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Australian Transport Safety Bureau

Engine pylon cracking involving Boeing 747-438, VH-OJT

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Addendum

| Page | Change | Date |
|------|--------|------|
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Engine pylon cracking involving Boeing 747-438, VH-OJT

What happened

On 5 October 2016, a Qantas-operated Boeing 747-438 aircraft, registered VH-OJT (Figure 1) was undergoing routine maintenance at a contracted repair and overhaul facility in the Hong Kong Special Administrative Region (SAR) in the People's Republic of China. Inspection of the No. 2¹ engine pylon identified cracking of four outboard strut ribs from within the torque box of the pylon (Figure 2).

Following technical advice from Boeing, the No. 2 engine was removed from its wing installation to allow access to the pylon and removal of the cracked strut ribs. The aircraft was repaired and, after completing the maintenance visit, it was returned to regular passenger service. The cracked ribs were sent to Boeing's facilities in the United States for specialist metallurgical examination.

Figure 1: Qantas Boeing 747-438 aircraft, registered VH-OJT



Source: Christopher Chai

Pylon inspection requirements

The engines on a Boeing 747 aircraft are mounted to pylons located on the underside of each wing. The pylons transmit thrust from the engine to the airframe and are designed to withstand flight loads from normal operation along with transient dynamic loading in the event of an engine failure. Hydraulic, fuel, electrical and air conditioning lines all pass through the pylon structure.

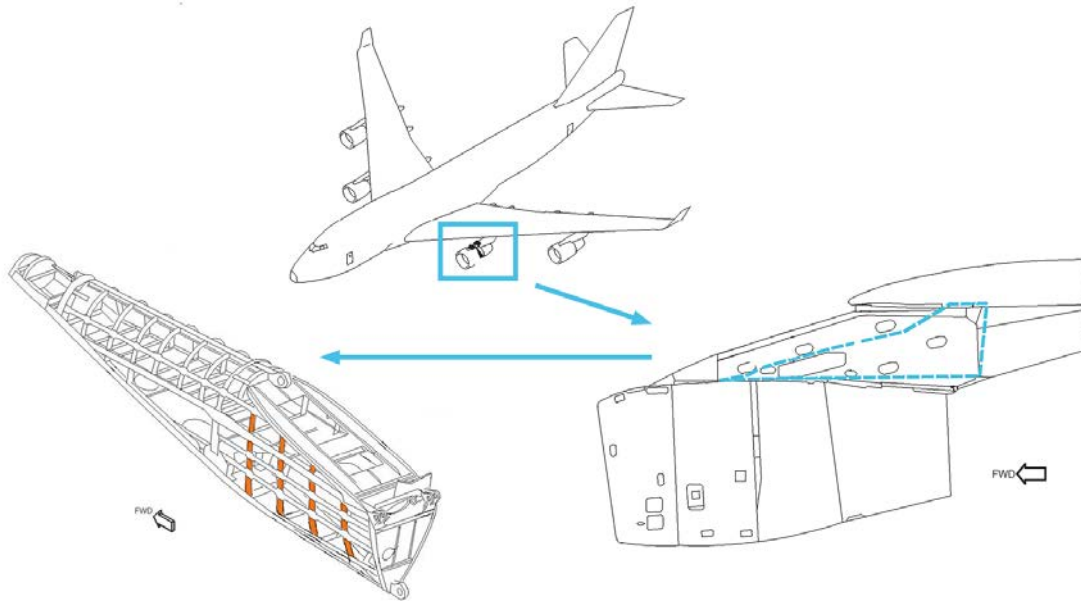
Boeing's ongoing maintenance requirements included an inspection of the engine pylon every 48 months. A general visual inspection within the torque box for corrosion damage was required

¹ The Boeing 747 has four engines numbered one through to four. The No. 1 engine is located at the outboard position on the left wing and the No. 4 engine is located at the outboard position on the right wing. Engines No. 2 and No. 3 are at the respective left and right inboard wing positions.

along with a more detailed inspection for cracking of the ribs. The procedures noted that during the inspection, particular attention should be applied to the cutaway where stringers passed through each rib.

Qantas reported to the ATSB that several years prior to this occurrence, it had independently increased the frequency of the zonal inspections from 48 to 24 months due to repeated instances of corrosion and cracking damage within the pylon region. That new inspection interval was formalised by Qantas within its maintenance documentation for its 747 fleet.²

Figure 2: Boeing 747 engine pylon showing the location of the cracking (highlighted)



Source: Boeing, annotated by the ATSB

Manufacturer’s examination

Following removal from the aircraft, four cracked outboard strut ribs were sent to Boeing for metallurgical examination and fracture analysis. The examination confirmed that five cracks had developed in the strut ribs, all emanating from the rib cutaway region, ranging in length from 3—19 mm (Figure 3 to Figure 5). Boeing’s report³ contained the following detail:

- Optical examination of the fracture surfaces was conducted and no anomalies were found that might otherwise have contributed to the development of the cracking.
- Scanning electron microscopy (SEM) of the fracture surfaces did not find any aberrations or defects on the surfaces of the strut ribs that might have otherwise contributed to the development of the cracking.
- SEM analysis of the fracture surfaces confirmed that each strut rib had striations and crack-progression marks consistent with fatigue cracking. No evidence was found of ductile tearing or plastic deformation at the crack origins, which might otherwise suggest that the fatigue cracking had initiated due to excessive vibration or torque loads from a transient engine event.
- Metallographic examination of the aluminium alloy microstructure from each rib did not reveal any abnormalities that could have led to the fracture of the strut ribs.
- Chemical analysis of each strut rib found the composition met the materials specifications, as listed within the engineering drawings.

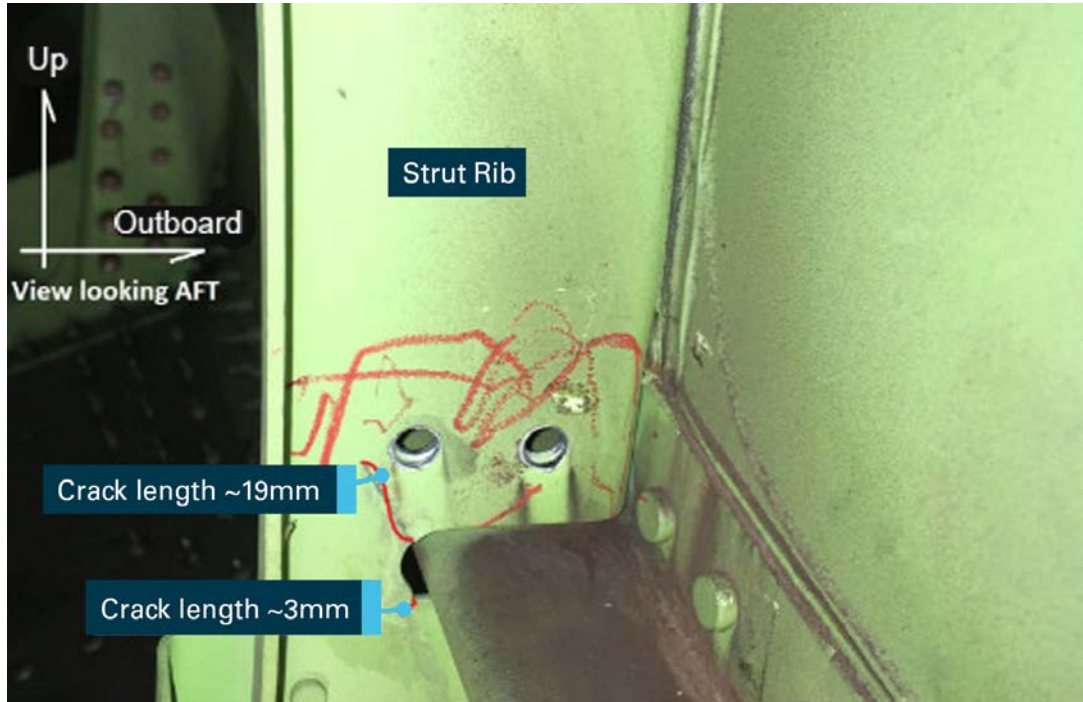
² Qantas Engineering and Maintenance procedure, J-744-C2-54-010 (Zonal inspection of No.2 engine strut).

³ Boeing Research and Technology Lab Report SR 15601, dated 20 May 2017.

- Hardness and conductivity measurements from each strut rib confirmed that they were within the correct range, as listed within the engineering drawings.
- The ribs were painted and primed in accordance with manufacturing specifications.

Boeing also conducted a structural loads analysis on the pylon, which confirmed that despite the presence of the cracking, the No. 2 engine pylon retained sufficient residual strength for all certified loading conditions.

Figure 3: A strut rib in-situ within the No. 2 pylon with two cracks identified



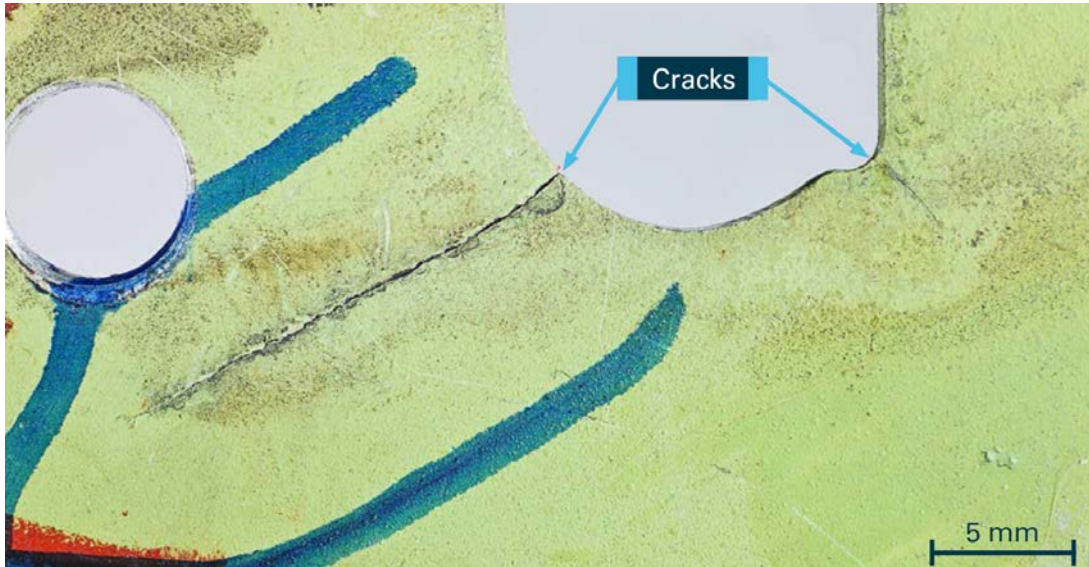
Source: Boeing, annotated by the ATSB

Figure 4: The strut rib from Figure 3 after removal from the pylon



Source: Boeing, annotated by the ATSB

Figure 5: Close-up of the cracking in the cutaway region shown at Figure 4



Source: Boeing, annotated by the ATSB

Aircraft history

On 24 June 2016, a few months before the detection of the pylon cracks, VH-OJT sustained a failure of the low-pressure turbine from the No. 2 engine during the take-off roll. This resulted in a high-speed seizure of the engine resulting in significant vibration and torque loads on the pylon. Following removal of that engine, the pylon was inspected and no damage to the critical structural members was evident.

Maintenance records noted that when the cracks were discovered in the Hong Kong SAR, the aircraft had accumulated 79,928 hours and 8,313 landings. There were no other identified defects reported from previous inspections on the No. 2 strut support assembly for VH-OJT.

Safety analysis

Cracking of the engine pylon strut ribs

During routine maintenance on 5 October 2016, four strut ribs from the No. 2 engine pylon were found to have developed fatigue cracks. The parts met the manufacturer’s engineering drawing and material specifications. With no obvious defects detected, it is likely that the fatigue cracking developed from exposure to vibratory loading that occurred within the pylon during normal engine operation. A factor that may have contributed to the crack growth was the number of hours and flight cycles that the airframe had accumulated within its service life. The manufacturer’s analysis indicated that despite the crack damage to the ribs, the pylon retained sufficient residual strength for all load cases, which indicates that the aircraft remained safe to operate.

Approximately 6 months prior to the detection of the strut rib cracking, the No. 2 engine sustained a seizure that resulted in the transmission of significant vibratory and torque loads into the pylon structure. Metallurgical analysis of the fracture at the crack origins did not show any evidence of plastic deformation or tearing of the alloy that might otherwise suggest that the seizure was a contributing factor to the cracking.

Pylon inspection

When compared with the 48-month inspection interval recommended by the manufacturer, the 24-month inspection interval set by Qantas provided greater opportunity for the timely detection of cracking and other defects within the pylon. The reduced inspection interval proved effective in this case, detecting cracks before they reached a level considered by the manufacturer to be a safety risk.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The fatigue cracking in four outboard strut ribs in the No. 2 engine pylon is likely to have developed from exposure to vibratory loading within the pylon during normal engine operation over the aircraft's service life.
- The extent of fatigue cracking in the ribs did not affect the structural integrity of the pylon for all certified load cases, which meant that the aircraft's safe operation was not affected.

Safety message

The Qantas Boeing 747 maintenance program for the engine pylon area is completed at a higher frequency and in more detail than is required by Boeing. This enhanced inspection regime was effective in detecting cracking of the strut rib assembly, before the cracks reached a level considered to be a safety risk.

This occurrence highlights the importance for vigilance during ongoing routine maintenance activities. It also highlights that, when relevant, operators should consider reviewing prescribed maintenance schedules in order to address issues that may develop as their aircraft age and accumulate time in service.

General details

Occurrence details

| | |
|--------------------------|------------------------------|
| Date and time: | 5 October 2016 |
| Occurrence category: | Incident |
| Primary occurrence type: | Component failure - fracture |

Aircraft details

| | |
|-------------------------|----------------|
| Manufacturer and model: | Boeing 747-438 |
| Registration: | VH-OJT |
| Operator: | Qantas Airways |
| Serial number: | 25565 |
| Aircraft damage: | Minor |

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. The ATSB 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; and 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 operations involving the travelling public.

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.

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.

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.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.