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POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT - ADDENDUM A

by

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NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C.

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POWERPLANT FACTUAL REPORT - ADDENDUM A

DCA94MA076

A. ACCIDENT

LOCATION:	Aliquippa, Pennsylvania
DATE:	September 8, 1994
TIME:	1904 Eastern Daylight Time
AIRPLANE:	USAir, Boeing 737-300, Flight 427, N513AU

B. GROUP

Jerome D. Frechette Group Chairman	National Transportation Safety Board Washington, D.C.
Mario L. Giordano	Federal Aviation Administration Coraopolis, Pennsylvania
Stephen Bray	FAA Transport Aircraft Directorate Northwest Region, Seattle, Washington
Clifford M. Schjoneman	The Boeing Commercial Airplane Group Seattle, Washington
Robert Wilson	The Boeing Commercial Airplane Group Seattle, Washington
Steve Slagle	The Boeing Commercial Airplane Group Seattle, Washington
A. David Wright	The Boeing Commercial Airplane Group Seattle, Washington
Robert A. Halsmer	USAir Pittsburgh, Pennsylvania

John D. Long	USAir, Air Line Pilot's Association Baltimore, Maryland
Mike Gardner	International Association of Machinists and Aerospace Workers, South San Francisco, California
Michael C. Lindamood	Aviall Dallas, Texas
Rex Rhodes	Parker Bertea Aerospace Irvine, California

C. SUMMARY

The two control valve modules were shipped to the NTSB, Seattle, Washington office from Washington, D.C., on October 13, 1994. The modules were hand-carried to the Boeing Company, Renton, Washington for visual and dimensional inspection on October 17, 1994, under the direction of the National Transportation Safety Board. The modules were inspected in the Equipment Quality Analysis laboratory, and upon completion the modules were boxed and place in bonded storage at the Boeing company, Renton, Washington, on October 18, 1994.

The inspections revealed that both modules were impact-damaged and both had the directional control valves in the "stowed" position, the hydraulic isolation valves in the "isolated " (off) position, and the manual isolation valve in the "normal" (on) position. Additionally, there were no preimpact conditions, anomalies or failures that would have prevented normal operation of the either hydraulic control valve module. The small hydraulic fluid samples taken from each module revealed that the fluid from system "A" was clean, clear with a green hue, and the fluid from system "B", was clean, and yellow. According to the Parker Bertea and Boeing engineers participating in the teardown, the wear marks inside the control valve modules were consistent with normal operation.

D. DETAILS OF THE INVESTIGATION

The two modules were tagged with the installation location from the accident airplane when removed from the shipping container. However, the engine position of each control valve module was reverified by matching serial numbers with the maintenance record. A sample module was available for visual and dimensional comparison.

1. CONTROL VALVE DESCRIPTION

The control valve modules are mounted on the forward bulkhead of the air conditioning equipment bay such that the valve spools, internal to the modules, are transverse to the direction of flight. The left-hand module controls the No. 1 engine thrust reverser and is integral to the "A" hydraulic system. The right-hand module controls the No. 2 engine thrust reverser and is integral to the "B" hydraulic system. The modules have three valve spools; the directional control valve (DCV), hydraulic isolation valve (HIV), and the manual isolation valve.

The DCV and HIV are hydraulically actuated by solenoid valves controlled by 28 volts direct current (VDC). The HIV is held in the closed position by spring force. Solenoid valve A ports fluid to the HIV to position the valve from the closed position to the open position. The DCV is held in the deploy and stowed position by five detent balls pushed into a groove in the spool by a retainer and spring. Solenoid valves B or C port fluid to the DCV to position the valve to "deploy" or to "stow" respectively. The DCV and HIV also have proximity detectors which provide valve position information to the engine accessory unit. The force required to manually shuttle the DCV spool from the stow to deploy position was measured with a force scale and found to be 42 pounds.

The hydraulic control module receives its electrical signal for reverser deployment following manipulation of the cockpit reverser lever, and either weight on the right main wheel or a radar altitude of less than 10 feet. As a result of the electrical signal, the HIV moves to the open position the DCV moves to the deploy position. The open HIV introduces hydraulic system pressure to the reverser, and the DCV routes hydraulic pressure to both sides of the actuator piston causing the actuator to extend. During the stow cycle, the signal input to the control valve module causes the DCV to move to the stow position, which routes pressure to the stow side of the actuators causing the actuator to retract. The HIV closes approximately 10 seconds after the thrust reverser is fully stowed, depressurizing the reverser actuators.

The thrust reverser system has an auto-restow feature where, following an uncommanded movement of a reverser sleeve, the HIV is opened repressurizing the thrust reverser with hydraulic system pressure. Additionally, the DCV which is normally in the stow position, receives a 28 VDC signal ensuring the valve is in the stow position. The HIV remains open, maintaining hydraulic pressure to the reverser, until the next reverser cycle or an electrical power interruption to the system. A restow signal follows detection by the thrust reverser proximity sensors of approximately 1/10 inch of uncommanded movement of the translating sleeve from the stowed position.

The manual isolation valve or maintenance valve is lever-actuated, and when in the "shutoff" position, prevents the inadvertent application of pressure from the aircraft hydraulic system to the reversers during maintenance.

2. CONTROL VALVE MODULE DISASSEMBLY AND INSPECTION

The control valve modules had been encrusted with dirt and were carefully cleaned. The external hardware, attachments, and components, except the spool valve endcaps, were removed. A visual inspection of the exteriors and a measurement of the valve spool positions were made. The valve spool endcaps were kept in place, to preclude disturbance of the valves, until a measurement of the distance from the exterior of the valve housing to the spool valve end could be accomplished. The endcaps and the HIV and DCV valve spools were removed. The manual isolation valves were not removed and the right-hand side valve housing was borescope inspected.

The dimensional and visual determination of the DCV and HIV positions was made by measuring and viewing the end of the valve spool through the proximity sensor boss and comparing the distance and view to the sample valve with the valve spools in a known position. The visual determination of the manual isolation valve was made by viewing the side of the valve spool through the deploy fluid port and comparing the view to the sample valve with the spool in a known position. The measurements are as follows:

	DCV		HIV
	Stow	Deploy	Closed
Sample Valve	2.181	1.716	2.107
		As Received	
Serial No. 00826	2.185		2.106
Serial No. 00135SD	2.188		2.098

2.1 Control Valve Module, Serial No. 00826

Control valve module, serial No. 00826 was the control for the thrust reverser on the No. 1 engine. The visual inspection of the module revealed that the manual isolation valve lever was missing, the mount bracket was wrapped around the valve housing and the mounting foot, next to HIV proximity detector was cracked and protruding into a hole in the valve housing. The four hydraulic B-nuts were in place with the tubing separated at the B-nut tops. The B-nuts were

removed and dirt was found in the pressure and return ports. The pressure port filter screen was intact. The deploy and stow ports were clean and the stow port restrictor was in place. The check valve was in serviceable condition.

Solenoid valves A,B, and C, part number 3820007-103, serial numbers 2500, 3661, and 2494 respectively, and the DCV and HIV proximity detectors sensors were intact. The solenoid electrical connector body was missing with the base flange in place. The DCV and HIV proximity detector electrical connectors were damaged. The proximity detectors were removed and the detector, target assemblies, and springs were intact and free to move within window housing. The solenoids were removed and the solenoid end screens, retainer, upper coil, O-rings, and back-up ring were in place and in serviceable condition. The electron beam (EB) weld joint had no visible cracks.

The DCV and HIV end caps and the DCV and HIV were removed. The DCV and HIV bodies were positioned against the end caps indicating "stow" and "closed" modes, respectively. Approximately 5-10 milliliters of an oily fluid, recovered from the valve body, visually appeared clean and clear with a greenish hue. Movement of the spools within their respective sleeve was smooth and free. The DCV and HIV spools had longitudinal scratches on the outer surfaces. The circumferential ball bearing grooves on the DCV spool had longitudinal track marks, from groove to groove, in line with the ball bearings. The ball bearing track marks were not discernable by touch. According to the Parker and Boeing representative, the longitudinal scratches and ball track marks were consistent with normal operation.

The manual isolation valve was not removed. The spool was in the normal "on" position as viewed through the deploy port. A borescope inspection of the valve interior did not reveal anything remarkable.

2.2 Control Valve Module, Serial No. 00135SD

Control valve module, serial No. 00135SD, was the control for the thrust reverser on the No. 2 engine. The visual inspection of the module revealed that the manual isolation valve lever was missing, the mount bracket corners were folded around the valve housing and the mounting foot next to HIV proximity detector was deformed and protruding into a crack in the valve housing. The stow and deploy port "B" nuts were in place with the tubing separated at the B-nut tops. The pressure port was fractured and the inlet filter was missing. The return port adapter separated at the B-nut threads. Dirt was in the pressure, return, deploy and stow ports. The stow port restrictor was in place. The check valve was in serviceable condition.

Solenoid valves A,B, and C, part number 3820007-103, serial numbers 474, 854. and 473 respectively, were intact. Solenoid C outer foot was deformed. The HIV proximity detector separated at the mounting plate. The DCV proximity detector was cracked through 360° and was partially attached. The DCV proximity detector window was cracked.

The proximity detectors were removed and the detector, target assemblies, and springs were intact and free to move within window housing. The solenoids were removed and the solenoid end screens, retainer, upper coil, O-rings, and back-up ring were in place and in serviceable condition. The electron beam (EB) weld joint had no visible cracks.

The DCV and HIV end caps and the DCV and HIV were removed. The DCV and HIV bodies were positioned against the end caps indicating "stow" and "closed" modes, respectively. Approximately 10-20 milliliters of an oily fluid, recovered from the valve body, visually appeared clean and yellow. Movement of the spools within their respective sleeve was smooth and free. The DCV and HIV spools had longitudinal scratches on the outer surfaces. The circumferential ball bearing grooves on the DCV spool had longitudinal track marks, from groove to groove, in line with the ball bearings. The ball bearing track marks were not discernable by touch. According to the Parker and Boeing representative, the longitudinal scratches and ball track marks were consistent with normal operation.

The manual isolation valve was not removed. The spool was in the normal "on" position, as viewed through the deploy port. No borescope inspection of the valve interior was performed.

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Jerome D. Frechette,
Group Chairman

12/12/94