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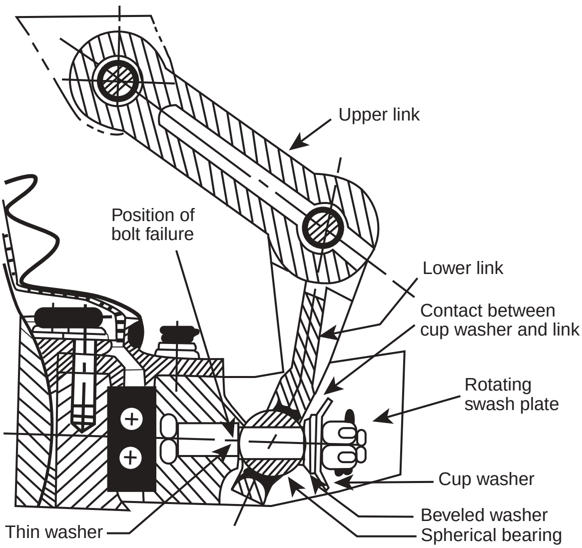
Incorrect Orientation of Lower Scissors Link Caused Contact Between Cup Washer and Link



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Robert A. Feeler, editorial coordinator

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Fractured Bolts Blamed for Loss of Control of Two Helicopters

The U.K. Air Accidents Investigation Branch said that both Agusta A109E Power accidents in England — and a similar accident in Spain — occurred after maintenance during which the swash-plate scissors-link assembly was installed incorrectly.

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FSF Editorial Staff

During the first six months of 2000, pilots of two Agusta A109E Power helicopters in England lost control of the helicopters because of fractures of swash-plate scissors-link attachment bolts. The helicopters were substantially damaged. The pilots of both helicopters and three of the four passengers received minor injuries; the fourth passenger was not injured.

The U.K. Air Accidents Investigation Branch (AAIB) said, in final reports on the two accidents, that the bolts had fractured because, on both helicopters, the swash-plate scissors link had been assembled and installed incorrectly. The same company operated both aircraft.

In the first accident, which occurred in night visual meteorological conditions (VMC) at 1655 local time Jan. 14, 2000, near Romney Marsh, Kent, the helicopter was being flown at about 148 knots indicated airspeed (KIAS) in cruise flight when the pilots heard "a muffled bang from above and behind them," the report said.

"The helicopter became almost uncontrollable, and … there was a sudden loss of electrical power. … The rear passenger described what he thought was a violent impact, as if they had collided with another aircraft, followed by the sensation of the helicopter becoming inverted, leaving his seat but [partially] restrained by his seat belt and banging his head on the helicopter roof."

The helicopter rolled left and pitched nose up. The captain, an A109E flight instructor with 5,000 hours of flight time, had difficulty controlling the helicopter. He believed that both engines had stopped, and he established the helicopter in autorotation. The left roll continued, and the helicopter entered a steep diving turn. The captain applied right and aft cyclic pitch to regain control and leveled the helicopter at 300 feet above ground level (AGL).

He lowered the landing gear for what he believed would be an engine-off landing, but when he raised the collective pitch level to cushion the touchdown, his action appeared to have no effect. The tail rotor struck the ground and detached. The nose landing gear collapsed, the helicopter yawed to the left, and the right-main landing gear collapsed, causing the helicopter to roll onto its right side. The main-rotor blades, pitch-change links and other components around the rotor head — including the scissors link that drives the rotating swash plate — were broken or dislodged.

Initially, accident investigators, relying on the pilot's description of a dual-engine failure followed by an electrical failure, concentrated their efforts on examining the engines and testing the electrical system. They believed that the swash-plate scissors-link attachment bolt had been damaged when the main-rotor blades struck the ground.

They expanded their investigation and re-examined the wreckage after the second accident, which occurred in VMC at 0833 local time June 17, 2000, in Arborfield Cross, Berkshire, as the pilot and two other crewmembers on the emergency medical services flight searched for the site where they were to pick up a patient. The helicopter was at about 300 feet AGL, being flown between 60 knots and 80 knots in a shallow right turn, when the crewmembers heard a bang, which apparently came from the upper rear of the passenger cabin, and felt the helicopter sink suddenly.

"This sensation was described as though the helicopter had flown through a vortex wake," the accident report said. "The [captain, who had 4,240 hours of flight time] instinctively applied additional collective control in order to arrest the sink but rapidly realized that the helicopter was not responding. The … main-rotor speed had increased to 105 percent N_R [main-rotor revolutions per minute]. … Initially assessing the problem as a loss of power, the [captain] lowered the collective lever to enter autorotation.”

The helicopter’s automated warning system showed no indication of an engine failure, and the captain continued the right turn to position the helicopter for a suitable landing field. He lowered the landing gear and told air traffic control (ATC) that he was declaring an emergency. Just before touchdown, the “low-rotor-speed” audio alert sounded, and the captain applied full collective control to slow the descent. The helicopter touched down heavily, and the nose landing gear, left-main landing gear and right-main landing gear collapsed. The helicopter bounced forward slightly and stopped upright with the nose against a fence in a field adjacent to the intended landing area.

Investigators initially believed that both engines had failed, but an examination of the main-rotor head revealed that the rotating scissors linkage had separated because of a failure in the bolt that attached the lower link to the rotating swash plate. Later, the investigation revealed that the lower scissors link “had been installed back to front, such that the spherical bearing at the base of the link, through which passed the attachment bolt, was restricted in its range of movement,” the report said.

The report on the June accident said that the re-examination of the wreckage from the first accident, in January, revealed that “the rotating scissors lower link had been installed back to front in an identical manner to that of [the second accident helicopter].” The attachment bolt also had failed.

The rotating swash plate is shaped like a four-pointed star. Spherical bearings attach rotor-blade pitch-change links to lugs at the four points. The rotating swash plate is driven by the scissors linkage, and the upper end of the scissors linkage is attached to the rotor mast. A fixed swash plate is located below the rotating swash plate and is operated by the flying control actuators; the fixed swash plate controls the vertical position and the angle on the mast of the rotating swash plate.

The June accident report said, “In the event of the scissors linkage becoming disconnected when the rotor is under power, there will be some loss of synchronization between the rotor head and the swash plate, such that the latter will tend to lag behind. The pitch links are normally at a near-vertical attitude. However, the failure of the scissors linkage attachment would result in the swash-plate driving loads being taken up by the pitch links, which would tend to lean in the direction of rotation. This change in geometry would result in a reduction of the rotor-blade pitch angles without any change in the swash-plate position, and probably accounted for the sudden loss of lift reported by the pilot."

In the first accident helicopter, the scissors-link assembly had been removed and replaced as part of a combined annual/100-hour inspection about 45 minutes flight time before the accident. The helicopter was manufactured in 1998; the accident reports did not say how many flight hours had been accumulated. In the second accident helicopter, the lower scissors link had been replaced the day before the accident because excessive play had been detected in the scissors-link hinge bearing; the helicopter then was flown for three hours and 10 minutes before the accident. The helicopter, which was manufactured in 1999, had accumulated 271 flight hours before the accident.

The June accident report said that the maintenance manual's diagram of scissors-link installation "has not been drawn in sufficient detail that could assist [a maintenance technician] in identifying the correct orientation. One clue to an incorrect installation would be that the flange on the hinge bush would have to be at the opposite end to that shown in order to engage with the machined shoulder on the side of the link. However, this would not preclude fitting the hinge bolt in its correct orientation, i.e., with the head facing the direction of rotation, as directed in the maintenance manual 'installation procedure.' This section of the manual otherwise contains no written guidance as to the correct orientation of the link. There is, in fact, an error in the instructions, in that the beveled washer (included in the attachment of the link to the swash-plate bolt) is called up as item no. 29, when it appears as item [no.] 25 in the diagram."

The June accident report said that the scissors-linkage design is unique to the A109E; other versions of the A109 have asymmetric lower links that cannot be installed incorrectly.

Metallurgical examinations were conducted in parallel on the relevant components of both helicopters.

The examinations determined that, on the second accident helicopter, the attachment bolt had failed where it emerged from the swash plate.

"[T]he bolt had failed in fatigue across most of its section, with the final 15 percent or so failing in overload," the June accident report said. "The fatigue initiation area was centered on the 12 o'clock position on the fracture face and was the result of a simple bending mechanism. This was entirely consistent with the loads that would have arisen as a result of installing the lower scissors link in the incorrect orientation. The loads would have been a combination of the spherical bearing running out of travel and the contact between the cup washer and the face of the link. Fretting damage on the link due to contact by the cup washer (which had become distorted as a result) was clearly visible."

Inspection also showed that the beveled washer that should have been located between the cup washer and the lower link was missing and that in its place was the thin washer that should have been between the swash plate and the scissors link.

"A fretting mark on the shank of the bolt inboard of the link was found to be the same width as the beveled washer … suggesting that the latter had been installed at this location for a period of time, probably since the helicopter was built," the report said. "A narrower mark adjacent to it could have been made by the thin washer. This being the case, the thin washer was probably installed underneath the cup washer during the maintenance carried out on the day prior to the accident."

Fretting marks on the bolt shank also indicated that there might have been relative movement between the components. The retaining nut was thread-bound (had been tightened to the end of the threaded portion of the bolt), and examination showed that the component stack-up was "essentially loose," the report said.

On the first accident helicopter, the examinations determined that the bolt fracture face had two areas of high cycle fatigue centered on the 12 o'clock position and on the 6 o'clock position.

"This was consistent with a reverse bending mechanism, although it was not clear how this could have arisen," the June accident report said. "As with the lower link from [the second accident helicopter], there was evidence of considerable contact between the underside of the cup washer and the outer face of the link, this giving rise to the *single* bending mechanism that occurred on [the second accident helicopter], with its fatigue initiation at the 12 o'clock position. [Although] a jammed [spherical bearing] or still spherical bearing in the link could have generated reverse bending in the bolt, it was apparent from examination that the bearing operated freely. There was some evidence of an increase in the progression rate of the crack … before overload separation took place."

The examination also found that the beveled washer was not in the correct position beneath the cup washer, and that "a band of scoring/fretting on the bolt shank suggested that it had been positioned inboard of the link," the report said. The retaining nut was thread-bound, in the same manner that appeared on the second accident helicopter, and the assembly was loose.

Two days after the second accident, the manufacturer issued information letter no. 109-2000-005, which told operators about the accident and recommended precautionary inspections for correct installation of the rotating scissors lower link "in accordance with figure 63-34 of the A109E Maintenance Manual." After the U.K. CAA told the manufacturer that the manual provided little help in determining the proper installation of the part, the manufacturer issued a second information letter, no. 109-2000-006, which included an installation diagram.

The precautionary inspections that followed issuance of the information letters resulted in the discovery of three other U.K.-based helicopters in which components had been assembled incorrectly on the swash-plate bolt.

"Although the lower links were correctly oriented, the beveled washers had been installed inboard of the links," the June accident report said. "Since no maintenance that required disassembly of the scissors linkage had occurred since any of the [three other] helicopters were delivered, it was concluded that all of them had left the factory in this configuration. The same was probably true for [the two accident helicopters], meaning that five out of eight A109E … helicopters in the U.K. were incorrectly assembled. However, the manufacturer has stated that, in a global survey, no other helicopters had been found in a similar condition."

An examination of one of the three intact helicopters with an improperly installed beveled washer revealed evidence of "light contact between the outer face of the lower scissors link and the cup washer" and faint marks on the inside face of the lower scissors link, apparently as a result of contact with the lip of the swash plate, the report said. The swash-plate bolt was replaced.

There was evidence that, even when the scissors link was installed in the correct orientation, contact occurred between the cup washer and the link at high pitch settings.

During the investigation, AAIB learned of a similar accident July 26, 1999, in Spain in which the pilot was killed. The Spanish Accident Commission said that the accident occurred within two flight hours after maintenance personnel had removed and replaced the rotating scissors linkage. An investigation revealed that the lower scissors link had been installed "the wrong way round," the AAIB June accident report said.

"The swash-plate bolt had failed, and [although] this initially had been assumed to have occurred as a consequence of the accident, [the bolt] was later found to have suffered a fatigue failure, similar to that of [the second U.K. accident helicopter]. Although the fracture had initiated at the 12 o'clock position [the same position as for the second U.K. accident helicopter], the fracture face was inclined at an angle of approximately 30 degrees to the bolt when viewed from above. The reason for this was not fully understood, although it was considered that the swash-plate driving loads may have had an effect."

The investigation also found that the nut was nearly thread-bound, as were the nuts in the two U.K. accident helicopters.

The June accident report said, "The common feature in the [three] accidents … was that, a short time beforehand, the lower scissors link had been installed in the incorrect orientation. The combined effect of the spherical bearing within the link running out of travel, plus contact between the cup washer and the link, was to impart a bending load to the swash-plate attachment bolt. This resulted in a fatigue crack developing in the bolts of all helicopters and led to the in-flight failure of the bolt in the case of [the second U.K. accident helicopter and the Spanish accident helicopter]. The same probably happened to [the first U.K. accident helicopter] but could not be established beyond doubt; the fatigue cracking was different … in that it resulted from a reverse bending mechanism, the derivation of which was not determined."

The June accident report said that, because incorrect installation of the lower scissors link was physically possible, the design did not comply with British Civil Airworthiness Requirements Section G4-8. That section says that "control systems shall be designed so as to minimize the risk of incorrect assembly" and that "other controls … should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system."

As a result of the accident investigations, AAIB recommended that the manufacturer:

- Consider modifying the lower scissors link to the swash-plate bolt to increase the margin of available thread and thereby reduce the possibility that the retaining nut will become thread-bound and unable to achieve the specified assembly torque. In response, Agusta added a thin washer between the cup washer and the beveled washer; the additional washer prevents the nut from reaching the end of the threaded portion of the bolt; and,

- Amend the aircraft maintenance manual to "emphasize the crucial nature of correct orientation of the lower link when assembling it onto the swash-plate bolt. The amendment should additionally include material that provides unambiguous information as to the correct orientation of the link. In the longer term, the design should be modified such that incorrect assembly of the link is impossible." In response, Agusta inserted a temporary revision in the maintenance manual.

Agusta also issued technical bulletin no. 109EP-12 on July 24, 2000, which described the procedures to be used in visually inspecting the rotating-scissors assembly for correct installation and replacing any part that was not airworthy. The technical bulletin also said that, within 50 hours time-in-service, the rotating scissors assembly should be removed to inspect the attachment bolt for a crack or other damage (unless the bolt was replaced as a result of the initial inspection).

AAIB also recommended that the Italian civil aviation authority, Ente Nazionale per l'Aviazione Civile (ENAC), issue an emergency airworthiness directive to operators of A109E helicopters requiring inspection of the swash-plate scissors linkage for proper assembly of the lower link and its washers onto the swash-plate bolt and replacement of the swash-plate bolt if incorrect assembly was detected. ENAC issued the airworthiness directive July 24, 2000.

Other recommendations resulted from the investigation of the first U.K. accident, in which no technical reason could be found for the helicopter's loss of electrical power. The investigation identified potential hazards involving the location and design of battery and generator switches at the front-left of the overhead panel. The report also said that the emergency cutoff gang bar, which operated on a single-action switch, was vulnerable to inadvertent shutoff.

"There was no evidence to show that the gang bar had been operated in flight, but the switches were all found in the OFF position after the accident," the report said.

Neither pilot recalled switching off the battery or generator switches. The report said that the sudden, abrupt movements of the helicopter might have permitted the top of the captain's headset to contact the battery switch and generator gang bar, moving them to off positions.

AAIB recommended that U.K. CAA:

- Inform operators of Agusta 109-series helicopters of the possibility of electrical power loss as a result of inadvertent movement of the battery and generator switches and the gang bar. In response, CAA wrote a letter Jan. 28, 2000, to U.K. owners and operators of Agusta A109 helicopters discussing the possibility of inadvertent de-selection of battery and generator switches;

- Determine whether there is a requirement for installation of the gang bar and, if not, whether the battery master switch should be controlled by a guarded switch as a safeguard against inadvertent shutoffs. In response, CAA said that officials would review the issue; and,

- Inform operators of helicopters authorized for flight under instrument flight rules (IFR) of the possibility of aircraft-handling difficulties in high-speed cruise, including the effects of yaw induced by lowering the collective pitch lever to reduce speed with the possibility of a rapid roll couple. AAIB said that such difficulties could result from the unexpected failure or unexpected de-selection of automatic stabilization systems. In response, CAA said that the information would be provided.♦

[Editorial note: This article, except where specifically noted, is based on U.K. Air Accidents Investigation Branch *AAIB Bulletin 2/2001*: reference no. EW/C2000/01/01, pages 61–67; and reference no. EW/C2000/6/6, pages 68–84.]

MAINTENANCE ALERTS

FAA Proposes Changes to In-flight Entertainment Systems

The U.S. Federal Aviation Administration (FAA) has proposed 14 airworthiness directives (ADs) to ensure that flight crews are able to shut off in-flight entertainment systems when necessary on several transport airplane models. An investigation found that current in-flight entertainment systems can remain powered even after the flight crew conducts shutoff procedures.

FAA said, “Operators would have to deactivate or modify the entertainment system, revise crew procedures for removing power from the system, or remove [the system] from the airplane. … The options available to comply with the ADs differ among affected operators, depending on how their aircraft are configured.”

Operators’ compliance with the proposed ADs could affect the availability of in-flight audio services and video services to passengers on the airplanes.

Airplane models affected by the proposed ADs would include Boeing 737-300 and B-737-700; Boeing 747-100, B-747-200, B-747-400 and B-747SP; Boeing 757-200; Boeing 767-200, B-767-300, and B-767-300ER; Douglas DC-9-51; McDonnell Douglas MD-83 and Douglas DC-10-30; and Airbus A340-211. About 74 U.S.-registered airplanes would be affected.

The proposed ADs say that airplane operators would have 18 months from the date that the ADs become final to take appropriate action.

FAA said, "The actions specified by these proposed [ADs] are intended to assure the crew's ability to remove power from the entertainment system during unusual or emergency situations. The FAA proposed these ADs after its review of current in-flight entertainment systems that were added to certain aircraft models as after-market modifications. The review indicated one or more of the following conditions could exist:

- "The entertainment system cannot be turned off without removing power from other required systems;
- "The entertainment system can only be deactivated by pulling circuit breakers; [and,]
- "Procedures for deactivating the entertainment system are not available to the flight crew."

FAA was developing four similar ADs involving other aircraft models.

FAA said that the proposed ADs were not related to the Sept. 2, 1998, accident in which the flight crew of a Swissair MD-11 reported smoke in the cockpit about one hour after takeoff from John F. Kennedy International Airport in New York, New York, U.S. While the crew attempted to divert the flight to Halifax, Nova Scotia, Canada, the airplane struck the Atlantic Ocean. All 229 people in the airplane were killed.

The Transportation Safety Board of Canada (TSB) has not determined the cause of the accident. Nevertheless, TSB has issued safety advisories involving electrical wiring in the forward ceiling areas of McDonnell Douglas MD-11 airplanes and the installation of flight-crew reading lights and safety recommendations involving methods of reducing risks related to the flammability characteristics of specific types of insulation-blanket materials.

TSB said that accident investigators recovered several electrical wires from the accident aircraft that showed signs of arcing and other wires that were damaged by heat. Some of the wires were part of an in-flight entertainment system installation that TSB described as "unique to Swissair aircraft"; other heat-damaged wires were common to other MD-11 airplanes.

Operating Limits Imposed on Some B-737 Fuel Pumps

The U.S. Federal Aviation Administration (FAA) has issued an airworthiness directive (AD) prohibiting U.S. operators of Boeing 737 airplanes from operating center-wing-tank fuel pumps when fuel quantity is below specific levels.

The AD is intended to prevent ignition of fuel vapors inside the center-wing fuel tank, FAA said.

"FAA has determined that it is necessary to turn off fuel pumps when the tank is depleted of fuel; extended dry operation can result in overheating and excessive wear of the pump bearings," FAA said. "This, in turn, has the potential to create an ignition source that could cause a fuel-tank explosion."

The AD, which applies to 1,501 U.S.-registered airplanes, requires that:

- During ground operations, center-wing-tank fuel-pump switches must not be in the on position when fuel quantity is below 1,000 pounds (454 kilograms);
- When both low-pressure lights illuminate, fuel-pump switches must be turned to the off position; and,
- Fuel pumps must not be on unless flight-deck personnel are available to monitor low-pressure lights.

Hydraulic Fluid Leak Leads to Landing Gear Collapse

During departure from Brindisi, Italy, the flight crew of a British Aircraft Corp. (BAC) 1-11 observed the brief illumination of the no. 1 hydraulic system engine-driven pump (EDP) "fail" light, indicating that either the reservoir pressure was below eight pounds per square inch (psi) or the EDP output pressure was less than 1,500 psi. Because the light was extinguished quickly and there was no obvious malfunction, the crew continued the flight to London, England.

During the descent, the EDP fail light illuminated again, at first intermittently but then continuously. The flight crew said that they switched the EDP either to the off position or to the isolate position and used the auxiliary pump to extend the landing gear. They also observed that the no. 1 hydraulic-system quantity indicator was "registering at the bottom of the green sector," said the accident report by the U.K. Air Accidents Investigation Branch (AAIB).

The flight crew conducted a normal landing and taxied the airplane to the gate. After shutdown, the captain observed "a major leakage" of hydraulic fluid in the left-main landing-gear bay.

Maintenance personnel determined that the hydraulic fluid had leaked from a flexible hose on the outlet (pressure) port of the no. 1 auxiliary alternating current (AC) pump. They replaced the flexible hose, added "about two-thirds of a five U.S.-gallon drum" (about 3.3 U.S. gallons, or 2.8 imperial gallons, or 12.5 liters) and pressurized the reservoir with air to the normal value of 38 psi. Then they started the auxiliary power unit and operated the AC pump. (The capacity of the hydraulic fluid reservoir was 2.75 imperial gallons (3.3 U.S. gallons.)

"After both engines were started and the EDPs [were] selected, they then exercised the flying controls and nosewheel-steering systems to bleed any air out of the system," the report said. "Because no aircraft jacks were available, they were not able to exercise the landing gear retraction/extension system (apart from the [main landing gear] doors) and appear to have omitted the copilot's [windshield] wiper from this action. The aircraft was then shut down, and the next time the no. 1 hydraulic system was powered was on the accident flight."

The BAC 1-11 has two independent hydraulic systems normally powered by the no. 1 EDP and the no. 2 EDP. If the EDPs fail, AC pumps can be used to provide hydraulic power. Both systems power the primary flight controls and secondary flight controls; the no.1 system alone powers extension and retraction of the landing gear and the copilot's windshield wiper.

As part of their preparations for departure on a repositioning flight to a maintenance facility, the flight crew selected the no. 1 EDP and the no. 2 EDP to the on position.

"Coincident with the normal 'clunk' sound from below the floor, the nose started to sink slowly with a 'stepping' motion and settled gently on the collapsed nose-landing-gear doors," the report said.

Damage to the airplane was minor, and none of the five occupants was injured.

An investigation revealed that the level of fluid in the no. 1 hydraulic system was low and that 2.5 U.S. quarts (2.4 liters) of hydraulic fluid were added before the quantity indicator registered "full." Subsequent examination of the gauging system showed that quantities below the "green" sector did not register.

For most aircraft, repairs of minor leaks of hydraulic fluid require subsequent exercising of the flight controls and other hydraulic equipment to bleed air from the system. The repairs typically do not require raising the aircraft using a jack to conduct landing-gear retractions. Nevertheless, the report said, in instances in which the fluid was drained from the system, the maintenance manual for the BAC 1-11 "required the aircraft to be jacked and all no. 1-system hydraulic-system services to be exercised until the reservoir-contents level stabilizes."

The manufacturer said that replacing the fluid in an empty reservoir "was analogous to a reservoir replacement or a 'completely drained' system … either of which required exercise of the landing gear."

The accident report said that maintenance personnel may not be fully aware of the possible consequences of air in the nose-landing-gear system after fluid is added following a major loss of hydraulic fluid. Therefore, AAIB recommended that Airbus U.K. reissue a 1978 service newsletter (Service Newsletter 32/43, originally issued after three incidents involving inadvertent retraction of the nose-landing gear) with the addition of details about the Feb. 28, 2000, incident and an emphasis on the importance of exercising the landing gear and the copilot's windshield wiper after a complete loss of hydraulic fluid from the no. 1 system reservoir. Airbus U.K. accepted the recommendation.

Cracks Found on Lower Wing Planks of Bombardier CL-600-2B19s

Transport Canada (TC) has issued an airworthiness directive (CF-2001-15) requiring detailed inspections of the wings of some Bombardier CL-600-2B19 Regional Jet airplanes for cracks.

The airworthiness directive, effective April 17, 2001, was prompted by the discovery of cracks on several CL-600-2B19 airplanes on the left side and right side of the lower wing plank at wing station 148. Failure of the lower wing plank would compromise the wing's structural integrity, the airworthiness directive said. CF-2001-15 applies to aircraft with serial numbers 7003 through 7999.

CF-2001-15 requires the inspections to be conducted according to Bombardier Alert Service Bulletin A601R-57-031, dated March 2001, or subsequent revisions approved by TC. Initial inspections are required according to the following schedule:

- For airplanes with 6,500 flight cycles or less, the inspections should be conducted before the airplanes exceed 7,000 flight cycles;
- For airplanes with between 6,500 flight cycles and 13,500 flight cycles, the inspections should be

conducted within 500 flight cycles of the directive's effective date or before the airplanes accumulate 13,700 flight cycles, whichever occurs first; and,

- For airplanes with more than 13,500 flight cycles, the inspections should be conducted within 200 flight cycles of the directive's effective date.

The inspections must be repeated at least every 5,000 flight cycles, and the results must be reported to Bombardier Aerospace. If cracks are found, they must be repaired before further flight according to Bombardier repair instructions.

Leaking Fuel Line Found in Cessna 340A

The owner of a Cessna 340A told maintenance personnel that he had smelled fuel in the cabin and that the airplane was leaking hydraulic fluid.

A report filed with the U.S. Federal Aviation Administration (FAA) said that maintenance personnel found a leak in the fuel-crossfeed line (part no. 5300108-41), located beneath the cabin floor. The line-wall thickness had been penetrated by corrosion. A maintenance technician said that the cause of the corrosion probably was water that had not been drained from the fuel sumps.

The maintenance technician also found the hydraulic leak in the pilot's right brake line beneath the floor. A pressure test of the right brake line revealed a pinhole. The FAA report said that the routing of the brake line placed it in contact with a heater-duct hose and that the maintenance technician believed that heat and the presence of moisture caused corrosion in the brake line.

The individual who filed the report with FAA said that the area should be inspected and that the brake line should be rerouted and/or insulated if necessary.

Corrosion Blamed in Bell 412 Accident

A tail-rotor blade of a Bell 412 failed during flight, and the pilot conducted an emergency landing, which led to an accident.

A post-accident investigation found that the tail-rotor blade (part no. 212-010-750-105) had failed about 14 inches (36 centimeters) from the outboard end, resulting in an imbalance that led to the separation of the tail-rotor assembly (part no. 212-011-701-101) and the gearbox.

A metallurgical analysis showed that the tail-rotor blade failure originated from a stress fracture that had been caused by corrosion beneath the blade skin.

Changes Recommended In B-737 Escape-slide Brackets

The U.S. National Transportation Safety Board (NTSB), citing a March 5, 2000, accident involving a Boeing 737-300, has recommended that the U.S. Federal Aviation Administration (FAA) issue an airworthiness directive to require replacement of escape-slide-cover latch brackets on forward-slide compartments of some B-737 airplanes.

NTSB said that the slide-cover latch brackets on forward-slide compartments of B-737-300-series through B-737-500-series airplanes should be replaced with the type of slide-cover latch brackets that are installed on the forward-slide compartments of B-737-600-series through B-737-900-series airplanes.

NTSB also recommended that FAA issue an airworthiness directive to require initial inspections and subsequent periodic inspections of pivot-bracket assemblies on Trans Aero Industries model 90835 jump seats installed in B-737-300-series though B-737-500-series airplanes.

The recommendations were generated by NTSB's ongoing investigation of an accident in which a Southwest Airlines B-737-300 overran the departure end of the runway after landing at Burbank-Glendale-Pasadena (California, U.S.) Airport.

"The airplane touched down at approximately 181 knots and, about 20 seconds later, at approximately 32 knots, collided with a blast fence and an airport perimeter wall and came to rest on a city street outside of the airport property," NTSB said. "During the accident sequence, the forward-service-door (1R) slide inflated inside the airplane, the nose gear collapsed, and the forward-flight-attendant jump seat, which was occupied by two flight attendants, partially collapsed."

The airplane was substantially damaged. Of the 142 people on board, two passengers were seriously injured, and 41 passengers and one flight crewmember received minor injuries; the others were uninjured.

Escape slides on B-737 doors are restrained by slide covers made of rigid plastic. The slide covers are attached to the door by a hinge along the top edge and by two U-shaped slide-cover latch brackets along the bottom edge. The two brackets join and are secured by a latch to keep the slide inside the slide cover. A chain connects the latch to a bar. When the door is opened, the chain pulls the latch to release pins, the brackets separate, and the slide emerges from the slide cover. The weight of the slide activates an automatic inflation lanyard, which in turn activates an inflation bottle, and the slide inflates.

NTSB found that the 1R slide-cover latch disengaged from the brackets that were designed to restrain the escape slide. The slide then slipped out of the slide cover and onto the galley floor, where the slide inflated.

"Flight attendants reported that the slide began inflating while the airplane was still moving," NTSB said. "The investigation has determined that the inflation most likely was triggered by the airplane swerving to the right during the hard-braking phase of the accident sequence. The weight of the uninflated slide as it moved left during this swerve apparently exerted sufficient force on the inflation lanyard to discharge the inflation bottle and inflate the escape slide. … The inflated slide extended nearly across the entire width of the airplane, blocking the aisle from the passenger cabin to both forward-door exits (1R and 1L) and preventing the two flight attendants seated on the forward jump seat from assisting in the evacuation."

U.S. Federal Aviation Regulations Part 25.810 requires that the escape slides on "next generation" (NG)-series airplanes (B-737-600-series through B-737-900-series airplanes) must pass tests to demonstrate that they will function properly if they are subjected to "ultimate inertia forces resulting from a simulated 'minor crash landing.'" A similar requirement does not apply to earlier B-737 airplanes, which were certificated before the requirement became effective.

NTSB said that the accident investigation has shown that the deployment of the escape slide and its inflation inside the airplane "might have been prevented if the slide-cover latch brackets … had been more resistant to load-induced deformation, as are the brackets on the B-737-NG series airplanes."

NTSB said that the accident investigation has shown that the pivot-bracket mounting bolts on the forward-flight-attendant jump seat were loose before the accident and that the loose bolts allowed the bracket to move from side to side. The movement reduced "the strength of the pivot-bracket assembly under applied vertical loads," NTSB said.

"The vertical loads that resulted from the nose-gear collapse caused the jump-seat pivot-bracket mounting bolt to shear through the bottom of the bracket, resulting in the seat partially collapsing and impeding the inboard flight attendant from getting out of the seat," NTSB said. "If the vertical impact forces had been higher, the broken pivot bracket might have led to complete separation of the seat bottom and caused injury to one or both of the flight attendants occupying the seat."

An airworthiness directive (AD-89-14-11) requires periodic inspections of seat-bottom roller fittings on Trans Aero Industries model 90835 jump seats but does not affect the pivot brackets. The pivot brackets are not subject to routine scheduled maintenance inspections. NTSB said that periodic inspections of the pivot-bracket assemblies probably would have detected the loose pivot-bracket mounting bolts in the accident airplane. ♦

NEWS & TIPS

Aerospace Congress Scheduled for September 2001

The 2001 Aerospace Congress and Exhibition (ACE) will be held Sept. 10–14, 2001, in Seattle, Washington, U.S.

The ACE, hosted by The Boeing Co., comprises six aerospace conferences: the Society of Automotive Engineers (SAE) World Aviation Congress, conducted in association with the Royal Aeronautical Society and the National Research Council of Canada; SAE Aerospace Manufacturing Technology Conference, conducted in association with the Society of British Aerospace Companies and the Environmental Sustainability Standing Conference; SAE Advances in Aviation Safety Conference, conducted in association with Flight Safety Foundation, the International Federation of Airworthiness and the Guild of Air Pilots and Air Navigators; SAE International Conference on Lightning and Static Electricity; SAE Aerospace Automated Fastening Conference and Exposition; and Airline Business Airline IT (information technology) Strategy Summit, sponsored by the Société Internationale de Télécommunications Aéronautiques.

The ACE will include an international exhibit by more than 400 companies and technical sessions about commercial aircraft, military aircraft, human factors, processes and tools in aerospace, automated fastening and lean manufacturing.

For more information: Leslie Rizzi, SAE Corporate Public Relations, 400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S. Telephone: +1 (724) 772-4031.

Compact Ratchet Designed for Hard-to-reach Spaces

A 3/8-inch (9.5-millimeter) drive ratchet is designed for hard-to-reach spaces, said the manufacturer, Wright Tool Co.

The model 3430 ratchet is 4.75 inches (12.1 centimeters) long and has an open-head design to allow the user to see if ratchet teeth are dirty or are not engaging properly. The ratchet has a round, single-pawl design with 45 teeth and a 0.75-inch (19-millimeter) swing arc. The reverse lever is designed to prevent the ratchet from reversing accidentally if it strikes an obstruction.

3/8-inch (9.5-millimeter) Drive Ratchet

For more information: Wright Tool Co., One Wright Drive, P.O. Box 512, Barberton, OH 44203 U.S. Telephone: (800) 321-2902 (U.S.) or +1 (330) 848-0600.

Cleaner Also Protects Aircraft Against Corrosion

Cortec VCI-415 is a water-based cleaner and degreaser formulated to be nontoxic, noncorrosive and without nonylphenolethoxylates, said the manufacturer, Cortec Corp.

Water-based Cleaner and Degreaser

The product also protects aircraft against corrosion and oxidation.

Cortec VCI-415 alters the hydrocarbons in aircraft soils so they can be removed with water. The product removes dirt, heavy hydrocarbons, hydraulic fluids and grease from aircraft skin, landing gear, engines and other components.

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

Fastener Withstands High Temperatures

The NYTEMP self-locking fastener, designed to withstand temperatures of up to 450 degrees Fahrenheit (230 degrees Celsius), is intended for assembly applications in aerospace operations, small engines and other areas in which high temperatures are encountered, said the manufacturer, Nylok Fastener Corp.

NYTEMP is manufactured from a high-temperature-resistant polymer element and is applied as a patch to internally threaded parts or externally threaded parts. The fasteners do not require drilling or milling and are unaffected by water, kerosene-based materials, hydraulic fluids and other materials.

For more information: Nylok Fastener Corp., 15260 Hallmark Drive, Macomb, MI 40842-4007 U.S. Telephone: (800) 791-7101 (U.S.) or +1 (810) 786-0100.

Self-locking Fastener

Nuts Ensure Proper Bolt Alignment

SPS Technologies' self-aligning nuts are designed to solve the problem of misaligned mating holes and to ensure that a bolt's load path is properly aligned with the nut, the manufacturer said.

Self-aligning nuts are available in diameters ranging from 0.164 inch to 0.750 inch (4.2 millimeters to 19.1

Self-aligning Nut

millimeters) and in a variety of materials, including alloy steel and steel. The nuts' ultimate tensile strength ranges from 125 kip (125,000 pounds dead weight) per square inch (KSI) to 160 KSI (8,789 kilograms per square centimeter to 11,250 kilograms per square centimeter).

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

Organization Publishes Aerospace Welding Standard

The American Welding Society (AWS) has published a guide that discusses procedures for welding repairs of in-service flight hardware and the design and repair of nonflight hardware.

Specification for Fusion Welding for Aerospace Applications (AWS

D17.1:2001) includes information on the welding of a variety of alloys, requirements for welding design, personnel qualification, inspection criteria and acceptance criteria. The 104-page standard was developed under the guidance of the AWS Committee of Welding in the Aircraft and Aerospace Industries.

For more information: American Welding Society, 550 NW LeJeune Road, Miami, FL 33126 U.S. Telephone: (800) 854-7179 (U.S.), (800) 443-9353 (U.S.) or +1 (305) 443-9353.

Positioning Rings Allow Coiling of Pipes, Tubes, Cable Bundles

Heat-shrinkable positioning rings allow the coiling of pipes, tubes, hoses and cable bundles, said the manufacturer, Tyco Electronics.

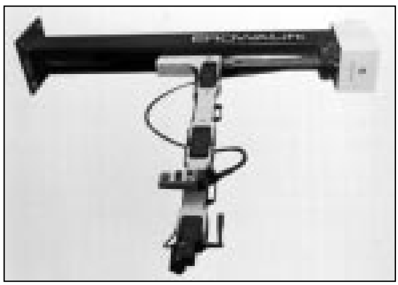
The positioning rings, designed for low-cost, high-volume installations in aerospace and other industries, provide protection against abrasion, reduction of noise and vibration and space savings, the manufacturer said. The positioning rings are available in a range of diameters and can be used in engine compartments and other environments that are subject to extremes of heat and cold.

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

Manual Loading Device Lifts 330 Pounds

The Erowa Lift 2 is a manual loading/unloading device that can maneuver loads of up to 330 pounds (150 kilograms) and can transfer heavy objects that typically are moved with an overhead crane, hoist or forklift, said the manufacturer, EROWA Technology.

The Erowa Lift 2 has a 360-degree range of motion and an articulated arm with five pivotal points for accurate, flexible movements.



Manual Loading/Unloading Device

For more information: EROWA Technology, 2535 South Clearbrook Drive, Arlington Heights, IL 60005 U.S. Telephone: +1 (847) 290-0295.♦

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