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Robert A. Feeler, editorial coordinator

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On the cover: Examination of the transcowl that separated from a Boeing 747 engine during landing in Manchester, England, revealed torn rivet holes and sunken rivet heads. The accident report said that the rivets were an incorrect type. (Photo: U.K. Air Accidents Investigation Branch).

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Use of Incorrect Rivets Blamed for Separation of Engine Cowling

The U.K. Air Accidents Investigation Branch said that the correct rivets on a fitting on one of the Boeing 747's engines had been replaced with others that 'failed to serve the design purpose.' When the fitting failed, a large section of the engine cowling fell from the airplane onto a runway shortly after a landing in Manchester, England.

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FSF Editorial Staff

At 0646 local time June 13, 2002, during a landing at Manchester (England) International Airport following a flight from the United States, a large piece of engine cowling fell from a Boeing 747 onto an active runway. The first officer on a Boeing 757 that was being taxied nearby observed the falling cowling and notified air traffic control (ATC) of the incident. The B-747 received minor damage; none of the 319 people in the airplane was injured.

The U.K. Air Accidents Investigation Branch (AAIB) said, in its final report on the incident, that the separation "was associated with an unnoticed degradation of the lower clevis-fitting attachment.

"The failed attachment rivets, which would have been visible during external inspection, had been replaced using an incorrect type, which failed to serve the design purpose," the report said. "This appears to have been done without appreciation of the significance of distressed fasteners for indicating local structural overload. The failure to record the replacement of the rivets defeated the operator's quality-assurance system and resulted in them not becoming aware of the degradation of the attachment. The replacement of the rivets made its subsequent detection more difficult."

The report said that the approach to Manchester and the touchdown on Runway 24R, following the flight from John F. Kennedy International Airport in New York, New York, U.S., were uneventful. After touchdown, the flight crew selected reverse thrust on all four General Electric CF6-50C2 turbofan engines, to about three-quarters power. After airspeed slowed to about 80 knots, reverse thrust was canceled; the reversers on engine no. 1, engine no. 2 and engine no. 4 stowed, but the reverser on engine no. 3 "remained unlocked and in transit," the report said.

After the B-757 first officer notified ATC of the incident, the crew of the B-747 taxied the airplane to the gate, where passengers disembarked. The runway was closed to landing traffic while the cowling and associated debris were removed.

The piece of the cowling that separated from the airplane was the outboard half of the thrust-reverser translating sleeve on the no. 3 engine, known as the transcowl (Figure 1, page 3).

The transcowl is one of two major subassemblies in the thrust-reverser assembly, which constitutes the rear section of an engine's fan-stream duct. The other major subassembly is the C-duct.

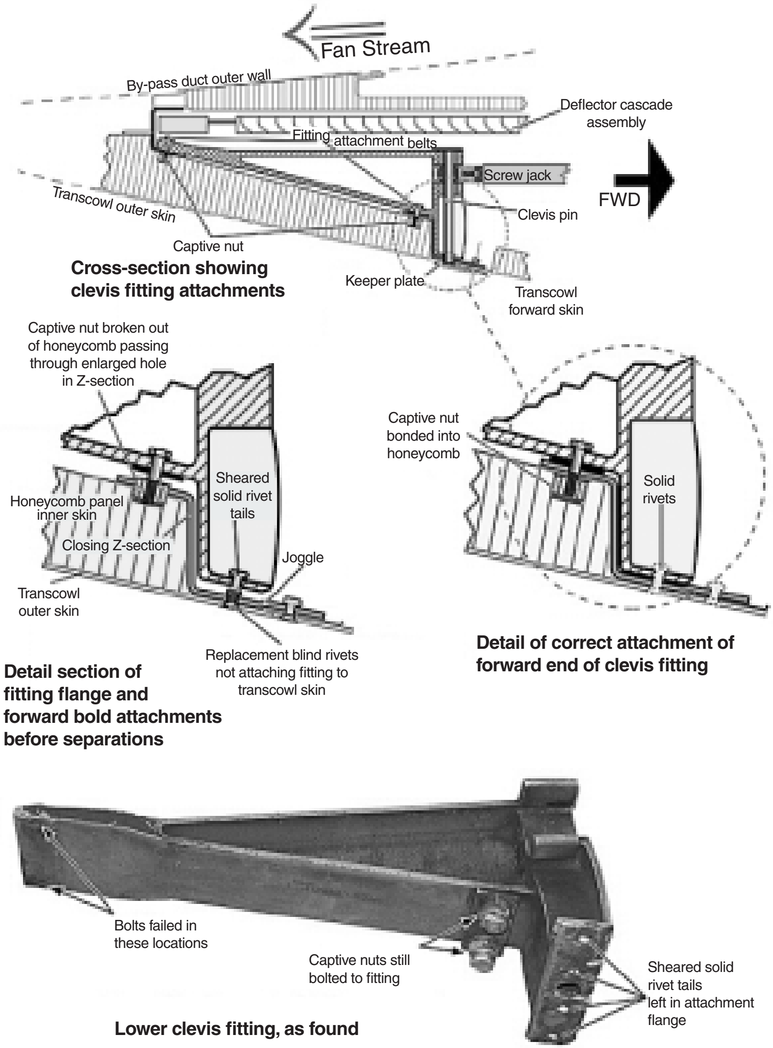
The report said, "The C-duct constitutes the core engine cowling and the inner wall of the fan stream. … At its forward end, the C-duct structure also constitutes the outer wall of the fan stream, on the aft end of which it carries the reversing cascades. The transcowl drive system consists of three synchronized and evenly spaced screw jacks, also mounted on the C-duct, which control its fore-and-aft position and maintain its orientation at right angles to the engine axis. The screw jacks are driven, via a flexible shafting (flexshaft) system, by an air motor mounted in the pylon. The top and bottom edges of the transcowl, which moves rearwards when reverse thrust is selected, run in slider tracks on the C-duct structure."

When the transcowl is stowed, it comprises the outer wall of the fan stream and the engine nacelle, with the thrust-reverser cascades between the outer walls. When reverse thrust is selected, the transcowl moves rearward, exposing the reversing cascades; the blocker doors, which are hinge-mounted on the transcowl, stop the rearward flow of the fan stream and divert it through the cascades.

The screw jacks are attached to the transcowl by pins that are inserted

(Continued on page 4)

Sections Showing Attachment of Lower Clevis Fitting to Transcowl



Source: U.K. Air Accidents Investigation Branch

Figure 1

through holes in the nacelle skin and into clevis fittings in the transcowl structure. The lower clevis fitting is larger than the others, with a more complex attachment involving rivets and bolts.

In the incident airplane, the degradation of the attachment of the lower clevis fitting to the transcowl meant that as the fitting moved, bolt holes gradually were enlarged until their nuts passed through the holes and the clevis fitting separated from the transcowl. This separation resulted in loss of positional control of the transcowl and led to the possibility that the transcowl could become misaligned and jammed, especially while the reverser was being stowed.

The investigation did not determine the cause of the degradation of the attachment of the fitting, although the problem may have been associated with "whatever gave rise to the need to adjust the transcowl-drive-system rigging in the recent past [twice during the three months preceding the incident]," the report said.

The thrust-reverser system has been in use for about 30 years, on General Electric CF6-6 engines installed on McDonnell Douglas DC-10-10 airplanes and on CF6-50 engines installed on DC-10-30, Airbus A300-B4 and Boeing 747 airplanes. About 400 of these airplanes are now in use worldwide.

"[Although] having been generally robust and reliable in its current design configuration, [the thrust-reverser system] has, over its whole service life, suffered a considerable number of transcowl detachment events, of which the majority typically occurred during stowage after the application of reverse thrust," the report said. "The underlying cause of most of these events has been attributed to either mis-rigging or incorrect maintenance/lubrication of the system, leading to abnormally high loads developing in the system during translation."

The report said that in this incident, the most probable cause of the separation was "either mis-rigging or misalignment resulting from loss of transcowl positional control."

The report said that, when the rigging is incorrect, the transcowl's movement along its slider tracks can become jammed more easily. In the event of jamming, the air motor can break other parts of the mechanism. If this occurs, the transcowl may separate from the C-duct.

(A similar problem has not been reported on CF6-80 thrust reversers because a less powerful air motor is used on those engines.)

The report said that engine manufacturers began an effort in the late 1980s to reduce the rate of "transcowl liberation events" by joining with operators to conduct a maintenance education program and by issuing a commercial engine service memorandum (CESM) for CF6-6 engines (CESM 75) and CF6-50 engines (CESM 76).

"These provided a consolidated listing of inspections and servicing tasks recommended by the engine manufacturer and were to assist maintenance planning only," the report said. "Procedures, limits and specific requests are defined in the referenced publications, such as the aircraft maintenance manuals, engine maintenance manuals, service bulletins and component maintenance manuals. The CESMs did not supersede operators' approved maintenance programs but provided a single publication [that] defined all the recommended scheduled inspection and servicing intervals. During this period, a number of hardware [changes] and maintenance procedural changes were also introduced. These measures have resulted in a marked decrease in the number of transcowl liberation events."

Failures of the system most often involved the flexible driveshafts or the screw jacks. One incident involved the failure of a clevis-fitting attachment.

An examination of the B-747 at Manchester showed that the transcowl and four blocker doors had separated from the C-duct and that all three clevis fittings had separated from the transcowl. The upper clevis fitting remained attached to the screw jack; the two lower clevis-fitting attachment pins had fallen out and had released the clevis fittings. All three screw jacks remained attached to the C-duct, with the upper screw jack and the lower screw jack almost fully retracted and the center screw jack "in a position consistent with being about halfway retracted and with its shaft … moderately bent; this had resulted in the seizure of the nut tube on the screw," the report said.

The transcowl's upper slider fitting was bent "in a manner consistent with the transcowl having separated from the C-duct by pivoting aft and upwards about the midpoint of the upper slider," the report said.

Wear marks indicated that the center screw jack had rotated after it was bent and while it was unattached to the clevis fitting.

"There were light wear marks at the position of the upper screw jack, where the clevis fitting had been drawn across the cascades after the clevis had been separated from the transcowl but the [screw] jack had continued to react," the report said. "There were also wear marks on the cascades, at the position of the lower screw jack and on the inner surfaces of its clevis fitting, which were consistent with the clevis fitting rubbing against them persistently over a considerable number of reverser deployments."

The tails of the four attachment rivets remained in their holes in the flange of the lower clevis fitting, and an examination revealed that all four had failed "in shear, in a direction consistent with the fitting being pulled forwards relative to the transcowl," the report said. "The two bolts immediately aft of the riveted flange were still attached to the clevis fitting, and their captive nuts, which had been bonded into the transcowl honeycomb skin structure, were still attached to the bolts. Of the two bolts [that] should have attached the tail of the fitting to the skin structure, one was completely missing, and only the threaded portion of the other remained in the captive nut."

Further examination of the C-duct showed that its inner surface had been crushed near the blocker doors and that scrape marks had been left behind this point. The report said that the position of the scrape marks indicated that the transcowl "had traveled further aft than would have been allowed by the screw jacks at full extension, resulting in the blocker doors becoming wedged against the inner wall as the positioning links drew them inwards. The implication was that the clevis attachment of the lower screw jack had separated, allowing some transcowl distortion, before the blocker door wedging could occur."

There was little indication of overload distortion where the lower clevis fitting had been attached to the transcowl; the clevis fitting had separated without distortion. The heads of the four rivets, which should have attached the forward flange of the clevis fitting to the transcowl, appeared to be in place. Nevertheless, the report said that the rivets "appeared to be [of the] blind type, unlike all the other rivets in the area, which were countersunk alloy solids. The replacement rivets were all deeply set into the countersinks, and the metal between the holes and the forward edge of the transcowl skin section had been torn out."

Although there was no shear distortion of the four rivets, the skin in front of the rivet holes "had been broken out," the report said. "This indicated that the rivets had been installed with the holes already in this condition."

Further examination of the failed clevis-fitting attachment points showed that the flange attachment had not been effective after the replacement rivets were installed and that the original solid rivets had failed in shear overload.

"The bond between the closing section and the honeycomb-panel inner skin had failed, allowing the honeycomb panel closing Z-section to flex forwards, tearing out the bolt holes in the inner skin to its forward free edge," the report said. "The captive nuts at this location had also separated from the inner skin, allowing the bolts to enlarge the holes in the Z-section."

The tails of the blind rivets left marks on the attachment flange of the clevis fitting, indicating that the fitting was "generally held against the rivet tails at a slight angle to its proper orientation and slightly forward of its proper position," the report said. Other marks indicated that the fitting had been pulled forward repeatedly; the forward movement caused the clevis pin end to move out of its insertion hole and to strike the joggle (a notch designed to prevent slipping) in the forward flange, causing a fatigue failure around the joggle line. The report said that this fatigue indicated that the thrust reverser had been operated repeatedly with the inadequate attachment of the lower clevis fitting to the transcowl.

"The fatigue had characteristics consistent with relatively rapid progression, indicating that the shear failure of the clevis fitting attachment rivets had been relatively recent," the report said.

The operator's[1] maintenance records showed that the no. 3 engine outboard thrust-reverser half had 2,961 landings when the incident occurred. (The life of a thrust-reverser half is limited to 5,500 landings.) Maintenance records also showed that the transcowl was installed on the airplane in November 1997. There was no record of any repair to the lower screw-jack clevis fitting during the three years before the incident.

Maintenance records showed that the most recent tasks performed on the thrust-reverser half were the following:

- All three flexible drive shafts were replaced with new flexible drive shafts Sept. 19, 2001;
- C-check maintenance was performed between Dec. 16, 2001, and Jan. 2, 2002, and included lubrication of all thrust-reverser flexible drive shafts. The airplane was flown about 1,800 flight hours and 300 flight cycles after the C-check maintenance and before the incident;
- The rigging on the no. 3 engine thrust reverser was adjusted during March 2002, after a defect was reported. (The report did not include other information about the defect.) No other significant work was performed to correct the defect; and,
- The rigging was readjusted April 20, 2002, after replacement of the directional pilot valve.

The report said that the two adjustments of thrust-reverser rigging performed in the months before the incident "demonstrated that the operator was well aware of the importance of the correct rigging of this mechanism."

The investigation compared the failure modes of the three clevis-fitting attachments to the transcowl and determined that the upper two attachments had been single-event overload failures that occurred when the transcowl separated from the screw jacks. The failure of the lower clevis-fitting attachment occurred over a longer time period.

"The marking found on the lower clevis-fitting riveted-attachment flange and on the forward flange of the honeycomb panel closing Z-section indicated that the effective rigidity of the attachment of the fitting to the transcowl had been low and had degraded progressively over a period before the separation of the transcowl from the nacelle," the report said. "It was clear that the flange-attachment riveting had failed in shear at some time in the relatively recent past and that the rivet holes in the skin had been refilled without restoring the joint."

The report said that there were indications that the aft pair of bolts also had failed, either at the same time that the rivets failed or earlier. The report said, "It was not possible to determine whether the overall attachment of the clevis fitting to the transcowl had already been compromised by the absence of one of the aft bolts, a loss of the bond between the Z-section and the transcowl inner skin, or a combination of both effects."

As a result of the investigation, AAIB issued the following safety recommendation:

The [U.S.] Federal Aviation Administration [FAA] and the European Aviation Safety Agency [EASA], in conjunction with the manufacturers of the thrust-reverser system and the affected aircraft types, should consider requiring an inspection procedure, to be performed whenever reverser rerigging becomes necessary, to ensure the soundness of the bonding and mechanical fastenings attaching the clevis fittings to the transcowl of the thrust reversers of CF6-6 and CF6-50 engine installations.

That safety recommendation was a revision of an earlier recommendation that FAA, "in conjunction with the aircraft [manufacturers] and thrust reverser manufacturers, should consider formulating and issuing an inspection procedure to assure the soundness of the bonding and mechanical fastenings attaching the lower clevis fitting to the transcowl … of the thrust reversers of CF6-6 and CR6-50 engine installations."

In response to the original recommendation, FAA said that no specific regulatory action was planned. The response said that the manufacturers of the aircraft, the engine and the thrust reverser agreed that the thrust reverser manufacturer already had acted to "significantly [reduce] the occurrence of translating sleeve problems" and that "the best course of action would be to reemphasize the importance of adequate thrust-reverser preventive maintenance." The response said that "FAA agrees the manufacturer's approach is adequate."

There was no further response from FAA to the revised recommendation, and, as of April 1, 2004, AAIB had received no response from EASA.♦

[FSF editorial note: This article, except where specifically noted, is based on the U.K. Air Accidents Investigation Branch (AAIB) report EW/C2002/06/03, published in *AAIB Bulletin* No. 3/2004. The 12-page report contains illustrations and appendixes.]

Note

1. The operator was not identified in the incident report by the U.K. Air Accidents Investigation Branch.

MAINTENANCE ALERTS

Galley-chiller Fan Vibration Causes Short Circuit, Fire

Soon after takeoff from Sydney, New South Wales, Australia, the flight crew of the Boeing 747-400 received a "FORWARD CARGO COMPARTMENT FIRE" warning on the engine indicating and crew alerting system (EICAS). The crew performed the appropriate checklist, activated the fire-suppression system and declared mayday, a distress condition. Meanwhile, flight attendants observed a fine mist and smelled smoke in the passenger cabin. The aircraft was returned to Sydney, where an uneventful overweight landing was conducted and occupants disembarked. No passengers or crewmembers were injured in the Aug. 10, 2002, incident.

Ground engineers among the emergency services crew that met the aircraft discovered a "hot spot" on the left side of the forward cargo bay, with the fiberglass sidewall lining showing signs of being affected by heat.

"Removal of the lining revealed burned insulation-blanket material, discoloration of the aircraft skin and burned/broken electrical wires that powered the forward galley-chiller boost fan situated in the area," said the incident report by the Australian Transport Safety Bureau.

The galley-chiller boost fan provided forced-air circulation over the forward galley-chiller units, increasing their efficiency. The fan was powered by the aircraft's no. 3 alternating current (AC) electrical system and was controlled by power from the aircraft's direct current (DC) electrical system. A 20-ampere circuit breaker and a cargo-fire cutoff relay provided circuit protection. The circuit breaker was a "trip-free" type, which delayed tripping so as not to be affected by momentary electrical power surges, thus avoiding "nuisance" tripping.

"An inspection of the [galley-chiller] boost fan revealed a burn hole and sooting on its casing adjacent to the electrical terminal," said the report. "The electrical wiring to the fan was found to have four of its seven wires broken, with all of the wires displaying sooting discoloration. The soot marks corresponded to those on the fan casing and, when positioned together, revealed that the wires had separated at a point adjacent to the corner of the electrical terminal. The failure of the wires produced electrical arcing, which melted the casing, resulting in the burn hole observed. Further inspection found that all of the fan impeller blades had failed just above their roots."

The galley-chiller boost fan's service history was examined. The fan had entered service in 1994 and was overhauled in June 2000 following electrical failure. The maintenance records for that overhaul said, "Unit noisy due [to] worn bearings … . Disassembled, cleaned and inspected, bearings renewed, unit reassembled and tested to [specifications]." The fan was installed on the incident aircraft on Aug. 2, 2000, and no subsequent maintenance was recorded for the unit.

Analysis of the aircraft's quick access recorder (QAR) revealed that during the climb, the no. 3 AC system's electrical load had momentarily increased from a nominal 31 percent to 54 percent. Four seconds later, the load had returned to within its normal range. About one minute later, the QAR recorded a forward cargo compartment fire, followed by the arming and discharge of the fire-extinguishing bottles.

The report said, "Due to the close tolerance between the impeller blades and the fan shroud, excessive wear in the bearings most likely led to oscillations of the armature and impeller, resulting in armature and blade-tip rubbing. The position of the broken/burned wires and the localized burning and soot marks on the fan-case electrical-terminal housing indicated that a probable chafing event had occurred, leading to electrical arcing. The chafing was most likely the result of the excessive vibration induced by the fan's imbalance after the impeller blades failed.

"Molten material from the fan case dripped onto the adjacent insulation blanket, where it smoldered and burned. It is possible that the fan continued to operate for a short period of time after the arcing had initiated. This condition would have provided a positive airflow into the confined area, feeding the fire."

The report listed the following "significant factors" in the incident:

- "Worn bearings led to impeller and shroud rubbing, weakening the blade tips;
- "The fan-blade tips failed, creating an out-of-balance condition and vibration;
- "Chiller-boost-fan vibration resulted in the wires chafing and [an] electrical short circuit initiating the fire; [and,]
- "The trip-free capability of the circuit breaker in the chiller-boost-fan electrical circuit prevented rapid electrical isolation."

As a result of the incident, the manufacturer issued alert service bulletin SB747-21A2427, recommending inspection and corrective routing of the electrical wire to the chiller-boost fan, and the incident aircraft operator conducted a fleet inspection of the fan wiring accordingly.

NTSB Derives Maintenance Recommendations From Beechcraft 1900 Fatal Accident

On March 5, 2004, as a result of its investigation of a fatal accident to a Raytheon (Beechcraft) 1900D at Charlotte-Douglas (North Carolina, U.S.) International Airport, the U.S. National Transportation Safety Board (NTSB) issued 21 safety recommendations to the U.S. Federal Aviation Administration (FAA).

[On Jan. 8, 2003, the aircraft, operated by Air Midwest (doing business as US Airways Express) as a regularly scheduled passenger flight, struck terrain shortly after takeoff. The two flight crewmembers and 19 passengers were killed, one person on the ground received minor injuries and the aircraft was destroyed by impact forces and a post-accident fire. NTSB determined that the probable cause of the accident was the aircraft's loss of pitch control during takeoff, resulting from the incorrect rigging of the elevator-control system, compounded by the aircraft's aft center of gravity, which was substantially aft of the certified aft limit.

[NTSB said that contributing to the cause of the accident were "(1) Air Midwest's lack of oversight of the work being performed at [its] maintenance station; (2) Air Midwest's maintenance procedures and documentation; (3) Air Midwest's weight-and-balance program at the time of the accident; (4) the Raytheon Aerospace [the maintenance contractor] quality assurance inspector's failure to detect the incorrect rigging of the elevator-control system; (5) [FAA's] average-weight assumptions in its weight-and-balance program guidance at the time of the accident; and (6) [FAA's] lack of oversight of Air Midwest's maintenance program and its weight-and-balance program."]

The following, among the NTSB recommendations, are those are most applicable to maintenance issues:

"[NTSB] recommends that [FAA]:

- "Adopt a program for performing targeted surveillance and increased oversight of maintenance practices at [U.S. Federal Aviation Regulations (FARs)] Part 121 air carriers to ensure that maintenance instructions are being followed as written and that maintenance personnel (including, but not limited to, management, quality assurance, tooling and training personnel, as well as mechanics) are following all steps in the instructions unless authorization has been granted in accordance with the air carrier's maintenance program (A-04-4);
- "Verify that [FARs] Part 121 air carriers have procedures in their Continuing Analysis and Surveillance System program for identifying deficiencies and incorporating changes to the carrier's maintenance program, and that maintenance personnel for these air carriers (including, but not limited to, management, quality assurance, tooling and training personnel, as well as mechanics) use these procedures (A-04-5);
- "Modify (1) appendix G of [FARs] Part 23 and appendix H of [FARs] Part 25 and (2) [FARs Part] 121.369 to require that the Instructions for Continued Airworthiness and air carrier maintenance manuals, respectively, include a complete functional check at the end of maintenance for each critical flight system (A-04-6);
- "Require manufacturers of aircraft operated under [FARs] Part 121 to identify appropriate procedures for a complete functional check of each critical flight system; determine which maintenance procedures should be followed by such functional checks; and modify their existing maintenance manuals, if necessary, so that they contain procedures at the end of maintenance for a complete functional check of each critical flight system (A-04-7);

- “Require [FARs] Part 121 air carriers to modify their existing maintenance manuals, if necessary, so that they contain procedures at the end of maintenance for a complete functional check of each critical flight system (A-04-8);
- “Prohibit inspectors from performing required-inspection-item inspections on any maintenance task for which the inspector provided on-the-job training to the mechanic who accomplished the task (A-04-9);
- “Require [FARs] Part 121 air carriers that use contractors to perform required inspection item (RII) maintenance tasks and inspections to have air carrier personnel who are physically present when a substantial amount of the RII planning, tasking, maintenance work and inspections are performed and are readily available when they are not physically present and who ensure that the processes and procedures used by contractors to perform RII maintenance tasks and inspections are the same as those used by air carrier maintenance personnel (A-04-10);
- “Develop detailed on-the-job training (OJT) requirements for [FARs] Part 121 air carriers that rely on OJT as a maintenance training method. These requirements should include, but not be limited to, best practices, procedures and methods for accomplishment and administration of this training. Ensure that these OJT requirements are incorporated into [FARs] Part 121 air carrier maintenance training programs (A-04-11);
- “Audit training records for personnel who are currently performing maintenance on Air Midwest airplanes to verify that the training was properly accomplished in accordance with the company’s Maintenance Procedures Manual and Maintenance Training Manual (A-04-12);
- “Require [FARs] Part 121 air carriers to implement a program in which carriers and aircraft manufacturers review all work-card [instructions] and maintenance-manual instructions for critical flight systems, and ensure the accuracy and usability of these instructions so that they are appropriate to the level of training of the mechanics performing the work (A-04-13);
- “Include the Continuing Analysis and Surveillance System guidance from Advisory Circular (AC) 120-16D, *Continuing Airworthiness Maintenance Programs*, and AC 120-79, *Developing and Implementing a Continuing Analysis Surveillance System*, in [FAA] Order

8300.10, *Airworthiness Inspector's Handbook* (A-04-14);

- "Require that all [FARs] Part 121 air carrier maintenance training programs be approved (A-04-15); [and,]
- "Require that [FARs] Part 121 air carriers implement comprehensive human factors programs to reduce the likelihood of human error in aviation maintenance (A-04-16)."

Spoiler-actuator Malfunction Causes Roll Event

During the descent of a Learjet 45 aircraft through 13,000 feet, the captain extended both spoilers as speed brakes. The left spoiler deployed, but the right spoiler barely moved, causing an uncommanded roll to the left. The captain retracted the spoilers, rolled the airplane back to a level attitude and began performing the appropriate emergency checklist. The descent was resumed, and the airplane was landed uneventfully. There were no injuries to the two flight crewmembers and two passengers in the Oct. 22, 2003, incident.

"The left and right spoiler actuators (part number 6627602001-003) were ground tested at [Denver (Colorado, U.S.) International Airport]," said the report by the U.S. National Transportation Safety Board (NTSB). "The tests showed high internal resistance in the actuator coils. The actuators were removed and retained for further examination. Later testing [by] the manufacturer confirmed this finding."

Fuel-system Contaminants Shorten Bell 206B Flight

As the Bell 206B-3 helicopter reached 50 feet above ground level after takeoff, the engine failed. The pilot conducted an autorotation to a nearby open field. The helicopter struck the ground hard and came to rest on its right side. Damage included the separation of the tail boom into two sections. The pilot, the only occupant, was uninjured in the Sept. 9, 2003, accident.

"The engine fuel filter was removed, revealing contaminants inside the filter element assembly," said the report by the U.S. National Transportation Safety Board (NTSB). "There was fuel in the fuel-pump filter bowl, and [the filter bowl] also revealed contaminants. … The fuel-control-unit filter assembly was removed, and the element was heavily contaminated."

Fuel samples taken from the fuel-pump filter bowl and fuel cell were subjected to laboratory analysis, which showed heavy water contamination in the fuel system. The operator said that the engine had been overhauled about 30 flight hours before the accident.

Lost Bolt Leads to Hughes 369D Forced Landing

The skid-equipped, turbine-powered Hughes 369D helicopter was being operated in an on-demand air taxi flight. About 100 feet above ground level, the "ENGINE OUT" annunciator sounded, and the pilot conducted an autorotation. "When the helicopter touched down, the engine power suddenly surged, and the helicopter then began to climb," said the report by the U.S. National Transportation Safety Board. "The main-rotor blades collided with several trees, and the blades then severed the tail boom."

The pilot moved the throttle to the "OFF" position, but the engine did not shut down. He then pulled the emergency fuel shutoff. The pilot and one passenger were not injured, and a second passenger received minor injuries, in the July 21, 2003, accident. The helicopter was substantially damaged.

The report said, "Examination of the helicopter revealed that a bolt, used to connect the N2 governor-input arm to an airframe-mounted bellcrank, was missing. The bellcrank is connected to the helicopter's collective-control linkage. As the pilot moves the collective control, through the bellcrank and governor-input arm, engine power increases or decreases. The bolt is normally retained by a castellated nut, and then secured in place by a cotter pin."

The missing bolt and its nut were found on the ground under the helicopter. A cotter pin with one broken side also was found, but it could not be determined whether the broken cotter pin was the missing pin from the bolt, the report said.

The helicopter's most recent inspection was a 100-hour inspection, conducted by operating company personnel, 51.8 service hours before the accident.

The report listed the probable cause of the accident as "the improper installation of a bolt in the gas-generator linkage by company maintenance personnel, which resulted in a loss of the bolt, a loss of engine power while maneuvering and subsequent forced landing and collision with trees."

Electrical Wire Shorts, Hydraulic Line Bursts in B-737

Passengers were boarding the Boeing 737-448 at Dublin (Ireland) Airport for a flight to Amsterdam, Netherlands. While the flight crewmembers were performing the preflight checks, they were unable to pressurize the hydraulic "B" system electric pump. The ground crew manager went to the aircraft cockpit and reset the ground-fault-protection circuit breaker. When the hydraulic pump was selected "ON," a puff of gray smoke and vapor was seen through the right cockpit windows, whereupon the pump was switched to "OFF." Fire was observed briefly by a fire services officer, but the fire subsided without intervention.

The ground crew manager exited the aircraft and went to the right wheel well, where hydraulic fluid was observed running out of the keel beam and spraying onto the back of the hydraulic pump. The reservoir was depressurized to stop the fluid flow, leaving vapor, hydraulic fluid spillage and a smell of burning in the area. An air traffic controller saw smoke emerging from the front of the aircraft and alerted emergency services. The captain ordered an immediate evacuation, which took place in an orderly way under the guidance of the cabin crew. No injuries were reported in the June 3, 1999, incident. (The report by the Irish Air Accident Investigation Unit was issued Jan. 30, 2004.)

When the aircraft was inspected, it was found that metal braid on a flexible hydraulic pressure line had chafed the insulation of one wire of the electrical supply to the "B" system hydraulic pump.

"This pump is located in the right-main wheel well," said the report. "As the insulation wore away in service, the wire became exposed. During this incident, the voltage on the wire arced across to the metal braid, puncturing the hydraulic [pressure line] and causing the hydraulic fluid to escape. This resulted in a large amount of smoke/vapor emanating from the wheel well."

Boeing had issued service letters (SL 737-24-50-B, SL B737-29-51 and SL B737-29-062) concerning the possible chafing of the hydraulic pressure line against the electrical wiring of the "B" system pump. As a result, the incident-aircraft operator had ordered a fleet-wide modification requiring that the elbow fitting between the acoustic filter and the hydraulic pressure line be "clocked" at the appropriate angle.

"The offending pump was changed during the 'D' inspection in February 1999," said the report. "The person who installed the pump at this time was asked if he was aware of the requirement to 'clock' the fitting at a particular angle. He said he was not. However, due to the time lapse since the pump change, he could not particularly remember very much about it."

Hydraulic fluid is not normally flammable in liquid form, the report said. "However, this fluid was under pressure and escaped from the [line] in the form of an oil spray such that the product could easily have vaporized," the report said. "This fluid, [being emitted] at pressure through the ruptured [line], appears to have ignited, causing a flashover of the vapor for approximately five seconds. It is likely that the circuit-breaker protection activated at that point, the arcing ceased, the hydraulic pressure reduced and consequently the flash could no longer be sustained."

The report said that the cause of the incident was that "an electrical short between the supply to the 'B' system hydraulic pump and the metal braid on the flexible hydraulic [pressure line] caused that pressure [line] to burst."

In July 1999, the maintenance organization issued a notice to its staff, informing them to refer to the aircraft maintenance manual chapters 29-15-17 and 29-15-22 when installing a hydraulic pump or acoustic filter to the aircraft type. The Irish Aviation Authority issued, in July 2000, a requirement for operators of Irish-registered B-737s to carry out a one-time inspection within 60 days and thereafter at each subsequent "C" check or every 18 months, whichever comes first.♦

NEWS & TIPS

Terminal Captures, Communicates Shop Data

Epic Data's MPT 9100 is a shop-floor data-collection and display terminal that the manufacturer says provides information visibility for a wide range of processing and applications, including data for work time and work attendance, inventory management, tool tracking and project costs.

The touch-screen terminal, which is designed to provide real-time data flow between workstations and management, includes a microphone and speakers for two-way voice communication. The display provides shop-floor access to drawings, corporate documents, policies and procedures. The manufacturer says that this function enhances worker safety by making procedure manuals and material safety data sheets available on line, and that specific instructions for responding to an emergency situation can be displayed on the terminal screen.

The unit features barcode scanning for identification of objects and radio frequency identification and other means of identity verification to ensure that only authorized users can access data and machinery. Advanced security technologies are integral with the unit, the manufacturer says. The device can be connected to standard personal computer ports, and transmits data via Ethernet connections.

For more information: Epic Data International, 6300 River Road, Richmond, British Columbia V6X 1X5 Canada. Telephone: +1 (604) 273-9146.

The Tie That Binds Is Stainless Steel

A line of stainless-steel ties for gathering together cables and hoses for critical applications is offered by Nelco Products. Self-Lock Stainless Steel Cable Ties are designed to provide a permanent, high-strength tie that is said to resist most chemicals, solvents, radiation and saltwater. According to the manufacturer, they are three times stronger than conventional nylon cable ties.

The ties can be installed by hand and have an integral self-locking mechanism. They are offered in lengths of 5.0 inches to 47.0 inches (12.7 centimeters to 119.4 centimeters).

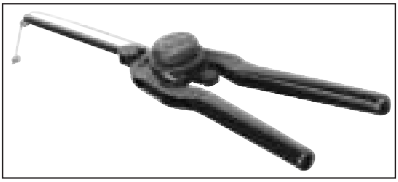
Stainless Steel Ties

For more information: Nelco Products, 22 Riverside Drive, Pembroke, MA 02359 U.S. Telephone: (800) 346-3526 (U.S.); +1 (781) 826-3010.

Lockwire Alternative Offered

Safety Cable is designed as an alternative to lockwire for aviation-engine threaded fasteners, and is said by the manufacturer to significantly reduce installation and removal time, as well as to reduce installation hazards by removing sharp edges that can injure operators.

The product is a system that includes the manufacturer's cable, ferrule fittings and a multiple-function tensioning, crimping and cutting tool. The tool tensions the cable to any preset load through any bolt pattern, crimps the ferrule fitting to the cable and cuts the cable flush to the fitting in a single motion, the manufacturer says. The system is said to operate in such a simple manner that entry-level technicians can learn the process in 30 minutes and then be ready to secure fasteners.



Safety Cable

Safety Cable is approved for installation under U.S. Federal Aviation Regulations (FARs) Part 43.13(a) and SAE International Aerospace Standards.

For more information: Bergen Cable Technology, 343 Kaplan Drive, Fairfield, NJ 07004 U.S. Telephone: (800) 237-4369 (U.S.); +1 (973) 276-9596.

Fire Extinguishers Designed for Hazardous Areas

Two high-pressure fire extinguishers from Ansul are designed, respectively, to protect areas where Class B (flammable liquids or gases) fires or Class C (energized electrical equipment) fires could occur. The fire extinguishers, which incorporate one or two carbon-dioxide bottles on a wheeled frame, are recommended by the manufacturer for use in aviation hangars, among other locations.

After the fire extinguisher is rolled to the vicinity of a fire, a discharge hose equipped with a squeeze-grip activation valve allows two-hand operation, said to be more efficient for delivery of the extinguishing agent. Carbon dioxide discharge time is 35 seconds to 70 seconds. The carbon

Fire Extinguishers

dioxide provides its own pressure for discharge, is noncorrosive and leaves no chemical residue to clean up, the manufacturer says.

For more information: Ansul, 1 Stanton St., Marinette, WI 54143 U.S. Telephone: (800) 862-6785 (U.S.); +1 (715) 735-7411.

Bench Makes Maintenance a Draining Experience

The Fluid Containment Bench is intended to ease the task of working with fluid-saturated components by preventing unsafe spills. The product includes a reinforced stainless-steel top with a drain, surrounded by a 0.5-inch (1.3-centimeter) lip to keep fluids from overflowing.

Excess fluids flow through a drain into a removable 3.0-U.S.-gallon (11.4-liter) storage receptacle. The bench's legs are welded and braced for strength, and a locking drawer secures regularly used tools and materials.

Fluid Containment Bench

For more information: Shure Manufacturing Corp., 1901 West Main St., Washington, MO 63090 U.S. Telephone: (800) 227-4893 (U.S.); +1 (636) 390-7100.

System Creates One Tool out of Many

The Link Tools system is based on what the manufacturer calls Quick-Lock Technology, which enables the various sockets and accessories in the system to lock together and to be released quickly with one hand. The system enables various tools to be combined into a unit, and sockets and tools cannot be dropped or lost, the manufacturer says. The system is said to increase productivity and reduce the physical effort needed by technicians.

The Link Tools product line includes a 1/4-inch (0.6-centimeter) drive set and a 3/8-inch (one-centimeter) drive set. Both sets include a ratchet, a palm wrench, t-bars, a u-joint and extensions of various lengths, as well as standard and metric sockets. The locking mechanism also can be used to fit pieces of the set with the owner's already-owned sockets.

For more information: Link Tools, P.O. Box 14609, Chicago, IL 60014 U.S. Telephone: (888) 727-5465 (U.S.); +1 (847) 676-5570.♦