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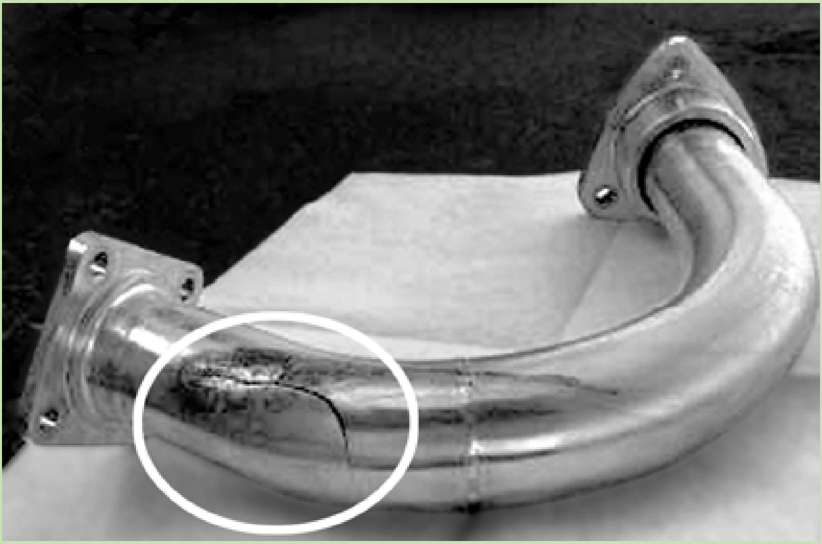

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Aviation Mechanics Bulletin

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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On the cover: Contact with a hydraulic line caused a 3.0-inch (7.6-centimeter) crack in a high-pressure fuel line aboard an Airbus A330. (Photo: Portuguese Aviation Accidents Prevention and Investigation Department)

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Fluid Line Mismatch Leads to Fuel Exhaustion During Oceanic Flight

A high-pressure fuel line fractured from contact with a hydraulic line on a recently replaced engine in an Airbus A330. The flight crew, who became aware almost too late that the airplane was leaking fuel, conducted a 'dead-stick' landing on an island airport.

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FSF Editorial Staff

Noncompliance with service bulletins during installation of an engine hydraulic pump was among several events that led to fuel exhaustion during a trans-Atlantic flight and to the forced landing of the Airbus A330 in the Portuguese Azores, according to the final report on the accident.[1]

The events began when the airplane operator, Air Transat, decided to replace the right engine — a Rolls-Royce RB211 Trent 772B — after metal particles were found in the oil system on two occasions in August 2001. The engine change began at midnight Friday, Aug. 17, 2001, at a maintenance facility in Canada.

The work was performed that weekend by several maintenance crews under the supervision of a lead technician who held an aviation maintenance engineer license and an endorsement to conduct A330 maintenance. The lead technician had supervised three A330 engine changes within the previous 12 months.

The lead technician normally worked the day shift, Monday through Friday. He was home at 1900 local time Friday when he was called and asked to supervise the engine change. He reported to work at 0630 Saturday, Aug. 18, and received a handover briefing from the night-shift maintenance crew, who had begun removing accessories from the engine that was to be replaced (the "removed engine"). The engine that was to be installed (the "replacement engine") did not have some accessories, including hydraulic pumps.

Behind Schedule

The engine change was scheduled to be completed by noon Sunday but began to fall behind schedule on Saturday when a leased jacking pad arrived late.

At 1830 Saturday, the lead technician briefed the night-shift maintenance crew, who continued work on the engine change. He returned to work at 0630 the next day. Early that morning, a problem occurred when technicians attempted to install, on the replacement engine, a hydraulic pump that they had taken from the removed engine. A high-pressure fuel line on the replacement engine interfered with the installation of the pump.

The engines on all three A330s operated by Air Transat had been modified in compliance with Rolls-Royce service bulletins (SBs) issued in 1999 "in reaction to several cases of hydraulic fluid leakage at the fuel pump or attached hydraulic lines," the report said.

The SBs were the following:

- SB RB.211-29-C664, which provided information on installing a modified hydraulic pump; and,
- SB RB.211-29-C625, which provided information on procedures necessary during installation of the modified hydraulic pump to prevent interference with an adjacent fuel line.

The interference mentioned in SB RB.211-29-C625 was caused by the wider housing on the modified hydraulic pump. The report said that the procedures discussed in the SB included replacement of the fuel line and the hydraulic line on the pump, and that the SB "stated that it was essential that the [lines] be fitted as a set."

The two Rolls-Royce SBs had not been incorporated in production when the replacement engine was manufactured. The report said that when the replacement engine was delivered, the airline had not recognized that it was in "pre-SB configuration."

While troubleshooting the difficulty encountered in installing the hydraulic pump on the replacement engine, the lead technician consulted the *Airbus A330 Illustrated Parts Catalogue*, which included a reference to SB

RB.211-29-C625, and "realized that the [replacement] engine … was in pre-SB configuration," the report said.

Access Denied

The lead technician used three computer stations in an attempt to review the SBs on the airline's computer network but was denied access to the information because of a network malfunction, the report said.

The lead technician then called a technician at the airline's Maintenance Control Center (MCC). The MCC technician, in turn, paged the airline's Trent engine controller. While awaiting a return call from the Trent engine controller, the MCC technician attempted to access the SBs on the computer network but also was denied access. The report said that neither the lead technician nor the MCC technician considered using a stand-alone computer to access the SBs from an available source on compact disc.

"When the Trent engine controller called back, he readily recalled the rationale for the pump modification as being excess vibration," the report said. "He also recalled that the modified pump interfered with the fuel lines and that [the fuel lines] would need to be replaced. He further advised the lead technician to confirm that when the pump and lines were installed, adequate clearances existed between [the lines] and [other] components."

The lead technician suggested that time could be saved by installing a pre-modification pump on the replacement engine. The engine controller told him that a pre-modification pump was not readily available.

"At this time, the controller was told, in passing, that the [maintenance] crew had not been able to access the SB," the report said. "While the difficulty in accessing the SB initially was a concern, the discussion quickly reverted to the time required to complete the work, without further discussion of the SB."

Misplaced Confidence

Pressure to complete the engine change in time for a scheduled flight and to clear the hangar for an upcoming event "might have played a role in reliance on direct and personal information about the SBs, rather than trying to resolve the existing problem of not being able to access the SBs," the report said. "The lead technician felt confident that the fuel[-line] replacement was the only remaining requirement to complete the hydraulic pump installation."

The maintenance crew took the post-modification fuel-line assembly from the removed engine and installed it on the replacement engine. The post-modification fuel line, which is shaped and routed differently than the pre-modification fuel line, facilitated installation of the hydraulic pump.

The pre-modification hydraulic line that had been received with the replacement engine, however, was retained. The hydraulic line was 11.0 feet (3.4 meters) long, with rigid ends and a flexible midsection.

Gaps in Training

The report said that fluid lines with both rigid sections and flexible sections are used extensively in aircraft; nevertheless, standards and procedures for installing the lines typically are not provided in maintenance training manuals and reference manuals.

"A visit to a government-sponsored regional aerospace training school in Canada also revealed that although training covers the installation of both rigid [lines] and flexible lines, training is not given on the installation of mixed-construction lines similar to the hydraulic line on the Trent engine," the report said.

The technician who installed the pre-modification hydraulic line on the pump told investigators that he achieved clearance between the hydraulic line and the post-modification fuel line by applying torque to the B nut on the hydraulic-line flange while holding the hydraulic line in position.

The report said that this method of achieving clearance is "not abnormal" and that the associated risks are not well known in the maintenance community and are not covered in maintenance-technician training.

"A flex tube will tend to expand radially, shorten in length and straighten once pressurized," the report said. "Considering the hydraulic system working pressure of 3,000 psi [pounds per square inch; 211 kilograms per square centimeter] and the pump pulsation, it is feasible that any clearance present at installation on the occurrence aircraft would have vanished once the line was pressurized."

Help Declined

A Rolls-Royce representative, who had visited the facility Saturday to check on the progress of the engine change, called the MCC on Sunday for an update and to offer help, if required. He was told about the problem that had been encountered during the initial attempt to install the hydraulic pump from the removed engine onto the replacement engine.

"The Rolls-Royce representative was not specifically told of the difficulties in accessing the SBs, nor was he specifically asked to consult his documentation," the report said. "His offer to attend on-site if required was not taken up."

The engine change was completed about 1730 Sunday. No discrepancies were found during inspection of the engine installation by the lead technician or during an independent inspection by a qualified technician who had not been involved in the engine change. The report said that the inspections did not require checks of the installation of the hydraulic pump, hydraulic line and fuel line. Subsequent ground runs of the engine revealed no discrepancies.

No quality-control inspectors had been on duty the weekend of the engine change. The airline had planned to perform a quality-control inspection of the engine-change documentation when the removed engine was prepared for shipment to a repair facility. The document inspection had not been conducted when the accident occurred.

After the airplane was released for service, it was operated approximately 60 hours before the accident flight.

Fuel Line Cracks

The accident occurred during a scheduled flight Aug. 24, 2001, from Toronto, Canada, to Lisbon, Portugal, with 13 crewmembers and 293 passengers aboard. The airplane had 46,900 kilograms (103,396 pounds) of fuel aboard on takeoff at 0052 coordinated universal time (UTC).

Contact between the fuel line and the hydraulic line caused the fuel line to crack. Digital flight data recorder (DFDR) data showing an increased rate of reduction of fuel quantity indicated that the fuel leak began at 0438.

At 0503, during a routine review of engine parameters, the crew observed indications on the electronic centralized aircraft monitoring system (ECAM) that the right engine oil temperature and oil quantity were substantially lower than the values for the left engine, and that oil pressure was almost twice as high.

The right engine oil indications were caused by an increase in fuel flow through the fuel/oil heat exchanger after the fuel leak began.

"The high fuel flow through the heat exchanger would have cooled the oil," the report said. "A characteristic of the Mobil Jet Oil II used for engine lubrication is that the viscosity increases rapidly when the temperature decreases. The higher viscosity resulted in an increase in oil pump outlet pressure and in a low flow rate of oil back to the reservoir. Because the oil quantity is measured at the reservoir, a lower quantity of oil would have resulted."

The indications were within specified engine-operating limits, however, and did not require diversion to an alternate airport in compliance with extended-range twin-engine operations (ETOPS) regulations or the airline's standard operating procedures (SOPs).

Out of Balance

At 0533, while discussing the oil indications with the MCC on high-frequency radio, the crew observed an indication on the ECAM that the left wing tanks contained 3,000 kilograms (6,614 pounds) more fuel than the right wing tanks.

The report said that although an imbalance of this magnitude likely would occur only with a significant fuel leak, the flight crew had not received specific training in identifying and responding to a fuel leak. At the time, 6,650 kilograms (14,661 pounds) of fuel had leaked from the airplane.

The ECAM was not designed to provide a specific indication of a fuel leak or to display the actions required to correct a fuel imbalance. The corrective actions are contained in the quick reference handbook (QRH).

The QRH "Fuel Imbalance" checklist included a cautionary note that the "Fuel Leak" checklist should be referred to if a fuel leak is suspected.

The report said that the crew did not refer to the QRH; they conducted by memory the procedures for correcting a fuel imbalance. They opened the fuel-crossfeed valve and deactivated the right wing fuel pumps to supply fuel from the left wing tanks to both engines and to isolate the right wing tanks.

"The opening of the crossfeed valve resulted in the fuel from the left wing tanks being fed to the leak in the right engine," the report said.

The airline's SOPs for flight-progress monitoring required that flight crews periodically check that the indicated fuel quantity plus the indicated fuel consumed equal the amount of fuel aboard the airplane on departure. The checks are required at each flight-planned waypoint.

"Crews are directed to suspect a fuel leak if the sum is unusually smaller than the fuel [aboard the airplane on departure]," the report said.

Leak Not Suspected

Flight plan log entries indicated that the accident flight crew had recorded time, fuel quantity and surplus fuel (projected reserves) at flight-planned waypoints until they had observed the abnormal oil system indications on the ECAM at 0503. The report said that at the time, the fuel indications were unremarkable; the surplus fuel quantity was within 200 kilograms (441 pounds) of the planned 7,000 kilograms (15,432 pounds).

Rare Event

The report said that fuel leaks are considered to occur rarely, if ever, and that a review of Air Transat's training programs and other airline training programs revealed no specific requirements to cover fuel leaks during initial training, recurrent training or line-oriented flight training.

DFDR data indicated that fuel was leaking at a rate of approximately 217 kilograms (478 pounds) per minute at 0545, when the crew observed indications that the airplane's fuel supply — 8,700 kilograms (19,180 pounds) — was below the minimum required to continue the flight to Lisbon. The crew told air traffic control (ATC) that they were diverting the flight to Lajes Airport on Terceira Island because of a fuel shortage.

"In attempts to resolve the sudden and unexplained reduction in the fuel quantity readings, the [flight] crew asked the cabin crew to visually check the wings and engines for a possible fuel leak," the report said. "The visual check did not reveal any evidence of a fuel leak."

Nevertheless, the crew considered that it was possible that the right tanks were leaking fuel. At 0554, they activated the right wing fuel pumps and deactivated the left wing fuel pumps, to "use up the fuel from the right wing," the report said.

At 0558, the master caution light illuminated and the ECAM displayed a cautionary message that fuel quantity in the right wing tanks was low. The ECAM was designed to display the message when fuel quantity decreased below 1,640 kilograms (3,616 pounds).

At 0559, while communicating with the MCC, the crew said that 1,000 kilograms (2,205 pounds) of fuel remained in the right wing tanks and 3,200 kilograms (7,055 pounds) of fuel remained in the left wing tanks.

At 0608, the master caution light illuminated and the ECAM displayed a cautionary message that fuel quantity in the left wing tanks was low.

Dual Flameout

At 0613, the right engine flamed out. The airplane was in nighttime visual meteorological conditions at Flight Level (FL) 390 (approximately 39,000 feet) and 150 nautical miles (278 kilometers) from Lajes Airport. The crew told ATC that an engine had flamed out, that the airplane was descending and that 600 kilograms (1,323 pounds) of fuel remained.

The report said that the crew acquired visual contact with lights on Terceira Island as the airplane was descending through FL 370, about 120 nautical miles (222 kilometers) northeast of Lajes Airport.

At 0623, the crew declared mayday and told ATC that they might have to ditch the airplane. About three minutes later, when the airplane was at about 34,500 feet and 65 nautical miles (120 kilometers) from Lajes Airport, the left engine flamed out. The crew conducted the "All Engines Flameout" checklist. The report said that the captain maintained an airspeed between the recommended glide speed and stall speed to "keep the aircraft airborne for the longest time."

The airplane was at 27,300 feet and 33 nautical miles (61 kilometers) northeast of the airport at 0631, when the crew established radio communication with Lajes Approach Control.

Runway in Sight

The airplane was at 22,000 feet and 14 nautical miles (26 kilometers) from the airport at 0636, when the crew told the approach controller that they had the runway in sight.

"Assisted by radar vectors and flashing of the runway lights, the aircraft arrived about 8.0 [nautical] miles [14.8 kilometers] off the approach end of Runway 33 at approximately 13,000 feet on a track of about 270 degrees," the report said. "The captain advised Lajes [ATC] that he was conducting a left 360-degree turn in order to lose altitude. During the turn, the aircraft was configured with leading-edge slats out and landing gear down for the landing. S-turns were conducted on final [approach] to lose additional altitude."

Airspeed was 200 knots at 0645, when the airplane crossed the threshold of Runway 33, which was 10,000 feet (3,050 meters) long. The airplane touched down hard 1,030 feet (314 meters) beyond the threshold, bounced and touched down again 2,800 feet (854 meters) beyond the threshold. The crew applied maximum emergency wheel braking and stopped the airplane 7,600 feet (2,318 meters) beyond the threshold.

"The captain's handling of the aircraft during the engines-out descent and landing was remarkable, given the facts that the situation was stressful, it was nighttime, there were few instruments available, pitch control was limited and he had never received training for this type of flight profile," the report said. "The first officer provided full and effective support to the captain during the engines-out glide and successful landing."

The fuselage skin near the trailing edges of the wings had been wrinkled during the hard touchdowns. With the anti-skid system inoperative because of the loss of power from the engine-driven generators, the main wheels had locked during the braking, and the tires had deflated because of the resulting abrasion.[2] Main landing gear components were damaged from contact with the runway; debris from the wheels and brakes punctured the airframe and the left engine nacelle.

Small fires that erupted in the left main landing gear wells after the airplane came to a stop were extinguished by aircraft rescue and fire-fighting personnel. Two occupants received serious injuries, and 16 occupants received minor injuries during the emergency evacuation, which was completed in about 90 seconds.

Three-inch Crack

An initial examination of the right engine found an L-shaped crack in the fuel line. The crack was approximately 3.0 inches (7.6 centimeters) long and 0.13 inch (0.33 centimeter) wide.

The report said, "The investigation determined that the double-engine flameout was caused by fuel exhaustion, which was precipitated by a fuel leak developing in the right engine as the result of the use of [a] mismatched fuel [line] and hydraulic [line] during the installation of the hydraulic pump. Facilitating the fuel exhaustion was the fact that the crew did not perform the 'Fuel Leak' procedure that was specifically designed by the manufacturer to reduce the consequences of an in-flight fuel leak."

The report said that the investigation resulted in the following findings as to causes and contributing factors:

- "The replacement engine was received in an unexpected pre-SB configuration to which the operator had not previously been exposed;
- "Neither the engine-receipt [planning process] nor the engine-change planning process identified the differences in configuration between the engine being removed and the engine being installed, leaving complete reliance for detecting the differences upon the technicians doing the engine change;
- "The lead technician relied on verbal advice during the engine-change procedure rather than acquiring access to the relevant SB, which was necessary to properly complete the installation of the post-mod[ification] hydraulic pump;
- "The installation of the post-mod[ification] hydraulic pump and the post-mod[ification] fuel [line] with the pre-mod[ification] hydraulic[-line] assembly resulted in a mismatch between the fuel [line] and hydraulic [line];

- "The mismatched installation of the pre-mod[ification] hydraulic [line] and the post-mod[ification] fuel [line] resulted in the [lines] coming into contact with each other, which resulted in the fracture of the fuel [line] and the fuel leak, the initiating events that led to fuel exhaustion;
- "Although the existence of the optional Rolls-Royce SB, RB.211-29-C625, became known during the engine change, the SB was not reviewed during or following the installation of the hydraulic pump, which negated a safety defense that should have prevented the mismatched installation;
- "Although a clearance between the fuel [line] and hydraulic [line] was achieved during installation by applying some force, the pressurization of the hydraulic line forced the hydraulic [line] back to its natural position and eliminated the clearance;
- "The flight crew did not detect that a fuel problem existed until [an] advisory was displayed and the fuel imbalance was noted on the fuel ECAM page;
- "The crew did not correctly evaluate the situation before taking action;
- "The flight crew did not recognize that a fuel-leak situation existed and carried out the 'Fuel Imbalance' procedure from memory, which resulted in the fuel from the left tanks being fed to the leak in the right engine;
- "Conducting the 'Fuel Imbalance' procedure by memory negated the defense of the caution note in the 'Fuel Imbalance' checklist that may have caused the crew to consider timely actioning of the 'Fuel Leak' procedure; [and,]
- "Although there were a number of other indications that a significant fuel loss was occurring, the crew did not conclude that a fuel-leak situation existed — not actioning the 'Fuel Leak' procedure was the key factor that led to the fuel exhaustion."♦

Notes

1. Portuguese Aviation Accidents Prevention and Investigation Department. *Accident Investigation Final Report: All Engines-out Landing Due to Fuel Exhaustion; Air Transat Airbus A330-243 C-GITS; Lajes, Azores, Portugal; 24 August 2001*. Oct. 18, 2004.

2. After both engines flamed out, the airplane's ram air turbine deployed automatically to provide hydraulic pressure to power the emergency electrical generator. The accident report said that the emergency generator did not provide, and was not designed to provide, electrical power to components including the anti-skid wheel-braking system and autobrake system.

Lightning, Manufacturing Anomaly Produce Undetectable Rotor-blade Damage

The Sikorsky S-76A+ helicopter was being operated in support of offshore oil and gas operations in the North Sea on July 16, 2002. The helicopter departed from Norwich, England, on a scheduled flight consisting of six sectors. The first four sectors were completed without incident; on the fifth sector, a catastrophic structural failure occurred while the helicopter was en route between two offshore platforms.

"The helicopter's main-rotor assembly separated almost immediately, and the fuselage fell to the surface," the report by the U.K. Air Accidents Investigation Branch (AAIB) said. "The fuselage disintegrated on impact, and the majority of the structure sank."

Fast rescue craft were launched from a nearby vessel and arrived at the accident site within a few minutes. There were no survivors among the nine passengers and two crewmembers.

The report said that investigators determined that a manufacturing anomaly had created an area of reduced insulation between a main-rotor blade's spar and one section of its two-piece leading-edge erosion cover. The affected blade later had been struck by lightning, the report said.

"Electrical energy from the lightning strike exploited the manufacturing anomaly and caused microstructural damage that was not detectable when the blade was returned to its manufacturer for assessment," said the report. "The blade was repaired before being returned to service, and a fatigue crack in the spar originated from the microstructural damage."

The repaired blade was installed on the accident helicopter and was in service for 1,403 flight hours before it failed, the report said. The fatigue-crack growth induced by the microstructural damage was dormant or slow for at least 1,300 flight hours.

"The fatigue crack probably began during the final 100 flight hours and may have progressed from an embryonic through-crack to 50 percent of the spar's circumference in as little as 24.4 flight hours," the report said. "A sympathetic crack formed in the recovered section of the erosion cover not less than 7.3 flight hours before the accident. When the sympathetic crack first appeared, it would have been hidden underneath a black, opaque protective patch that had been fitted to prevent water ingress into the scarf joint. The manufacturer's *Composite Materials Manual* specified the use of a clear patch material, but opaque patches were commonly used."

Eddy-current inspection, ultrasonic inspection, radiographic inspection or X-ray inspection likely would not have alerted maintenance personnel to the crack's presence, the report said.

"There was no existing line maintenance inspection that could realistically have detected the spar crack or revealed symptoms of the eventual blade failure," said the report.

The only feasible method of monitoring the structural integrity of an embedded tubular blade spar is by monitoring the pressure of gas trapped inside the spar, said the report.

"The helicopter manufacturer's proprietary method of achieving this is the BIM [blade inspection monitoring] system," the report said. [The BIM is an on-board system that fills the internal cavity of the spar with a gas and measures any decrease in pressure, which could indicate a leak through a crack.]

The report did not recommend retrofitting a BIM system on S-76 main-rotor blades.

"The S-76 main-rotor blade was not designed to have a gas-tight spar," the report said. "Modifications to the root and tip of the blade would be required to make the BIM system work. There would probably be spurious warnings due to gas leaks from imperfect seals, and spurious warnings tend to be ignored after a while. Also, the spar itself would have to be drilled to install the BIM detector.

"Unfortunately, a drilled hole would introduce a stress concentration near the blade root that would enhance the probability of crack development. The end result could be a BIM system that was unreliable but which detected genuine cracks induced by retrospective fitting of a BIM system."

AAIB made six recommendations as a result of the accident. Among them were the following:

- The U.S. Federal Aviation Administration (FAA) should take appropriate action to ensure the continued airworthiness of Sikorsky S-76 main-rotor blades that have either a two-piece leading-edge titanium sheath (erosion strip) or have suffered a lightning strike. [FAA acted the same day by issuing an emergency airworthiness directive, said the report];
- The Sikorsky Aircraft Corp. should, within Repair Procedure no. 6, clearly specify a durable transparent patch material for covering cracks in the leading-edge

erosion covers of S-76 main-rotor blades;

- Sikorsky should ensure that new cracks in the leading-edge erosion covers of S-76 main-rotor blades are frequently monitored for growth by an appropriately qualified person and for a suitable period to ensure that the crack is not symptomatic of a deeper flaw within the blade; and,

- Sikorsky should amend the S-76 preflight check and 50-hour inspection procedures to include a search for cracks in the upper skins and lower skins of main-rotor blades. The procedures should prompt investigation of the underlying reason(s) for such cracks before the next flight.

Incorrect Part Installed, Landing Gear Fails

The Fairchild SA-227-AC Metro III was flown from Stony Rapids, Saskatchewan, Canada, on a passenger flight to La Ronge, Saskatchewan. On the approach to La Ronge, the flight crew completed the approach-and-landing checklists and confirmed that the landing gear was down and locked.

As the airplane touched down, the left wing lowered and the left propeller struck the runway. Despite full rudder and aileron inputs, the airplane veered left. As the crew applied maximum right-wheel braking, the airplane departed the runway. The nose gear and right main gear were torn rearward, and the left main gear collapsed into the wheel well. The airplane slid before coming to a stop about 300 feet (91 meters) off the side of the runway. Three of the nine passengers received minor injuries from the sudden stop when the landing gear collapsed; the other passengers and the three crewmembers were not injured in the Sept. 21, 2004, accident.

The report by the Transportation Safety Board of Canada (TSB) said, "The landing gear is designed with a three-piece drag brace attached to the gear struts and the aircraft wheel wells. Each drag brace hinges at both ends and in the center to allow it to fold up into the wheel well during retraction. To ensure that the gear will remain down and locked during ground operations, the drag-brace center hinge travels slightly upward, to a locking over-center travel-limit stop, opposite to its normal folding movement.

"Because the drag brace hinges at three points, devices are needed to hold it against its over-center stops. Two of these devices are positioning cams that bolt to the inboard [ends] and outboard ends of each upper drag brace. Each cam has a concave cutout to receive the roller of a bell-crank-and-roller assembly, which is mounted to the aircraft wheel well.

When the landing gear is fully extended, the drag brace is forced into its over-center position by the bellcrank roller resting against the heel of the positioning cam. With the roller in this position, the gear is said to be in the 'down-and-locked' position."

A review of the airplane's maintenance records showed that the left gear outboard bellcrank roller had been replaced on Aug. 9, 2004, about 209 flight hours before the accident, said the report.

The aviation maintenance engineer (AME) who replaced the bellcrank roller was an employee of a contracted maintenance organization and was fully trained on the aircraft type, said the report.

"During an inspection of the aircraft [on Aug. 9], the roller was found to be missing, having broken away from the attachment bolt," the report said. "This was the first occurrence of a roller breakage on this aircraft that the AME had encountered. The AME, however, was aware of similar roller breakages on Metro 23 aircraft operated by another company. [The Fairchild Metro 23, a variant of the Metro III, has a greater maximum takeoff weight and a greater maximum landing weight for increased payload, as well as various additional modifications.]

"In those incidents, the AME believed that the rollers re-installed on the aircraft were of a solid-material type [rather than using an outer race running around rollers over an inner race, the type specified by the aircraft manufacturer], designed to alleviate the shattering of the rollers due to the heavier landing weight of the Metro 23 [15,675 pounds (7,110 kilograms) maximum compared with 14,000 pounds (6,350 kilograms) maximum for the Metro III]. When the roller breakage was discovered on [Aug. 9], the AME went to the company stores area and located a solid roller, the same type of roller that the AME believed was used by the other company as a replacement roller on the Metro 23."

Thus, an incorrect roller of a smaller diameter and type than the correct one was installed on the left main landing gear, said the report.

"The smaller diameter roller reduced the required rigging tolerances for the bellcrank-to-cam assembly in the down-and-locked position and allowed the roller to eventually move beyond the cam cutout position, resulting in the collapse of the left landing gear," said the report.

The AME installed the roller without checking the part number against the manufacturer's parts manual, said the report.

"Once the roller was installed, the AME did not do the required rigging checks to ensure that the bellcrank roller had been positioned properly in relation to its location on the heel of the positioning cam," the report said. "A parts-number cross-check and a rigging check are standard company [practices] and industry practices for the type of work that was performed."

Fatigue Fracture Disrupts Landing

A Beech 1900D received minor damage when the lower portion of the oleo strut of the left main landing gear turned within the housing during the landing roll. The two flight crewmembers and 17 passengers exited the airplane on the runway, and no injuries were reported in the July 6, 2004, incident.

The report by the U.S. National Transportation Safety Board (NTSB) said that the NTSB materials laboratory examined the main landing gear socket assembly and piston (part no. 114-810021-607) and scissors with upper and lower torque link (part no. 101-810032-5).

"The socket assembly was fractured in two pieces at the base of the lug that connects the socket assembly to the scissors," the report said. "The fracture [had] propagated all around the base of the lug into the bolt hole that goes through the piston and continued down on the right side to within approximately 0.5 inch [1.3 centimeters] of the axle. Both lower corners of the lug appeared to have the original contour, though localized impact damage was present from contact with the scissors. The fracture [had been] initiated from pre-existing fatigue regions at both the left and right radii at the base of the lug."

The material composition and hardness of the socket assembly were within specifications, and the only nonconformity noted was that the lug radii were smaller than specified, said the report.

At the time of the incident, the main landing gear assembly had accumulated 7,262 flight hours and 9,167 cycles.

Unsecured Linear Actuator Cited in Helicopter Accident

The Bell 412 helicopter was on a proficiency-check flight at Juhu Airport, Mumbai, India, on April 19, 2003. During the last part of the proficiency check, at an altitude of four feet, the helicopter yawed to the right and became uncontrollable. After three turns, the helicopter struck the runway and was substantially damaged. There was no injury to the two pilots.

The report by the Directorate General of Civil Aviation of India said that the probable cause was "non-availability of tail-rotor control due [to] dislodging of the linear actuator from its housing, as it was not properly secured in its position during [the] 3,000-hours/five-year inspection schedule."

Wiring-loom Abrasion Causes Electrical Arcing

On Nov. 25, 2003, passengers were boarding a Boeing 747-300 for a flight from Tokyo, Japan, to Sydney, Australia. The flight crew noticed that the circuit breaker for the "NO SMOKING/FASTEN SEAT BELT" sign in the "C" zone (on the main deck, between main cabin doors no. 2 and no. 3) tripped when the sign was actuated. The cabin crew reported seeing a flash and detecting a burning odor near seat 37K, on the right side of the main deck. The passengers and crew were disembarked, with no injuries, and ground engineers were called to examine the affected area.

"On removal of the side-wall trim and stowage bins adjacent to seat 37K, the 'NO SMOKING/FASTEN SEAT BELT' sign circuit wires and other wires in the wiring loom were found to have been damaged," the report by the Australian Transport Safety Bureau said. "The engineers reported that the loom was pinched between the outboard corner of the stowage bin and the adjacent structural frame."

The wiring loom had chafed against the frame, and the wiring insulation had been progressively abraded until the conductors contacted the metal frame, said the report.

"Electrical arcing resulted in localized damage to the wiring loom and the structural frame, extensive charring of the two adjacent insulation blankets and the tripping of the 'NO SMOKING/FASTEN SEAT BELT' sign circuit breaker," the report said. "The charring occurred when the blankets' outer reinforced plastic film melted due to the heat generated during the arcing event."

The wiring loom was properly constructed and supported, and the individual wires and the wiring loom location complied with the aircraft manufacturer's specifications, said the report.

"The operator advised that a review of the aircraft maintenance documents revealed that wiring in the 'C' zone was last inspected in 1997," the report said. "At that time, no chafing or damage to the wiring loom was reported."

The storage bins had been removed and re-installed during a "D" check in 2002.

"Pinching of the wiring loom most likely occurred when the storage bins had been installed during the last 'D' check in October 2002," the report said. "Neither the aircraft maintenance manual, nor the operator's task card detailing installation of the overhead bins, calls for inspection of the wiring looms and other components in the area of the stowage bins to ensure their adequate clearance from the bins."

The aircraft operator has since amended the task cards to include an inspection to ensure that the wiring looms have adequate clearance from the stowage bins, the report said. Boeing Commercial Airplanes, after reviewing the incident and the installation procedures for the overhead bins in the B-747, said that wire-bundle separation, including minimum-clearance requirements, are provided for in the *Boeing Standard Wiring Practices Manual* (DC-54446).♦

NEWS & TIPS

Get a Grip

Described as having long shelf life and high structural strength, Precote chemical fastener adhesives provide vibration-resistant locking and sealing properties. Used on screw threads, the adhesive will not harden prematurely because of chemical reactions with moisture or solvent penetration, the manufacturer says.

The adhesives are fast curing in aerospace applications and eliminate the need for additional locking methods.

The chemical fastener adhesives are offered in varying strengths, denoted by color, including Precote 5 (white) for thread sealing only; Precote 30 (yellow) for sealing and locking where lower strength and easy removal are needed; and Precote 80 (pink) for standard locking with high strength and temperature resistance to 340 degrees Fahrenheit (171 degrees Celsius).

Chemical Fastener Adhesives

For more information: Nylok Corp., 15260 Hallmark Drive, Macomb, MI 48042 U.S. Telephone: +1 (586) 786-0100.

No Salt, Please

Cortec VpCI-415, a foaming alkaline cleaner, is formulated for removing salt and preventing corrosion on aircraft. Its biodegradable formula provides heavy-duty cleaning and degreasing, removing oils, hydraulic fluids and exhaust buildup, the manufacturer says.

The cleaner is effective on ferrous metals and non-ferrous metals, the manufacturer says. It is designed to leave no residues on glass, plastics or composite material. VpCI-415 is formulated to protect the smallest crevices and voids on an aircraft's outside skin and interior surfaces, even in chloride-rich environments.

For more information: Cortec Corp., 4119 White Bear Pkwy., St. Paul, MN 55110 U.S. Telephone: 1 (800) 426-7832 (U.S.); +1 (651) 429-1100.

Drill Team Gets New Energy

Ergomax motors for drilling or installation have been added to the Jiffy Air Tool modular drill system. The manufacturer says that the motors, which are available at speeds of 150 revolutions per minute (rpm) to 4,500 rpm, include a quiet rear exhaust and a textured throttle lever for comfort and easy control.

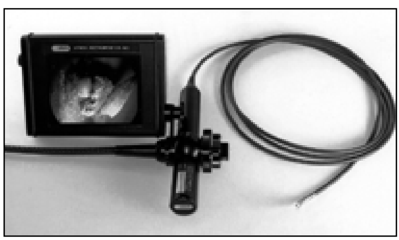
The anti-vibration handle glove is of polyvinyl chloride closed-cell foam that provides durability and resistance to dirt and oils, the manufacturer says. The handle glove is unaffected by most solvents and chemicals and is highly ultraviolet resistant, the manufacturer says.

The motors are rated at 0.45 horsepower (0.34 kilowatts) and have an ergonomic swivel air inlet that allows access to small spaces and eases wrist strain.

For more information: Jiffy Air Tool, P.O. Box 2222, Carson City NV 89702 U.S. Telephone: 1 (800) 828-8665 (U.S. and Canada); +1 (775) 883-1072.

Videoscope Optimizes Image

For viewing inside complex assemblies, the Lenox Instrument VideoFlex videoscope includes a tight bending radius and a four-way, 150-degree articulated tip for manipulation around corners. The integrated control-and-display hand piece, containing a 6.4-inch (16.3-centimeter) liquid-crystal display, enables the operator to manipulate the tip with one hand.



VideoFlex Videoscope

The video technology and automated management of optimized video parameters provide a high-definition image, the manufacturer says. The unit's functions include video-processor initialization, which varies according to the color temperature of the light source used, and automatic shutter activation.

For more information: Lenox Instrument Co., 265 Andrews Road, Trevose, PA 19053 U.S. Telephone: 1 (800) 356-1104 (U.S.); +1 (215) 322-9990.

System Offers Light, Not Heat

The NeuLite System of fiber-optic lighting was designed as a lightweight, flexible and safe light source for work in aircraft fuel systems, as well as other maintenance locations.

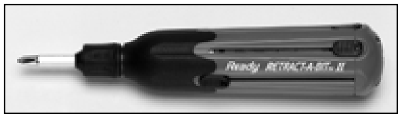
A single, 150-watt light is transmitted to as many as four light heads through fiber-optic cables. No electrical transmission of light takes place, so there is no electrical hazard or heat buildup where flammability might be present.

The power box containing the light source is portable, and a version that can be used in hazardous locations is available. Different cable lengths and light-head sizes are available.

For more information: Stewart R. Browne Manufacturing Co., P.O. Box 500008, Atlanta, GA 31150 U.S. Telephone: +1 (770) 993-9600.

Now You See Bit, Now You Don't

Bits can be changed with the push of a button on the Retract-A-Bit screwdriver system. They are integral with the tool to prevent lost bits.



Screwdriver System

Selecting a bit and sliding its corresponding button into place makes the tool ready to use. A locking collar provides stability during use, the manufacturer says. To change bits, the collar is depressed and the bit is retracted into the handle.

The tool includes two Phillips-head bits, two slotted-head bits, one square bit and one T15 Torx head bit.

For more information: Ready Products, 5855 Olympia Fields Court, West Chester, OH 45069 U.S. Telephone: +1 (866) 942-9230.

Less Sound, More Sight

Earmuffs that perform double duty, as noise blockers and visibility enhancers, are offered by Bilsom. Leightning Hi-Visibility Earmuffs' fluorescent green ear cups contrast with dark backgrounds in low-light or outdoor-night settings.

The earmuffs include a reflective headband that makes them conspicuous when illuminated by ambient or outside light sources. Steel-wire headband construction provides durability, and the foam-padded headband relieves pressure on the head for the wearer's comfort, the manufacturer says.

Snap-in ear cushions are designed to be easily replaced if they become soiled or damaged.

For more information: Bacou-Dalloz Hearing Safety Group, 7828 Waterville Road, San Diego, CA 92154 U.S. Telephone: 1 (800) 430-5490 (U.S).

Cable Wrap Can Take the Heat

Bundling, organizing and protecting wires and cables sometimes requires self-extinguishing material. Heli-Tube Fire-Resistant Polyethylene Spiral Wrap conforms to Underwriters Laboratories 94V-1 specifications for flame-retardant material.

The spiral wrap is available in eight sizes, from 0.125 inch to 1.5 inches (0.318 centimeters to 3.8 centimeters) outer diameter. The material can operate in temperatures to minus 4 degrees Fahrenheit (F) to 176 degrees F (minus 20 degrees Celsius [C] to 80 degrees C), and is unaffected by most acids, alkalis and solvents, the manufacturer says.

For more information: M.M. Newman Corp., 24 Tioga Way, Marblehead, MA 01945 U.S. Telephone: 1 (800) 777-6309 (U.S.); +1 (781) 631-7100.

Heavy-duty Hand Towels

Disposable hand towels for heavy-duty cleaning are now wrapped individually as Scrubs Singles. A package includes 100 towels, each 8.00 inches by 12.25 inches (20.32 centimeters by 31.12 centimeters), wrapped in a tear-open package.

The towels are pre-moistened with a citrus-based liquid, which the manufacturer says provides an absorbent, non-scratching surface. The towels are intended for fast removal of paints, urethanes, solvents, catalysts, resins, gel coatings, adhesives, sealants and inks.

The product can also be used for cleaning equipment, tools, metals, vinyl, work surfaces, painted surfaces, composites and plastics.

For more information: Binks, 195 International Blvd., Glendale Heights, IL 60134 U.S. Telephone: +1 (630) 237-5000.♦

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