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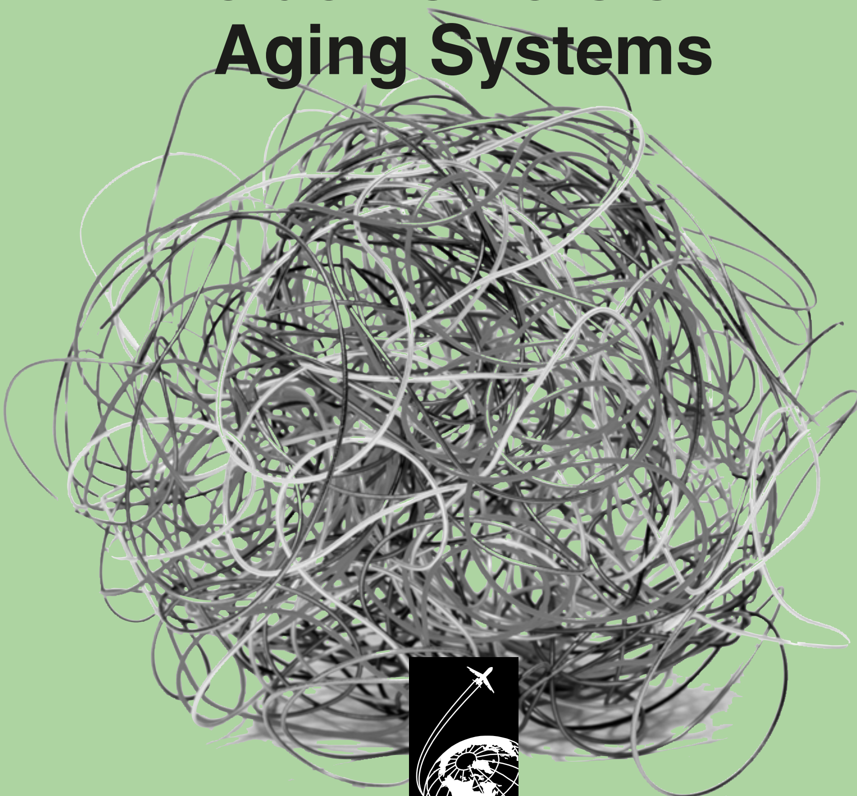

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Robert A. Feeler, editorial coordinator

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Aircraft Wiring Incidents Persist in Aging Systems

The U.K. Air Accidents Investigation Branch cited four recent incidents in which wiring problems were associated with aging aircraft electrical systems and/or maintenance issues.

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FSF Editorial Staff

The U.K. Air Accidents Investigation Branch (AAIB), citing several recent accidents and incidents involving electrical arcing and damaged aircraft wiring, has recommended that the U.S. Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) accelerate the distribution of guidance material for development of electrical systems standard wiring practices manuals.

"Aging[-related] and maintenance-related wiring incidents continue to occur despite, generally, an enhanced awareness of the problems associated with aircraft wiring systems," AAIB said in its *Overview: Incidents Resulting From Damage to Electrical Wiring*. The overview was published along with AAIB reports on four incidents involving wiring problems that occurred between Nov. 8, 2002, and July 30, 2003.

"All these incidents show how prone electrical wiring is to damage occurring over time or being introduced during maintenance or modification action," the overview said.

Electrical Fire Disables Interphone, Cabin Lights

In the first incident, the flight crew of a Boeing 737-400 observed smoke and detected the odor of electrical burning soon after departure on Nov. 8, 2002, from London (England) Heathrow Airport for a flight to Kiev, Ukraine. Six crewmembers and 68 passengers were in the airplane. The cabin-call aural warning sounded, indicating that cabin crewmembers were calling the flight crew on the interphone, but the captain and first officer were unable to contact the cabin crew on the interphone. They donned oxygen masks and conducted the "electrical smoke/fumes or fire" checklist.

"Both pilots were aware of continued banging on the locked cockpit door, which had commenced after their failed attempts to reply to the cabin crew on the interphone," the incident report said. "This heightened the pilots' concerns about what was happening since they were unable to either communicate with the cabin crew or establish the cause of the smoke."

After the smoke dissipated, the captain briefed the first officer and "cautiously removed his [oxygen] mask" so that he could reach the flight deck door unencumbered by the mask's hose.

"He … checked through a peephole for signs of fire or possible intruders," the report said. "Seeing neither, he opened the door and was met by a flow of water coming from a panel in the roof between the forward toilet and the galley. The cabin services director (CSD), who had been the person banging on the door, explained that about 15 minutes after takeoff, he had seen sparks and flames coming from the panel, followed shortly thereafter by a continuous stream of water."

A cabin crewmember had turned off the water-isolation valve but had been unable to stop the water from pouring off the roof panel. Concerned that the water might flow into the avionics bay, the crewmember then stuffed towels into the gap beneath the flight deck door. Another cabin crewmember working in the rear of the airplane said that the rear galley and some cabin lights had stopped functioning.

The flight crew flew the airplane back to Heathrow where they conducted a precautionary landing, stopped the airplane on the runway and shut down the engines to allow an inspection of the airplane by aircraft rescue and fire fighting (ARFF) personnel. The visual inspection revealed no fire or damage, and thermal imaging revealed no hot areas in the airplane's ceiling; nevertheless, the report said, "on pulling down the damaged ceiling panel [just outside the flight deck door], a [burned] wiring loom [bundle of wires] could be seen. Next to this was the water-supply hose to the forward galley, from which water was still pouring."

The investigation found that damage had occurred in an area inside the ceiling panel where a braided-steel hose (a water hose that delivered water from the crown of the fuselage to the galley on the right side of the forward cabin) had been secured with a nylon electrical tie-wrap strap.

The report said, "It appeared that there had been abrasion and arcing between the wires and the hose, resulting in the severing and shorting of a number of the wires. The braided-steel hose was lying against the frame of the ceiling panel, and it appeared that there had also been electrical shorting to this portion of the airframe."

In one section of the hose, the steel braid had melted, and at least two holes had formed in the inner hose, resulting in the water leak.

"Comparison with a sister aircraft … indicated that the hose was too long for this application and that the extra length … had been looped through this overhead area and then only secured by a tie-wrap to adjacent wire bundles," the report said. "Part of the hose was protected by plastic spiral wrap, but this did not extend to the portion of the hose in contact with the wire bundles."

Twenty-five circuit breakers were activated (tripped) during the incident, including those that provided the cabin interphone and cabin lighting.

The report identified three principal causal factors of the incident:

- "The excessive length of the steel-braided water hose to the forward galley;
- "The lack of an established routing or restraint of this extra hose; [and,]
- "The unexplained securing of this hose to the electrical loom."

Investigators were unable to determine when or how the hose was attached to the electrical loom, but the report said, "It is most likely that it occurred during the period of maintenance [from June 29, 2002, to Aug. 15, 2002] and that the attachment was simply a short-term expedient while systems were being disconnected and disassembled and that the 'temporary' tie-wrap was then missed during reassembly.

"In each of these three cases (excessive length, informal routing, inappropriate securing), the hazard created was inadvertent, and in each case, there existed, in principle, a procedure to avoid this type of hazard. In principle, the interface documents between the airframe manufacturer and the suppliers of customer-specified equipment (such as galleys) should have prevented the … galley [from] being supplied with a hose of excessive length. In principle, the quality processes of the maintenance organization should have identified the hazard consistently posed by the excessive hose length and the lack of routing or restraint; the same quality processes should, in principle, have prevented the securing of the water hose to the electrical loom and [should have] identified the hazard after it occurred.

"However strenuous the efforts to avoid these design and maintenance quality lapses, their essentially random natures make them very difficult to eliminate. This has been apparent in the AAIB investigations of a number of recent accidents and serious incidents where a range of circumstances have led to electrical arcing failures, where conventional circuit breakers have not tripped."

Based on the findings of the incident investigation, AAIB recommended that Boeing Commercial Airplanes review the section of the maintenance manual that provides information about the installation of the forward galley in the B-737-400 and other affected models "to give clear instruction as to where the galley water-supply hose disconnection should be made when removing the galley" for maintenance.

In response, Boeing said that maintenance manual instructions are "often generic in nature for this type of application" because of the variety of galley installations in B-737s. (For example, the operator of the incident airplane had B-737s with six different galley installations.) Nevertheless, Boeing said that its representatives would review the hose installation "to ensure the security of the extra length of hose and validate any necessary changes to the galley installation and/or its procedures"; the review was to include "necessary specific instructions for securing the extra length of hose, or [development of] alternative solutions."

Wiring Failure Cited in Depressurization Incident

In the second incident, a B-737-400 was in cruise flight near Lyon, France, en route from Marseille, France, to London Gatwick Airport, on May 30, 2003, when the cabin-altitude warning horn sounded, indicating that cabin altitude had exceeded 10,000 feet. The pressurization control panel indicated that cabin altitude was increasing. Both the primary pressurization control system and the secondary pressurization control system failed, and the flight crew was unable to control the cabin altitude using the manual pressure-control mode. The crew conducted an emergency descent to establish a cabin altitude below 10,000 feet and diverted to Lyon. Seven of the 128 passengers received minor injuries (ear problems and/or sinus problems) as a result of the depressurization.

A preliminary inspection of the airplane showed that no circuit breakers had been activated during the incident, that the rear outflow valve (OFV) could be operated in the standby mode and in one of the manual control modes but not in the primary mode or the first manual control mode, and that the OFV-position indication on the flight deck was incorrect. During an unpressurized ferry flight to Gatwick, the circuit breaker for the aft drain-mast heater was activated twice.

The investigation revealed that the depressurization incident resulted from a wiring failure in a loom at the rear of the aft cargo hold.

"The wiring loom had been damaged by abrasion … that, over time, resulted in the conductors becoming exposed, leading to short circuits and subsequent burning of the wires," the report said. "The wiring for all the modes of operation of the [OFV], in addition to other services, [runs] through this loom."

The report said that the short circuits probably "allowed erroneous signals to be sent to the OFV, causing it to start to open, thus increasing the cabin altitude."

Insulation-blanket material was found in the over-pressure relief valve — an indication that the valve had operated sometime in the past to prevent excessive pressure in the fuselage.

The report said that this incident was an example of "the problem of routing the wiring for redundant systems — in this case, the primary … and secondary [standby] systems for control of the aircraft's pressurization — in the same loom. This defeats the object of having such alternative systems, should a single-point failure of the wiring loom occur.

" … Had the wiring for the [primary] and [standby] pressurization mode commands and the position feedback wire to the OFV been suitably separated, then it is less likely that the failure of one loom would have resulted in the effective failure of all control modes."

AAIB recommended that Boeing consider "separating or protecting the wiring associated with the different modes of operation of this system, which connects the cabin pressure controller to the [OFV], such that any single-point failure of the loom would not result in effective failure of the pressurization-control system."

Chafed Wire Ignites In-flight Fuel Fire

In the third incident, a routine maintenance investigation of a reported defect resulted in the discovery on June 21, 2003, of a short circuit of the fuel-quantity-indication system wiring for fuel tank no. 7 on a Concorde. Maintenance personnel also found fire damage to an associated wire bundle in the wing/fuselage fairing area behind the main landing gear and below fuel tank no. 3. The report said that "fuel seepage from this tank, in the area of the chafed wire, had collected in a box-section fairing-support member and had been ignited, resulting in a short-duration, low-intensity fire."

The report said that the fire probably occurred during a flight June 13, 2003, from Heathrow to John F. Kennedy International Airport (JFK) in New York, New York, U.S., with nine crewmembers and 98 passengers aboard the airplane. The flight crew received no indication of a fire during the flight. There had, however, been intermittent displays of "failure flags" for several of the Concorde's fuel tanks and for the center of gravity (CG) computer; the report said that the gauges did not actually fail during the flight and that the indications on the CG computer appeared to be near the calculated value.

"The ignition source for the fire was identified as a chafed wire for the main-tank no. 3 fuel pump, which carries 115 [volts alternating current] power, arcing against the aluminum fairing," the report said. "It was possible that the chafing of this wire had been precipitated during maintenance activity two years prior to the incident when this wiring had been disturbed. The fire probably occurred during a flight from [Heathrow] to JFK on 13 June 2003, although no indications were apparent to the flight crew at that time."

After the incident, action was taken to prevent fuel accumulation in the area where the fire occurred.

The investigation found that the wiring in the area of the fire had been installed during manufacture of the airplane in 1975. In 2001, during maintenance to repair structural cracks, "it was necessary to disturb the wiring," the report said.

"It is likely that in reinstating the wiring, the possibility for the chafe to occur was introduced. This area is not routinely inspected, and given the low number of hours flown by each aircraft, [the area] is unlikely to have been inspected within the period since the repair."

Damaged Feeder Cables Cited in Preflight Fire

In the fourth incident, the six-member crew of a B-737-300 was preparing for departure from Newcastle Airport, Tyne and Wear, England, on July 30, 2003, when they observed that both ground-service circuit breakers had been activated and tried unsuccessfully to reset them.

"The commander became aware of an electrical burning smell and smoke, and asked the engineer to shut the aircraft down, ordered an evacuation and requested that the fire service be called," the report said. "A short-duration flash fire had apparently occurred below the cockpit floor on the right side, forward of the electrical and electronics compartment."

An examination of galley-power-feeder cables revealed pre-existing damage "consistent with the insulation material having been torn away from the wires," the report said.

The report said that the galley-power-feeder cables probably were damaged earlier, possibly when the forward toilet service panel was replaced in November 2002, and that investigators could not determine why arcing occurred on this occasion.

Quick Development of Guidelines Recommended

The overview said that visual inspections conducted by the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC), established by FAA in 1999 and also including members from the European Joint Aviation Authorities (JAA), the U.S. Department of Defense and the U.S. National Aeronautics and Space Administration, found that aircraft wiring — especially wiring located in areas that are subject to frequent maintenance — deteriorates over time.[1]

In developing recommendations for changes in U.S. Federal Aviation Regulations and related guidance material concerning aging aircraft, ATSRAC emphasized electrical wiring systems, and FAA in 2002 prepared three draft advisory circulars to provide guidance on changes in existing maintenance practices and analysis methods to ensure adequate consideration of the potential for the deterioration of electrical wiring systems, to provide guidance for developing an effective wiring systems training program and to provide guidance on developing an electrical systems standard wiring practices manual.

FAA has proposed publication in January 2005 of a notice of proposed rulemaking on aging aircraft systems.

The AAIB overview recommended that FAA "accelerate the publication and adoption of the guidance material produced by … ATSRAC on developing an electrical systems standard wiring practices manual, developing an effective wiring systems training program and on changes to existing maintenance practices and analysis methods, which could be applied to both in-service aircraft and new design, to ensure adequate consideration of the potential deterioration of electrical wiring systems."

JAA has established the European Aging Systems Coordination Group (EASCG) to develop the ATSRAC proposals for use in the European Union.

The AAIB overview recommended that the European Aviation Safety Agency (EASA) "expedite the transcription [by EASCG] of the material in the FAA advisory circulars … which gives guidance for operators and maintenance organizations on developing an electrical systems standard wiring practices manual, [on] developing an effective wiring systems training program and on changes to existing maintenance practices and analysis methods. This guidance should be applied to both in-service aircraft and new designs to ensure adequate consideration is given to potential in-service deterioration of electrical wiring systems."

In response to the recommendation, EASA said that EASCG had drafted several documents and was beginning its "notice of proposed action" process.

AAIB Recommends Improved Circuit Breakers

The AAIB overview said that numerous incidents and accidents have occurred in situations in which circuit breakers either failed to operate or did not operate in sufficient time to prevent serious wiring damage.

"Electrical circuits are protected against electrical overheating of wires by thermal/mechanical types of circuit breaker," the report said. "The 'thermal trip' type of circuit breaker is tripped, and thus the electrical circuit [is] broken, by heat generated within the [circuit] breaker from the current in excess of its rating. This is most suitable for a 'solid' and continuous short-circuit, but less reliable for transient arcing faults, which develop high energy over a very short period of time insufficient to trip the circuit breaker. An 'intelligent' circuit breaker, which could directly replace the circuit breakers presently in widespread use, can recognize the rapid current and/or voltage signature associated with arcing faults."

FAA research has led to the development of these "arc-fault" circuit breakers, and the AAIB overview recommended that FAA "expedite a requirement for the replacement of existing thermal/mechanical-type circuit breakers by arc-fault circuit breakers in appropriate systems on in-service and new-build civil air transport aircraft for which they have issued type certificates when these devices are judged to have been developed to an acceptable standard and where the safety objectives for the circuits would be enhanced."

The AAIB overview also recommended that EASA, "on behalf of the member countries which have issued type certificates for civil air transport aircraft, expedite a requirement for the replacement of existing thermal/mechanical-type circuit breakers by arc-fault circuit breakers in appropriate systems on in-service aircraft and new-build aircraft when these devices are judged to have been developed to an acceptable standard and where the safety objectives for the circuits would be enhanced."♦

[FSF editorial note: This article, except where specifically noted, is based on *Letter From the Chief Inspector of Air Accidents* (one page); *Overview: Incidents Resulting From Damage to Electrical Wiring* (seven pages); and four accompanying aircraft incident reports — EW/C2002/11/02 (18 pages with illustrations), EW/C2003/05/06 (seven pages with an illustration), EW/C2003/06/03 (six pages with illustrations) and EW/C2003/07/07 (five pages with illustrations). The documents were published in the June 2004 *AAIB Bulletin*.]

Note

1. The Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) said that its visual inspections of aircraft showed "deterioration of electrical wire, wire bundles, earthing [grounding] leads, clamps and shielding. Items such as improper clamp sizing, inadequate clearance to structure and accumulation of dust or debris were also common. Isolated cracking of outer layers of multi-layer electrical insulation and corroded electrical connectors were also found. The majority of the wiring discrepancies were found to be in areas of frequent maintenance activity, or related to housekeeping. Fluid contamination, dust and dirt accumulations were seen on the wiring on most of the aircraft."

Further Reading From FSF Publications

FSF Editorial Staff. "When Circuit Breakers Trip, a Hands-off Policy Prevents Fires." *Cabin Crew Safety* Volume 39 (March–April 2004).

FSF Editorial Staff. "Electrical Arc Identified as Likely Source of In-flight Fire Aboard Swissair MD-11." *Accident Prevention* Volume 61 (March 2004).

FSF Editorial Staff. "Boeing 747 In-flight Breakup Traced to Fuel-tank Explosion." *Accident Prevention* Volume 58 (May 2001).

FSF Editorial Staff. "Age-related Failures of Aircraft Wiring Remain Difficult to Detect." *Aviation Mechanics Bulletin* Volume 46 (July–August 1998).

FSF Editorial Staff. "FAA Airworthiness Directives Focus on Ignition Sources in Boeing 747 Fuel Tanks." *Aviation Mechanics Bulletin* Volume 45 (November–December 1997).

Fuel-line Failure Causes Engine Fire

A Boeing 757-200, operated by a major U.S. airline, was being leveled off at 10,000 feet following takeoff when the "LEFT ENGINE FIRE" warning light illuminated. An emergency was declared, and the left engine was shut down. The warning light remained illuminated. A fire bottle was discharged, and when the warning light remained illuminated, a second fire bottle was discharged.

During the final approach for the subsequent emergency landing, the warning light extinguished. After the B-757 had been landed without incident, aircraft rescue and fire fighting personnel determined that there was some "residual smoke" but that the fire was extinguished. There were no injuries to the six crewmembers or 117 passengers in the incident on April 17, 2003.

"Engine examination revealed a flex line routed near the thrust reverser had failed," said the report by the U.S. National Transportation Safety Board (NTSB). "There was a fuel leak, and a hole had burned through the [cowling] surrounding the hot section."

NTSB determined that the probable cause of the incident was the "total failure of a flex fuel line. A contributing factor was a fuel leak, resulting in an in-flight engine-compartment fire."

Helicopter Forced Landing Traced to Fuel Contamination

Following a day of capturing wild game in the Kwandwe Nature Reserve, South Africa, the Robinson R22 Beta helicopter was refueled to capacity, after which the pilot planned to fly the aircraft to a nearby game reserve.

At first, the pilot assisted with the refueling but then left the operation to an assistant to complete. No fuel sample was taken because the same fuel drum had been used earlier in the day in refueling the aircraft.

The report by the South African Civil Aviation Authority said, "The pilot was then approached by the reserve owner's son (eight years old), requesting a short pleasure flight over the reserve, prior to the relocation of the helicopter … . The duration of the flight was approximately 12 minutes. During approach for the landing, at a height of approximately 50 feet above ground level and at an indicated airspeed of approximately 20 knots, the engine stuttered and failed."

The pilot immediately lowered the collective and initiated an autorotative landing. During the landing, the aircraft skidded forward and struck a cactus bush, causing the helicopter to roll over. No one was injured in the Aug. 28, 2002, accident.

The probable cause, the report said, was that "the engine failed as [a] result of contaminated fuel being allowed to enter the engine fuel system." The report said that a contributory factor was "inadequate supervision during [the] refueling procedure, including sampling of fuel for grade and contamination prior to flight," and cited "inadequate control over the storage and testing of the fuel during game-capturing operations."

The report said that fuel was being transported in drums, on the back of a light delivery vehicle, in an upright position, in rainy conditions during nighttime, "which creates an ideal environment for condensation and subsequent contamination."

Recirculation-fan Failure Prompts Unscheduled Landing

The Boeing 747-400 was being flown on a scheduled passenger flight from Kuala Lumpur, Malaysia, to Melbourne, Victoria, Australia. During cruise flight at Flight Level 390 (about 39,000 feet), the cabin crew reported an electrical smell in the area of door no. 1, door no. 2 and door no. 4. The pilots completed the "Smoke, Fumes, Fire, Electrical" checklist, and the smell dissipated. When a similar smell was experienced on the flight deck about one hour later, the flight crew chose to make a precautionary landing in Adelaide, South Australia, Australia. There were no injuries in the April 20, 2004, incident.

After the landing, the operator's maintenance personnel inspected the aircraft. "This inspection revealed that the air conditioning right-overhead recirculation fan had seized and the left-overhead recirculation fan was causing the circuit breaker to trip," said the report by the Australian Transport Safety Bureau. "Both overhead recirculation fans were isolated electrically in accordance with the requirements of the aircraft's minimum equipment list, and the aircraft was returned to service."

Flap Section Lost in Flight

On Aug. 30, 2002, following takeoff on a scheduled passenger flight from Auckland (New Zealand) International Airport to Los Angeles (California, U.S.) International Airport, the flight crew of a Boeing 747-419 felt a "bump," followed by another. There were no cockpit indications of a problem, and the captain, the pilot flying, believed that turbulence was the cause. The 12-hour flight proceeded uneventfully.

When the aircraft was established on the instrument landing system (ILS) localizer, the captain called for "flap 20" and for the landing gear to be extended. After the first officer selected the flap setting and before she could select gear down, the engine indication and crew-alert system (EICAS) displayed a "FLAPS DRIVE" caution message. The captain initiated the missed approach and told the first officer to advise air traffic control (ATC); ATC cleared the flight for a second approach.

An off-duty captain in the cabin saw that a large section of the right-inboard fore flap was missing, and told the flight crew. After the second officer viewed the damaged flap, the captain determined that a landing could be conducted safely. The second approach was followed by an uneventful landing. There were no injuries to the 17 crewmembers and 355 passengers.

About 70 percent of the right-inboard fore flap had separated during a left turn shortly after departure, said the report by the New Zealand Transport Accident Investigation Commission. [The B-747 flaps include three sections: fore flap, main flap and aft flap. The forward edge of the fore flap is attached to its roller-carriage assembly by an inner link and an outer fitting. The fore-flap inner link contains a self-aligning monoball bearing of stainless steel.] Because the flaps had been retracted normally and the takeoff had occurred in darkness when no one was able to see the flap-section separation, the flight crew had no knowledge of the damage until the flaps were extended in preparation for landing.

The report said, "The flap separated because its inboard attachment link failed. The link failed because a pre-existing stress corrosion crack had grown to critical size, probably in a short period of time. …

"The crack probably started because of fretting [rubbing together of surfaces] and corrosion between the outer stainless-steel self-aligning monoball bearing shell and the aluminum-alloy link. The fretting will have exacerbated the ingress of moisture into the gap between the bearing shell and the link. The fretting damage that was evident probably formed over a number of years and was probably accentuated by bearing wear that had also occurred over the same time."

Records showed that the aircraft had been maintained in accordance with the routine-maintenance requirements, and the fore-flap assembly last had been inspected visually during a "4A" check completed on Aug. 1, 2002. The assembly previously had been inspected visually during a "C" check in October 2001, and the fore flaps had been removed and inspected during a major-maintenance "D" check in August 2000.

"During the 'D' check, the left-inboard trailing-edge fore-flap inner link bearing was replaced," said the report. "The right-inboard fore-flap inner link bearing was not replaced and it had remained in service since the aircraft was new." At the time of the incident, the B-747 had accumulated 61,157 flight hours and 8,393 cycles.

"The damage to the link would not have been detectable before a significant crack had started and grown, unless the bearing was removed from the link," said the report. "There was no requirement in place to remove or routinely replace the link bearing or the link itself. The required link inspections would not be expected to detect the cracking found."

Because of three earlier fore-flap attachment-link failures on this aircraft type, the manufacturer had begun a design-improvement program in June 2002 to improve the fore-flap fitting's corrosion resistance, which included changing the aluminum-alloy fitting material. In December 2002, the manufacturer notified operators of recommended actions to maximize the reliability of the fore-flap system.

Crew Injured in Accident Following Incorrect Cable Installation

"The helicopter came out of maintenance, the captain and first officer conducted a test flight, and then ferried it to the area of operation," said the report by the U.S. National Transportation Safety Board (NTSB) about an accident involving a Sikorsky S-61A engaged in a commercial logging flight on Jan. 3, 2003. The report said, "The captain entered a 155-foot out-of-ground-effect hover [the next day], and an external load was connected. About the same time, the helicopter started a slow uncommanded yaw to the right. The captain applied full-left pedal, released the load and entered an autorotation."

The helicopter was substantially damaged when it struck terrain during the forced landing, and the two pilots aboard were injured seriously.

Examination of the tail-rotor flight-control system after the accident indicated that the left tail-rotor control cable had broken. The break, in the aft section of the cabin, was associated with a pulley assembly.

"Examination of the cable break revealed that some of the cable strands were bent rearward and deformed," said the report. "Examination of the cable fracture surfaces under a stereomicroscope revealed that some of the fractures were irregular and deformed. Examination of the associated keeper pins under a stereomicroscope revealed that both pins displayed wear marks and light scratches consistent with control-cable contact. The associated pulley was intact. The pulley channel contained an oil-based debris and control-cable fragments."

While the helicopter underwent maintenance prior to its return to service on Jan. 11, 2003, both tail-rotor cables were removed and reinstalled, the report said. At the time of the accident, the helicopter had been flown 5.3 hours since being returned to service. The report said that the probable cause of the accident was "the improper installation of the left tail-rotor control cable by company maintenance personnel."

APU Oil Leak Sends Smoke In, Passengers Out

The British Aerospace (now BAE Systems) 146-200, with a crew of five and 53 passengers, was about to begin a scheduled flight from Belfast (Northern Ireland) City Airport to Manchester, England, on Aug. 1, 2003. The auxiliary power unit (APU) was used at the gate and shut down before taxi.

During the taxi out, cabin crewmembers became aware of fumes and smoke, which seemed to be most intense in the aft section of the cabin. The senior cabin crewmember informed the captain of the situation via the interphone. The captain stopped the aircraft, contacted air traffic control (ATC) and said that the aircraft would remain in position until the problem was resolved.

The smoke did not dissipate, and the captain was told by the senior cabin crewmember that passengers were becoming alarmed. Although he suspected that the problem was caused by an APU fault rather than by a fire, the captain ordered an emergency evacuation, which resulted in a minor back injury to one passenger.

When no evidence of fire was discovered, the APU, which had been in service for more than 500 hours since installation, was removed and sent to the manufacturer's U.K. agent for examination. The "tear-down" examination showed oil deposits and staining on the compressor rotor and the air intake.

"There was also evidence of a recent and more significant oil loss, indicated by areas where clean oil had washed away dirt deposits on the compressor-bearing housing," said the report by the U.K. Air Accidents Investigation Branch. "These indications were symptoms of oil leaking from the compressor carbon seal into the air path. Minor leakage is not atypical for this type of APU, but a small leak was unlikely to have caused the sudden increase in smoke and fumes in the cabin."

The oil that had washed away the dirt on the compressor area showed that there had been a sudden increase in the rate of oil leakage from the compressor bearing, the report said.

The report said, "The underlying reason for the sudden increase in oil leakage was attributed by the manufacturer's agent to a compressor surge. Compressor surge causes the rotor assembly to move aft due to poor airflow through the power section. This, in turn, causes the spring washer that supports the main-rotor ball bearing to be heavily loaded, and thus compressed. The movement of the main rotor also moves the seal rotor aft, which in turn bears against and compresses the compressor carbon-seal bellows.

"After the surge dissipates, the main rotor returns to its original position and the seal bellows relaxes. Repetition of this process unseats the compressor carbon seal, allowing oil to escape. … Once the APU returns to normal operation, the compressor carbon seal re-seats."

Service bulletins SB-49-7076, Revision 1, and SB-49-47-36162, issued by the APU manufacturer (not identified), have modified the system. The report said, "These changes ensure that an oil leak from the compressor carbon seal will be 'captured' by negative pressure within the gearbox. With these modifications embodied, after an oil-seal leak the APU should eventually shut down due to low oil pressure or be removed from service due to high oil consumption, before smoke is evident in the cabin."

Drive-belt Failure Cited in Helicopter Accident

Between 300 feet and 500 feet above ground level prior to landing, the pilot of the Robinson R22 Beta heard a loud "grumbling" noise and felt a "twitch" to the left. He believed that the engine had failed, and lowered the collective and began an autorotation. The helicopter struck the ground with a high vertical speed, right-skid-first, and both skids and the cabin-seat structure were compressed. The helicopter rolled onto its right side. The pilot and his passenger were injured (the nature of the injuries was not specified in the accident report), and the helicopter was damaged beyond economic repair in the April 27, 2003, accident near Royston, England.

The report by the U.K. Air Accidents Investigation Branch (AAIB) said that investigators found that both rotor blades and the drive train had been in motion at the time of the accident, indicating that the engine had been operating at the time.

"The engine rotational power output is transmitted to the main gearbox via two drive belts carried on two 'sheaves' or pulley assemblies," said the report. "Each belt effectively consists of two 'V' belts joined together; thus, the pulley has four grooves. The belts transmit the drive to a similar pulley assembly immediately above."

AAIB investigators and manufacturer representatives found that one of the "V" belts was missing. There were rubber deposits around the transmission compartment, in which small fragments of the missing belt were recovered, suggesting that the missing belt had failed, the report said. There was no evidence of any other pre-impact failures.

The report said, "The belts are maintained 'on condition' and do not have a finite service life imposed. The helicopter had completed 2,132 [flight] hours at the time of the accident, [and] the 'V' belts had been replaced at 2,120 [flight] hours, i.e., 12 [flight] hours before the accident.

"Previous failures have not been associated with belt manufacturing or quality issues. The only consistent factor identified by the manufacturer has been that the failures almost always occur with relatively new belts with less than 50 hours [time-in-service] and most with less than 20 hours time-in-service. Initiation is thought to be either a belt strand coming out of a groove or rolling over in a groove, leading to an overload condition which tears the belt apart."

Previous belt failures, the report said, have been associated with the following conditions or combinations of them:

- High-gross-weight power applications or above-gross-weight power applications (sometimes compounded by turbulence);

- Sheave alignment at installation or alignment shifts caused by initial belt wear;

- Sheave surface condition (new belts on worn sheaves or corroded sheaves);

- Actuator tension out of specification (the actuator is mounted between the upper pulleys and lower pulleys, and raises the upper pulley in response to the clutch); and,

- Excessive belt slack at initial engagement, allowing a belt strand to be outside of the forward groove or aft groove when tensioned.♦

Wing-corrosion Inhibitor Meets Airline, Manufacturer Specs

Aeroflex Finish G 12 E 25 from Akzo Nobel is a one-pack, corrosion-inhibiting upper-wing coating that meets specifications of Airbus, Air France, Boeing, Boeing Long Beach and FedEx. The coating is aluminum pigmented, fast drying and rain-erosion resistant, the manufacturer says.

Application can be by suction-feed gun or airless equipment. Use of a thinner is recommended for some applications.

For more information: Akzo Nobel Aerospace Coatings, P.O. Box 3, 2170 BA Sassenheim, Netherlands. Telephone: +(31) 71 3082905; East Water St., Waukegan, IL 60085 U.S. Telephone: +1 (847) 623-4200.

These Boots Are Made for Working

A line of industrial footwear from DeWalt features 13 styles that the manufacturer says need no "breaking in," providing a comfortable fit beginning the first time they are worn. The footwear includes lace-up boots and pull-on boots, as well as shoe styles, in soft-toe and steel-toe versions. The line features full-grain leather uppers, corrosion-resistant eyelets on lace-up models, and acid-resistant, oil-resistant and slip-resistant outer soles. Comfort is enhanced by padded collar and ankle areas to prevent chafing, and removable cushioned inner soles with gel heel pads (except in air-circulation models) that reduce shock, knee strain and back strain, according to the manufacturer.

The line includes three specialty styles: a lightweight series that uses athletic shoe–like construction for reduced weight and greater flexibility; a series featuring a heel-protection system that is said to provide extra support and stability for reduced foot fatigue and increased safety; and an air-circulation series that incorporates air-cushioning chambers for additional shock absorption.

Industrial Footwear

For more information: DeWalt, 701 E. Joppa Road., Baltimore, MD 21286 U.S. Telephone: 1 (800) 433-9258 (U.S.); +1 (410) 716-3900.

Snips Trim Sheet Metal

Klein Tools offers aviation snips for cutting and trimming sheet metal used in the aviation industry. Offset snips — designed to enable easy cutting of tight curves — are available in right, left and straight cutting patterns, with the capacity for cutting 18-gauge cold-rolled sheet metal and 22-gauge stainless-steel sheet metal. Snips with a notch cutting pattern are suitable for use on 16-gauge cold-rolled sheet metal and 18-gauge stainless-steel sheet metal.

Forged and heat-treated, the snips' steel blades offer strength and durability for cutting or notching sheet metal, the manufacturer says. The contoured plastic handles are color-coded according to the cutting pattern.

Aviation Snips

For more information: Klein Tools, 7200 McCormick Blvd., P.O. Box 599033, Chicago, IL 60659 U.S. Telephone: 1 (800) 533-4857 (U.S.); +1 (847) 677-9500.

Hangar Floors Wear a Coat

Garland Floor Company's Chemi-Cote UR 5000, designed to protect concrete and metal, provides a low-maintenance surface on the hangar floor. The polyurethane coating resists abrasion, impacts, chemicals and stains, including stains caused by tires, jet fuel and hydraulic fluid, the manufacturer says.

Floor Coating

Chemi-Cote UR 5000 provides a smooth, nonporous surface that is easy to clean and does not abrade under repeated washings, the manufacturer says. The glossy coating is said to be stable against ultraviolet light and to retain color and gloss over long periods. The finish is light reflective, enhancing even illumination in the hangar.

For more information: Garland Floor Co., 4500 Willow Parkway, Cleveland, OH 44125 U.S. Telephone: 1 (800) 321-2395 (U.S., Canada and Mexico); +1 (216) 883-4100.

Reinforcements Are on the Way

Lightweight Epocast 1633 epoxy syntactic materials from Huntsman Advanced Materials are designed for the rapid reinforcement of fasteners and inserts in honeycomb-core aircraft components such as floorboards, bulkheads and overhead bins. They meet manufacturers' specifications of Airbus and Boeing.

The product, dispensed from dual-barrel cartridges containing premeasured amounts of resin and hardener, is described by the manufacturer as rapid setting and high strength. Available in light blue, black, orange and gray, Epocast 1633 is self-extinguishing and contains no halogen.

For more information: Huntsman Advanced Materials, Everslaan 45, B-3078 Everberg, Belgium. Telephone: +(41) 61 96 61 589. U.S. office: 5121 San Fernando Road. West, Los Angeles, CA 90039 U.S. Telephone: 1 (800) 817-8260 (U.S., Canada and Mexico); +1 (818) 247-6210.

Work Gloves Are 'Ergonomically Correct'

PowerCoat gloves, a line of work gloves from Perfect Fit Glove Co., are designed for protection against chemicals and liquids such as acids, solvents, petrochemicals, caustics, grease and oils. The gloves also resist punctures, cuts and abrasions, the manufacturer says.

PowerCoat Gloves

Materials, depending on the model, include polyvinyl chloride, nitrile, neoprene or natural latex. Described as ergonomically correct and extremely flexible, the gloves are said to improve productivity and lessen the likelihood of fatigue-associated injuries. A seamless liner in all models is designed for greater comfort and strength.

For more information: Perfect Fit Glove Co., 85 Innsbruck Drive, Buffalo, NY 14227 U.S. Telephone: 1 (800) 245-6837 (U.S.); +1 (716) 668-2000.

Cable Wrap Can Take the Heat

TFE (tetrafluoroethylene) can be used as a wrapping material in temperatures from −450 degrees Fahrenheit (F; −268 degrees Celsius [C]) to 500 degrees F (260 degrees C). Heli-tube Spirally Cut TFE Cable Wrap for bundling and protecting wires, cables and hoses is nonflammable and is suitable for enclosed aerospace applications where sparks or flame could cause a fire, the manufacturer says. The flexible wrap can be applied like tape without using tools.

The product is available in 10 sizes, with outer diameters ranging from 1/6 inch (0.43 centimeter) outside diameter to 1.5 inch (3.81 centimeters) outside diameter.

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.

Dry It, You'll Like It

The compression of air in pneumatic tools produces water condensation that collects in air hoses and on tool surfaces and fittings. If the tools are stowed in unheated locations during cold weather, the moisture can freeze and make the tools inoperable.

Kilfrost by Keystone Lubricants is a fluid that lubricates the tool, absorbs moisture and lowers the freezing point of water. The result is that tool freezing is prevented, the manufacturer says.

Moisture-absorbent Lubricant

The product's formula is semi-synthetic and will not affect polycarbonate, polyurethane or buna seals, the manufacturer says. Kilfrost is nontoxic, nonflammable and noncorrosive.

For more information: Keystone Lubricants, 5 North Stiles St., Linden, NJ 07036 U.S. Telephone: 1 (800) 344-2241 (U.S.); +(33) 1 41 35 29 84 or +1 (908) 374-5052 (international).♦