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Examination of Engine Gas Generator Fairing Panels

Boeing 747-438, VH-OJJ

EXAMINATION OF ENGINE GAS GENERATOR FAIRING PANELS

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EXECUTIVE SUMMARY

On 24 April 2001, a Boeing 747-400, VH-OJJ, experienced the loss of both left and right combustion fairing panels from the number three engine during take-off on a flight from Sydney to Los Angeles.

The fairing panels were ejected forcefully from the bypass duct of the engine, causing minor localised damage to the duct internal surfaces and the trailing edge of the centre wing flap section.

Examination by the Technical Analysis unit showed the damage to be consistent with fairing mis-installation, whereby the hooks on the right panel were not engaged with the respective socket pins of the upper fairing. This then permitted the free movement of the fairing sections to a point where they were caught by the bypass airflow and forcefully ejected.

The examination did not identify any defects in manufacture or maintenance of the fairing mounts or latches that could have contributed to the release.

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Technical Analysis

EXAMINATION OF ENGINE GAS GENERATOR FAIRING PANELS

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FACTUAL INFORMATION

Introduction

On the early evening of April 24 2001 at the commencement of a flight from Sydney to Los Angeles, Boeing 747 VH-OJJ lost both the left and right gas generator fairing panels from the number three engine during take-off. First knowledge of the incident came when the damaged panels and other smaller components were recovered from the undershoot area of runway 34L during a routine inspection the morning following the departure (figure 1). Confirmation of the loss subsequently came from a ground inspection of the aircraft at its destination, where damage to the trailing edge of the flap extension behind the number three engine was also noted.

Figure 1. Combustion fairing panel sections as recovered from the Sydney 34L runway undershoot area.

The panel sections and all recovered components were subsequently forwarded to the ATSB Technical Analysis unit for determination of the factors contributing to the loss of the items.

Component Description and History

The left and right combustion fairing panels fitted to the core of RB211-524 engines are located circumferentially around the gas-generator region (figure 2). Both side panels engage with a top panel using a pin and hook arrangement, with the entire assembly locked in place by two latches at the base of the larger right panel.

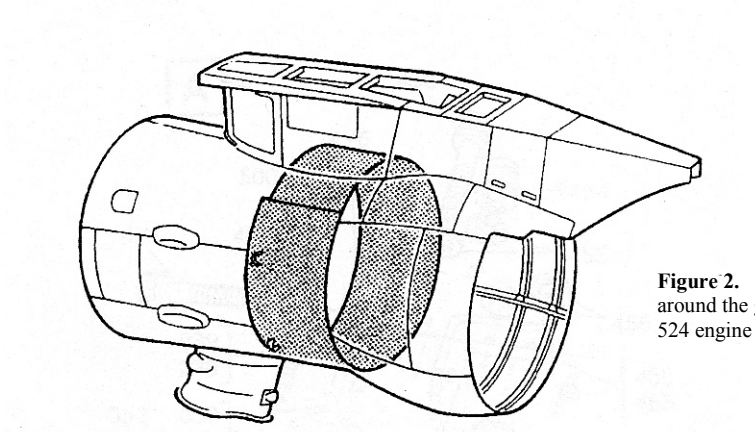


Figure 2. Location of the combustion fairings around the gas generator section of the RB211-524 engine core.

The right and left fairing panels were part numbers UL26239 and UL26237 respectively. The engine illustrated parts catalogue (IPC) identifies these part numbers as applying to panels manufactured to service bulletins SB71-8939 and pre SB72-C674.

The specific service history of the combustion fairing components was not routinely recorded. The panels in question however were removed during routine service activities immediately before the aircraft departure on April 24.

Visual Examination

Left Fairing Panel

The smaller left fairing panel was recovered intact. The forward edge of the panel showed extensive inward crushing and structural distortion (figures 3 & 4). Traces of yellow paint were found on the surfaces of the two partly flattened external vents (figure 5).

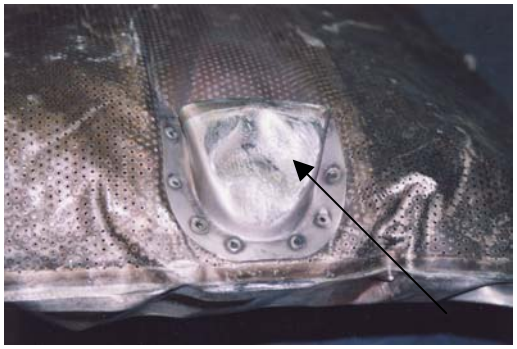


Figure 3 (Top Left). Left (smaller) fairing panel exterior, showing the crushing damage along the forward facing edge.

Figure 4 (Top Right). Interior of the left fairing section.

Figure 5 (Bottom Left). Damaged air vent within the left fairing, showing evidence of the yellow paint used inside the engine bypass duct.

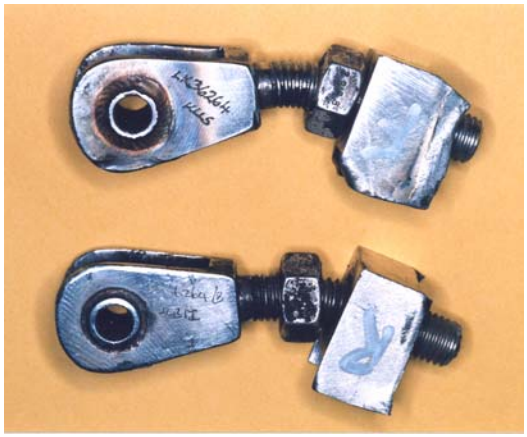
The three mounting hooks along the upper edge of the fairing panel showed varying degrees of mechanical damage and distortion (figure 6). The forward hook had opened extensively and showed backward and sideways bending (figure 7). Contrastingly, the centre and rear hooks had not opened to any great degree, although the rear hook had bent inward and showed evidence of a forceful impact with the runway surface.

Two adjustable clevises, which engage with a lever and hook arrangement on the right fairing, are normally located along the lower edge of the panel. In this case, both components had been physically torn from their mounts, producing considerable damage to the lower edge of the fairing (figures 8 & 9).

Figures 6 & 7. Mounting hooks along the top edge of the left fairing panel. Note the degree of distortion and opening of the right hook, which is the forward hook when installed on the engine.

Figures 8 & 9. Mounting points for the clevis fittings along the lower edge of the left fairing panel. Both had been physically torn from the structure of the panel.

The clevises themselves were recovered from the runway area and showed similar levels of threaded shank bending (figure 10). Both had failed at the point of connection between the mounting blocks and the sheet metal structure of the fairing panel. Several of the fractures between clevis mount and fairing were adjacent to weld seams (figure 11), although no evidence of welding defects or other related manufacturing faults was noted. All fractures were ductile in nature and were often associated with areas of plastic deformation of the associated panel structure (figure 12).



Figures 10 & 11. Clevis fittings and mounting blocks torn from the panel structure. Note the degree of bending overload present on the clevis shafts and the failure alongside the welded joint between mounting block and sheetmetal panel structure.

The clevises themselves showed varying degrees of wear and damage – most obviously to the pin of the rear unit, which presented appreciable outward bending and wear of the inside surfaces (figures 13 & 14).

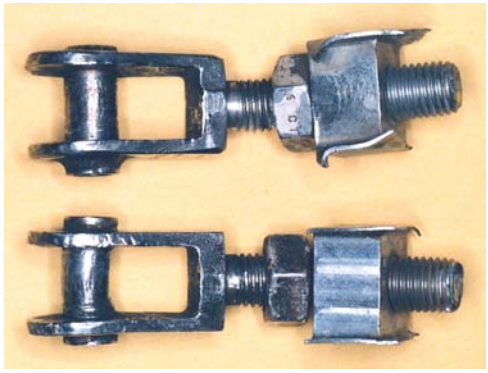


Figure 12. Clevis mounting block, showing clear evidence of a ductile overload fracture along the base.
Figures 13 & 14. Clevis fittings showing wear and distortion of the pins – most prominent on the forward fitting.

Right Fairing Panel

This unit was the largest of the three panels which surround the engine core and was recovered in two pieces – having fractured along a central join between the fabricated sections (figures 15 – 18). The failure of the panel along this location was characterised by torn and lifted sheet metal from the outer surface and by a seam of rivets that had been overloaded and torn from the connecting surfaces (figure 19). The single-piece fire seal strip (figure 20) had been torn away completely during the panel liberation and was recovered at some distance from the panel sections.

Figures 15 & 16 (Top). Exterior surfaces of the right fairing panel, which had fractured into two sections.
Figures 17 & 18 (Btm). Interior surfaces of the right fairing panel sections.

Figures 19 & 20. Fracture of the right fairing panel section – characteristic of bending overloads. The fire seal strip (R) had also torn away from the panel and was recovered some distance from the panel sections.

The three mounting hooks on the upper edge were comparatively undamaged and showed no appreciable wear across the throat (figure 21).

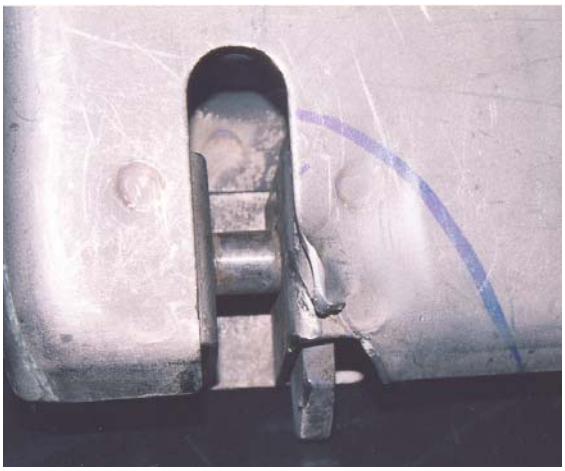
The right fairing panel contained two lever-action hook latches, which engaged with the clevises on the mating left panel. Hooks from both latches were found intact and undamaged, although the rear aluminium alloy latch lever had sustained distortion and damage consistent with having struck another object whilst in the open position (figures 22 & 23). No appreciable wear or other operational damage was noted within the hooks or on the pivoting sections of either latch assembly.

Figure 21 (Left). Mounting hooks along the top edge of the right fairing panel. All were sound and undistorted.

Figures 22 & 23 (Bottom). Latch positions at the base of the right panel. Although damaged by the ejection event, both hooks and mounting points were sound.

Upper Fairing Panel

This panel completed the full circumferential shroud of the engine core gas generator section and was located between the engine core and the pylon mount (figures 24 & 25). The panel remained in place on the aircraft during the event and was removed in Los Angeles when the fairing set was replaced. The left and right upper panel hooks engage with inset pins within the upper panel body and are held in place by the clamping action of the two clevis-hook latches previously examined. The three pins on both ends of the panel showed no appreciable physical damage or failure that could be considered contributory to the loss of the fairings. The forward pin socket on the left side showed some disruption and folding of the sheetmetal around one side, with prominent gouging along a defined path on one side of the socket (figure 26).



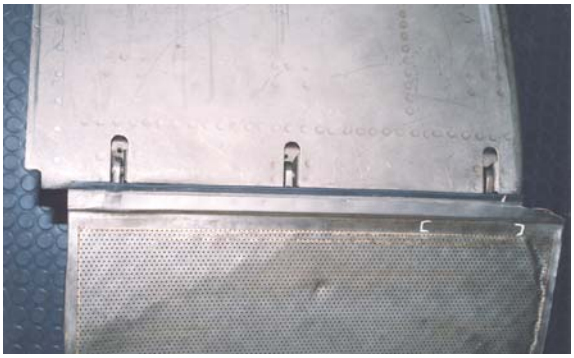
Figures 24 & 25 (Top). Undamaged internal and external surfaces of the upper fairing panel section, which sits above the engine core and was not released.

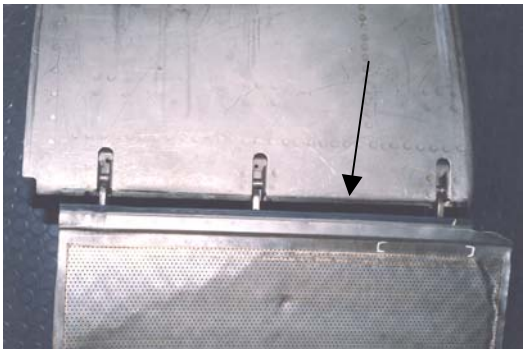
Figure 26 (Left). Forward pin and socket on the left side of the upper fairing panel. Note the gouging and distortion damage consistent with the damage to the forward hook on the left panel.

Fairing Interconnection

A trial assembly of the hook connections between the upper and side panels was carried out to examine the potential for miss-assembly and the visual cues that may indicate this.

Correct assembly (figure 27) is typified by the absence of a gap between the sealing edge of the side panel and the mating surface of the upper panel. Aligned, yet uncoupled panels (figure 28) clearly show this gap and the incorrect position of the hooks in respect to the socket pins (figure 29).





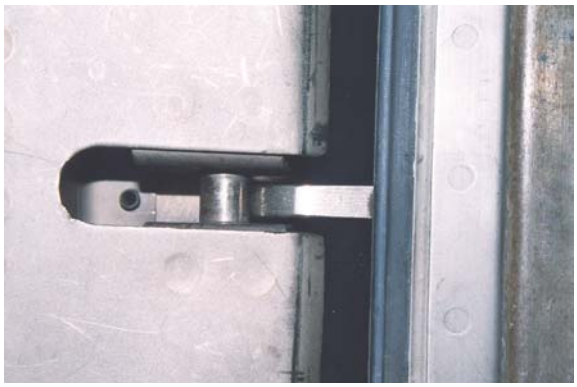


Figure 27 (Top Left). Mounting hooks along the top edge of the right fairing panel correctly engaged with the upper panel.

Figure 28 (Top Right). Mounting hooks incorrectly engaged. Note the distinct gap between the upper panel and the right panel-sealing strip (arrowed).

Figure 29 (Left). Close view of an incorrectly mounted panel hook.

Secondary Damage

Several fragments of composite materials (figure 30) that were not part of the combustion fairing assembly were recovered from the runway undershoot area during the sweeping operation. Two fragments gave the appearance of having originated from the flap trailing edge, as evident from the supplied photographs showing the aircraft damage (figures 31 & 32). The third fragment was considered to be from the inside surface of the engine bypass duct.

Figure 30 (L). Debris recovered from the runway with the panel sections. The top two pieces are sections of the wing flap, the lower piece is part of the acoustic material within the engine bypass duct.

Figures 31 & 32 (Btm). Damage to the underside and trailing edge of the centre wing flap extension. Note the impact marks present on the undersurfaces.

ANALYSIS

Examination of physical evidence and information provided indicated both left and right combustion / gas generator fairing panels released from the number three engine of VH-OJJ early in the take-off run. Both panels showed evidence of impact with the inside of the bypass duct. The left unit experienced heavy crushing on the forward edge, consistent with the panel pivoting out sideways from its mounted position. The forward mounting hook on the upper edge of the left panel showed clear evidence of having forcefully pulled out from the pin socket during the release. The hooks from the right panel were sound and undamaged. Both clevises from the panel latches had been bent and torn away in overload from the base of the left panel – evidence that both were engaged and locked at the time of the fairing release. The pin sockets into which the hooks from the left and right fairing panels engaged were intact and undamaged.

It is concluded that the separation of the fairing panels was precipitated by incorrect engagement of the right panel hook mounts during installation. This would have permitted the fairing to slide downward and around the core, moving the left panel outward and away from the core and into the bypass airstream of the accelerating engine. In this circumstance, the panel would have been immediately torn away from the hook mounts and ejected forcefully to the rear, taking the connected right panel with it and producing the secondary damage to the bypass duct and flap trailing edges. The nature of the damage to these surfaces was consistent with a solid object impact.

The examination found no evidence of component flaws or defects having contributed to the panel release.

CONCLUSION

Findings

- The release of the fairing panels occurred early in the take-off run of the aircraft.
- The release occurred as a result of mis-installation of the fairing panels. Failure to engage the mounting hooks of the right fairing unit with the socketed pins in the upper fairing allowed the panels to move away from the core and into the bypass airstream.
- The panels and fairing components contained no defects or faults that contributed to the miss-installation or the subsequent release.
- Damage to the engine bypass duct and the flap trailing edge was a result of impact with the ejected fairing panel sections.