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Aviation Mechanics Bulletin

JULY–AUGUST 2003

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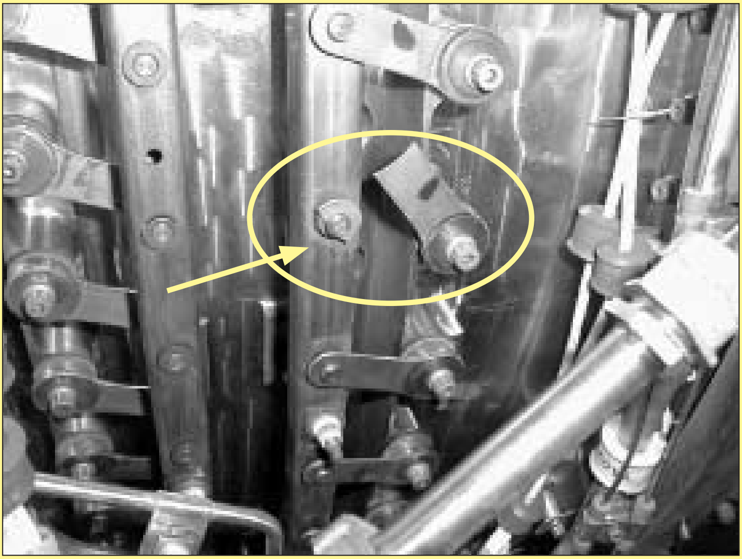

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Aviation Mechanics Bulletin

Dedicated to the aviation mechanic whose knowledge, craftsmanship and integrity form the core of air safety.

Robert A. Feeler, editorial coordinator

July–August 2003 **Vol. 51 No. 4**

On the cover: An investigation by the Australian Transport Safety Bureau identified a fractured variable-stator-vane control lever as the cause of a Boeing 777 in-flight engine failure. The arrow points to the fractured control lever. (Photo: Australian Transport Safety Bureau)

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Fatigue Cracking Cited in Boeing 777 Engine Failure

The Australian Transport Safety Bureau said that a technical analysis of the incident showed that the fatigue cracking led to failure of a variable-stator-vane control lever, which caused a variable stator vane to close, resulting in disruption of the airflow on passing blades.

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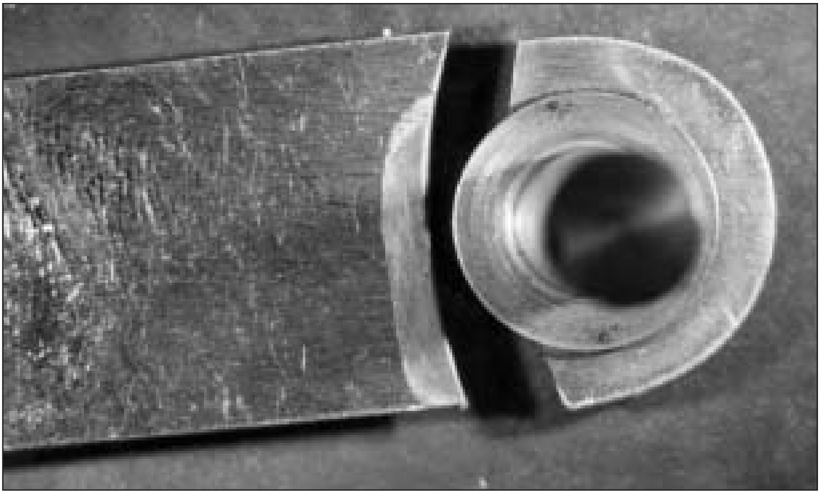
FSF Editorial Staff

About 1745 local time Nov. 18, 2001, during a flight from Brisbane, Australia, to Singapore, the crew of a Boeing 777 heard and felt two thumps from the right engine, followed by severe vibration from the right engine. The vibration subsided, then recurred several minutes later, along with a rapid increase in exhaust-gas temperature and oil temperature in the right engine.

The flight crew shut down the right engine and diverted the flight to Darwin, Australia, where they conducted a single-engine landing. Damage to the airplane was limited to the right engine; no one in the airplane was injured.

Maintenance personnel in Darwin inspected the airplane and found a broken first-stage variable-stator-vane (VSV) control lever in the right engine (see photo, page 2). A subsequent borescope inspection of the engine's interior revealed damage to a number of compressor blades. The engine was removed from the aircraft and transported to an overhaul facility for disassembly and evaluation; the Australian Transport Safety Bureau (ATSB) examined the broken control lever and a number of other control



The underside of the broken variable-stator-vane (VSV) control lever shows the curved fracture path and wear that was attributed to in-service movement after the fracture. (Source: Australian Transport Safety Bureau)

levers from the first-stage VSV assembly.

ATSB said, in the final report on the incident, that the following were significant factors:

- "A number of IPC [intermediate-pressure compressor] stage-two blades were found to be damaged during a [borescope] inspection on April 8, 2001, but remained in service on the engine;
- "Fatigue cracking of the VSV-1 [control] lever led to its failure, resulting in the closing of the no. 28 variable stator vane; [and,]
- "The closure of the no. 28 variable stator vane created a disrupted airflow, which acted on the passing blades."

The right engine was a Rolls-Royce Trent 800 triple-spool turbofan engine. Within the engine, a single-stage low-pressure fan was connected to a five-stage low-pressure turbine, an eight-stage IPC was connected to a single-stage intermediate-pressure turbine, and a six-stage high-pressure compressor (HPC) was connected to a single-stage high-pressure turbine.

The incident report said, "To maintain maximum efficiency during all power settings, the airflow through the engine needed to be controlled to prevent stalling or surging. This was achieved by a single stage of variable inlet guide vanes installed between the fan and the first stage of the IPC and two stages of variable stator vanes, VSV stage one and VSV stage two (VSV-1 and VSV-2) installed between IPC stages, one/two and two/three, respectively. Each variable stator vane was attached to a [control] lever that transferred the linear input from the controlling actuators and unison rings to a rotational movement of the vane. These [control] levers consisted of an arm and connecting pin.

"During engine start, these vanes would have been in their most closed position, with internal engine bleed valves open. As the power was increased, the bleed valves would close, and the vanes [would] move toward their full-open position, allowing optimum airflow through the engine."

An inspection conducted before the engine was disassembled showed that the broken VSV-1 control lever was on the no. 28 vane. The inspection revealed no other external defects and no bird-strike damage. There were no anomalies in the VSV control system, and no cracking was found on any other VSV-1 control levers or VSV-2 control levers.

IPC, HPC Damage Found

The IPC and HPC also were disassembled for inspection, which found significant damage, the technical analysis report said.

Inspection of the IPC revealed soft-body impact damage (damage caused by impact with an object made from a softer material) on six stage-two blades; corners of two of the blades were detached. Hard-body impact damage (damage caused by impact with an object made from a material as hard or harder) was found on three blades, whose surfaces contained small cuts. Minor nicks were found on two stage-three blades, one stage-five blade and all stage-eight blades. Disc material near the blade roots was not damaged.

The no. 28 VSV-1 vane was worn on a horizontal area above its base, and the adjacent no. 29 VSV-1 vane had contact marks on the base and at midpoint. The base of each VSV contained dark deposits that "formed a black ringed area around all except for the no. 28 vane, where the mark was crescent-shaped," the incident report said.

When the no. 28 vane and the no. 29 vane were positioned so that the wear marks were aligned, the no. 28 vane was "beyond its normal closed position," and the crescent-shaped mark matched the angle of the vane's root, the incident report said. When the no. 29 vane was moved to the closed position, "it was seen to nudge the no. 28 vane up towards its normal closed position."

The incident report said that the wear marks on the no. 28 vane and the contact points on the no. 28 vane and the no. 29 vane indicated that the no. 28 vane had remained in "a predominantly closed position" during engine operation.

The technical analysis report said that an ATSB metallurgical examination of the no. 28 VSV-1 control lever revealed that the control lever "had fractured transversely through the end of the arm section, at a location coincident with the riveted connection to the actuator pin. The fracture path followed a uniform arc, extending from one side of the arm to the opposite [side] and intersecting the pin connection at the center.

"A prominent track mark had developed on the underside of the arm where the relative movement between the separated arm and the pin flange had produced appreciable wear. The effects of wear extended to the fracture surfaces themselves, which were heavily eroded and all fracture surface detail obliterated. … The fracture path appeared to intersect the bore of the rivet hole, with slight upward dishing of the arm section beneath the rivet head."

Report Cites Progressive Fatigue Cracking

The report said that because there were no associated physical deformations, the failure probably resulted from progressive fatigue cracking that originated from the rivet hole.

"The examination found evidence of distortion of the arm section by the forces used to rivet the control pin to the arm body," the technical analysis report said. "During riveting, the expansion of the rivet shaft could induce tensile stresses within the bore of the rivet hole if the diameter was insufficient to allow for the expansion. Tensile stresses of this nature would be expected to predispose the lever arm to the initiation and propagation of fatigue cracking."

Examination of four other VSV-1 control levers revealed cracking on all four that was consistent with the cracking on the control lever that failed during the incident flight.

The technical analysis report said that the riveted joints between the actuator pins and the arms of the VSV control levers were designed to be "fully mechanical … not reliant on metallurgical bonds." Partial fusion that developed between the actuator pin body and the arm section of the control levers probably resulted from the forces and temperatures of the riveting operation. The partial fusion produced notchlike defects at the ends of the fused areas. Cracking observed in these areas may have been caused in part by embrittlement of heated material at the rivet interface; embrittlement may have been a result of inadequate shielding during the riveting operation, the technical analysis report said.

The cracking provided "ideal stress-raising conditions for the subsequent initiation of fatigue cracking, leading to eventual component failure," the report said.

Marks and wear at the site of the VSV control-lever fracture were indications of independent movement of the two halves of the lever before the engine was shut down. The marks showed that the vane probably remained at its travel limit while the actuator ring and pin moved laterally in response to the movement of the throttle, the technical analysis report said.

Examination of the HPC revealed that all stage-one blades had received severe hard-body impact damage and that one blade had separated above the blade root. The failed blade was chipped in the leading edge, and crack-progression marks indicated that the failure had progressed during numerous cycles. Blades in stage two to stage six also had received hard-body impact damage on all blades.

Blade Damage Found in 2001 Inspection

The engine, which was introduced into service in December 1998, had accumulated 8,923 flight hours and 2,373 cycles when the accident occurred. Records showed that a routine borescope inspection on April 8, 2001, revealed damage to a number of IPC stage-two blades, whose tips were bent and curled. The damage was determined to be within the manufacturer's allowable limits, and the engine remained in service. (The incident report said that the damage was consistent with damage that would result from engine ingestion of a bird, ice or another soft object.) Because the blade damage was within allowable limits, the blades would not have failed "unless additional abnormal forces were applied to them," the incident report said.

On Oct. 17, 2001, another borescope inspection was conducted on the engine after detection of a substantial change in turbine gas temperature. The inspection revealed no damage other than the IPC stage-two bent-blade damage that had been detected during the April inspection. Maintenance personnel did not determine the reason for the change in turbine gas temperature. The incident report said that the temperature increase might have resulted from the movement of the no. 28 vane to the closed position after the failure of the control lever.

"The nudging of the no. 28 vane towards its normal closed position by the no. 29 vane during engine shutdown may have been enough to allow the failed lever to assume its normal position, thereby escaping easy detection," the incident report said.

Rolls-Royce said that there was no record of previous VSV-1 control-lever failures; two failures of VSV-2 control levers had been recorded, however. The incident report said that in both of those failures, the connecting pins "had fretted [worn] through the body of the [control] lever [because of] inadequate riveting during the manufacturing process." When the control levers failed, the associated variable stator vanes closed, resulting in disruption of the airflow behind them. The disruption in airflow caused the blades to vibrate; the vibration caused fragments of material to break away from the discs and migrate through the engine, damaging other blades. The failures caused an increase in the engines' turbine gas temperature during the following two weeks to four weeks.

As a result of the VSV-2 control-lever failures, Rolls-Royce issued Service Bulletin RB211-72-D516, recommending that operators inspect "the six VSV-1 and VSV-2 levers [on] either side of the actuating mechanism control-rod connection, for significant relative movement between the lever and connecting pin."

The incident report said that in this incident — as in the VSV-2 control-lever failures — the "out-of-sequence position of the [no. 28] vane created turbulence in the airflow. This would have been felt on the IPC stage-two blades, inducing abnormal loads. Two of the bent IPC stage-two blades were unable to tolerate that excitation, and as a result, their blade tips failed. The released sections of blade then ricocheted within that stage before being projected through the engine, impacting blades in other stages downstream.

"As the sections of blade and accumulated debris passed through the engine, a piece of material impacted the leading edge of [an] HPC stage-one blade, chipping and cracking it. The crack then progressed to a point where the blade failed and detached."

As a result of the incident, the following actions were taken:

- The operator replaced "all VSV levers of the same manufacture as the failed item"; and,
- Rolls-Royce "amended the IPC tip-bend acceptance criteria text in the aircraft maintenance manual and issued a revision to Service Bulletin RB211-72-D516 extending the range of the inspection to include all VSV-1 [levers] and VSV-2 levers. The engine manufacturer has also designed a strengthened VSV lever that has been certified for use under Service Bulletin RB211-72-E042."

As a result of the investigation, the ATSB, on Feb. 13, 2003, issued the following two safety recommendations:

- That Rolls-Royce revise Service Bulletin RB211-72-D516 to emphasize “the potential for cracking failure between the lever and connecting pin of the variable-stator-vane lever assemblies and ensure that inspections contained within this service bulletin adequately address this mode of failure”; [and,]

- That the U.K. Civil Aviation Authority (CAA) review Rolls-Royce Trent 800 engine-inspection procedures for variable-stator-vane lever assemblies and that the CAA review Service Bulletin RB211-72-D516 “to ensure that they adequately address and manage the potential for cracking failure of the lever assemblies.”

In response, CAA said that the service bulletin had been revised and that the revision “adequately addresses and manages the potential for cracking and failure of the variable-stator-vane lever assemblies.”♦

[FSF editorial note: This article, except where noted, is based on an Australian Transport Safety Bureau (ATSB) incident report on occurrence no. 200105494 and an ATSB technical analysis report on the same occurrence, report no. 03/02, *Examination of Variable Stator Vane Control Levers, Rolls-Royce Ltd. RB.211-Trent 800 Turbofan Engine, Boeing 777-212ER, 9V-SRE*. The eight-page incident report and the six-page technical analysis report both contain illustrations.]

MAINTENANCE ALERTS

Defective Torque-Signal Conditioning Unit Cited in Propeller Autofeathering

During the initial climb of a de Havilland DHC-8-315 (Dash-8) after takeoff from an airport in Sydney, Australia, the propeller of the right Pratt & Whitney PW123E engine autofeathered. The pilots retarded the right-engine throttle lever, declared an urgency situation to air traffic control and conducted a single-engine return to the departure airport. No one was injured in the Dec. 19, 2002, incident.

The flight data recorder (FDR) showed that the right engine had over-torqued to 120 percent for seven seconds after the autofeathering. The FDR also showed that the left engine had over-torqued to 117 percent for 20 seconds. Neither condition exceeded the over-torque limit specified by the engine manufacturer.

"Maintenance personnel found that a loose connection of the right-engine torque-signal conditioning unit (TSCU) connector pins [had] resulted in an intermittent electrical connection," said the incident report by the Australian Transport Safety Bureau (ATSB). After the TSCU was replaced and the connector was cleaned and reinstalled, the aircraft was test flown and was returned to service.

The report said, "The autofeather system, when selected, was designed to automatically feather the propeller during takeoff if the engine torque decreased below about 22 percent rated torque.

"Interlock features in the autofeather logic and control circuits provided arming control and prevented autofeather of the operating propeller, once the autofeather sequence for one of the propellers was initiated. The system provided for relaying a 'power-uptrim' (engine-power-increase) signal to the operating engine."

Two previous similar incidents had been investigated by ATSB, the report said. Searching databases maintained by the manufacturer, Transport Canada and the U.S. Federal Aviation Administration (FAA), ATSB found records of an additional 23 similar incidents between June 19, 1993, and Oct. 27, 2001. Of the 26 total incidents reported, 19 were attributed to electrical problems (including the electrical harness, the connector or the TSCU). Fourteen incidents occurred during initial climb and 10 occurred during the takeoff roll.

"The aircraft manufacturer advised that their data indicated that propeller autofeathering as described in this incident was a result of loss of torque signal to the TSCU, most likely due to 'connector intermittencies,'" said the report. "Improvements to the system included design changes to strengthen the torque signal and flight crew procedural changes. The aircraft manufacturer considered that the present decrease in reported occurrences reflected the success of these changes."

The engine manufacturer recommended that to respond to propeller-autofeathering incidents, the operator should conduct a fleetwide electrical-harness inspection, clean the connectors and improve connector-tightening procedures, the report said.

Pratt & Whitney Canada has issued three service bulletins (SBs) about the autofeather-control system:

- SB 21269 (May 25, 1993) concerned the application of shrink tubing to the TSCU wiring harness to reduce the chance of moisture entry and loosening of the connectors;
- SB 21456 (Dec. 19, 1995) addressed false "uptrims" and activation of the autofeather-control

system when the system was in the armed condition. "Those problems were attributed to the torque-sensor air gap not being optimized," said the report. "The procedures were described for decreasing the torque-sensor air gap by replacing a spacer in the unit. The modification improved signal strength and reduced sensitivity to electrical 'noise'"; and,

- SB 21463 (Jan. 31, 1996) recommended a modification to reduce the likelihood of fretting of the TSCU electrical-connector socket pins. The modification involved installing a more secure connector assembly with sockets that were less susceptible to fretting.

On Dec. 11, 1997, in Operator Message Number (OMN) 464, Pratt & Whitney Canada informed customers of two recent in-flight engine shutdowns involving autofeathering, which were suspected of resulting from incorrect tightening torque on the TSCU connectors. The engine manufacturer recommended that operators inspect the TSCU connectors for security and, if found to be loose, remove the connectors and inspect them for contamination and moisture.

Although compliance with the SBs was not mandatory, the maintenance organization for the incident aircraft followed the recommendations of the SBs.

Gear-uplock System Failure Leads to Nosewheel-up Landing

The Cessna Citation X, with two flight crewmembers and two passengers, was on an air taxi flight from St. Petersburg, Russia, to Helsinki-Vantaa (Finland) Airport on April 8, 2001. After takeoff, when the captain, who was the pilot flying, selected the landing gear "UP," the red "GEAR UNSAFE" light for the nose landing gear remained illuminated. The pilots decided to select gear "DOWN" and then attempt the retraction a second time. When they selected gear "DOWN," the green "GEAR SAFE" lights for the main landing gear were illuminated, but the red warning light for the nose gear remained illuminated. The lights indicated that the main landing gear, but not the nose gear, had extended. Attempting to retract the landing gear again, the pilots found that the landing gear lever could not be moved.

The pilots believed that there was no immediate risk and continued the flight to Helsinki-Vantaa, an airport with which they were familiar and where known aircraft rescue and fire fighting (ARFF) services were available. In addition, their company's technical facilities were at Helsinki. The aircraft was flown to its destination at the maximum speeds and altitudes prescribed by the manufacturer for landing gear–down operations.

While en route, the pilots read the "Abnormal and Emergency Situation" checklist. No procedures were included in the checklist for a situation in which *only* the nose gear could not be operated. For a landing gear–system malfunction there were two backup procedures: first, use of a pressure bottle and then, if necessary, a free-fall method for release of the landing gear. While the flight was still in cruise phase, the pilots tried the free-fall method first so that, if successful, time and expense for recharging the bottle would be avoided. The attempt was unsuccessful.

When the pilots contacted Helsinki approach control, they requested a holding pattern and activated the pressure bottle. That attempt also failed to lower the nose gear.

The pilots then prepared for a nose-gear-up landing and received assistance from air traffic control (ATC) and company maintenance technicians at the airport. When ATC asked if they wanted fire-extinguishing foam spread on the runway, the pilots elected to have a narrow strip of foam placed along the runway centerline, where it would presumably not reduce the friction for the main wheels.

With ARFF standing by, the aircraft was landed, the main wheels touching down about 375 meters (1,230 feet) past the beginning of the foam strip. Thrust reversers were deployed, and the aircraft nose contacted the runway about 140 meters (459 feet) past the foam strip. The aircraft stopped less than one meter (3.3 feet) to the right of the centerline after a total landing roll of about 735 meters (2,411 feet). After the aircraft stopped, ARFF directed foam onto it as a precaution. The passengers and crew disembarked without injury, and damage to the aircraft was minor.

The initial investigation was centered on the nose-gear-uplock system, which consists of an uplock hook, locking spring, shuttle valve, uplock actuator and uplock switch.

The accident report by the Finland Accident Investigation Board said, "The nose landing gear … can be extended and retracted hydraulically and it is [actuated] along with the main landing gear with a common electrically controlled hydraulic valve. The lever in the cockpit (an electric switch) has a locking solenoid whose purpose is to prevent the selection of the 'UP' position while the aircraft is on the ground. The lock is switched off when the WOW (weight-on-wheel) switch of either of the main landing gear and the SQ switch [commonly known as the "squat switch"] in the torque link of the nose landing gear show that the gear is fully extended. …

"The gear is held up by the uplocks during the flight when there is no pressure in the gear system. The uplock goes into the locked position powered by a spring and [is actuated] into the open position normally with the aid of an uplock actuator. The uplock actuator acts as a sequence valve so that hydraulic pressure will first open the uplock and then let the pressure into the gear actuator. …

"The strut of the nose landing gear has two chambers. There is a piston between the chambers. Hydraulic liquid functions as a damper and pressurized nitrogen as an absorber in the lower chamber. Standard pressure is 50 psi [pounds per square inch; 3.5 kilograms per centimeter] while the gear is fully extended. The higher chamber has only pressurized nitrogen, with a pressure of 390 psi [27.4 kilograms per centimeter]."

The initial investigation revealed the following facts:

- "The landing gear was locked in the 'UP' position while the uplock roll was at the bottom of the slot of the uplock hook (with no pressure in the uplock cylinder);

- "The uplock switch was depressed and electrical measurement indicated that the landing gear was in the 'UPLOCK' position;

- "The strut had compressed 12 millimeters [0.47 inch]; [and,]

- "The [squat switch] of the nose landing gear had been released. There was a gap of about one millimeter [0.04 inch] between the target and the roll of the switch. Electrically measured, the switch was in the 'aircraft on ground' position."

The report said, "After the observations and measurements, an attempt was made to take out the landing gear with the mechanical backup system. The handle was pulled with a force of about 200 newtons (20 kilograms) without result. The fact that the locking spring had been completely compressed prevented the hook from being released, which limited the movement of the hook regardless of the system for opening the uplock hook. The usable travel of the uplock hook was not enough to release the landing gear from the 'UPLOCK' position, because the position of the locking [roller] had moved. [The locking roller, located on the moving lower part of the landing gear strut, latches the gear in the "UPLOCK" position when gear "UP" is selected.] The position was 12 millimeters further back than normal.

"The strut was extended by hitting the lower part of the landing gear with a rubber mallet. The blow of the rubber mallet released the friction caused by the seals in the strut, after which it extended fully in one movement."

Following temporary repairs in Helsinki, the aircraft was flown with the landing gear extended to the Cessna Citation European Service Center in Paris, France, for additional repairs. The service center removed the nose landing gear and its associated parts and sent them to the Cessna factory in the United States for further analysis. The Finland Accident Investigation Board asked the U.S. National Transportation Safety Board (NTSB) to supervise the investigation at the Cessna factory.

Investigators could not determine exactly when the gear had been locked in the "UP" position, but the sequence of events was reasonably certain, the report said.

"When the gear was in transition near the wheel well, the forces affecting it (air drag, longitudinal acceleration and the component of earth's gravity) were able to compress the strut by about 12 millimeters," said the report. "This is possible when the pressure in the strut is lower than normal. The [locking roller] situated in the moving lower part of the strut moved from its normal position by the corresponding length and hit the lower surface of the uplock hook in such a position that the gear was not able to go into the 'UPLOCK' position."

The report said that the uplock cylinder acts as a sequence valve, opening the uplock before hydraulic pressure reaches the "GEAR DOWN" side of the gear actuator.

The report said, "At the moment of the 'DOWN' selection, the AOA (angle-of-attack) of the aircraft was about 6.6 degrees with a speed of 166 knots when the aerodynamic force affecting the doors was sufficient to help the gear all the way up before the gear actuator had time to function in the 'GEAR DOWN' direction. …

"After reaching the wheel well, the strut remained compressed by the friction inside the strut, and simultaneously [shifted] the squat switch into the 'aircraft on ground' position. When the gear actuator got the pressure into the 'GEAR DOWN' direction, the travel of the locking hook was not sufficient to release the [locking roller] because the strut had been compressed by 12 millimeters [which displaced the locking roller from its normal position]. The attachment structure of the hook does not allow it to give downwards, but it can give slightly when the [locking] roller is moving upwards due to the chamfer of the hook. This enabled the gear to be 'trapped' in [the] 'UP' position. It must be noted that the motion of the locking hook needed to [release the locking roller and] allow the gear to move down would have been very small.

"The squat switch in the nose landing gear works when the strut is compressed by about three millimeters [0.12 inch] from its full extension. Due to this the aircraft was in the 'aircraft on ground' position for the rest of the flight. …

"The gear switch could not be selected 'UP' again because the fact that the strut remained compressed caused the squat switch to change into the 'aircraft on ground' position and the prevention mechanism inhibited the gear selector from moving."

The report said that the nose gear had been maintained according to requirements, but that the maintenance system was insufficient because it did not include measuring the pressure in the struts. The cause of the incident was "the jamming of the nose landing gear in the uplock position … caused by imperfect design of the uplock system," the report said. Contributing factors included the following:

- "Reduced pressure in the nose landing gear strut;
- "Pressurization of the struts is not monitored in the landing gear maintenance system with the aid of a [measuring] device; [and,]
- "Visual estimation of the pressure in the nose landing gear strut during preflight check is inaccurate if carried out by the measures stated in the checklist."

In Cessna's response to the report draft, Cessna said that "several of the safety recommendations have already been accomplished." Cessna also issued a Service Bulletin, SB 750-32-39, for the nose-gear-uplock system.

Landing Gear Cylinder-support-frame Failure Leads to Rough Landing of DC-10

The McDonnell Douglas DC-10-10 was being operated by FedEx as a U.S. Federal Aviation Regulations (FARs) Part 121 scheduled domestic cargo flight when a failure of the no. 3 hydraulic system occurred during the approach to Tampa (Florida, U.S.) International Airport. The "LEFT-MAIN LANDING GEAR UNSAFE" light in the cockpit illuminated. In the subsequent landing, eight of the aircraft's tires were punctured. Three flight crewmembers and another pilot occupying the jump seat evacuated the aircraft. There were no injuries, and the aircraft sustained minor damage in the Aug. 10, 2002, incident.

The flight was normal until the landing gear was extended, said the report by the U.S. National Transportation Safety Board (NTSB). There was a loud noise and the aircraft shuddered. The indications for the no. 3 hydraulic system quantity decreased to zero, and the red "LEFT-MAIN LANDING GEAR UNSAFE" lights on the captain’s, first officer’s and second officer’s panels illuminated.

The pilots declared an emergency and conducted emergency checklists.

The report quoted the captain as saying, “We attempted to determine gear position using main gear indicators (buttons). Because of [the] window condition [not specified in the report], [the second officer] was unable to visually check. Next we accomplished the ‘Landing Preparation With Gear Up or Partial Gear Down’ checklist. Next we accomplished [the] ‘Landing With One Gear Up or Unsafe’ checklist. The left gear touched down with a loud crunch, and I thought the gear was collapsing. I shut down the engines in accordance with the checklists. We then accomplished the ‘Emergency Quick Evacuation’ checklist and evacuated the aircraft through R1 [the right-front exit] using the slide.”

When maintenance personnel examined the landing gear system, they discovered that there had been a failure of the left-main landing gear retract-cylinder-support frame, part no. ARB0642-501, at the point of attachment to the main landing gear–retract cylinder.

“Upon landing gear extension at [Tampa], the gear extended when the landing gear door, [which] was supporting the gear, opened, breaking the hydraulic lines attached to the retract cylinder, dumping no. 3 hydraulic-system fluid overboard,” said the report. “The proximity-switch target that activates both the pilots’ and the second officer’s displays broke off due to the inertia of the unrestricted extension of the left-main landing gear. Thus both red/unsafe lights would not extinguish.”

When the flight crew read the “Landing With One Gear Up or Unsafe” checklist, the antiskid system became inactive because shutting down the engines and pulling the fire handles caused a loss of electrical power, the report said. There was therefore no skid protection during the landing.

The failed part had a total of 67,913 flight hours and 27,081 cycles since it was installed when the aircraft was manufactured, the report said. The part had accumulated 5,845 flight hours and 2,814 cycles in FedEx operations.

Service Bulletin no. DC10-57-105, issued May 19, 1998, said, “Four operators have reported seven instances of main landing gear (MLG) retract-cylinder support-frame-assembly failures [that] resulted in free fall of the MLG and loss of the no. 3 hydraulic system. A design engineer determined that the frames failed due to fatigue and determined that detectable cracks may initiate after 4,000 landings.

"If not corrected, failure of the support frame could cause damage to MLG adjacent structure, and/or unscheduled maintenance. Inspection of the affected frames will determine the frame condition."

The report did not indicate whether the previous operator or FedEx had accomplished the service bulletin.

As a result of the Aug. 10 incident, FedEx issued on Aug. 12, 2002, a directive to conduct eddy-current inspection of all DC-10/MD-10 main landing gear retract-cylinder support-frame assemblies. Two additional cracked support frames were found, on aircraft having between 15,904 flight hours and 39,559 flight hours (14,306 cycles and 19,485 cycles).

Anti-ice Controller Failure Causes Loss of MD-11 Cockpit Window

Shortly before the intended pushback of a McDonnell Douglas MD-11F cargo airplane at Seattle-Tacoma (Washington, U.S.) International Airport, the flight crew observed a crack forming in the right-forward windshield. The flight crew then saw what they described as flames on the exterior of the windshield. The first officer opened the cockpit right-side window and attempted to extinguish the flames using a Halon fire extinguisher. The aircraft electrical power was shut down, and the fire was extinguished. Neither pilot was injured in the May 31, 2002, incident.

Before observing the fire, the captain had conducted the standard preflight "flow" checks, during which he had noted that the windshield anti-ice system was selected "OFF" and the windshield defog system was selected "ON."

"Although the engines were not running, the aircraft was powered up electrically [at the time of the fire]," said the report by the U.S. National Transportation Safety Board (NTSB).

The failed R1 (right-forward) windshield panel and its associated anti-ice heat controller were removed and replaced. The investigator in charge examined both parts. The windshield was sent to the manufacturer for more detailed evaluation. The heat controller was sent to the operator's avionics department and then to the manufacturer for further examination.

"A visual examination revealed several delamination islands (voids) along the upper edge of the windshield," said the report. "The delaminations were irregular in shape and lacked any coloration, and they occurred at the interface of the outer-ply inner surface (anti-ice heating-film layer). The fracture was observed to originate at the lower edge of the windshield just forward of the aft right-lower corner and was characteristic of a thermally related fracture. There was no evidence of moisture ingress or other discrepancies in the vicinity of the fracture origin. Additionally, there was no evidence of fire."

The heat controller that was shipped to the manufacturer failed the initial bench test and a simulated overheat condition did not cause the controller to switch off automatically. The evaluation found several failed components, the report said, indicating that the following sequence of events had occurred:

- "When electrical power was initially applied to the controller in the 'OFF' mode it was observed that the controller commanded the windshield anti-ice system to begin heating (uncontrolled outflow of 336 volts);
- "The circuitry within the controller had failed, thus preventing the auto-heat control system from functioning and regulating the heating to the anti-ice panel;
- "The unregulated output commanded the anti-ice panel to increase in temperature, ultimately to failure of the panel;
- "A short within the controller prevented the system from being de-powered as long as power was available to the aircraft systems (contacts C2 and C3 shorted, Q1 shorted and Q2 open); [and,]
- "When aircraft power was removed (crew shutdown of external/APU power), power was then terminated to the windshield controller, which could no longer command full heat to the windshield."♦

NEWS & TIPS

Evaporation Air Coolers Require Low Maintenance

Cool-Space portable air coolers that reduce work-space air temperature through water evaporation are available from Advanced Radiant Systems. Unlike air conditioning systems, Cool-Space units do not use compressors, coils or refrigerant fluids. Evaporation coolers are more energy-efficient and need less maintenance than air conditioners, the manufacturer said.

Inside the cooler, hot ambient air is drawn by a motor-driven fan through water-soaked pads, which cools the air as the water evaporates. The exiting cooler air is then directed at specific locations or people. For mobility, casters are standard on larger models and a cart is available for smaller models.

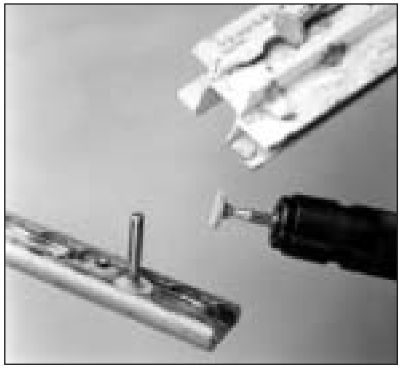
The water source can be an ordinary building-water outlet or optional portable tank, connected to the cooler by a garden hose. Water consumption averages two U.S. gallons to eight U.S. gallons (7.6 liters to 30.3 liters) per hour, the manufacturer said. The fan motor is powered by North American–standard 115-volt, 60 Hz electrical supply, but export models can be factory-configured for other electrical systems.

For more information: Advanced Radiant Systems, 12910 Ford Drive, Fishers, IN 46038 U.S. Telephone: +1 (317) 577-0417.

Abrasive Wheels Clean Seat Tracks

Grinder-mounted abrasive wheels from Rex-Cut enable maintenance personnel to remove dirt, gum and soft-drink deposits from all inside surfaces of aircraft-seat mounting tracks using a single tool.

Rex-Cut Seat Track Cleaners consist of multiple layers of nonwoven cotton fiber and abrasive grains, compressed and bonded into wheels that are configured to match all the interior surfaces of seat tracks, the manufacturer said. The wheels can be affixed to a standard grinder having a 0.25-inch (6.35-millimeter) rotating shaft.



Seat-track Cleaners

The wheels can be custom-designed with different abrasives for a wide variety of mounting-track cleaning applications, the manufacturer said.

For more information: Rex-Cut Products, 960 Airport Road, P.O. Box 2109, Fall River, MA 02722 U.S. Telephone: (800) 225-8182 (U.S.) or +1 (508) 678-1985.

Electronic-equipment Cleaner Leaves Protective Film

Cortec Corwipe 500 wipes are designed to clean electrical and electronic equipment by removing light oxidation, dirt, oil and grime. The product is suitable for use on a variety of metals, as well as plastics, epoxies, fiberglass, glass and rubber, the manufacturer said.

Besides restoring electrical performance, the wipes — each of which measures five square inches (12.7 square centimeters) — deposit a film that is said to protect against dust and rust for as long as three months.

The water-based cleaning formulation is free from chemicals that are hazardous to individual users or the environment, the manufacturer said. After use, the wipes require no special disposal methods or containers.

Electronic-equipment Wipes

For more information: Cortec, 4119 White Bear Parkway, St. Paul, MN 55110 U.S. Telephone: (800) 426-7832 (U.S.) or +1 (651) 429-1100.

Mobile-phone Holders Are Strong, Lightweight

Three mobile-phone holders available from Klein Tools are made of Cordura Plus, which the manufacturer describes as a high-strength and lightweight material. The two smaller holders are designed to contain many models of small and medium-sized mobile phones.

Mobile-phone Holder

A larger mobile-phone holder can hold other electronic devices such as personal digital assistants (PDAs), two-way radios and testing equipment.

The mobile-phone holders feature a quick-access Velcro flap, an antenna cutout, a securely closed bottom and a heavy-duty metal clip for belts as wide as two inches (five centimeters).

For more information: Klein Tools, 7200 McCormick Boulevard, P.O. Box 599033, Chicago, IL 60659 U.S. Telephone: +1 (847) 677-4476.

Video Camera 'Looks' Up, Down, Around

Mobile video-camera viewing around bends, through small entries or from heights of as much as 14 feet (4.3

meters) is made possible by the Walk-About System from Zistos Corp.

The basic system features three components: a portable video display, a flexible camera body and an illuminating camera head. Numerous options enable the system to be configured for specific uses.

The swiveling, four-inch (10.2-centimeter)-diagonal display attaches to a battery pack that can be clipped to a belt or carried on a chest harness. The system is powered by an internal, rechargeable nickel-metal-hydride (NiMH) battery or by eight "D" cells.

Mobile Video Camera

Various types of camera bodies are available, most of which are flexible enough to enable operators to look up, down sideways or backward, in addition to straight ahead. One option, the telescoping-pole camera body, facilitates viewing the top of vehicles from the ground. Camera bodies are of rugged construction, are submersible and are oil-resistant, the manufacturer said. An optional transmitter can send the signal to a receiver with a larger monitor so that the image can be viewed by groups of people or at a different location.

The standard camera head, with a 1.2-inch (three-centimeter) diameter, can be supplemented with camera heads for black-and-white infrared, low-light color or low-light black-and-white infrared applications.

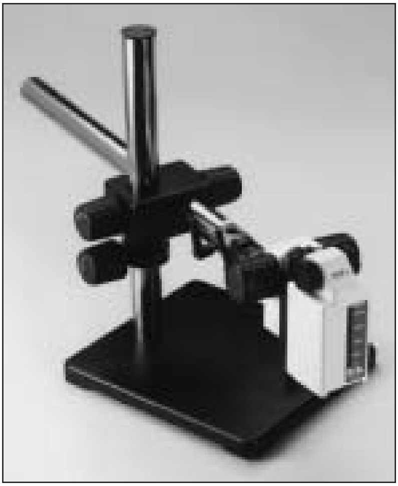
For more information: Zistos Corp., 55A Kennedy Drive, Hauppauge, NY 11788 U.S. Telephone: +1 (631) 434-1370.

Video Microscope System Captures 270,000 Pixels

The IS-3 video microscope inspection system from ASG transmits images that can be viewed on a video monitor or, with an optional frame grabber, on a computer monitor. Two models provide magnification to 450 times actual size or to 230 times actual size, respectively, based on a 14-inch (35.6-centimeter) monitor.

A 0.25-inch (6.35-millimeter) charge-coupled device (CCD) camera, lens and white light-emitting diode (LED) are integrated with the microscope. Full-color resolution is 270,000 pixels.

An optional stand with a boom provides greater stability and additional flexibility of inspection angles, the



Video Microscope

manufacturer said. The stand is constructed of solid steel.

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

Software Uses Internet for Record Management

WebStore 2.0, file-management software from ArkivMedium, offers a suite of applications for making aircraft-maintenance documents available to users through an Internet-based system. Personnel can then access documents from any computer with a connection to the World Wide Web, without the need for a company to create its own intranet or to add hardware. The developer said that features include:

- MediaFilter, which converts more than 80 file formats into Web-browsable images, both full-size and thumbnail, including MPEG (derived from Moving Picture Experts Group, an organization that creates condensed digital video formats) and Apple QuickTime. Any type of file, including those based on proprietary software, can be stored;

- Document Indexing System, which extracts text from documents and stores it in a searchable database to enable thousands of documents to be searched in seconds;

- WebZip, which automatically compresses files for storage; and,

- WebSupply, a tracking and monitoring system that records when and by whom files were downloaded.

WebStore 2.0 can be deployed in five days or less, the manufacturer said.

For more information: ArkivMedium, 7 Gilliland Drive, East Stroudsburg, PA 18301 U.S. Telephone: (888) 349-7244 (U.S.) or +1 (617) 669-0209.♦