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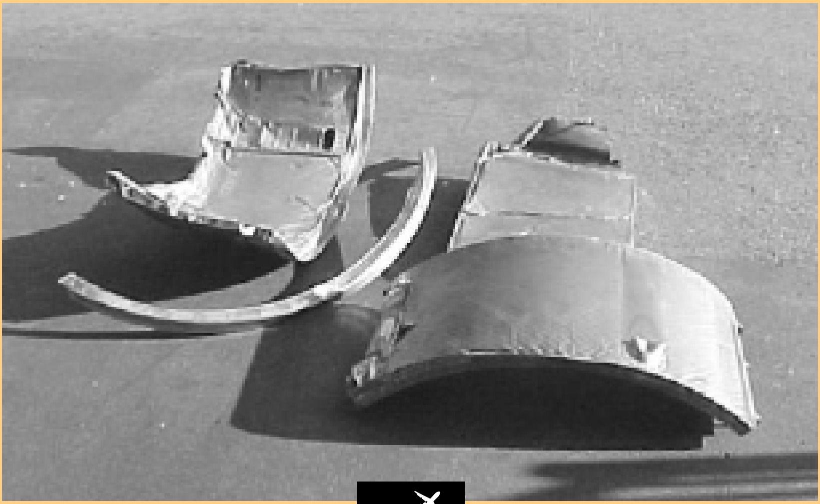

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Aviation Mechanics Bulletin

Dedicated to the aviation mechanic whose knowledge, craftsmanship and integrity form the core of air safety.

Robert A. Feeler, editorial coordinator

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Cover photograph: Two combustion fairing panels (one broken into two pieces) from the no. 3 engine of a Boeing 747-438 were recovered from the Sydney Airport Runway 34L undershoot area the morning after the afternoon departure. (Photo: Australian Transport Safety Bureau)

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Improperly Installed B-747 Panels Separate on Takeoff

Maintenance technicians found minor localized damage to the no. 3 engine bypass-duct internal surfaces and to the trailing edge of the right-center wing-flap extension after the airplane completed an intercontinental flight. The Australian Transport Safety Bureau said that two of three engine gas-generator fairing panels caused the damage when they were released and ejected forcefully.

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FSF Editorial Staff

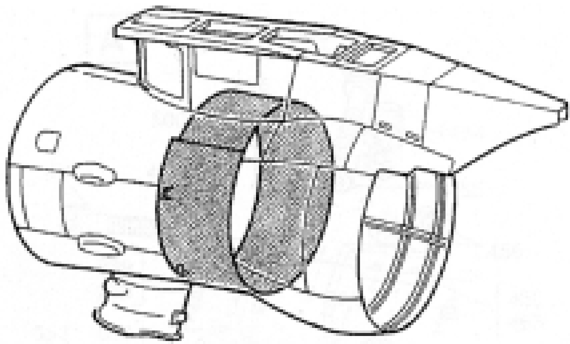
The left and right gas-generator (combustion) fairing panels (Figure 1, page 2) were released and ejected forcefully from the no. 3 engine of a Qantas Airways Boeing 747-438 during takeoff April 24, 2001, at 1720 local time from Sydney Airport, New South Wales, Australia, on a flight to Los Angeles, California, U.S.

The final report on the incident by the Australian Transport Safety Bureau (ATSB) said that no injuries occurred during the scheduled international passenger flight. Minor localized aircraft damage was found on the engine bypass-duct internal surfaces and on the trailing edge of the right-center wing-flap extension.

Damage to parts recovered from the departure runway was consistent with incorrect installation of the fairing panels during the routine maintenance check that immediately preceded the flight, the report said.

"Hooks on the right [fairing] panel were not engaged with the respective socket pins of the upper fairing

Engine Gas-generator (Combustion) Fairing-panel Assembly



Source: Australian Transport Safety Bureau

Figure 1

[panel]," the report said. "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 [by the ATSB Technical Analysis Unit] did not identify any defects in manufacture or maintenance of the fairing mounts or latches that could have contributed to the release."

The incident began when the B-747 flight crew heard a noise described as "similar to an engine stall" while applying takeoff thrust. An immediate engine-parameter check showed no abnormal indications, and the crew continued the takeoff. The crew subsequently did not hear any similar noises. The cabin services director told the flight crew during climb that a small area of damage was visible on the "right outboard trailing-edge flap" (examination of the B-747 after landing showed that minor damage had occurred to the trailing edge of the right-center wing-flap extension behind the no. 3 engine).

"The first officer then [viewed] the area and reported that he believed that the damage was the partial delamination of the composite flap section," the report said. "All engine parameters, including vibration levels, were subsequently rechecked and found to be normal. After discussions with ground maintenance personnel, the crew decided to continue the flight. 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 [by Sydney Airport staff] the morning following the departure."

After the aircraft was landed in Los Angeles, airline maintenance technicians confirmed the absence of the two fairing panels; found indentation damage and scraping damage on the internal surfaces of the bypass airflow nozzle behind the combustion fairing; and determined that the trailing-edge flap damage was limited to an area immediately behind the engine.

ATSB's investigation included review of the design of the assembly mechanism for the fairing panels; procedures and equipment used in installation of the fairing panels; how the fairing panels could be installed incorrectly and the resulting visual indications; and analysis of damage to the fairing panels that were ejected from the incident aircraft engine.

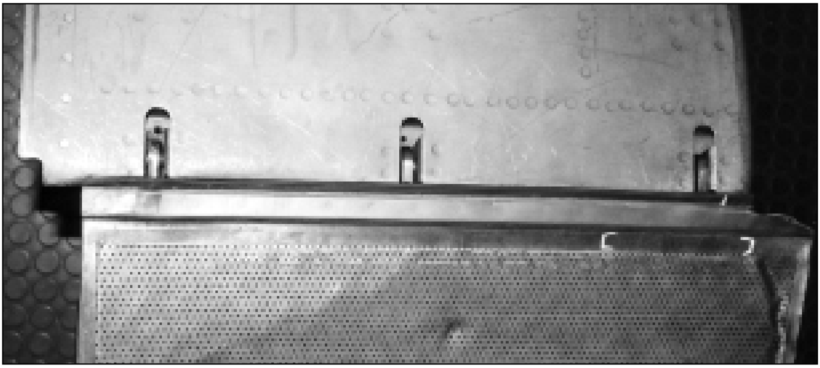
The mechanism for securing the three panels of the fairing-panel assembly — which is mounted to the core of the engine and located circumferentially around its gas-generator section — comprises a pin-and-hook arrangement (a row of three hooks that engage with recessed pins on the upper-panel section), and the entire assembly must be secured by two latches (incorporating adjustable hooks and clevises) at the base of the engine.

"Correct assembly [see top photo, page 4] is typified by the absence of a gap between the sealing edge of the side panel and the mating surface of the upper panel," the report said. "Aligned, yet uncoupled panels [see bottom photo, page 4] clearly show this gap and the incorrect position of the hooks in respect to the socket pins."

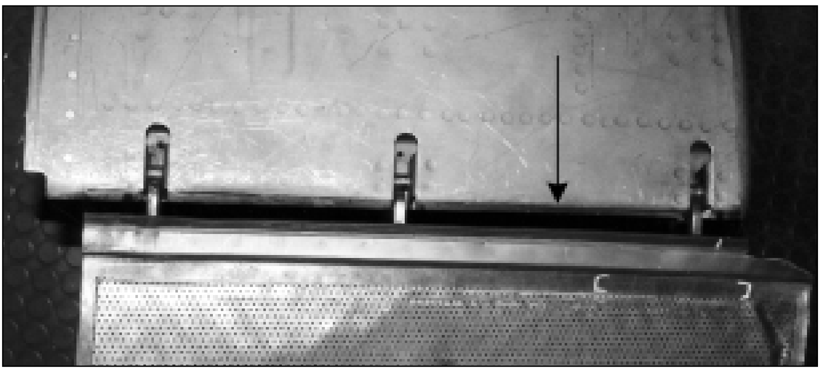
Investigators determined — from their examination of the fairing assembly during installation and from study of its design — that the fairing panels could be placed in position around the engine and latched without engaging the upper mounting hooks.

"The clamping action of the interlocking fire seal along the rear edge of the fairing panels allowed the [fairing panels] to stay in position without the support of the hooks," the report said. "Latching action between the fairing panels was also unaffected. When the panels were installed incorrectly, inspection of the upper connection points clearly showed a large gap between the upper [fairing panel] and side [fairing panels]."

Investigators determined that inspection of the upper connection points was difficult for maintenance technicians because of "the restricted confines of the cold-stream duct surrounding the panels." To inspect this area, Rolls-Royce maintenance-manual procedures — including requirements in manual revisions



No distinct gap is visible when the mounting hooks along the top edge of the right fairing panel are engaged correctly with the upper fairing panel. (Photo: Australian Transport Safety Bureau)



A distinct gap is visible between the upper fairing panel and the right-fairing-panel sealing strip (arrow) when the mounting hooks are engaged incorrectly. (Photo: Australian Transport Safety Bureau)

issued February 18, 2001, for the use of integrated-nozzle-assembly access platforms — required maintenance technicians to use access platforms within the cold-stream duct. Nevertheless, maintenance personnel told ATSB investigators that the platforms rarely were used.

"Testing the platforms showed a degree of instability in use, and [the platforms] further restricted the access to the lower areas of the duct," the report said.

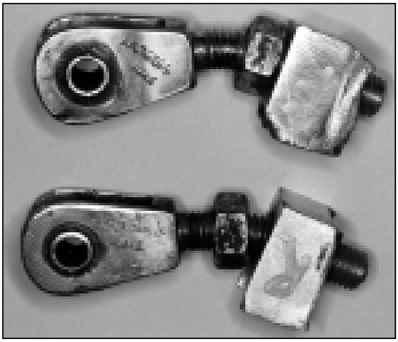
Investigators determined — based on their study of all fairing-panel mounting-and-latching points — that the right fairing panel was not engaged with the upper fairing panel the last time that the right fairing panel was refitted, causing the right fairing panel to be released and ejected.

"Technical examination of the combustion fairing panels found that [they] were released and ejected from the no. 3 engine because of incorrect [engagement of the right-fairing-panel hook mounts] during maintenance activities before the flight," the report said. "This would have permitted the [right fairing panel] to slide downward and around the core, moving the left [fairing] panel outward and away from the core and into the bypass airstream of the accelerating engine. In this circumstance, the [left fairing] 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.

"All three mounting hooks [of the right panel were sound and] undamaged and showed no sign of having been forcibly pulled away from the upper fairing [panel] pins. In comparison, both latches and the forward hook from the left [fairing] panel showed damage consistent with the connections being overloaded and pulled apart. The left [fairing panel] experienced heavy crushing on the forward edge [and structural distortion], consistent with the panel pivoting out sideways from its mounted position. The forward mounting hook on the upper edge of the left [fairing] panel showed clear evidence of having forcefully pulled out from the pin socket during the release. The three mounting hooks along the upper edge of the [left] fairing panel showed varying degrees of mechanical damage and distortion. The forward hook had opened extensively and showed backward and sideways bending. Both clevises from the panel latches had been bent and torn away in overload from the base of the left [fairing] panel — evidence that both were engaged and locked at the time of the [release of the fairing panels]. The pin sockets into which the hooks from the left and right fairing panels engaged were intact and undamaged."

Damage to the recovered clevises and mounting blocks (see photo, page 6) and the absence of damage to the upper fairing panel also supported the sequence of fairing-panel release and ejection determined by ATSB investigators.

Investigators reviewed the procedures and checklists used by maintenance technicians in releasing the B-747 to scheduled service upon completion of the maintenance A-check, which



Clevis fittings and mounting blocks were torn from the fairing-panel structure and show the degree of bending overload on the clevis shafts.
(Photo: Australian Transport Safety Bureau)

included several tasks that required the removal and reinstallation of combustion fairing panels from all four engines. Work instructions for the A-check tasks involving the no. 3 engine included a "panels-and-fairings final-fitment check," the report said.

"[This check] was signed off as completed by a licensed maintenance engineer," the report said. "The engine had been subsequently ground-run for five minutes at idle speeds, with no noted anomalies. Check sheets for the examination of engines after ground-running incorporated eight specific inspections, including a check for correct installation and latching of the fairing panels. Those checks had also been signed off as being satisfactorily completed. However, neither inspection [the panels-and-fairings final-fitment check nor the check sheet for inspections after ground run] identified the problem."

Several work instructions produced by the airline — referring to its minor-maintenance manual and to the Rolls-Royce maintenance manual — provided text and illustrations showing how combustion fairing panels were to be installed on this engine model. ATSB said that failure to conduct such specific inspections and to use required equipment increased maintenance technicians' risk of failure to detect incorrectly mounted fairing panels.

"The need for inspection of mounting-hook engagement after installation was … clearly stated, with clear warnings of the potential for incorrect installation and the damage that may result," the report said. "Visual cues that signal a lack of hook engagement are not obvious and require specific inspection to verify correct installation. A possible reason for the failure to identify the incorrect installation of the combustion fairing [panels] was the reluctance of the operator's maintenance staff to use the cold-stream-duct-access platforms. Without the platforms in place, inspection of the panel mounts for the signs of incorrect installation is difficult."

The report contained the following findings and significant factors:

- “The release of the fairing panels occurred early in the takeoff run of the aircraft;
- “The design of the RB211-524 engine combustion fairing allowed the individual panels to be installed without the proper engagement of the upper mounting hooks;
- “During maintenance before the occurrence flight, the right-side combustion fairing panel was fitted to the no. 3 engine without the mounting hooks being engaged with the upper-panel section;
- “Inspections following maintenance work and, subsequently, following engine ground-running did not identify the incorrectly installed panel;
- “The release occurred as a result of [incorrect installation] of the fairing panels;
- “The panels and fairing components contained no defects or faults that contributed to the [incorrect installation] or the subsequent release; [and,]
- “Damage to the engine-bypass duct and the flap trailing edge was a result of impact with the ejected fairing-panel sections.”

ATSB recommended that “Rolls-Royce expedite the development, trial and implementation of a suitable engineering solution to prevent the [incorrect installation] of combustion fairings on RB211-524 and RB211-22B engines [Recommendation R20010230].” After this incident, Rolls-Royce distributed a brief instructional video that explains the correct methods for fitting the combustion fairing panels to these engines and says that maintenance technicians must check for correct installation after fitting the panels. [Rolls-Royce said that development fitting trials of the new fairing design are underway and plans include release of a service bulletin in the third quarter of 2002.]

Qantas Airways introduced — pending implementation of a mechanical balking feature to prevent incorrect fairing-panel installation — a dual-inspection requirement after installation and latching during main-base maintenance visits, the report said.♦

[FSF editorial note: This article, except where specifically noted, is based on the Australian Transport Safety Bureau (ATSB) Air Safety Occurrence Report no. 200101776 and ATSB Technical Analysis Report no. 18/01, *Examination of Engine Gas Generator Fairing Panels, Boeing 747-438, VH-OJJ*. Jan. 31, 2002. The occurrence report contains seven pages; the technical analysis report contains 10 pages, one illustration and 31 photographs.]

Inspections, Repairs Ordered for Hamilton Sundstrand 568F Propeller Blades

The U.S. Federal Aviation Administration (FAA), citing a Jan. 12, 2002, incident in Colombia in which a propeller blade separated from the propeller hub, has ordered inspections and repairs of Hamilton Sundstrand 568F propeller blades with serial numbers 1 through 1,698 that have been in service longer than six years or 11,700 operating hours.

In response to a recommendation from the U.S. National Transportation Safety Board (NTSB), FAA said that the following emergency airworthiness directives (ADs) were issued:

- Emergency AD 2002-03-51, to require removal of the oldest of the propeller blades by March 31, 2002;
- Emergency AD 2002-04-52, which superseded the previous AD but retained the blade-removal program and required ultrasonic inspections by March 4, 2002, for cracks on all blades that were manufactured before a design change that was implemented to prevent corrosion; and,
- Emergency AD 2002-05-51, which superseded the previous AD and required 50-flight-hour repetitive ultrasonic inspection for cracks on suspect blades until they are repaired or replaced in accordance with the AD's requirements. The AD also defined a blade-removal program that requires all suspect blades to be removed by Dec. 31, 2002.

FAA said that it also had approved blade repairs for a "corrosive-critical area" on the propeller blade.

The FAA actions followed an incident in which a Hamilton Sundstrand 568F propeller blade separated from the propeller hub on the no. 2 (right) engine of an Avions de Transport Regional (ATR) ATR 42-500 operated by ACES (Aerolíneas Centrales de Colombia) and being flown on a domestic flight in Colombia from Cartagena to Bucaramanga.

The pilots said that about five minutes after takeoff, they felt vibration and observed the no. 2 engine low-oil-pressure warning light illuminate. They tried to shut down the no. 2 engine with the fuel lever, but the fuel lever jammed. The NTSB, which is assisting the Colombian Aeronáutica Civil in investigating the incident, said that the pilots then shut down the engine by pulling the fire handle. They conducted an emergency landing in Cartagena. The airplane received minor damage to the cowling of the no. 2 engine; the 41 people in the airplane were uninjured.

The investigation by the Colombian Aeronáutica Civil revealed that one of the propeller's six blades had separated through the metal base outboard of the propeller hub.

The base of the blades is manufactured from low-alloy steel forgings. NTSB said that the attached airfoils are "made with graphite fiber-reinforced epoxy spars, surrounded by structural foam and covered by a Kevlar-reinforced epoxy outer shell." The spar and the outer shell are bonded with adhesive to the outside of the base and secured by a fiberglass composite compression wrap.

At the request of the Colombian Aeronáutica Civil, the NTSB materials laboratory examined the inboard portion of the fractured propeller blade. The examination revealed that the blade separation was a result of a fatigue fracture of the base. The fracture originated in "an area of widespread corrosion" that would not be visible during a visual inspection, NTSB said.

"Red rust and other evidence of corrosion were visible on the outer diameter surface of the [base] adjacent to the fracture and on the counterweight flange," NTSB said.

The fractured blade was manufactured in December 1995 and had been in service for about six years and 11,700 operating hours. An examination of the bases of the other five propeller blades in the same propeller assembly revealed that four bases (all manufactured in 1996) had rust and corrosion pitting in the fillet (fairing) radius but no visible cracking; there was no rust or corrosion pitting on the fillet radius of the base of the fifth blade (manufactured in 1997).

The FAA-accepted Hamilton Sundstrand maintenance program requires a major inspection of 568F propeller blades every 8,000 flight hours. The inspection includes "a detailed visual examination of the blade but does not involve removal of the compression wrap or nondestructive inspections to detect corrosion or cracks in the fillet radius," NTSB said. "The fractured blade underwent a major inspection on Feb. 22, 1999, about 5,939 hours before the blade separated, with no corrosion noted. However, the area of the [base] under the compression wrap (including the fillet radius) was not exposed, nor was it required to be, during this inspection."

After the Colombia incident, Hamilton Sundstrand told NTSB that more detailed inspections of selected high-service-time blades had revealed rust and corrosion pitting — but no cracks — in the fillet radius beneath the compression wrap.

"Hamilton Sundstrand indicated that as a result of the early findings of rust and corrosion pitting, it modified the design of the 568F propeller blade in 1998 so that the adhesive layer applied to the [base] extended farther inboard, past the end of the compression wrap, fully covering the fillet radius," NTSB said. "The tightly adherent adhesive layer was intended to act as a barrier to deter corrosion; thus, the modification would protect the fillet radius."

Hamilton Sundstrand said that the 1,353 affected blades are installed in six-blade propeller assemblies used on ATR 42-410, ATR 42-500 and ATR 72-500 airplanes. ATR said that 151 of those airplane models, with 35 operators, are in service worldwide.

After the accident, on Feb. 1, 2002, Hamilton Sundstrand issued Alert Service Bulletin 568F-61-A33 to require inspections and repairs of the oldest 568F blades (with serial numbers 1 through 1,698) by March 31, 2002. The service bulletin did not discuss repetitive inspections or terminating action. Hamilton Sundstrand also was developing an ultrasonic inspection to detect cracking without removing the compression wrap.

In its recommendations, NTSB said that Hamilton Sundstrand's schedule "is not aggressive enough and is inadequate to prevent another fatigue fracture because of the uncertainties in the failure mechanism.

"Although the accident flight crew in this case was able to perform a safe emergency landing after the blade separated, propeller blade separations can quickly cause the flight crew to lose control of the airplane, which could result in injuries or death and damage to the airplane. Because the sample population of blades examined suggests that a large percentage of blades with serial nos. 1 through 1,698 have rust and corrosion pitting on the [base] fillet radius, immediate action is warranted to prevent another blade separation."

FAA said that another NTSB recommendation was being evaluated by FAA and the manufacturer. In that recommendation, NTSB said that FAA should require Hamilton Sundstrand to conduct further tests and analysis of high-service-time 568F blades, "including removal of the compression wrap so that the [base] can be fully examined … to determine if rust and corrosion pitting are occurring in the fillet radius and … require additional inspections, modifications or repairs."

Fatigue Blamed for Broken Landing-gear Bolt

After takeoff from Sumburgh Airport in England, the captain of a Cessna 441 Conquest observed that the landing-gear "UNLOCKED" light and the hydraulic pressure "ON" light both remained illuminated. He told air traffic control (ATC) that the landing gear apparently had not retracted correctly. When the landing gear was extended, the abnormal indications disappeared, but ATC observers said that the nose landing gear did not appear to be extended correctly.

The crew flew the airplane to its base at Teesside International Airport in England, where the nose landing gear collapsed after touchdown at about 70 knots. Both propellers, the engines and the forward fuselage were damaged. The three people in the airplane were uninjured.

An investigation revealed that the bolt connecting the leg assembly of the nose landing gear to the drag brace link was missing.

The report by the U.K. Air Accidents Investigation Branch said, "It was concluded that the location of the downlock switch on the actuator body ensured that a 'gear safe' indication was provided in the cockpit once the gear was reselected down. This occurred even though the nose leg was no longer geometrically constrained by the drag link and drag brace, once the bolt had been lost."

The absence of geometric locking allowed the nose-landing-gear leg to pivot backward during landing.

The head of the missing bolt was found at Sumburgh Airport, and the report said that the bolt probably had failed earlier and had fallen out after the previous landing. The remainder of the bolt and the attached nut and split pins were found "in a position which suggested that [the remainder of the bolt] had fallen out during taxiing just prior to takeoff on the accident flight," the report said.

Laboratory analysis revealed that the bolt fractured perpendicular to the longitudinal axis about halfway along the shank at a point that would have been at the center of the drag brace link.

"Fatigue cracking was evident, which appeared to have initiated from a single point and extended until the remaining bolt cross-section was insufficient to carry the applied load," the report said. "No evidence of any defect at the origin point was found. …

"It was concluded that loads due to landing, or those applied during towing operations, resulted in various magnitudes of bending moments being applied to the bolt, which in turn created fatigue stresses. Although no evidence of a specific defect could be seen at the origin of the fatigue crack, it is considered likely that a corrosion pit formed such an origin and thus initiated the fatigue process."

Loose Fitting Cited in In-flight Engine Shutdown

The Fairchild SA227-AC Metro III was being flown on a domestic flight in Australia on Nov. 11, 2001, when the flight crew observed fluctuations of the left-engine oil-temperature indication. They inspected the engine visually while in flight and observed nothing unusual. Later, the left-engine-oil warning light illuminated. The crew shut down the engine and conducted a single-engine approach and landing at the nearest airport.

An incident report by the Australian Transport Safety Bureau (ATSB) said that a post-flight inspection revealed that there was no oil in the left engine. An investigation revealed that the engine oil had leaked from a loose right-angle oil line fitting and that the fitting had loosened after being forcibly contacted by the left starter-generator electrical connector block. The contact occurred after the generator rotated on its mounts because of a loose attaching clamp and several missing locating pins, the report said.

The report said that the generator had been removed and had been reinstalled during contractor maintenance about two weeks before the incident.

After the incident, maintenance personnel received briefings on the occurrence "and the ramifications of incorrect component installation," the report said.

Installation of Incorrect Landing-gear Component Blamed for Gear-up Landing

A McDonnell Douglas DC-8-71F was being flown on a visual straight-in approach to Nashville (Tennessee, U.S.) International Airport at 0629 local time April 26, 2001, when the flight crew attempted to extend the landing gear. The gear-extended light for the left-main landing gear did not illuminate.

The crew of the Emery Worldwide Airlines cargo flight conducted a go-around, conducted the emergency/abnormal procedures checklist and communicated with company maintenance personnel to receive information on further troubleshooting procedures.

The crew landed the airplane with the left-main landing gear retracted. The airplane stopped about 400 feet (122 meters) from the end of the 11,000-foot (3,555-meter) runway and about four feet (1.2 meters) left of the centerline, resting on the nose landing gear, the right-main landing gear and the bottom of the cowlings of the two left engines. The airplane received minor damage; the three crewmembers were uninjured.

The accident report by the U.S. National Transportation Safety Board (NTSB) said that maintenance logs showed that the day before departure from James M. Cox Dayton (Ohio, U.S.) International Airport, Emery maintenance personnel in Dayton had replaced a valve in the left-main-landing-gear hydraulic system. An investigation revealed that a one-way check valve — instead of a restricted-flow valve — had been installed in the left-main-landing-gear-extend hydraulic lines.

The part number of the replacement valve did not appear on the valve; an identification tag removed from the valve during installation contained the incorrect factory specification number and the correct vendor's part number. The correct part number was 4776708-5503; the factory specification number contained on the identification tag was 4776708-5503A.

The maintenance log said that the valve had been installed as required by the maintenance manual and included the notation "Lk [leak] and ops [operations] checks good." The maintenance technician who performed the valve installation and the inspector both said that the completed job was "leak and ops tested."

The report said, "The maintenance/recovery crew had to bypass the [left-main-landing-gear]-extension side hydraulic valve to get the [left-main landing gear] to extend on the ground. When the hydraulic tubing to the valve was unsecured and opened by maintenance personnel, the [left-main landing gear] free-fell and locked down. For added confirmation that the [left-main-landing-gear-]extension hydraulic valve had malfunctioned, the [right-main-landing-gear-]extension hydraulic valve was removed from its location and installed in the [left-main-landing-gear] system and normal hydraulic extension operation … occurred."

The report said that the probable cause of the accident was the "failure of company maintenance personnel to install the correct hydraulic landing-gear-extension component and the failure of company maintenance inspection personnel to comply with proper post-maintenance test procedures, resulting in the impossibility of the [left-main landing gear] to extend and the subsequent [left-main landing gear]-up landing. A factor in the accident was the improper identification tag marking on the replacement component and no marking on the component itself."

The report said that the hydraulic valve that was removed from the airplane was sent to the U.S. Federal Aviation Administration, "reportedly to pursue a 'suspected unapproved parts' case."

DC-8 Engine Cowls Separate, Inadequate Inspections Cited

Inadequate inspection by company maintenance personnel of the no. 1 engine cowl and the no. 2 engine cowl of a McDonnell Douglas (now Boeing) DC-8-63F airplane and inadequate preflight inspection by the flight engineer were the probable causes of the separation of the unsecured cowls during takeoff, said the final report of the U.S. National Transportation Safety Board (NTSB). A factor was the unsecured cowls, NTSB said.

No injuries occurred in the accident Feb. 19, 2000, as the American International Airways flight was departing from Seattle-Tacoma (Seattle, Washington, U.S.) International Airport for an unscheduled international cargo flight. The left wing and the left horizontal stabilizer received substantial damage when they were struck by the cowls during and shortly after takeoff.

The captain's first indication of the problem came during rotation when the airplane rolled left slightly and the captain observed engine-instrument indications.

"The no. 2 engine N2 (high-pressure section) rpm [revolutions-per-minute] indication went to zero and the no. 2 engine generator light came on," the report said. The captain told investigators that he and other crewmembers were diagnosing the problem when the control tower told the captain that the aircraft had left debris on the runway. The captain decided to return to the departure airport, and the crew landed the airplane without further incident.

The aircraft maintenance log showed that on the aircraft's previous flight, which arrived the morning of the accident, the flight crew had reported that the no. 2 engine would not produce reverse thrust, and that the captain's course deviation indicator (CDI) was "frozen" [immobile].

"The frozen … CDI was determined to be a non-deferrable, aircraft-on-ground (AOG) item," NTSB said. "There was also a deferred-maintenance item (DMI) on the no. 1 thrust reverser. Due to concerns expressed by the captain of the incoming flight about the operability of the thrust reversers in consideration of icy runway conditions at Anchorage, [Alaska, U.S.,] maintenance also decided to lube, inspect and check all four thrust reversers for proper operation."

Company maintenance personnel worked on the airplane's four engine thrust reversers before the accident flight. The report said that the maintenance technician who worked on the thrust reversers did not close the no. 2 cowl before going off duty. This technician told investigators that he also spent several hours during his shift troubleshooting the CDI problem and that he had worked three hours of overtime. Before leaving, he asked another maintenance technician to close the no. 2 cowl.

"The second mechanic [who worked 3.75 hours of overtime on the shift] subsequently lowered the no. 1 and [no.] 2 cowl doors but was unable to secure and lock them," the report said. "[The second technician told] mechanics on the next shift that all four engine cowls needed to be secured, and annotated this in the shift-turnover log." He told investigators that all cowls were held wide open by their hold-open rods when he left.

The entry in the end-of-shift turnover log said that the aircraft "requires all four [cowl] doors secured." A company maintenance technician who received the turnover log said that he had received a verbal briefing that all cowlings needed to be secured, but that he did not review the turnover log when he began working on the aircraft at about 1630 or 1645. This technician told a U.S. Federal Aviation Administration inspector that he had reported for duty at 1500 on the day of the accident, that he had worked until 0800 on the previous shift although he was scheduled to work until 0130, and that he had been unable to sleep while at home between the two shifts.

The technician told investigators that when he began working on the accident aircraft, the cowls for the no. 1 engine and the no. 2 engine were closed, and the cowls for the no. 3 engine and the no. 4 engine were wide open. He assisted in closing the no. 3 engine cowl but said that he did not check the no. 1 engine cowl or the no. 2 engine cowl to ensure that they were secure, the report said. Company maintenance technicians who assisted in closing and latching the no. 3 engine cowl and the no. 4 engine cowl also said that the other two engine cowls were closed at the time, but they did not say that they had checked that the closed cowls had been latched.

The company flight operations manual requires preflight inspection of the cowls, including confirmation that the cowls are latched. Nevertheless, the flight engineer failed to detect the unlatched cowls during his preflight inspection, the report said.

"The flight engineer [said] that the cowlings were closed when he arrived at the aircraft, that he observed no abnormalities during the exterior preflight inspection, and that 'all engine cowlings [were] verified closed and latched prior to takeoff,'" the report said. "No [recovered] cowl sections were attached to each other by any latch mechanisms, and no evidence of distress to any latches, latching pins or associated areas was observed."

Rivet Failure Causes Falcon's Uncontained Turbine Failure

The probable cause of a disk burst and uncontained high-pressure-turbine failure on the no. 2 engine of a Dassault Falcon 2000 was fatigue failure of the rivets used to secure the inner casting forward static seal to the first-stage low-pressure turbine support/nozzle assembly, said the final report of the U.S. National Transportation Safety Board.

"The failure of the rivets allowed the forward static seal to machine a groove into the second-stage high-pressure-turbine [HPT] disk to a depth [at which] the disk could not withstand the operating loads," the report said.

No injuries occurred in the incident on June 27, 2000, during climb after takeoff on a positioning flight operated by Aviación Comercial de América of Monterrey, Mexico, from Fort Lauderdale, Florida, U.S. The crew remained in the airport traffic pattern and conducted an uneventful landing, according to the captain's report to investigators.

"The copilot was flying the aircraft, and after rotation, as [the aircraft was] climbing through about 150 [feet] to 200 feet, there was the sound of a loud bang, and they felt extreme vibrations," the report said. "The no. 2 engine gauges went to zero, and there was no indication of fire."

Damage included penetration of the engine combustion case and right-engine nacelle, two fuselage skin ruptures, broken stringers and multiple puncture holes.

"A two-foot [0.6-meter] to three-foot [0.9-meter] section of the right-engine nacelle, from approximately the nine [o'clock position] to the six o'clock position, had torn outward, in line with the [HPT] area of the engine," the report said. "Examination of the right engine revealed an approximate 270-degree penetration of the combustion case. Both HPT disks had exited the engine, and were discovered in a parking lot about 150 feet [46 meters] from the runway."

Macroscopic examinations and microscopic examinations of the no. 2 engine and recovered portions of the engine revealed a 360-degree circumferential groove on the aft face of the [second-stage HPT] disk, just outboard of the aft four-tooth knife-edge steel flange.

"In addition [to the groove], rivet holes on the forward static seal and on the forward flange revealed the presence of fretting marks, which were inconsistent with those of a tightly mated assembly," the report said. "Instead, the fretting was indicative of an assembly that allowed relative motion between the surfaces."

Examination with a scanning electron microscope revealed that one of the rivet shanks had indications of fatigue originating from at least two areas on its outer-diameter surface, representing high cycle fatigue. Heavy fretting — underneath the heads of the rivets on the surface that mated with the seal — was similar to fretting on the front face of the seal, which is consistent with insufficient clamping preload on the rivets, the report said.

"There were no indications of fatigue or other anomalies on the [second-stage HPT] disk, and disk fracture surfaces were indicative of tensile-overload failures," the report said.

The aircraft had accumulated about 2,092 flight hours and had been inspected on May 3, 2000, about 73 flight hours before the incident. Both CFE 738-1-1B turbofan engines manufactured by the CFE Co. (a partnership between Honeywell and General Electric) had accumulated 1,891.14 hours total time since new and 1,059 cycles at the time of the incident.

The engine manufacturer notified operators and technical representatives about the incident; issued service bulletins that specified additional borescope inspections of the CFE 738-series engines for grooving on the aft face of the second-stage HPT disk; introduced a new forward static seal design and attachment method; specified a schedule for compliance with the service bulletin; and specified additional monitoring checks and break-in periods for the CFE 738 engine.♦

NEWS & TIPS

Oversleeve Protects Cables From Chafing, Abrasion

The Roundit 2000 NX oversleeve protects cable assemblies, hoses and wire harnesses used in aerospace applications from chafing, cutting and abrasion, said the manufacturer, Federal-Mogul Systems Protection Group.

The oversleeve contains no halogen and is a woven blend of Nomex and polyphenylene sulfide rated to 200 degrees Celsius (392 degrees Fahrenheit). It has passed the U.S. Federal Aviation Regulations Part 25 flammability test and is approved for use in aerospace applications by more than 10 international companies. The oversleeve has a self-wrapping feature for speedy application and removal without disturbing connectors and fittings.

For more information: Federal-Mogul Systems Protection Group, 241 Welsh Pool Road, Exton, PA 19341 U.S. Telephone: +1 (610) 363-2600.

Rubber Lubricant Provides Increased Viscosity

P-80 Thix rubber lubricant has increased viscosity to prevent dripping, puddling and running, said the manufacturer, International Products.

P-80 Thix Rubber Lubricant

P-80 Thix and other P-80 lubricants aid in the attachment or insertion of tight-fitting rubber parts and soft plastic parts by providing a water-based emulsive film that temporarily makes rubber surfaces slippery. After the part has been installed, the film disappears and the rubber returns to its non-slippery condition. P-80 lubricants contain no silicones or petroleum distillates and are designed for various applications, including uses in the aircraft industry, the manufacturer said.

For more information: International Products, P.O. Box 70, Burlington, NJ 08016-0070 U.S. Telephone: +1 (609) 386-8770.

Coverings Protect Out-of-service Aircraft

Aircraft "mothball kits" provide protective covering for strategic parts of many out-of-service commercial aircraft, said the manufacturer, Specialty Bags.

The kits, which have been designed for most Boeing commercial aircraft, include landing-gear covers to protect tires from sunlight and moisture; engine-intake covers and exhaust covers with clear windows to measure humidity; window coverings; red-flagged screens with tape to cover pitot openings; drying agents for engines, flight deck and cabin; humidity-indicator cards to measure humidity inside engines and aluminum aircraft tape.

For more information: Specialty Bags, 1746 W. Crosby Rd., Suite 108, Carrollton, TX 75006 U.S. Telephone: (800) 945-2247 (U.S.) or +1 (972) 446-2247.

Portable Hardness Tester Functions on Metals, Nonmetallic Materials

Krautkramer Ultrasonic Systems new portable hardness tester uses the "through indenter viewing" (TIV) method to assess the hardness of a variety of metals and has the potential to assess some nonmetallic materials, the manufacturer said.

TIV is not affected by the mass and thickness of the part being tested. The TIV portable hardness tester weighs 4.4 pounds (1.9 kilograms) and displays results on a color liquid-crystal-display screen. Instrument functions are conducted by touching the screen or pressing a key on the instruments keypad. Conversion tables stored in the instrument allow the test results to be displayed using different hardness scales.

Portable Hardness Tester

For more information: Agfa NDT, 50 Industrial Park Road, Lewistown, PA 17044 U.S. Telephone: +1 (717) 242-0327.

1/4-inch Drive System Provides Automatic Locking

Link Tools International has introduced a 1/4-inch (6.4-millimeter) drive system to provide automatic locking of various tool combinations, the manufacturer said.

Automatic Locking Drive System

The system includes more than 80 items, including ratchets; extension bars; u-joints; palm wrenches; six-point metric sockets, standard-depth sockets and deep-well sockets; and 18 machine steel single-piece construction socket bits. The tool combinations can be locked together or released with one hand.

For more information: Link Tools International, 2440 Lakeview Ave., Chicago, IL 60614 U.S. Telephone: +1 (773) 549-3000.

Portable Diagnostic Kit Tests Cabin Management Systems

DPI Labs Fly-Away Kit is a portable collection of tools for testing avionics and cabin management systems and identifying miswiring and mispinning problems, the manufacturer said.

Portable Diagnostic Kit

The kit is designed for use with DPI Smart-Link II and Smart-Link III cabin management operating systems and functions with a laptop personal computer to update configuration software and diagnose systems problems. The kit also can be used as an alternate method to operate cabin lighting, audio, display panels and other systems, the manufacturer said. The kit includes a shipside bus tester, a shipside tester SL-1955, a relay-control module, a switch-panel simulator and a dialogue module.

For more information: DPI Labs, 1350 Arrow Highway, La Verne, CA 91750 U.S. Telephone: +1 (909) 392-5777.

Gripper Fingers Allow 180-degree Part Repositioning

Schunk Precision Workholding Systems gripper fingers allow part repositioning of up to 180 degrees while the part is being gripped. This flexibility saves time by eliminating an additional regripping process, the manufacturer said.

Gripper fingers are available in four sizes with output torques from 0.4 kilonewton to 11 kilonewtons and accommodate a range of parts. They are lightweight and are housed in hard-coated, high-strength aluminum.

For more information: Schunk, 211 Kitty Hawk Drive, Morrisville, NC 27560 U.S. Telephone: (800) 772-4865 (U.S.) or +1 (919) 572-2705.♦