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Robert A. Feeler, editorial coordinator

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On the cover: Fire retardant is dropped from a Lockheed C-130 Hercules onto a forest fire in the United States. (Photo: U.S. Bureau of Land Management, Office of Fire and Aviation).

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‘Rigorous’ Maintenance Programs Recommended for Fire Fighting Aircraft

Citing three accidents in which fire fighting airplanes broke apart during flight, the U.S. National Transportation Safety Board said that maintenance programs had not considered the unique problems that affected these specialized aircraft, including their typical high time in service and the stresses of their operating environment.

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FSF Editorial Staff

Maintenance and inspection programs have not adequately accounted for safety risks encountered by aircraft used in the U.S. federal government’s fire fighting operations — risks that stem from the advanced age of the aircraft and the extreme stresses of the operating environment, the U.S. National Transportation Safety Board (NTSB) said.

In an April 23, 2004, safety recommendation, NTSB cited three accidents involving fire fighting aircraft and issued recommendations to improve maintenance programs and to ensure that the aircraft are airworthy.

The NTSB report on each accident said that the probable cause was the in-flight failure of a wing because of fatigue cracking and that a factor was “inadequate maintenance procedures to detect fatigue cracking.”

The safety recommendation said that, although “frequent and aggressive low-level maneuvers with high acceleration loads and high levels of atmospheric turbulence” make aerial fire fighting a high-risk operation,

"the risk of in-flight structural failure should not be considered an unavoidable risk of fire fighting."

Accident Airplanes Formerly Military

The most recent of the three accidents cited by NTSB involved a Consolidated-Vultee (Convair) P4Y-2 Privateer (manufactured as a PB4Y-2 and later modified) that was owned, maintained and flown by Hawkins and Powers Aviation of Greybull, Wyoming, and was operated under contract by the U.S. Department of Agriculture's Forest Service as a public use fire fighting flight.[1] The airplane was being maneuvered for delivery of fire retardant over a forest fire near Estes Park, Colorado, on July 18, 2002, when the left wing separated from the fuselage just inboard of the no. 2 engine. The airplane was destroyed, and the two crewmembers were killed.

The NTSB safety recommendation said, "A fatigue crack measuring approximately 21 inches [53 centimeters] had propagated from the lower portion of the forward spar-cap members upward into the spar web. The crack initiated in rivet holes used to attach three L-shaped spar-cap members to the spar web. The portion of the wing containing the fatigue crack was obscured by the retardant tanks and would not have been detectable by an exterior visual inspection."

The airplane had undergone a company "C" check maintenance inspection June 11–14, 2002, when the airframe time was 8,259 flight hours. Maintenance records showed that on June 14, repairs were made to two cracks in the lower fitting of the right-wing forward spar and to one crack in the lower fitting of the left-wing forward spar.

The accident report said, "A company mechanic, qualified to perform 'C' check inspections, explained and demonstrated how the detailed inspections were performed. The mechanic pulled the appropriate inspection card for the item (in this case, it was Item 1-1, left wing), read the card and then said he would get a mirror and a flashlight and get up on a scaffold up close to the wing and then visually inspect the wing from wing tip to the fuselage. He said that this could take one [day] to two days to perform. The mechanic said if he found a crack during the inspection, he would fill out a discrepancy card and write up a description of the crack and its location on the wing. The mechanic said the crack would be investigated further, possibly using a dye [penetrant] or eddy current so as to determine the extent of the crack. The mechanic said, 'We will support the wing as required.' The mechanic said that the director of maintenance would be notified and would coordinate with their engineering firm to determine how they would support the wing."

The accident report said, "The owner developed service and inspection procedures for the air tanker; however, the information contained in the procedures did not adequately describe where and how to inspect for critical fatigue cracks. The procedures were based on U.S. Navy PB4Y-2 airplane structural repair manuals that had not been revised since 1948."

The accident report said that the airplane was manufactured and delivered to the U.S. Navy in 1945, and was transferred to the U.S. Coast Guard in 1952. The airplane was retired from military service in 1956, when it had about 2,861 flight hours, and was placed in storage until 1958, when it was converted to an air tanker; the same year, the airplane entered Forest Service operations. Hawkins and Powers acquired the airplane and registered it in 1969; from 1969 until the accident, the airplane accumulated 5,485 flight hours. Neither the type certificate data sheet nor the airworthiness certificate contained specifications for maintenance or inspection. The maintenance and inspection program for the airplane was based on P4Y military manuals dating from the 1950s.

C-130 Lost Both Wings

On June 17, 2002, one month before the P4Y-2 accident, a Lockheed C-130A Hercules broke apart in flight while dropping fire retardant over a forest fire near Walker, California. The airplane, registered to Hawkins and Powers and operated by the Forest Service, lost both wings after they separated from the fuselage at the wing box-to-fuselage attachment points. The airplane was destroyed in the accident, and the three flight crewmembers were killed.

Records showed that the accident airplane had accumulated 21,863 flight hours, including 2,316 flight hours after the airplane was retired from military service.

The NTSB safety recommendation said, "Metallurgical examination of the center wing box lower skin revealed a 12-inch [30-centimeter] … fatigue crack on the lower surface of the right wing, with two separate fatigue-crack-initiation sites at stringer-attachment rivet holes. The cracks from both initiation sites eventually lined up to create a single crack. The portion of the wing skin containing the fatigue crack was covered by a manufacturer-installed doubler [a piece of sheet metal placed against the skin to provide stiffness or additional strength], which would have hidden the crack from view and therefore prevented detection of the crack from a visual inspection of the exterior of the airplane."

The accident report said that "A" check maintenance had been performed the same day as the accident

and that the last detailed 2,400-hour wing inspection was performed during "C" check maintenance June 22, 1996, when the airplane's flight time totaled 20,417 flight hours. Maintenance records showed that the left outer wing was replaced with a refurbished outer wing in 1998 and that the right outer wing was replaced with a refurbished outer wing in 2001; the accident report said that investigators found no documentation to indicate that the center wing had ever been replaced.

The airplane was delivered new in 1957 to the U.S. Air Force, was retired from military service in 1978 and placed in storage until 1988, when it was acquired by the Forest Service. Later in 1988, the Forest Service sold the airplane to Hemet Valley Flying Service of Hemet, California, which installed retardant tanks and then sold the airplane to Hawkins and Powers.

FAA then issued a restricted category special airworthiness certificate. The airworthiness certificate and the type data sheet both said that the airplane was to be maintained and inspected in accordance with Air Force technical orders available in 1988. The Hawkins and Powers maintenance program was developed using those documents.

1994 Accident Reviewed

The NTSB also cited an Aug. 13, 1994, accident in which the right wing of a C-130A separated from the fuselage near Pearblossom, California, while the crew was fighting a forest fire. The airplane was destroyed, and the three flight crewmembers were killed. Originally, the accident report cited a different probable cause; a subsequent review of accident information and an examination of wreckage that was not recovered during the initial investigation resulted in the revised findings.

A metallurgical examination of the right wing revealed two fatigue cracks. One of the cracks was 0.6 inch (1.5 centimeters) long and had initiated from a rivet hole that had been created in the lower wing skin to allow installation of a doubler; the doubler covered the fatigue crack. The second crack was 0.8 inch (2.0 centimeters) long and had propagated in the doubler. (The report said that the fatigue cracks might have been larger and that their total length could not be determined because only a small portion of the right wing was recovered.)

The airplane was delivered new to the Air Force in 1957 and was placed in storage for two years beginning in 1986. In 1990, FAA issued a restricted category special airworthiness certificate authorizing fire fighting operations.

When the accident occurred, the airplane was registered to Aero Firefighting Service Co. and was operated by the Forest Service for public fire

fighting flights. The airplane had 20,289 flight hours, including 19,547 flight hours acquired during military service.

The Forest Service and the U.S. Department of the Interior both conduct fire fighting flights using a total of about 700 aircraft. Until 2003, these aircraft included about 40 large air tankers. As a result of the two 2002 accidents, the agencies stopped using C-130A airplanes and PB4Y (or P4Y) airplanes. About 30 large air tankers — many of which were surplus military aircraft with restricted category type certificates[2] and restricted-type airworthiness certificates[3] — remained available for use. [Their average age was 48 years; some were more than 60 years old.][4]

[A report on the federal aerial fire fighting program written after the 2002 accidents said that the in-flight structural failures "signaled the recurrence of a problem that has periodically plagued fire fighting air tankers for half a century." The report described three cycles of about 20 years each, which began with the acquisition of retired military aircraft and the refurbishment of the aircraft for fire fighting operations.

"Large air tankers, operated for 15 [years] to 20 years by private companies under contract to the Forest Service, experience varying degrees of engine [problems], systems [problems] and structural problems," the report said. "To date, each approximately 20-year cycle has ended with fatal accidents, which are often attributed to structural failures. … [I]n the panel's view, the fatal air tanker crashes this year were predictable."][5]

Fatigue, Corrosion Cited as Risks

In its safety recommendation, NTSB said that the structural integrity of aging airplanes is "of particular concern since factors such as fatigue and corrosion manifest themselves with age.

"Accordingly, the owner or operator should be alert to the possibility that the airplane is being used in a manner significantly different from the originally intended mission profile and should continuously monitor the maintenance program for necessary changes. Therefore, airplanes should be maintained and inspected in accordance with a program that is continuously evaluated and updated, based on technical and engineering support, including the manufacturer's knowledge of in-service experience."

Limited technical support and engineering support are available for many of the aircraft used in fire fighting operations, however, because the manufacturers are no longer in business or

because the military no longer operates the aircraft types.

The safety recommendation said, "Further, the current operators of these fire fighting aircraft are typically unable to structure a maintenance program that accounts for the new mission profile because:

- "[T]he airplane's design [information] and service life information (such as service reports and maintenance data) [are] not readily available;
- "[T]he operator lacks the necessary engineering expertise;
- "[T]he magnitude of maneuver loading and level of turbulence in the fire fighting environment is not defined; and,
- "[T]he effects of this operating environment on the service life of the aircraft structure are undefined."

For example, the safety recommendation said that the Hawkins and Powers inspection and maintenance programs for the 2002 accident airplanes were based on military standards and required "general visual inspections for cracks but did not include enhanced or focused inspections of highly stressed areas, such as the wing sections, where the fatigue cracks that led to those accidents were located.

"The … investigation revealed that Hawkins and Powers did not possess the engineering expertise necessary to conduct studies and engineering analysis to define the stresses associated with the fire fighting operating environment and to predict the effects of those stresses on the operational life of the airplanes. Further, no infrastructure was in place to provide independent oversight of the continuing airworthiness and maintenance programs for these airplanes."

The safety recommendation said that a "dynamic continuing airworthiness maintenance program" is especially important for aircraft typically used in fire fighting operations because of their age and the operating conditions.

Such a program "might well have identified the areas of fatigue cracking on the accident airplanes as high-risk points that warranted frequent and/or enhanced inspections for signs of potential cracking," the safety recommendation said.

The recommendation said that an airworthiness maintenance program for aircraft used in public fire fighting operations should "take into account and be based on" the following five factors:

- "[T]he airplane's original design requirements and its intended mission and operational life;

- "[T]he amount of operational life that has been used before entering fire fighting service;

- "[T]he magnitude of maneuver loading and the level of turbulence in the fire fighting environment, and their effect on the remaining operational life;

- "[T[he impact of all flight hours (both public and civil) on the airplane's remaining operational life; and,

- "[A] detailed engineering evaluation and analysis to predict and prevent fatigue separations such as those involved in the three accidents discussed above."

The letter issued recommendations to the Forest Service and the Interior Department calling for development of maintenance and inspection programs "that take into account and are based on" the five factors. The letter said that the two agencies should "require that aircraft used in fire fighting operations be maintained in accordance with the maintenance and inspection programs developed in response to the NTSB recommendations and that the two agencies also should hire specialists in aviation engineering and maintenance to oversee the new maintenance programs."

The letter also said that the FAA's oversight of owners or operators of restricted category aircraft that are flown for part of the year on public fire fighting flights "will be of limited safety value if the oversight associated with the nonpublic use of those aircraft does not take into account the flight hours, structural stresses and other factors associated with the public fire fighting operations."

The letter recommended that FAA require that such aircraft be maintained "in accordance with appropriate maintenance and inspection programs that take into account and are based on" the same five factors and that FAA "assume the responsibility to serve as the focal point for collecting continuing airworthiness information about surplus military aircraft from the organization that last provided technical [support] or engineering support (for example, the original manufacturer or the military) and disseminating that information to subsequent owners and operators."

Tankers Grounded

On May 10, 2004, in response to the safety recommendations, the Forest Service and the Department of the Interior grounded 33 large air tankers "due to concerns over the airworthiness of the aircraft and public safety" and terminated government contracts with the private operators of the aircraft.

"Safety is a core value of the fire fighting community, and it is non-negotiable," said Dale Bosworth, chief of the Forest Service. "To continue to use these contract large air tankers when no mechanism exists to guarantee their airworthiness presents an unacceptable level of risk to the aviators, the firefighters on the ground and the communities we serve. … Clearly, the days of operating older aircraft of unknown airworthiness for fire fighting operations are over."[6]♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board (NTSB) Safety Recommendations A-04-29 through A-04-33 and the probable cause statements and narrative reports on three accidents in which airplanes used in fire fighting operations separated during flight: report no. LAX94FA323, report no. LAX02GA201 and report no. DEN02GA074.]

Notes

1. A public use flight differs from a civil flight in that compliance with many sections of the U.S. Federal Aviation Regulations (FARs) is not required. For example, aircraft used in public use flight operations are not required to be equipped with flight data recorders or cockpit voice recorders. In addition, operators are not required to comply with regulations regarding aircraft certification and maintenance, and flight crew training and licensing. (Nevertheless, public use fire fighting aircraft may be used for civil flights when they are not under contract to the U.S. Department of Agriculture's Forest Service or the Department of the Interior, and many crewmembers are employed by civilian operators that are required to comply with the FARs.)
2. FARs Part 21.25, "Issue of Type Certificate: Restricted Category Aircraft," says that applicants for restricted category type certificates for surplus military aircraft being used in special-purpose operations must show that "no feature or characteristic of the aircraft makes it unsafe when it is operated under the limitations prescribed for its intended use."
3. FARs Part 21.185, "Issue of Airworthiness Certificates for Restricted Category Aircraft," says that restricted category airworthiness certificates will be issued for surplus military aircraft or other aircraft previously type certificated in another category if the aircraft have been "inspected by the administrator and found by him to be in a good state of preservation and repair and in a condition for safe operation."
4. U.S. National Interagency Fire Center. *USDA Forest Service and Department of the Interior Agencies Cancel Large Airtanker Contract.* May 10, 2004. <www.nifc.gov/nr_airtanker-contracts.html>. May 11, 2004.
5. Blue Ribbon Panel on Aerial Wildland Firefighting. *Federal Aerial Firefighting: Assessing Safety and Effectiveness.* December 2002.
6. U.S. National Interagency Fire Center.

Safety Audits Reveal Noncompliance With Fire-prevention AD

Foundation safety auditors say some airplane operators do not fully understand the 30-year-old U.S. Federal Aviation Administration airworthiness directive, which requires ashtrays outside some airplane lavatories.

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Robert A. Feeler

During their audits of corporate airplane operators, Flight Safety Foundation (FSF) Audit Team members have found several instances of noncompliance with an airworthiness directive (AD) issued 30 years ago by the U.S. Federal Aviation Administration (FAA) to prevent fires in airplane lavatories.

The FSF safety auditors believe that some operators of the affected airplanes do not clearly understand the requirements of AD 74-08-09, which concerns airplane modifications to "prevent possible fires that could result from smoking materials being dropped into lavatory paper or linen waste receptacles" and which requires modifications and ongoing repetitive inspections to confirm continued compliance.

The safety auditors have discovered that some operators believe that the AD does not apply to their airplane because they do not permit smoking on the airplane. This belief is

incorrect, and failure to comply with the AD could subject the operator or maintenance technicians to violation action and/or civil penalties.

The AD says that it applies to "all transport category airplanes, certificated in any category, that have one or more lavatories equipped with paper or linen waste receptacles."

The safety auditors said that the term "all transport category airplanes" includes the Cessna 500/525/560/650/750 series, the Bombardier 600/601/604/CRJ series, the Dassault Falcon DA-10/20/200/2000/50/900 series, the Embraer EMB-120/135/145/170 series, the Gulfstream 159/1159/III/IV/V series, the BAE Systems HS-125 series, the Israel Aircraft Industries IAI-1121/1225 series, the Lear 25/31/35/45/55/60 series, and any other airplanes that have been certificated under U.S. Federal Aviation Regulations Part 25, *Airworthiness Standards: Transport Category Airplanes* and that have an enclosed lavatory.

The primary misunderstanding involves paragraph (c) of the AD, which says:

> Except as provided by paragraph (d) of this AD: [W]ithin 180 days after [Aug.] 6, 1974, or before the accumulation of any time in service on a new production aircraft, whichever occurs later, except that new production aircraft may be flown in accordance with [Parts] 21.197 and 21.199 of the Federal Aviation Regulations … to a base where compliance may be accomplished, install a self-contained, removable ashtray on or near the entry side of each lavatory door. One ashtray may serve more than one lavatory door if the ashtray can be seen readily from the cabin side of each lavatory door served. [Part 21 is titled "Certification Procedures for Products and Parts."]

Simply stated, if a transport category airplane is equipped with an enclosed lavatory, there must be a self-contained, removable ashtray mounted outside the lavatory door.

Some completion centers apparently have told operators that their airplane was exempt from this requirement because the interior configuration was certificated with no ashtrays installed. This issue was discussed with representatives of the FAA Flight Standards Service office in Washington, D.C., U.S., and they confirmed that unless the operator (or completion center) has obtained a specific exemption, the requirement of the AD applies.

FAA representatives said that there is no record of any operator having obtained approval of any alternative method of compliance. Verbal statements to the effect that "it does not apply to your airplane" are not a valid reason to ignore the requirements of the AD. If someone says that an airplane is exempt from the AD, the operator should insist that the statement be put in writing, with FAA approval confirmed.

In addition, Part 25.853, "Compartment Interiors," which discusses the material requirements and construction requirements for all interior materials in transport category airplanes, says, in Paragraph (g):

> Regardless of whether smoking is allowed in any other part of the airplane, lavatories must have self-contained, removable ashtrays located conspicuously on or near the entry side of each lavatory door, except that one ashtray may serve more than one lavatory door if the ashtray can be seen readily from the cabin side of each lavatory served.

Part 39, "Airworthiness Directives," consists almost entirely of a question-and-answer section intended to clarify the applicability of ADs. Part 39.15 asks, "Does an airworthiness directive apply if the product has been changed?" and answers the question this way:

> Yes, an airworthiness directive applies to each product identified in the airworthiness directive, even if an individual product has been changed by modifying, altering, or repairing it in the area addressed by the airworthiness directive.

Each operator/technician of *any* transport category airplane with an enclosed lavatory should review the requirements of AD 74-08-09 and ensure that the airplane is in compliance.♦

About the Author

Robert A. Feeler has been a certificated aircraft maintenance technician since 1952 and has served in senior management positions at two U.S. airlines. A frequent contributor to Aviation Mechanics Bulletin*, he was appointed editorial coordinator of the publication in 1991. Feeler also served as manager of Flight Safety Foundation (FSF) safety audit programs from 1992 through 1999, when he participated in developing the FSF Q-Star Charter Provider Verification Program and was appointed program administrator.*

Input Freewheel Unit 'Spit-out' Cited in Fatal Accident of Sikorsky S-61L

The Sikorsky S-61L helicopter was being used to transport a load of logs with a 200-foot (61-meter) long line. The sound of engines stopped, the long line was dropped, white smoke was seen coming from the engine-exhaust area for about three seconds and the main rotor slowed.

"The helicopter descended about 700 feet with the rotor continuing to slow until the aircraft struck trees and the ground," said the accident report issued by the Transportation Safety Board of Canada (TSB). Both pilots were killed, and the helicopter was destroyed, in the accident at Wendle Creek, British Columbia, Canada, on Aug. 8, 2002.

"The engines were not operating and the main rotor had little or no rpm [revolutions per minute] at impact," said the report. "Inspection of the engines did not find any anomalies that would have caused the engines to stop operating prior to impact. However, the white smoke coming from the engine-exhaust area after the engine sounds stopped suggests that, although the engines were still turning and fuel was being introduced, the fuel was not being burned. The most likely explanation for these events is an engine overspeed and shutdown."

The investigation showed that the engines stopped operating because of an overspeed condition that probably was induced during a "spit-out" of an input freewheel unit (IFWU), a one-way clutch that allows the engine to drive the rotor but prevents the rotor from driving the engine. ["Spit-out" refers to a rapid, forceful and complete disengagement of the rollers in the IFWU during operation.]

Inspection of the IFWUs revealed abnormalities. "The rollers exhibited multiple flat spots, smeared metal and bronze contamination," said the report. Oilite bushings, which support the roller retainer, "exhibited a variety of damage types such as bending, cracking, crushing and wearing."

The right IFWU and left IFWU had been overhauled on Sept. 12, 2001, and at the time of the accident had accumulated 532 service hours. That was within the manufacturer-recommended time between overhauls

(TBO) of 500 hours, plus or minus 50 hours, for IFWUs on helicopters used in repetitive external lift operations.

Nevertheless, the report said that "the oilite bushings in the IFWUs deteriorated, causing instability of the rollers and bronze contamination in the roller path, resulting in reduced ability of the IFWU [singular in original] to maintain engagement. Both IFWUs malfunctioned in rapid sequence, causing the engines to overspeed and subsequently shut down. Following the loss of power of the engines, drive to the main rotor was lost, leading to rotor rpm decay and loss of control of the helicopter." The IFWU rollers were also not through-hardened to the required specification during manufacturing, the report said.

"The TSB is aware of numerous Sikorsky S-61 IFWU slips," said the report. ["Slip" is a term for the disengagement of the rollers followed by re-engagement of the rollers in an IFWU during operation.] "As well, the TSB has investigated several Sikorsky S-61 accidents prior to this investigation … in which the IFWU spit out."

On Oct. 11, 2002, Sikorsky issued alert service bulletin (ASB) 61B35-67A, which reduced the TBO of IFWUs in the aircraft used for repetitive external lift operations from 500 hours to 350 hours. Transport Canada was reviewing the ASB, the report said.

Trunnion Assembly Separates From Landing-gear Structure

During taxi-out, the Cessna 402B's left-main landing-gear assembly collapsed. The aircraft's left-wing assembly was substantially damaged. The pilot, the only occupant of the flight operated under U.S. Federal Aviation Regulations (FARs) Part 135 as a domestic cargo flight, was not injured in the accident on July 7, 2003.

Inspectors from the U.S. Federal Aviation Administration and from the operator examined the collapsed landing-gear assembly. The report by the U.S. National Transportation Safety Board (NTSB) said, "The examination revealed that the roll pin (part no. NAS 561P4) that retains the attaching shaft (part no. 0841011-1) to the trunnion assembly was fractured. This allowed the landing-gear attaching shaft to shift from its installed position, resulting in the trunnion assembly separating from the landing-gear support structure."

The operator inspected the landing gear of its other six Cessna 402 aircraft and identified two aircraft with broken landing-gear roll pins,

the report said. The defective roll pins were replaced, and the operator said that the landing-gear assemblies would be re-examined at six-month intervals.

Inoperative Fuel-boost Pump Forces Autorotative Landing of Bell 206B

The pilot of the Bell 206B helicopter departed on a positioning flight with 33 U.S. gallons (125 liters) of fuel indicated, enough fuel to reach the destination with a reserve. While en route, the pilot observed the fuel-gauge needle "sticking" (moving in increments instead of a continuous movement). The needle indication went from 14 gallons (53 liters) to seven gallons (26 liters), which alerted the pilot to the possibility that the fuel supply might have been lower than originally was indicated. He elected to continue flying the seven nautical miles (13 kilometers) to the destination.

About one minute later, about five nautical miles (nine kilometers) from the destination, the fuel-boost-pump CAUTION light flickered. The engine then failed with the fuel gauge indicating six gallons (23 liters) or seven gallons. The pilot performed an autorotation, deployed the aircraft's emergency flotation system and ditched the helicopter in shallow water. The pilot, the only occupant of the aircraft, was not injured in the Nov. 25, 2003, incident.

"Examination of the fuel-quantity-indicating system revealed that when the tank was empty, the gauge's needle indicated below the 'E,' and approximately three gallons [11 liters] of fuel were added before the needle rested on 'E,'" said the report by the U.S. National Transportation Safety Board. "However, according to the Bell 206B maintenance manual, when the tank is empty, the gauge should sit on the 'E,' plus or minus three gallons."

The report quoted the Bell 206B pilot operating handbook, which said, "Due to possible fuel sloshing in unusual attitudes or out-of-trim conditions and one or both fuel-boost pumps inoperative, the unusable fuel is 10 gallons [38 liters]."

The forward fuel-boost pump and the aft fuel-boost pump were functionally tested. "The forward [fuel-]boost pump, which sat lower in the tank, was found to be inoperative, and the aft [fuel-boost] pump was operative," said the report. "The fuel-boost-pump CAUTION light was tested and examined. The examination revealed that the fuel-[boost-pump] pressure switch to the forward [fuel-]boost pump was inoperative."

The report said that the probable cause of the incident was "the failure of the

forward [fuel-]boost pump while in cruise flight while operating with less than 10 gallons of fuel onboard, which resulted in a loss of engine power. A factor was the inoperative forward fuel-boost-pump CAUTION light switch."

As a result of the investigation, the operator examined the remainder of its Bell 206B fleet to ensure that the forward fuel-boost pumps, aft fuel-boost pumps and both fuel-boost-pump pressure switches were operative, the report said.

Starter Generator Past TBO Causes Multiple Failures in Saab 340B

The Saab 340B, en route to Townsville, Queensland, Australia, with three crewmembers and 34 passengers, was climbing through Flight Level 180 (about 18,000 feet) when the copilot's two electronic flight information system (EFIS) screens on the right side of the instrument panel failed. The flight crew performed the "EFIS Failure/Disturbances" checklist, after which the central warning panel ICE-PROTECTION annunciator and then the CABIN-PRESSURE annunciator illuminated.

The crew declared pan-pan, an urgent condition, and initiated an emergency descent. During the descent, other cockpit warnings and cautions activated and some aircraft systems failed. The anomalies included illumination of the RIGHT-STALL-FAIL annunciator, the RUDDER-LIMIT annunciator, the ELECTRICAL-SYSTEM annunciator and the right DC-GENERATOR-OUT light. The global positioning system (GPS) navigation system, the copilot communication systems, the no. 2 automatic direction finder (ADF) and the right-engine instrumentation all failed.

"The crew became aware that the right DC [direct current] generation system was operating abnormally," said the report by the Australian Transport Safety Bureau (ATSB). "Their attempts to rectify that situation were unsuccessful. The crew diverted the aircraft to Cloncurry [Queensland, Australia] and landed." There were no injuries and no aircraft damage in the incident on Dec. 5, 2001. (The ATSB report was issued Feb. 4, 2004.)

"The failure of the EFIS screens and the subsequent warnings, cautions and failures were consistent with a right-system voltage drop from the rated 28 volts to below 18 volts," said the report. "During the investigation, it became apparent that in some Saab 340 aircraft, a starter generator could fail without taking the generator off line and alerting the crew, resulting in low system voltage. On this occasion, the crew overlooked the first item of

the 'EFIS Failure/Disturbances' checklist, which required a check of the generator voltage. Consequently, the crew did not recognize the developing low-voltage condition that led to the cascading series of warnings, cautions and failures."

The investigation determined that the right DC generation system had failed prior to the failure of the EFIS screens, and that the aircraft had been dispatched with the right starter generator operating in excess of its scheduled time before overhaul (TBO). The right starter generator had been installed for 1,601.9 flight hours at the time of its failure, the report said. The aircraft manufacturer had stipulated a TBO of 1,200 hours, or 1,600 hours if preceded by a brush replacement at 800 hours time in service (TIS); the brush in the right starter generator had not been replaced at 800 hours TIS.

"The pilot-in-command reported that, prior to dispatch, the in-service maintenance record (ISMR) had been annotated by one of the maintenance personnel to indicate that a 10 percent extension had been applied to the starter-generator TBO," said the report. "The operator's engineering management reported that the supporting maintenance system document required to legitimize the extension was not completed." The operator's engineering manager did not know why the 10 percent extension to the 1,600-hour starter-generator maximum TIS was applied, and could not explain the absence of supporting documentation, the report said.

The TBO of 1,600 hours, provided that the brush is replaced at 800 hours TIS, derived from the Maintenance Review Board (MRB) report for the Saab 340. MRB reports are developed by manufacturers and approved by regulatory authorities, and must form the basis of an aircraft's maintenance program in Australia.

The report said, "Job cards that provided specific task directions were produced by the aircraft manufacturer and incorporated into the operator's system of maintenance. However, the job card relating to brush replacement did not accurately reflect the MRB requirement. That job card specified brush inspection at 800-hour intervals, with replacement required only if wear exceeded the stated limit. …

"Given that excessive brush wear was implicated in the unalerted failure of the starter-generator system, replacement of the brushes after 800 hours or removal of the starter generator at 1,200 hours should have prevented this occurrence."♦

Footwear Is Work Shoe's Sole Support

Standing or walking for extended periods on maintenance-shop floors can add to a technician's work-induced fatigue. ErgoMates are strap-on footwear designed to counteract the effect of hard, smooth floor surfaces.

The ErgoMates system consists of adjustable straps that fit over the technician's shoes to hold cushioned anti-fatigue soles in place under the shoes. The soles function like segments of anti-fatigue mats that travel with the user. The system can be applied to almost any street shoes or work shoes, the manufacturer said.

ErgoMates are said by the manufacturer to reduce fatigue by as much as 50 percent. They provide slip resistance, although not marketed for that purpose, and are resistant to oil and most chemicals, the manufacturer said. ErgoMates come in four sizes and two colors.

Anti-fatigue Soles

For more information: Safety Seven Manufacturing, 1182 Alder Ave., Moose Jaw, Saskatchewan, Canada S6H 0Y7. Telephone: +1 (866) 849-4747.

Tape Goes On, Moisture Stays Out on Aircraft Floors

3M Aerospace Polyurethane Protective Tapes, described by the manufacturer as "carpet-like," are designed to provide a continuous barrier against corrosion caused by moisture on aircraft floors. The tapes, intended for use in areas such as galleys, lavatories and entryways, are said to be easily applied over aircraft floor panels and conform well to corners and side walls.

The tapes are puncture-resistant, solvent-free and meet flame-performance requirements of U.S. Federal Aviation Regulations (FARs) Part 25.853 for use on aircraft floors, the manufacturer said.

For more information: 3M Aerospace, 3M Center, Building 220-9W-14, St. Paul, MN 55144 U.S. Telephone: (800) 235-2376 (U.S.); +1 (651) 736-7918.

Inspection Kit Deals With Wheels

Zetec, a supplier of nondestructive testing (NDT) equipment, offers the Tie-Bolt Inspection Kit for inspection of nonferrous inconel and steel tie bolts that join aircraft wheels. The Tie-Bolt Inspection Kit includes a probe that allows thread inspection and radius inspection to be combined in one cycle, which the manufacturer said increases inspection speed and accuracy.

Inspection Kit

The kit can detect cracks in the head-to-shank radius and bolt threads with minimum dimensions of 0.050 inch long by 0.025 inch deep (1.27 millimeters long by 0.64 millimeter deep). A toggle switch on top of the fixture allows the operator to quickly change between test probes, and replaceable coil shoes simplify changeovers for different bolt diameters, the manufacturer said. The kit is compatible with all Zetec eddy-current test instruments and some other manufacturers' eddy-current test instruments.

The Tie-Bolt Inspection Kit includes the fixture, one head-to-shank radius-inspection probe, one thread-inspection probe, a battery-operated driver with socket head, battery charger, spare battery and operating guide.

For more information: Zetec, 1370 N.W. Mall St., Issaquah, WA 98027 U.S. Telephone: +1 (425) 392-2086.

Microscopy Is at Hand

A hand-held video microscope, the ASG HD-5000 functions as a portable, high-resolution inspection system for observation and recording. The unit has switchable 20x or 50x magnification that can be output to a video monitor. Integral white light-emitting diodes (LEDs) provide illumination for the 0.25-inch

Hand-held Video Microscope

(0.64-centimeter) charge-coupled device (CCD) camera.

A "freeze" button allows capturing an image for evaluation, and an optional universal serial bus (USB) interface kit permits output to a personal computer.

The camera's 1.0-pound (0.5-kilogram) weight enables it to be quickly positioned and repositioned, giving the operator greater flexibility than with a stand-mounted camera, the manufacturer said.

For more information: ASG, 15700 South Waterloo Road, Cleveland, OH 44110 U.S. Telephone: +1 (216) 486-6163.

Program Puts Maintenance Records in Circular Files

Record keeping is both essential and time-consuming in aviation maintenance. The Logbooks on CD (LBCD) Program from AirLog Imaging is designed to make documentation storage and retrieval faster and easier by transferring paperwork to compact disc (CD).

AirLog digitizes every page, tag and other document and adds a word-search program to the CD. Documents can be viewed on a monitor with their original appearance preserved. Among the documents that can be searched are work orders, logbooks and technician records.

The manufacturer said that advantages of storage of maintenance records on CD, besides making searching easier than with paper records, include space saving, portability and resistance to damage.

For more information: AirLog Imaging, 3269 Highway 231 South, Ozark, AL 36360 U.S. Telephone: +1 (334) 774-8946.

Chemical Clarifies Views

Eldorado AWC is an aircraft window and mirror cleaner designed to remove grease and dirt. The product can be used on other transparent surfaces including Plexiglas and polycarbonate.

Eldorado AWC is said to have antifogging properties on glass surfaces, is biodegradable, nontoxic, nonflammable and noncrazing. It is registered with the U.S. Environmental Protection Agency (EPA) and meets Boeing specifications, the company said.

For more information: Eldorado Solutions, Eldorado Chemical Co., 11611 North Meridian St., Suite 600, Indianapolis, IN 46032 U.S. Telephone: (800) 531-1088 (U.S.); +1 (317) 818-9500.

Recovery Is Just Around the Corner

A tool is available for the technician who drops a screw or a tool into a location that is awkward to reach. FlexLine Magnets from Carica feature flexible shafts that bend as needed to retrieve metallic objects, even in locations that cannot be reached by hand.

A magnet is mounted at the end of a 23-inch (58-centimeter) flexible shaft. The shaft can be bent in any needed configuration and will retain its shape. Alternatively, the copper core of the shaft can be removed, and the tool can be used to "snake" its way through whatever path is needed to reach its target object.

The unit has a solvent-resistant polyvinyl chloride (PVC) grip and comes in two models, with three-pound (1.4-kilogram) and 14-pound (6.4-kilogram) lifting capacities, respectively.

For more information: Carica, Ken Tool, 768 E. North St., Akron, OH 44305 U.S. Telephone: +1 (330) 535-7177.

Flexible Magnet

Storage Cabinets Roll, But Don't Rock

Lista International Corp. describes its mobile storage cabinets as versatile workstations on wheels with built-in safety features.

Mobile Cabinet

The cabinets feature a range of optional top surfaces selectable according to the application. Drawers are individually locked for added safety when moving the unit. Each mobile storage cabinet has two swivel casters and two fixed casters, with a foot-pedal lock for secure parking. Drawers are interlocked so that when one drawer is extended, the others are locked in place to ensure the unit's overall stability.

For more information: Lista International Corp., 106 Lowland St., Holliston, MA 01746 U.S. Telephone: (800) 722-3020 (U.S.); +1 (508) 429-1350.♦