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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 14, 1995

In reply refer to: A-95-74 through -76

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On February 2, 1995, at 0008 local time, VASP flight 957, a Boeing 737-200 with Brazilian registry PP-SMV, made an emergency landing at Sao Paulo/Guarulhos International Airport (GRU), Brazil, after the loss of hydraulic system A and the standby hydraulic system. The airplane touched down near the 1,300-foot point of runway 9L and departed the right side of the runway 11,482 feet down the runway. The nose landing gear collapsed, the right main landing gear folded into the wheel well, and the right engine separated before the airplane stopped beyond the rollout end of the runway. Seven of the 118 passengers were injured during the evacuation. The airplane was being operated as a regularly scheduled flight from Sao Paulo, Brazil, to Buenos Aires, Argentina, and had departed GRU at 2300 local time. Examination of the airplane revealed that the inboard leading edge (Krueger) flap actuator on the right wing had separated from the front wing spar and the hydraulic lines connected to the actuator had been breached.

The National Transportation Safety Board is participating in the Government of Brazil's ongoing investigation in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation.

The crew stated that the takeoff was uneventful. After the flaps were selected up, the crew noticed that the in-transit light for the No. 3 leading edge flap remained illuminated. They then observed the No. 2 Engine Pressure Ratio (EPR) indication rapidly increase from 1.90 to 2.11 and then gradually to 2.16. The autothrottles, which had been selected "on" soon after takeoff, were disengaged. Efforts at that time to retard the No. 2 throttle lever were unsuccessful, and the crew continued the climb due to the increasing airspeed.

The crew subsequently noticed that the low-pressure light for hydraulic system A was illuminated and the pressure and quantity were decreasing. The pressure soon indicated "0." Hydraulic system A was then selected off.

Hydraulic power on the Boeing 737-200 airplane is provided by three independent sources: system A, which is provided pressure from two engine-driven pumps; system B, which is provided pressure from two electrically-driven pumps; and the standby system, which can be used to restore hydraulic pressure to certain systems if system A or B is lost and is provided pressure from one electrically driven pump.

Hydraulic system A provides operating pressure to the inboard brakes, inboard flight spoilers, ground spoilers, ailerons, elevators, rudder, trailing edge flaps, leading edge devices, landing gear, nose wheel steering, and thrust reversers. Hydraulic system B provides operating pressure to the outboard brakes, outboard flight spoilers, ailerons, elevators, and rudder. The standby system provides operating pressure to the rudder, leading edge devices, and the thrust reversers.

The standby hydraulic system can be activated by positioning the "A" or "B" Flight Control switch to its "STDBY RUD" position or by positioning the Alternate Flaps master switch to "ARM." If system A pressure is lost, the leading edge devices can be extended by "arming" the Alternate Flaps master switch and momentarily positioning the switch to "DOWN." The leading edge devices can be hydraulically extended with the standby hydraulic system, but cannot be retracted. The trailing edge flaps can be extended or retracted electrically by holding the Alternate Flaps master switch in the "DOWN" or "UP" position, respectively.

The crew stated that they continuously banged on the No. 2 throttle in an attempt to reduce the thrust and were eventually successful. After selecting the standby hydraulic system and arming Alternate Flaps, the crew noticed that the "low quantity" and "low pressure" lights for the standby hydraulic system had illuminated. They proceeded to electrically extend the trailing edge flaps using the alternate flap system.

The first officer went into the cabin to observe the position of the leading and trailing edge devices. He indicated that the leading and trailing edge devices appeared to be retracted. The crew then elected to execute an "all flaps up" landing. The airplane touched down on the wet runway at 183 knots, with the No. 2 engine EPR at 1.15. Reverse thrust was not available during the landing roll due to the loss of the necessary hydraulic sources.

Examination of the airplane revealed that the No. 3 Krueger flap actuator had separated from its aluminum aft support fitting (identified by Boeing Part Numbers (P/N) 69-37892-9 and -10 on the left and right wing outboard positions, respectively, and P/Ns 69-37893-1 and -2 on the left and right wing inboard positions, respectively). The area of the front wing spar below the fitting showed evidence of contact from the actuator. In the same area, one of the No. 2 engine start lever cables had been damaged and the No. 2 thrust lever cable had been knocked off the pulley and wedged between the pulley and the pulley bracket. The three hydraulic lines connected to the actuator (A system, standby system, and return) were broken, and hydraulic fluid residue from the A and standby systems was observed along the front spar and the underside of the wing aft of the No. 3 Krueger flap. Subsequent examination of the failed aft support fitting revealed evidence of corrosion on and around the fitting's fracture surface.

The aluminum support fittings for Boeing 737 Krueger flap actuators were the subject of Boeing Service Bulletin (SB) 737-57-1129, dated March 6, 1981, and the revision dated October 30, 1981. The SB cites eight airplanes that had experienced cracking of the subject fittings. The cracking was attributed to fatigue, stress corrosion, and high clamp-up stresses. One of the incidents cited in the SB involved events similar to the VASP accident, including a loss of the A and standby hydraulic systems and subsequent control difficulties. The SB recommends visual and periodic eddy current inspections on all airplanes with 15,000 or more flights. The revision to the SB provides information on the terminating action, which involves replacing the aluminum fitting with a steel fitting. The SB applies to the first 813 B-737s manufactured. The accident airplane was line number 367 and had accumulated approximately 57,600 flight hours and 53,600 flight cycles at the time of the accident.

VASP indicated that it had reviewed SB 737-57-1129 when it was issued but did not adopt the recommended eddy current inspections. The airline was performing visual inspections of the fittings during every C check. The aft support fitting from the accident airplane's No. 2 Krueger flap actuator had been replaced with another aluminum fitting supplied by Boeing, but VASP could not provide records of its replacement. (Boeing indicated that some of the subject aluminum fittings continued to be supplied to customers after issuance of the SB, but that they have now been purged from the Boeing parts inventory.)

A review of Boeing data revealed that several cracked fittings were discovered during inspections after issuance of the SB, including one in 1993. The Safety Board believes that the consequences of a failure of one of the fittings, as illustrated by the VASP accident, justify a requirement that the aluminum fittings be replaced with the steel fittings.

The Safety Board is also concerned that the leading edge hydraulic fuse in the standby system of the VASP airplane did not function as intended to prevent the total loss of fluid after the hydraulic line had been breached. An inspection and test of the fuse revealed leakage in excess of allowable limits due to corrosion of the magnesium piston in the fuse.

The hydraulic fuse was manufactured by Waterman and is identified by Waterman P/N G838-8-160 and Boeing P/N 10-61245-1. The fuse was the subject of Boeing Service Letters (SLs) 737-SL-29-19 dated July 28, 1981, and 737-SL-29-21, dated December 16, 1982, which referenced SBs issued by Waterman. The Boeing SLs, which recommended replacement of the subject hydraulic fuse, were prompted by the same serious incident cited in SB 737-57-1129, wherein an airplane lost the A and standby hydraulic systems and experienced control difficulties.

Examination of several of the subject hydraulic fuses had revealed that they were prone to leakage because of corrosion and sticking of the internal magnesium piston. Service Letter 737-SL-29-21 recommended that the magnesium piston be replaced with an aluminum piston. A new fuse utilizing the aluminum piston (Waterman P/N G8381-8-160, Boeing P/N 10-61245-11) was installed on all B-737 production airplanes beginning with line number 836.

On some B-737-100 and -200 airplanes, the same fuse was installed in the brake system and similar hydraulic fuses (containing the magnesium piston) were installed in the thrust reverser standby hydraulic system. Those installed in the thrust reverser standby hydraulic system are identified by P/N G838-8-40 (Boeing P/N 10-61245-2) and G838-8-60 (Boeing P/N 10-61245-3). Boeing also indicated that a similar fuse was installed in the brake system on two customer-specific B-737 airplanes. This fuse is identified by Waterman P/N G904-8-20 and Boeing P/N 10-60597-1.

The Safety Board is concerned that normal airplane maintenance manual procedures do not confirm whether the hydraulic fuses are functioning properly and that a malfunctioning unit can remain in service until being removed for test or overhaul. One B-737 operator revealed that its maintenance program had no requirement to remove or test the subject fuses. Another U.S. B-737 operator indicated that the subject fuses are removed for overhaul approximately every 20,000 flight hours. Examination of the fuses indicated that excessive corrosion could result well before 20,000 hours of service. The Safety Board believes that the magnesium-piston fuses may still be installed on some of the affected airplanes and that these fuses should be replaced within an appropriate timeframe.

Discussions with Boeing and Parker Hannifin, which acquired Waterman in 1987 and now supplies new versions of the subject fuses, revealed that a similiar fuse is also used with anti-skid assemblies on early B-747 airplanes. This fuse is identified by Waterman P/N G905-120 and Boeing P/N 60B00238-1 and was the subject of Boeing SL 747-SL-32-19. Parker Hannifin stated that none of the magnesium-piston fuses on Boeing airplanes were produced or supplied by Waterman after the SBs were issued in 1982.

The failure of another Waterman hydraulic fuse was discovered during the Safety Board's investigation of an incident involving a Henson Airlines de Havilland DHC-8 airplane in Savannah, Georgia, in 1991. The fuse failed to prevent the loss of a large quantity of hydraulic fluid that occurred after a hydraulic line was severed following a landing gear fitting failure. As with the other fuse failures, corrosion and sticking of the magnesium piston was cited as the probable reason that hydraulic fluid loss was not contained. On March 24, 1992, Transport Canada issued airworthiness directive (AD) CF-92-08, which required the replacement of the fuse on DHC-8 and DHC-7 airplanes. On May 12, 1993, the FAA issued AD 93-06-07, which was similar to AD CF-92-08. The Board believes that the FAA's action should have addressed all transport-category airplanes with hydraulic fuses containing magnesium, and not just the DHC-7 and DHC-8.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Issue an airworthiness directive requiring repetitive eddy-current inspections of aluminum Krueger flap aft support fittings installed on Boeing 737-100 or -200 series airplanes until the fittings have been replaced with steel fittings, in accordance with Boeing Service Bulletin 737-57-1129, before completing the next

C check or 3000 flight hours, whichever occurs first. (Class II, Priority Action) (A-95-74)

Issue an airworthiness directive requiring the replacement of magnesium pistons in hydraulic fuses installed on Boeing 737-100 and -200 series airplanes and identified by Waterman Part Numbers G838-8-40, G838-8-60, and G838-8-160, and on Boeing 747-100 and -200 series airplanes and identified by Waterman Part Number G905-120, with aluminum pistons before completing the next C check or 3000 flight hours, whichever occurs first. (Class II, Priority Action) (A-95-75)

Identify transport-category airplane models, other than the Boeing 737 and 747, that contain hydraulic fuses with magnesium pistons and require, within an appropriate timeframe, the replacement of such fuses with a more serviceable piston material. (Class II, Priority Action) (A-95-76)

Chairman HALL, Vice Chairman FRANCIS, and Member HAMMERSCHMIDT concurred in these recommendations.

By: Jim Hall
Chairman