircraft identified during inspection

Figure 15: Microstructural cross section of terminal shown in Figure 14 showing network of cracks



Piper PA-18 aileron cable terminal

In March 2012, the New Zealand Civil Aviation Authority reported an aileron control cable terminal failure on a Piper PA-18 aircraft (terminal part number MS20668[6]). Failure of the terminal was

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[6] MS20668, *Terminal, wire rope, swaging, eye end*, Revision G with Amendment 2, 8 March 2011. This part number included an eye fitting instead of a threaded end, but was otherwise similar to part number MS21260.

identified during an inspection, and it had a reported service life of more than 20 years. While the failure mechanism was identified as stress corrosion cracking, the location differed from those previously examined in Australia, in that the cracks had initiated on the inside of the swaged end, at the surface in contact with the cable. Multiple crack origins were identified and were located between wires that had been pressed into the inside surface of the terminal or to one side of a wire. Not all cracks had propagated through to the external surfaces, and as such, would not have been detectable during a visual examination.

Safety actions

The subject of stress corrosion cracking (SCC) of flight control cable terminals has been an ongoing issue, with the first failure reported in Australia in 1995. A number of safety actions have been taken by various parties in Australia and abroad, and have been focussed on generic cable terminals with part numbers AN669 and MS21260, or those that have been manufactured from SAE-AISI grade 303Se stainless steel. The following is a summary (but does not include all) of the action taken to date:

- National Transportation Safety Board (NTSB), *Safety Recommendations A-01-6 through -8*, April 16, 2001.

  The recommendations were directed at the Federal Aviation Administration (FAA) and included:

  - That the FAA issue airworthiness directives, applicable to Piper PA-28, Piper PA-44, and Cessna 172 airplanes older than 15 years, to require visual inspections of terminal fittings.
  - That the FAA determine which aircraft models have control cable terminals manufactured from SAE AISI-303Se stainless steel and evaluate the need to require recurrent visual inspection.

    The NTSB determined that terminals like the MS21260 and AN669 were generic components that were used in across a variety of aircraft types and manufacturers, including Piper, Cessna and Beech, but that it may also be used widely across helicopters and commercial aircraft. While the majority of failures were on Piper aircraft, which apply a higher tension on the stabilator cables, there did not appear to be a threshold stress below which cracking would not occur.

  - That the FAA immediately notify all manufacturers of the cracking and corrosion problems currently being experienced with terminals made from SAE-AISI 303 Se stainless steel.

The recommendations were closed by the NTSB on 17 May 2002 citing that acceptable alternate action had been taken.

- Federal Aviation Administration (FAA)*, Special Airworthiness Information Bulletin (SAIB) CE-02-05*, November 1, 2001.

  The SAIB recommended that owners or operators of rotary and fixed-wing aircraft inspect the flight control cables at 100 flight hour intervals, or at each annual inspection. If corrosion or pitting was found, the control cable attachment fittings were to be replaced, even if the manufacturer’s maintenance manual did not recommend replacement of corroded fittings.

  It also stated that the FAA had found no evidence of corrosion or pitting in the aircraft fleet, but in isolated specific airframe applications, especially in models where the battery was located very close to the area in which control cables enter the bottom of the fuselage. The Piper PA12, -14, -18, -2 and -28R have batteries installed in the tail cone and had 18 reported cases of corrosion in a fleet of 14,564 aircraft. Cessna 172 models had 11 reported cases of broken/frayed cables in a fleet of 24,925 aircraft. It continued that while the problems were reported on Piper and Cessna aircraft, the same problems may occur or exist on any aircraft of other manufacturers.

- Civil Aviation Safety Authority (CASA) Airworthiness Bulletin AWB 27-1, *Control cable terminal – retirement*, August 2001

  Issue 2 of the AWB was released on 31 October 2011. The bulletin urged operators and maintainers to consider replacing all control cables having terminal fittings manufactured from stainless steel SAE-AISI 303Se before reaching 15 years in service.

  Issue 3 was released on 5 June 2012 with an additional example of a terminal that had corroded from within the swaged end where the cable was attached.
- FAA, *SAIB CE-11-01*, October 4, 2010.

  The purpose of the SAIB was to provide information to reduce the possibility of failure of the horizontal stabilator turnbuckle/control cable assembly. The SAIB recommended the incorporation of a Piper service letter which detailed procedures to inspect the flight control cables and fittings at 100 flight hour intervals or at each annual inspection.
- Piper Aircraft Company, Service Bulletin (SB) No 1245, *Stabilator control system inspection,* May 3, 2012.

  The SB advised operators of specific failures related to the horizontal stabilator turnbuckle/control cable assembly on Piper airplanes, and stipulated an initial inspection at the next scheduled maintenance event upon reaching 15 calendar years in service. Following the initial inspection, compliance was to be accomplished on a recurring basis, at an interval not to exceed 2,000 hours or 7 calendar years in service.

  The SB was updated as SB No 1245A on November 28, 2012 to clarify cleaning and inspection instructions.
- FAA, *Airworthiness Directive AD 2013-02-13*, March 11, 2013

  The AD was applicable to Piper Aircraft PA-28, PA-32, PA-34 and PA-44 airplanes and was prompted by reports of control cable assembly failures that may lead to failure of the horizontal stabilator control system; potentially resulting in loss of pitch control. The AD required visual inspection of the control system in accordance with the Piper Aircraft Company SB No. 1245A and replacement of parts where necessary.

  The AD was supported by the NTSB, who stated that they had investigated a further two accidents and one incident[7] in the past two years which involved control cable assembly failures on Piper PA-32R aircraft as a result of SCC. One of the failed terminals (case number ERA12IA237) had a ‘bell” marking and according to a logbook entry, had undergone an annual inspection in accordance with the Piper airframe inspection on the day prior to the occurrence flight.

CASA has also initiated project CS 12/41, *Amendment to CAO 100.5 inclusion of a mandatory inspection of Control Cable Terminals manufactured from SAE-AISI 303 Se stainless steel*[8]. The proposed amendment was in response to a number of service difficulty reports from aircraft operators reporting control cable terminal failures of terminals that had been manufactured from SAE-AISI 303 Se and had a time in service of 15 years or greater. The amendment to CAO100.5 (*General requirements in respect of maintenance of Australian Aircraft*) seeks to mandate a recurring inspection of cable terminals that have a total time in service of 15 years or greater.

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[7] Full reports for NTSB case numbers CEN11LA048, CEN11LA275 and ERA12IA237 are available on the NTSB website at http://www.ntsb.gov./aviationquery/index.aspx

[8] Information and updates on the project can be found on CASA’s website at the following address; http://www.casa.gov.au/scripts/nc.dll?WCMS:PWA::pc=PC_101270

Safety analysis

A selection of 54 aircraft control cable terminals were received from the Civil Aviation Safety Authority (CASA) for metallurgical examination, in an endeavour to identify whether any of the terminals was exhibiting the characteristics of a stress-corrosion cracking (SCC) mechanism. The terminals were of the type identified in CASA Airworthiness Bulletin (AWB) 27-001, as being manufactured from SAE-AISI 303Se free-machining austenitic stainless steel; that alloy being particularly susceptible to SCC when exposed to environments containing levels of chloride-containing compounds (such as common salt).

Stress Corrosion Cracking

While no cracking was identified on the large batch of terminal samples submitted by CASA, evidence of pitting was observed on several of the terminals, with pitting attack being a known precursor to SCC. It was noted that the terminals were all collected from an operator in north-western Victoria, and although the full operational life of the terminals was not confirmed, the environmental conditions in north-western Victoria were considered to be relatively benign for SCC, due to the relatively low average humidity and the low potential for environmental chloride exposure.

The two fractured terminals received by CASA and passed to the ATSB during the course of the investigation had failed in a manner consistent with an SCC mechanism. Some years previously, the ATSB had investigated an instance of SCC of a control cable terminal on a Beech V35A aircraft. All the failed terminals had been in service for approximately 35 years at the time of failure.

While a number of inspections have previously been recommended and guidelines issued to mitigate the risk of SCC-related control cable terminal failure, such events continue to occur. It is considered that effective in-situ inspection of the terminals is an inherently difficult task to undertake, and not discounting the issues associated with gaining physical access to the components, there is an inherent difficulty in identifying fittings that may be at an increased risk of failure. As demonstrated by the failure identified in New Zealand, the early indicators of impending failure, such as corrosion pits and discolouration, may not always be visible on the surfaces being inspected.

Stress corrosion cracking of SAE-AISI 303 Se stainless steel terminals, like similar ageing aircraft issues, will continue to be an area of risk for aircraft owners and operators into the future as the terminals of a susceptible material are exposed to the corrosive environment for longer periods of time.

Findings

From the evidence available, the following findings are made with respect to the examination of the flight control cable terminals submitted by the Civil Aviation Safety Authority and should not be read as apportioning blame or liability to any particular organisation or individual.

Key findings

- The flight control cable terminals of part number MS21260 and AN669 had been manufactured from a material (SAE-AISI 303 Se austenitic stainless steel) that is particularly susceptible to chloride stress corrosion cracking.
- Many of the terminal samples originally submitted for examination revealed corrosion pitting and surface discolouration, however none exhibited evidence of stress corrosion cracking.
- Failure of two flight control cable terminals during the course of the investigation were confirmed to be a result of a chloride stress corrosion cracking mechanism.
- Visual inspection alone has been shown to be an incomplete defence against stress corrosion cracking related failures.
- Failure of control cable terminals due to stress corrosion cracking is an ageing aircraft issue with a potential for safety impact that will increase over time.

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Civil Aviation Safety Authority
- National Transportation Safety Board
- US Federal Aviation Administration

References

Civil Aviation Safety Authority, Airworthiness Bulletin 27-001, *Control cable terminal – retirement, Issue 3*, 5 June 2012.

Federal Aviation Administration, *Special Airworthiness Information Bulletin No. CE-02-05*. November 1, 2001.

Federal Aviation Administration, Airworthiness Directives, AD 2013-02-13, March 11, 2013.

National Transportation Safety Board, *Safety Recommendation A-01-06 through -8*, April 16, 2001.

Piper Aircraft Corp, *Service Bulletin No. 1245A, Stabilator control system inspection*, November 28, 2012.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority (CASA). The submission received from CASA was reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of z taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical safety issue:** associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant safety issue:** associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor safety issue:** associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

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Investigation

ATSB Transport Safety Report
Aviation External Investigation
Aircraft control cable terminal fittings –
ATSB technical examination
AE-2012-028
Final – 9 April 2013