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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Investigation – 200501462
Final

Engine-driven fuel pump bearing – material substitution

Teledyne-Continental Motors (TCM) aircraft engines

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Abstract

On 11 August 2003, a twin-engine Cessna 404 'Titan' aircraft (VH-ANV) crashed into scrub land near Jandakot airport, WA, following the failure of the right engine immediately after takeoff. The ATSB investigation (200303579) found that the engine failure had been precipitated by the seizure of an engine-driven fuel pump (EDFP), which had been previously repaired using an inappropriate (non-original) material to replace the pump shaft sleeve bearing. That repair had been designed and approved by a person authorised under the Civil Aviation Regulations (1988) part 35 (CAR 35).

In April 2005, after the discovery of another CAR 35 approved pump repair that substituted the original pump bearing material with an unsuitable alternative, the ATSB commenced an investigation into the circumstances surrounding the material selection processes and the factors contributing to the inappropriate material selection. Concurrent with the ATSB investigation, an inquest conducted by the WA State Coroner examined the circumstances of the VH-ANV accident, including the pump bearing material issues.

The ATSB investigation found that in both instances, the authorised persons that prepared the Engineering Orders (EO) for the EDFP repairs, had done so without specific knowledge of the differences between the original and newly selected materials in regard to their bearing properties, and the precise conditions under which the fuel pump bearings operated.

Safety action resulting from the investigation of these issues included the publication of the VH-ANV investigation findings in various industry journals and educational materials. The findings and recommendations of the VH-ANV coronial inquest, and the industry communications released by the Civil Aviation Safety Authority (CASA) acted to further promote understanding of the material selection deficiencies.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external bodies.

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 enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, 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 proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

INTRODUCTION

Background information

On 11 August 2003, a Cessna 404 'Titan' aircraft, registered VH-ANV, sustained an engine failure shortly after takeoff from Jandakot Airport, WA, and subsequently crashed into adjacent scrub with the loss of two lives. The ATSB occurrence investigation (200303579) found that the engine failure had been precipitated by the seizure of the associated engine-driven fuel pump (EDFP), which had been previously overhauled to replace the original equipment manufacturer's (OEM) leaded bronze[1] shaft bearing with a remanufactured aluminium bronze[2] bearing. The selection of aluminium bronze for the application was inappropriate, and led to the progressive accumulation of frictional damage, culminating in bearing seizure and pump failure. Remanufacture of the pump bearing was permitted under the Civil Aviation Regulations (CAR) by the issue of an Engineering Order (EO) from an aeronautical engineer authorised by the Civil Aviation Safety Authority (CASA) under the provisions of CAR part 35. The final report for the ATSB investigation of the VH-ANV occurrence was released in March 2005. The findings of a coronial inquest into the accident by the State Coroner for Western Australia were published in December of that year.

On 7 April 2005, shortly after the release of the VH-ANV report, the ATSB became aware of the existence of another engineering order, issued by a CAR 35 authorised individual, which provided for the replacement of specific EDFP bearings with an aluminium bronze alloy, similar to that which contributed to the failure of the VH-ANV pump. In concert with actions by CASA and the ATSB to identify and remove from service any bearings produced to that EO, the ATSB initiated an investigation into the circumstances surrounding the issue of that second EO and the associated material selection processes.

1 A leaded bronze is an alloy of copper and tin, with the addition of lead to enhance the boundary lubrication properties and embeddability of the material.

2 An aluminium bronze is typically an alloy of copper, aluminium and iron, producing a hard, high strength and corrosion resistant material.

FACTUAL INFORMATION

Engineering order preparation

The ATSB sought and was provided information from the organisation that had prepared the second EO, regarding the processes followed in the preparation of the specification for the bearing replacement. While the organisation had acted to suitably identify the OEM fuel pump bearing material, it had elected to substitute an aluminium bronze alternative, on the basis of the reported unavailability of the original alloy type, and the assumption that the alternative had 'overall superior properties'. It was stated that, at the time the EO was prepared, the higher strength and wear resistance of the aluminium bronze was considered to represent an improvement over the OEM leaded bronze, which would reportedly become unserviceable due to excessive wear.

Anecdotal information made available to the ATSB during the investigation of the VH-ANV occurrence suggested that the availability of OEM replacement bearings and fuel pump components was limited; thus necessitating the local remanufacture of components in order to avoid prolonged aircraft unserviceability.

Coronial inquest

An inquest into the loss of life resulting from the VH-ANV accident was convened by the State Coroner for Western Australia on 18 April 2005, with the inquest findings delivered in December 2005. As part of its scope, the inquest closely investigated the circumstances surrounding the inception and content of the EO for the fuel pump bearing replacement. The salient findings of the inquest in regard to those issues were:

- At the time of the EO inception and creation, the EDFP sleeve bearings were not available from the OEM as separate, discrete items.
- For commercial reasons, the specifications for the sleeve bearings were not available from the OEM.
- Part 35 of the 1988 Civil Aviation Regulations (CAR) permits individuals authorised by CASA, the ability to approve the design of a modification or repair to an aircraft.
- The steps undertaken in the preparation of the design for the sleeve bearing replacement did not include any form of positive identification or characterisation of the original sleeve material.
- Aluminium bronze was selected as the material for the remanufacture of the sleeve bearing on the basis of a presumption that it was the same material as the original item, and that published literature supported its use in the EDFP application.
- In the context of the manner of EDFP bearing operation, aluminium bronze materials are unsuitable for the replacement of the original leaded bronzes, in light of their poor resistance to adhesive wear (galling) under conditions of marginal external lubrication.

The coronial inquest also considered the role of CASA in its oversight of CAR 30 approved organisations and CAR 35 authorised persons. The inquest found:

> 'At the time of the crash, CASA's primary mechanism for identifying problems of the type relevant to engineering order EO6826/1 was by way of audits.'

It was also noted that:

> 'CASA had conducted limited audits during the relevant period and did not comply with the intervals which it had set for itself in relation to the conducting of audits.'

ANALYSIS

Safety issues

Several interrelated safety issues became evident as a result of investigations into the VH-ANV accident and the issue of engineering orders for the remanufacture of original-equipment fuel pump bearings from non-original alloy types.

In the context of the VH-ANV occurrence, the organisation that designed the repair of the engine-driven fuel pump stated that their intent was to replace the bearing 'like for like', however, they failed to properly identify the original alloy type, and thus were not adequately equipped to make a decision in respect of a replacement alloy. In respect of the second engineering order, that organisation had properly identified the alloy type, however, they subsequently made a decision to substitute an alternative on the basis of their own interpretation of generic material property information alone.

The decisions taken by both organisations, on analysis, would appear to be knowledge-based errors, in that neither company nor individual had the depth of knowledge and understanding to adequately identify the risks associated with material-based decisions without independent verification or suitable test work being undertaken.

Less definitively, in terms of direct contribution to a reduction in safety, was the frequency and thoroughness of CASA audits undertaken of approved organisations and individuals. The evidence suggests that oversight by a central authority (in this case CASA) is important in ensuring consistency and technical adequacy, with infrequent or shallow audits potentially leading to variability in the quality of engineering outputs.

SAFETY ACTION

Previous ATSB investigation findings

The awareness of the need to consider the broader implications of material selection has been well promoted by the publication of the ATSB final report into the VH-ANV accident, and the subsequent coronial inquest findings. A synopsis of the investigation findings was also published in the ATSB supplement of the March/April 2005 edition of CASA's *Flight Safety Australia* magazine.

Information and photographs from the investigation have also been incorporated into a commercially-developed software system designed to assist engineers in bearing material selection[3].

Coronial inquest findings

As part of the inquest findings, the State Coroner included a series of recommendations arising from the inquest. Of the 15 recommendations, four addressed the issue of CAR 30 organisations and CAR 35 authorised persons, including a recommendation for such organisations and individuals to:

> '…ensure that engineering orders contain sufficient information in each case to provide a clear indication as to the basis of the engineering order and specify whether the engineering order is proposing 'like for like' replacement or the construction of an entirely new item. In the event that an engineering order is approving a material change, the relevant file should contain a metallurgical report providing information in relation to the material in question.'

In respect of the oversight issue, the State Coroner recommended:

> 'That in future CASA ensure that reasonably comprehensive audits are in fact conducted in respect of all CAR 30 organisations and CAR 35 authorised persons on a regular basis of no more than 24 months duration.'

Civil Aviation Safety Authority

Upon being notified of the existence of the second engineering order providing for the substitution of the OEM EDFP bearing material with an aluminium bronze alloy, CASA undertook to notify all CAR 35 approved persons of the issue and requested that CASA be advised of any operational installations of pumps that had been repaired in such a manner. A draft Airworthiness Directive was subsequently issued to require the removal from service of any affected pumps, and consequently one such pump was located, identified and quarantined.

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3 'Mechanic's Toolbox' published by Sacramento Sky Ranch Inc. http://www.sacskyranch.com/mechanic.htm