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Robert A. Feeler, editorial coordinator

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On the cover: A close-up of the fractured left-main landing-gear outer wheel on a Fokker 100. Left-main landing-gear components on the airplane failed during two landing incidents in Australia. (Source: Australian Transport Safety Bureau)

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Inadequate Shot Peening Cited in Two Failures of Left-main Landing Gear On Fokker 100

The Australian Transport Safety Bureau said that the two incidents, which occurred three months apart in the same airplane, involved cracks in parts of the landing gear that had been repaired and in areas where shot peening was faulty.

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FSF Editorial Staff

About 1030 local time July 4, 1999, the crew of a Fokker 100 experienced a severe vibration from the left-main landing gear when they applied the wheel brakes during the landing roll at Norfolk Island Airport after a domestic flight in Australia. The airplane received minor damage; none of the 43 people on board was injured.

Three months later, at 1040 local time Oct. 9, 1999, the same airplane was being landed at the same airport when the crew experienced a severe vibration throughout the airframe. The airplane received substantial damage; none of the 84 people on board was injured.

The incidents were investigated by the Australian Transport Safety Bureau (ATSB), which issued a technical report on the analysis of the airplane's left-main landing-gear failures and air safety occurrence reports on each incident.

ATSB said in its technical report that, in the first incident, the outboard wheel on the left-main landing gear separated from the wheel hub during landing and that the second incident involved the fracture of the left-main landing-gear upper-torque-link attachment lugs.

A similar landing accident in May 2001 involving a Fokker 100 at Dallas-Fort Worth (Texas, U.S.) International Airport resulted in several safety recommendations from the U.S. National Transportation Safety Board (see "Inspections Recommended for Some Fokker 100 Landing-gear Cylinders," page 3).

After the first incident, examination of maintenance documents showed that the wheel had accumulated 99.8 hours in service and 77 landings and takeoffs since overhaul. The air safety occurrence report said that during the overhaul, repairs had been performed to remove scoring from the hub that was caused by "rubbing contact with the brake heat shield during service."

The repairs included the reduction of the hub diameter by 0.02 inch (0.51 millimeter). The work was conducted in accordance with requirements of repair no. 15 of the Aircraft Braking Systems Corp. maintenance manual of Sept. 27, 1998, and the Aircraft Braking Systems Corp. authorized an increase of the repair tolerance for the hub-diameter reduction from between 6.41 inches and 6.48 inches (16.28 centimeters and 16.46 centimeters) to between 6.39 inches (16.23 centimeters) and 6.48 inches. Instructions for the repairs said that after material was removed for the hub-diameter reduction, the repaired area was to be shot peened. The air safety occurrence report said that shot-peening parameters were to be "adjusted to produce a specific surface quality."

The technical report said that a comparison of the surface of the repaired area and the original surface of the wheel hub revealed a "markedly different" intensity in the shot peening of each area. The intensity of shot peening was lower on the repaired surface, the report said.

"This variation would be expected to lower the resistance of the wheel to fatigue cracking," the air safety occurrence report said. "The lower level of compressive residual stress associated with the less intense shot-peening process applied to the repaired [area] would also increase the likelihood of fatigue failure under normal loading conditions."

Shot peening is a method of strengthening a metal's resistance to fatigue and other types of stress-induced damage, typically by using compressed air or a rotating wheel to hurl round metallic shot at high speed toward the surface of the metal.[1]

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Inspections Recommended for Some Fokker 100 Landing-gear Cylinders

The U.S. National Transportation Safety Board (NTSB), citing a May 23, 2001, accident in which the right-main landing gear of an American Airlines Fokker 100 failed during touchdown at Dallas-Fort Worth (Texas, U.S.) International Airport, has recommended inspections of Fokker 100 series airplanes with the same type of main landing gear.

The lower portion of the right-main landing-gear assembly separated from the airplane, and the airplane was substantially damaged. None of the 92 people in the airplane was injured.

The right-main landing gear was part of the airplane's original equipment and had accumulated 21,589 flight hours and 15,380 takeoffs and landings during nearly nine years in service.

Post-accident examination revealed that the right-main landing-gear cylinder, manufactured by Messier-Dowty from a forged block of an aluminum alloy, had broken into five pieces.

One of the fractures on the forward face of the main landing-gear cylinder developed from a pre-existing crack that measured 2.5 millimeters (0.1 inch) in depth and 12 millimeters (0.5 inch) in length above a dowel pin bushing and forward of the up-stop damper abutment. Examination revealed "features typical of a forging fold," which NTSB defined as "a defect that can be caused by hot metal that flows back onto itself while it is flowing into the die cavity."

After the accident, U.S. operators of Fokker 100s inspected similar main landing gear using eddy current inspections.

"One [main landing gear] identified as having flaws similar to those found on the accident [airplane] was … found to contain a pre-existing crack … on the forward face of the [main landing-gear cylinder] above a dowel pin bushing and forward of the up-stop damper abutment and also originated from a forging-fold defect," NTSB said.

The manufacturer began conducting eddy current inspections of a larger area of the main landing gear and found six units with flaws similar to those on the accident airplane.

"Several of those cracks were outside the area covered by the inspections conducted by U.S. operators," NTSB said. "If these flaws and/or cracks had remained undetected, they could have continued to propagate to their critical crack length and resulted in [main landing-gear] failures."

In June 2001, Fokker Services issued service bulletin (SB) F100-32-128 Revision 1, and Messier-Dowty issued SB F100-32-100 Revision 1. The SBs advised Fokker 100 operators to perform one-time, fleetwide eddy current inspections of the forward face of some main landing-gear cylinders and, if necessary, to repair or to replace them. (SB F100-32-100 Revision 1 said that the SB applied to "part/type numbers 201072011 through 201072016, which includes main-fitting subassemblies 201072283, 201072284 and 201251258 [main fittings 201072383, 201072384 and 201072389])."

NTSB said, "Because this inspection area goes beyond that already inspected by

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U.S. operators and because of the potentially catastrophic consequences of [a main landing-gear] failure, [NTSB] is concerned that the eddy current inspections called for in the SBs are not mandatory. Therefore, [NTSB] believes that the FAA [U.S. Federal Aviation Administration] should require all operators of Fokker 100 series airplanes equipped with the [main landing gears] that are identified in Messier-Dowty SB F100-32-100 Revision 1 to immediately conduct an eddy current inspection of the [main landing-gear] cylinders for forging folds and fatigue cracks … and to remove from service all landing gear in which such forging folds or cracks are found until the gear are returned to an airworthy condition."

NTSB also recommended that FAA:

- Require Fokker Services to "immediately determine a repetitive inspection interval that will prevent structural cracks in main landing gear that are identified in Messier-Dowty Service Bulletin F100-32-100 Revision 1 from propagating to failure between inspections";
- Require operators of Fokker 100 airplanes with the main landing gear identified in the Messier-Dowty SB to perform periodic eddy current inspections of main landing-gear cylinders for forging folds or fatigue cracks;
- Require Fokker Services to review forging processes and inspection procedures discussed in the Messier-Dowty SB and to modify them, if necessary; and,
- Review the processes used by Messier-Dowty to manufacture and inspect landing gear and require modification if necessary.♦

The intensity of the shot peening is determined by shot size and air pressure or the speed of the rotating wheel.

The result of the process is that residual compressive stress is created on the metal's surface; the presence of the residual compressive stress is designed to delay the initiation or extension of fatigue cracks that otherwise might develop from features on the surface.

The U.K. Air Accidents Investigation Branch said, in an explanation of the shot-peening process that was included in a report on a 1995 accident, "Essentially, applied tensile stresses are offset by the residual compressive stress from peening."[2]

Viewed using low-power magnification, effective shot peening appears in the form of small indentations in an even pattern across the surface of the treated metal.

The ATSB air safety occurrence report on the July 4 landing incident said that the wheel failed because of fatigue cracking that began at the surface of the metal in the repaired area of the wheel hub.

"No single stress point concentrator had started the cracking," the report said. "It had begun at numerous closely spaced points around the circumference of the hub, known as ratchet marks. This was consistent with sideways flexure of the wheel web and with crack growth from the repaired surface of the hub. There was no indication the growth had started at any crack that had been present prior to the repair."

The fatigue crack spread in a manner consistent with the sideways flexing of the wheel web — flexing that occurs "when a turning moment (torque) is applied to the main landing gear while the wheels [are] rotating, such as during ground turning or crosswind landings," the report said.

High crosswind components were typical during takeoffs and landings at Norfolk Island, the flight crew said.

The technical report said that the ability of the main landing-gear wheels to withstand such a turning moment depends on "the resistance of the component … and the magnitude and frequency of the alternating stresses created by the applied loads and any geometric stress concentrators."

The final fracture of the wheel occurred just after touchdown, an indication that significant torque was being applied to the left-main landing gear at the time, the report said.

The incident investigation also revealed that, during the last overhaul before the landing incident, a portion of the left-main landing-gear shimmy damper had been reassembled incorrectly. The error had little effect, if any, on the initiation of the fatigue crack or the spread of the fatigue crack, the air safety occurrence report said. (Similarly, the air safety occurrence report on the second landing incident said that the incorrect assembly of the shimmy damper had little effect, if any, on the initiation or development of the fatigue cracks cited in that incident.)

The report on the second landing incident said that the upper torque-link attachment lugs on the left-main landing gear had broken during landing. (The upper torque-link attachment point was an integrally forged double lug with a stiffening web between the two lugs.) Examination of maintenance documents showed that the landing gear had accumulated 658 cycles since overhaul and 16,579 cycles since new.

The technical report said that the upper torque-link attachment lugs had failed because of "the extension of pre-existing cracking in the lug-stiffening web while torque was transmitted through the torque links. The cracking in the stiffening web was caused by stress corrosion."

The report said that the extension of the crack was consistent with loading that resulted in sideways flexing of the wheel rim during such situations as crosswind landings.

"The fracture of each lug section occurred as a result of rapid, unstable crack propagation," the report said. "In addition to the fractures in the lug sections, fracture and crack growth had extended from the locking-pin hole in the stiffening web. Initially, cracking from both the upper and lower locking-pin holes extended on a plane approximately 45 degrees to the pivot-pin bore. The cracks branched as they approached the lugs. One branch of the cracking extended around the circumference of the web, approximately parallel with the plane of the lugs; the other branch extended on a plane toward the lugs and arrested at the point of change in cross-section between the web and lugs."

The stiffening web, the pivot-pin bore and the locking-pin hole had been "reworked" during the most recent overhaul.

"Material had been removed by localized surface grinding in an attempt to remove corrosion," the report said. "The pivot-pin bore surface had been peened and repainted with a chromate-based paint primer. However, the paint film exhibited poor adhesion, and the shot-peening coverage was haphazard."

The presence of the stress corrosion crack in the stiffening web reduced the fracture-resistance of the lug during times when tensile stresses existed in the lug, including during crosswind landings, when main landing-gear turning moments were transmitted through the torque links, the report said.

The report said that the inboard lug fractured shortly after touchdown "as a result of the tensile stresses created by torque transmission [during the crosswind landing] and the lowering of the lug fracture resistance by the presence of a stress corrosion crack in the stiffening web. The failure of the inboard lug was followed by the bending fracture of the outboard lug."

Both air safety occurrence reports included a recommendation to the U.K. Civil Aviation Authority (U.K. CAA) to review the repair process and the overhaul process for the failed wheel and for the failed torque links that were identified during the ATSB investigation of the second landing incident to ensure that the processes conform to airworthiness requirements.

In response, CAA said that the repair and overhaul processes would be reviewed.

The technical report also included a recommendation for an audit of the company responsible for the repair and overhaul of the left-main landing gear "to establish why the repaired surface of the wheel hub differed from the 'as manufactured' condition."

The report said, "In particular, it should be established if the specification of the repair was adequate, or if repair instructions were followed. The reasons for any inadequacy or lack of compliance should be established.

"Similarly, the reworking of the torque link attachment lugs of the main-landing-gear fitting should be reviewed to establish why the surface treatment and surface protections schemes were inadequate."♦

[FSF editorial note: This article, except where specifically noted, is based on the Australian Transport Safety Bureau (ATSB) *Analysis of left-main landing-gear failures, Fokker 100, VH-FWI*, ATSB Air Safety Occurrence Report 199903327 and ATSB Air Safety Occurrence Report 199904802. The reports include photographs and diagrams.]

References

1. U.K. Air Accidents Investigation Branch. *Report on the accident to Douglas Aircraft Company MD-83, G-DEVR at Manchester Airport on 27 April 1995*, Section 1.16 "Tests and research." Aircraft accident report 1/97 (EW/C95/4/2).

2. Ibid.

Further Reading From FSF Publications

FSF Editorial Staff. "Fatigue Crack Leads to MD-83 Left Main Landing Gear Collapse on Rollout." *Aviation Mechanics Bulletin* Volume 45 (May–June 1997).

FSF Editorial Staff. "Corrosion and Fatigue-crack Detection Remains Critical to the Continued Airworthiness of Aging Aircraft." *Aviation Mechanics Bulletin* Volume 46 (March–April 1998).

Safety Actions Required for Some PW4000 Engines

The U.S. Federal Aviation Administration (FAA) has required operators of airplanes equipped with some models of Pratt & Whitney PW4000 turbofan engines to remove the engines before they exceed specified time limits.

The requirement is contained in Airworthiness Directive (AD) 2001-15-12, which also limits the number of PW4000 engines with a particular configuration of the high-pressure compressor (HPC) section that may be installed on an airplane and requires specified standards to be met in rebuilding the affected engines.

"The FAA has noted a growing number of takeoff surge events in Pratt and Whitney PW4000-series turbofan engines," the AD said. "These surges typically occur within 60 seconds after throttle advance to [takeoff] power, a critical phase of flight. These events have resulted in numerous aborted [takeoffs], in-flight engine shutdowns and diverted flights. A surge of this kind on a single engine of a multi-engine airplane would not normally result in an unsafe condition."

Nevertheless, two surge events involving surges of two engines on the airplane have been reported, including one on March 9, 2001, in which an Air Sudan Airbus A300 lost power in both engines during takeoff from Jeddah, Saudi Arabia, FAA said.

Investigations have revealed "no special causes" of the surges, but FAA believes that "a low stall margin results from open clearances in the aft stages of the HPC" and that "the worst-case open-clearance condition in the aft stage compressor of the HPC occurs about 60 seconds after the throttle is advanced for [takeoff]."

AD 2001-15-12 supersedes two similar ADs (AD 2000-22-01 and AD 2001-09-07) whose requirements were not sufficient, FAA said.

The new AD, which took effect immediately upon issuance July 26, 2001, requires:

- "Limiting the number of engines with the HPC CBS [cutback stator] configuration to one on each airplane within 100 cycles-in-service (CIS) after the effective date of this AD;
- "Limiting the number of PW4000 engines with potentially reduced stability on each airplane, based

upon airplane and engine configuration, within 50 CIS after the effective date of this AD;

- "Removing certain PW4000 engines from service before exceeding cyclic limits on the HPC, based on CSO [cycles since overhaul], within 50 CIS after the effective date of this AD;
- "Preventing the buildup of PW4000 engines that have an HPC with 1,500 or more CSO greater than the HPT [high-pressure turbine] CSO; and,
- "A minimum rebuild standard for engines that are returned to service."

FAA said that the AD affects 500 engines used on U.S.-registered Boeing 747s and 767s, McDonnell Douglas MD-11s and Airbus A300s and A310s. About 2,100 PW4000 engines with the affected configuration are in use worldwide, FAA said.

Damaged Electrical Wires Found on A320

The Australian Air Transport Safety Board (ATSB) said that damaged bundles of twisted-pair electrical wires found in the leading edge of the right wing of an Airbus A320 resulted from surface rubbing and contact with sharp edges.

In a technical report on the wiring, ATSB said that there were two distinct types of damage:

- Surface rubbing damage, which was "consistent with the wire experiencing a shallow angle of contact against the corner of a solid object." In several instances, insulation indentations and rub marks were found near primary areas of damage.

  The report said, "Rubbing and scraping of the wires against the harpoon tie tongues as the aircraft wing flexes in flight could be expected to produce such damage and could produce the characteristic indentations that were noted. The end profile of some areas of damage also matched the edge radius of the harpoon tie tongues"; and,

- Sharper, "intrusive-type" damage sometimes was accompanied by the partial shaving of the outer insulation.

  The report said, "While not knife-cut in its sharpness, the more intrusive and localized nature of the damaged areas suggests a less acute angle of contact against a sharper corner or edge along the raceway path."

The report said that there was no evidence that any of the damage resulted from tooling or "other influences external to the raceway installation."

FAA Orders Inspections of MD-88, MD-90 and DC-9 Static-port Heaters

The U.S. Federal Aviation Administration (FAA) has issued Airworthiness Directive (AD) 2001-10-10 requiring operators of McDonnell Douglas DC-9, MD-88 and MD-90 airplanes to inspect the wiring of static-port heaters for signs of electrical arcing, chafing and loose connections and to make necessary repairs.

The AD also requires operators to determine whether the insulation surrounding the heaters is covered with metalized Mylar (polyethyleneteraphthalate); if so, the AD says that the operators must replace the metalized Mylar with Tedlar-covered insulation, or take other appropriate action.

The AD was issued in response to a recommendation by the U.S. National Transportation Safety Board, which said that a spark from a static-port heater ignited a fire in the forward cargo compartment of a Delta Air Lines MD-88 on Sept. 17, 1999, after takeoff from Cincinnati/Northern Kentucky International Airport in Covington, Kentucky, U.S. (See "Inspections Recommended for MD-80, MD-90 and DC-9 Static-port Heaters." *Aviation Mechanics Bulletin* Volume 49 [March–April 2001]: 10–12.) The fire consumed the metalized-Mylar-covered insulation blankets that surrounded the heater. No one was injured; the airplane received minor damage.

The AD affects 605 U.S.-registered airplanes.

Stiff Aileron Controls On BAE 146 Result in New Maintenance Test

A British Aerospace (now BAE SYSTEMS) 146-300 was parked for several hours at a gate in light rain and in temperatures no lower than 7 degrees Celsius (45 degrees Fahrenheit), before departure from Aberdeen, Scotland, for a flight to Amsterdam, Netherlands.

The flight crew said that as they flew the airplane to Flight Level (FL) 250 (25,000 feet), the aileron controls became "stiffer to operate and eventually locked solid."

The incident report by the U.K. Air Accidents Investigation Branch (AAIB) said, "The aircraft was leveled at FL 270, and, because it had been climbing in a wings-level attitude, the [captain] decided not to apply excessive force to overcome the aileron jam, as would have been the case if he had adhered to the 'aileron jam or uncommanded roll' drill; the aircraft was therefore maneuvered laterally using aileron trim."

The captain said that he believed that any attempt to overcome the restriction on the controls could have led to a sudden, violent rate of roll that might have been difficult to control. The flight crew also believed that rainwater had entered the control runs and had frozen at altitude; after they declared an urgency (pan pan) and descended the airplane to 2,500 feet, the controls gradually became free. The flight crew conducted a long, straight-in approach and a normal landing at London (England) Stansted Airport. None of the 99 people in the airplane was injured.

A post-incident inspection of the aileron controls revealed no signs of stiffness or jamming.

A similar aileron-restriction incident had occurred 10 months earlier and apparently had been corrected by the replacement of the autopilot aileron servomotor, which drives the aileron linkage through a gearbox and a clutch. After the second incident, which occurred when the airplane had accumulated about 20,000 flight hours and 21,000 takeoffs and landings, inspections and test flights revealed no evidence that the problem was associated with the autopilot aileron servomotor. Nevertheless, the airplane was returned to service with a replacement autopilot aileron servomotor. Investigators delayed a planned inspection of the spoiler camboxes, which send signals to their associated roll spoilers about roll direction and aileron deflection, and two more aileron-restriction incidents occurred before the inspection was conducted.

The inspection revealed a metallic particle that "had become trapped between the [cam] roller and the slot" and may have been associated with at least one aileron-restriction incident.

The ailerons then were removed and disassembled.

"The left aileron servo-tab input mechanism felt 'notchy' when operated by hand," the report said. "Further disassembly revealed that the back-to-back bearing assembly on the upstream end of the torsion bar was stiff in operation. The bearings were located on a common shaft within a fitting forming part of the aileron structure and were separated by an aluminum-alloy spacer. The space between each bearing thus took the form of an annular void, which, it appeared, was susceptible to filling up with water.

"Disassembly of the bearings revealed no evidence of corrosion, although in the absence of lubrication, 'galling' between the stainless steel balls and races hindered smooth operation. In addition, the solid residues from the grease, which probably included dirt, also contributed to the bearing rolling resistance. … The distinguishing feature of the … bearings was that they were located at the edge of a joggle [a step-shaped offset] in the aileron leading edge, which was thus effectively an end rib. The retaining plate on the exterior surface of the end rib was not designed as a seal and was thus able to admit external contaminants, such as water, to the outer bearing, and thence to the inner bearing via the annular void. The bearings themselves were 'on condition' components and were pre-packed with grease at manufacture; there was no provision for in-service lubrication."

A revision was made to the bearing type (part no. SL4421-01) in 1991 — one year after the incident airplane was manufactured — to allow either Aeroshell 7 grease or Aeroshell 22 grease to be used during manufacture. (Aeroshell 22 grease is less likely to retain moisture, the report said.) Before 1991, only Aeroshell 7 grease was used.

The report said that examination of the operator's maintenance records showed that "potentially similar aileron problems" had occurred in four of its 10 BAE 146 aircraft and that after the incident, inspections revealed aileron bearings on two airplanes that resembled the aileron bearings on the incident airplane. In other instances, corrosion was found in the aluminum-alloy spacers that separated the back-to-back bearing assemblies. The manufacturer was unaware of any similar problems experienced by other operators of BAE 146 and BAE Regional Jet (RJ) airplanes, and a low volume of spare bearing sets had been ordered since 1983, when the aircraft were registered.

"It was not established why other operators of this type of aircraft had apparently not experienced similar problems," the report said.

The investigation also did not determine why only one aileron on the incident airplane had been affected.

Nevertheless, the report said, "The subject bearings have been causing problems for a number of years, and … the symptoms may have been misidentified as autopilot servomotor malfunctions. The situation was further confused by the presence of a contaminant particle within the left-hand spoiler cambox of [the incident airplane]. The bearing problem appeared to be the result of water ingress. This would most probably have been rain, as its location would not permit direct impingement of the jet from a high-pressure hose during washing operations.

Some of the grease had been washed out, leaving solid residues that impeded the rolling action of the balls in the races. Additional rolling resistance would have been caused by the formation of ice crystals as the aircraft climbed above the freezing level. It is thus possible that there would be a higher risk of an aileron restriction developing where the aircraft climbed on a constant heading, with consequently small aileron deflections. Large and frequent aileron movement would be more likely to crush the ice crystals as they formed."

After the incident, the manufacturer revised the maintenance manual to include a "subjective friction test" for aileron servo-tab circuits and elevator servo-tab circuits that involves disconnecting the linkage near the torsion-bar input to check for stiffness when the servomechanism is operated by hand. Such stiffness could indicate the presence of a worn bearing, which then could be examined and replaced.

Absence of Oil in Tail-rotor Gearbox Cited in Fatal Accident

A Bell 47 flown by a student pilot and a flight instructor was being flown through 700 feet after departure from Abbotsford (British Columbia, Canada) Airport when tail-rotor thrust was lost and the helicopter entered a spin to the right. The helicopter descended out of control, stuck the ground in a steep, nose-down attitude, broke apart and burned. Both pilots were killed.

Investigation showed that the tail rotor was not turning when the helicopter struck the ground and that gears in the tail-rotor gearbox suffered heat distortion and had disengaged. No oil — and no remnant of burned oil — was found in the tail-rotor gearbox. No control anomalies were found.

Records showed that maintenance personnel had conducted a 100-hour inspection of the helicopter the day before the accident. The inspection required that oil be changed in the tail-rotor gearbox, and the task was assigned to an apprentice aviation maintenance engineer (AME).

"The apprentice AME drained the tail-rotor gearbox oil, inspected it for metal particles and installed and lockwired the drain plug," said the accident report by the Transportation Safety Board of Canada. "In addition to the normal actions of the 100-hour inspection, the forward section of the cables that move the horizontal stabilizer were replaced. The [supervising] AME signed the aircraft journey logbook as having completed the 100-hour inspection. The 100-hour inspection check-sheet item that called for draining and refilling of the tail-rotor gearbox was initialed by the apprentice AME."

The next morning, the student pilot conducted a preflight inspection, which calls for visual inspection, through a sight gauge (small window), of the level of oil in the tail-rotor gearbox.

The flight instructor joined the student pilot after the student had started the helicopter's engine. They operated the helicopter for about 15 minutes on the ground and about two minutes in the air before the accident occurred.

The report said, "Since there was heat distortion of the gears and no remnant of oil in the tail-rotor gearbox, it is concluded that no oil was in the gearbox when the helicopter started operating on the morning of the accident. It is also concluded that, since the lack of oil was not detected prior to flight, the apprentice AME, the AME, the student and the instructor did not check the oil level or erred in reading the sight gauge. … It is sometimes difficult to tell whether there is oil behind the window."

The report also said that after the helicopter began to spin, the pilots did not respond by conducting an immediate autorotative descent — the action prescribed by the Bell 47 flight manual in the event of a tail-rotor failure.

Unauthorized Use of Degreaser Blamed for Wheel Bearing Failures

After departure, the flight crew of a Beech 1900D was notified that a tire had been found on the runway, said a report by Transport Canada. (The report did not identify the airport or the country where it is located.)

"Maintenance [personnel] discovered that the wheel had fallen from this aircraft as a result of a bearing failure," the report said. "The bearing failure resulted from a lack of lubrication caused by the use of a degreasing fluid to clean the landing gear."

The same degreasing fluid had been used on other aircraft, and in some instances, their bearings were dry and required lubrication.

Investigation revealed that, five days before the incident, a main wheel on the same airplane had malfunctioned and that its outboard bearing was dry and "self-destructing."

Investigation also revealed that the operator had hired cleaning personnel "who had taken it upon themselves to select a product [the degreasing fluid] to clean the 'greasy' wheels" on all of the company's aircraft, the report said. After the incident, the company began inspecting — and, if necessary, regreasing or replacing — all bearings and other affected wheel-well components, and the cleaning personnel were instructed in correct cleaning methods.

Inspection of the fleet revealed that 75 five percent of wheel bearings were dry.

Shop Rag Jammed Spoiler-control Pulleys

The U.S. National Transportation Safety Board (NTSB) said that a shop rag jammed the spoiler-control pulley system of a McDonnell Douglas MD-11, causing the flight crew to have roll-control difficulty during takeoff from Honolulu (Hawaii, U.S.) International Airport.

"Post-landing inspection showed that three of the five spoilers on top of the right wing were fully deployed," the final accident report said. "Mechanics found a general-purpose shop rag lodged in the spoiler-control pulley system, jamming it in the deployed position."

The rag was found in an open area in the center-body landing-gear wheel well. The center-gear doors usually are closed when the airplane is on the ground, but maintenance personnel can open the doors to work in the area. Employees of a contract fuel-systems repair company had worked in that part of the airplane two days before the incident, when they opened several lines to check for fuel leaks.

The report said that neither the maintenance organization nor the maintenance technician responsible for the rag could be determined.

Stress Corrosion Cracking Cited in Landing Accident

Stress corrosion cracking of a landing-gear leg has been identified as the possible cause of an accident involving a Lockheed L-188C Electra. The airplane was being flown on a night training flight, which included take-offs and landings at Prestwick Airport in Scotland.

The touchdown for the third landing at first appeared to be normal, but the report by the U.K. Air Accidents Investigation Branch (AAIB) said that the captain was "immediately aware of a directional control problem."

"The aircraft was veering to the left to such an extent that he had to use full right rudder, in addition to asymmetric reverse thrust, to maintain the centerline," the report said. "Directional control became progressively more difficult as the aircraft decelerated."

The captain applied full braking and maximum reverse thrust on all four engines and stopped the airplane about 10 feet (three meters) from the left edge of the runway and on a heading 70 degrees to the left of the runway direction.

The airplane received minor damage; neither pilot was injured.

Investigation revealed that the lower (piston) oleo cylinder of the left-main landing-gear leg had fractured above the axle and that the axle and the two wheel-brake assemblies had separated from the leg. The upper section of the piston cylinder remained in the upper leg and was further damaged by contact with the runway as the airplane decelerated.

Only the lower section of the fractured piston cylinder was available for metallurgical examination, which revealed that the fracture had begun at the lowest area of the piston's outer surface, near the limit of normal travel by the piston.

"This location was on the inboard side of the piston and was characterized by corroded arcs on the fractured surface, which extended some 2.5 [millimeters; 0.1 inch] into the material from the outer surface. … Visual examination also revealed the presence of some parallel secondary cracking adjacent to the main fracture."

Further examination revealed brittle cleavage cracking in the chromium plating on the surface and intergranular cracking in the underlying steel in the corroded arc regions.

"Beyond and between these areas, the steel section had failed in overload," the report said.

"Several areas of cracking of the steel substrate were found, and within the chromed surface on the front side of the leg, from 25 [millimeters; one inch] above the normal limit of travel to below this limit, a pattern of fine, vertically orientated cracks [was] observed in the chromium plating, which was generally about 100 micrometers [0.004 inch] thick in this area. Remote from the fracture-initiation zone, the chromium thickness was reduced to between 25 micrometers [0.001 inch] and 40 micrometers [0.002 inch], probably due to wear. Some cracking in the plating was apparent in both the vertical [orientations] and horizontal orientations, but this was not generally fully penetrating. Evidence of some remaining grit-blasting debris was present in the chrome/steel interface, but the plating was strongly adherent to the parent steel substrate."

The report said that stress corrosion cracking was the most likely cause of the cracking. Stress corrosion-cracking failures typically result from "a field of cracks produced in a metal alloy under the combined influence of tensile stress … and a corrosive environment," the report said.

Because of the multiple orientation of cracks on the piston, internal stresses in the steel probably were associated with the cracking, the report said.

"The distribution of the cracking detected in the chromium plating … was consistent with excessive loads having been generated in the plating by grinding-wheel operations during manufacture/refurbishment of this component," the report said. "[Although] it is not unusual for some cracks to form in chromium 'as-plated,' the many cracks observed were considered to have resulted from a combination of the plating process used and excessive grinding action. Those cracks in the chrome surface had then allowed the underlying high-strength steel to be exposed to corrosive conditions, inducing [stress corrosion cracking]."

The aircraft manufacturer's records showed that four similar failures had occurred involving landing-gear-leg piston cylinders. Metallurgical examinations were performed in three of those instances. The examinations showed that one failure resulted from stress corrosion cracking and that stress corrosion cracking was a possible cause of the other two failures.

The manufacturer said that when the aircraft type was certified, there was no requirement to establish safe lives for landing-gear components. Proper maintenance and proper plating procedures during overhaul were considered adequate for inhibiting stress corrosion cracking. Electra Service Information Letter (SIL) 88/SIL-88A, which discussed stripping procedures and plating procedures, was issued in October 1974; the manufacturer believed that all aircraft operators possessed the SIL.

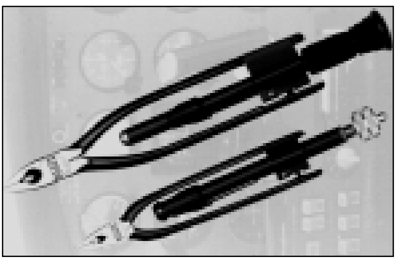
The authorized overhaul life of the main landing gear was 16,000 flight hours. The landing gear on the accident airplane had accumulated 15,400 flight hours since its previous overhaul. The airplane had accumulated 49,500 flight hours and 22,300 landings.♦

Wire-twisting Pliers Designed for Safety Wiring

Diagonal wire-twisting pliers have been designed for reliable safety wiring or lock wiring, said the manufacturer, Klein Tools.

The pliers are available in a right-hand twist style (model 12213 and model 12215) and a reversible twist style (model 12214 and model 12216), which rotates clockwise and counterclockwise. Both styles are available in two sizes — six inches (15 centimeters) and nine inches (23 centimeters). They are designed for wire-diameter capacities of 0.041 inch (one millimeter) to 0.060 inch (1.5 millimeters).

For more information: Klein Tools, P.O. Box 599033, Chicago, IL 60659 U.S. Telephone: (800) 553-4676 (U.S.) or +1 (847) 677-9500.



Wire-twisting Pliers

Vacuum-base Drill Used for Cutting, Tapping

The Vac-Force vacuum-base portable drill press can be used in applications that are difficult for magnetic-base drills, said the manufacturer, Sioux Tools.

Portable Drill Press

The Vac-Force uses an air cylinder that is controlled by an indirect lever to feed the cutter through the material being cut. The drill is lightweight and can be used in almost any position, including overhead, and in a range of applications, including cutting, drilling and tapping, said the manufacturer.

For more information: Sioux Tools, 2901 Floyd Blvd., P.O. Box 507, Sioux City, IA 51102 U.S. Telephone: +1 (712) 252-0525.

Hardness Tester Is Portable Measuring Tool

The DynaPOCKET compact hardness tester is designed to determine the hardness of large components that cannot be moved easily, said the manufacturer, Krautkramer.

The hardness tester measures 1.5 inches (3.8 centimeters) by 6.7 inches (17 centimeters) and weighs seven ounces (198 grams). The device contains standard conversion tables for nine material groups, and the measured hardness value is reported on a liquid crystal display.

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

Adhesive Provides Fluid-resistant Seal in High Temperatures

The Raychem S1125 Kit 8 is a fluid-resistant and diesel-resistant adhesive designed to be used with heat-shrinkable components to seal connections that are subject to high operating temperatures and/or flexural loads, said the manufacturer, Tyco Electronics.

The adhesive is a two-part epoxy-polyamide adhesive developed for engine-bay requirements in aerospace applications and other applications. The adhesive provides strain relief and creates a long-term seal that is resistant to a variety of chemicals and fluids. Its operating-temperature range, when used with accepted high-performance components, is from minus 75 degrees Celsius (C) to 150 degrees C (minus 103 degrees Fahrenheit [F] to 302 degrees F).

For more information: Tyco Electronics, 300 Constitution Drive, Menlo Park, CA 94025 U.S. Telephone: +1 (650) 361-4470.

Grippers Provide Increased Grip Forces

The PGN-plus series of parallel grippers provide increased grip forces for handling heavier loads with greater efficiency, said the manufacturer, Schunk Precision Workholding Solutions.

The PGN-plus series includes six versions of grippers in five sizes with various gripping forces. The housing is made from high-tensile strength, hard-anodized aluminum alloy, and all functional parts are made of hardened steel.

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

Solid-wall Inserts, Studs Lock Into Place

Solid-wall design inserts and studs designed for aerospace applications have integral locking stakes that resist torque-out and pull-out, said the manufacturer, SPS Technologies.

Solid-wall Inserts and Studs

The solid-wall staked inserts, staked studs, swaged inserts and ringlock studs are available in a range of sizes, materials and configurations, and their integral locking stakes are driven into parent materials to lock the insert in place mechanically. They can be installed with simple hand tools, said the manufacturer.

For more information: SPS Technologies, 301 Highland Ave., Jenkintown, PA 19046-2692 U.S. Telephone: +1 (215) 572-3718.

Solid-state Power Controller Provides Load Protection

The AMPHION solid-state power controller is a plug-in component that protects sensors, wiring and 28-volt direct-current data buses against shorts to ground, shorted sensors and overloads, said the manufacturer, AMETEK Aerospace.

AMPHION detects intermittent arcing in the load and wiring and detects the fault-current pattern that is typical of an arc. Its circuitry prevents a failure in a short-circuited condition.

Solid-state Power Controller

For more information: AMETEK Aerospace, 50 Fordham Road, Wilmington, MA 01887 U.S. Telephone: +1 (978) 988-4639.♦