



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 10, 1994

In reply refer to: A-94-64 through -66

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

On March 15, 1993, a Boeing 737-100, N14212, operating as Continental Air Lines flight 1659, experienced a loss of control of the left aileron while departing from Newark International Airport, Newark, New Jersey. The captain stated that the airplane rolled to the left as soon as it became airborne. Considerable difficulty was experienced controlling the airplane, but when the flaps were retracted and full right aileron was applied, control was maintained with less difficulty. An in-flight visual inspection of the left aileron panel revealed the panel in the full up position. The crew elected to return to Newark. The captain reported that control became increasingly difficult during the approach to land when the flaps were extended from 15° to 30°. The captain said he used 30° of flaps because of ice and snow on the runway at Newark. The captain reported that just before touchdown, he needed full right aileron and a significant amount of left rudder to keep the airplane lined up with the runway. The airplane was landed without further incident, and none of the occupants were injured.

Examination of the airplane's aileron controls revealed that the aileron cable that controlled the downward deflection of the left aileron was broken at the point where the cable travels over a pulley in the main gear wheel well.¹ Initial examination of the left "up" aileron cable identified a reduced diameter area at the pulley location, but broken wires were not apparent. However, when rigging tension was released, the reduced area relaxed and numerous wire fractures became apparent. The right aileron

¹The B737 aileron panels are configured with two aileron bus drums mounted on the forward wall of the main gear wheel well. The cables running outboard from the bus drums to the left and right ailerons are labeled ABSA, for control of the "down" aileron movement, and ABSB, for control of the "up" aileron movement. These cables travel over pulleys located inside the wheel well and outboard wing panel and extend out to the left and right aileron wing quadrants. The cables terminate at the wing tip where they separately attach to a turnaround pulley connected to a cable slack takeup spring.

cable also exhibited significant wear and reduced diameter along the portion of the cable traveling over a pulley.

Metallurgical examination of the broken left "down" aileron cable at the Safety Board's materials laboratory revealed that 98 of the 133 total wires in the aileron cable showed wear through their entire cross-sectional areas. The remaining 35 wires exhibited a reduction of their cross-sectional areas by as much as 90 percent prior to failure. Further examination of the left "up" aileron cable found 32 broken wires in the outer strands of the cable, all of which showed severe internal wear.

The right "up" cable wires were found intact, but measurements of the cable revealed a localized reduction in its diameter of .027 inches less than the nominal cable diameter of .184 inches. The metallurgical examination revealed that the wear of these cables was consistent with strand-on-strand movement and internal cable wear.

On June 9, 1988, Boeing released B737-100/200 In-Service Activities Report #88-06, involving the separation of a B737 aileron cable. This document reported that the incident airplane's right aileron cable separated about 1 inch outboard of a pulley. Following the failure of the cable, the right aileron reportedly traveled to the full up position. This report also indicated that, "numerous wires in the vicinity of the separation were found to have a reduced cross-sectional area due to rubbing against each other." In addition to this report, a review of B727 and B737² Service Difficulty Reports (SDRs) regarding aileron cable failures between January 1, 1986, and May 19, 1993, revealed four incidents of cable failure. The reports also contained 13 separate accounts of aileron cable replacement as a result of conditions such as corrosion, wear, fraying, twisting, and chafing.

Two procedures for the inspection of control cables are found in the Boeing 737 Maintenance Manual. One procedure, the inspection for broken wires, recommends replacing the cable when four wires are found broken in 12 continuous inches of cable. The recommended procedure includes running a cloth over the cable to detect broken wires. The other (optional) procedure involves inspecting for external cable wear. This procedure recommends replacing the cable when the diameter of any single wire is reduced by 40 percent or more in one strand. The Boeing manual does not directly address internal cable wear, with the exception of one illustration showing an "example of internal wear." There is no Boeing-recommended life limit for these cables.

²According to Boeing Engineering, the B727 and B737 aileron control systems are similar in design and operation.

Four other operators of the B737 airplane indicated that they had never experienced an aileron cable failure, although fraying and wear had occurred frequently enough to require replacement of the cables on the average of every 3 years. All four operators inspect their cables during the "C" check, at intervals of 12 to 15 months, or 3,000 to 4,800 hours. Continental Airlines inspects its cables during the "C" check, at 3,000 hour intervals. Continental Airlines was unable to locate records that would indicate whether the aileron cables had been replaced in N14212 prior to this incident.

To determine the frequency of control cable failures in other transport aircraft, an SDR review of rudder, spoiler, and aileron control cable failures was conducted for large airplanes weighing 12,500 pounds or more. The review focused on failures that resulted in broken cables and excluded those reports of worn or partially broken cables. There were a total of 11 spoiler, five rudder, and 25 aileron cable failures reported for the period January 1, 1986, through October 6, 1993. Large airplanes having broken spoiler cables included seven B727s and four B737s. There was one account of an MD-87 rudder cable failure and two reports of both DC-8 and DC-9 rudder cable failures. The majority of broken aileron cables were experienced by the DC-8 airplane, with a total of 12 incidents of cable failure. However, SDRs also revealed six B727 and B737, two B747, two Fokker F27 and F28, two DC-9, and one DeHavilland Dash 7 aileron cable failures.

One report of a B737 spoiler cable failure indicated that when the airplane was climbing to 10,000 feet, a loud bang was heard on the captain's side and the "aircraft rolled left,...took full aileron in opposite direction to control aircraft...trim yoke position was at 45 degrees." The report indicated that the crew declared an emergency, landed without incident, and later discovered a broken spoiler cable. A report of a DC-8 broken rudder cable revealed that during a flight control check, while taxiing, the right rudder went to full travel and would not return to neutral. Further inspection of the airplane's systems revealed a broken rudder control cable. In addition, a report of a DC-9 aileron cable failure indicated that after takeoff, "the left wing takes a dip," and "right aileron trim was needed." The report revealed that the right aileron down cable separated at a pulley in the airplane's right wheel well.

On October 12, 1993, the Safety Board issued Urgent Safety Recommendation A-93-133, regarding the failure of Boeing 737 speedbrake cables and improper routing. The recommendation was issued as a result of a USAir B737 speedbrake cable failure that was discovered by an off-duty crewmember who observed a fully deployed spoiler panel before takeoff. The failure occurred because the cable had been misrouted over two spacers that attach cable guards to the pulley where the cable should have been routed. Friction from riding on the spacers had ultimately resulted in the cable's failure. The recommendation letter also noted two other B737 speed brake control cable failures related to misrouting.

Although no air carrier accidents are known to have occurred as a result of a broken control or aileron cable, the Safety Board believes that the failure of any control cable constitutes an unsafe condition. The internal strand-against-strand wear inside the B737 aileron cable is not easily detected with Boeing's recommended inspection for broken wires. The failure of N14212's left "down" cable with 98 of the total 133 wires completely worn through prior to failure supports this belief. The failure occurred 580 hours after the airplane's last "C" check, which was performed on December 20, 1992. At the time of the failure, the airplane had accumulated 58,997 total hours and 60,682 total cycles. Also, after the incident flight, the left aileron "up" cable initially passed inspections with only a reduction in diameter noted, when in fact the cable subsequently was found to have 32 broken wires from severe internal wear. The Safety Board believes that Boeing's recommended inspection for broken aileron wires in B727 and B737 airplanes is inadequate and additional information should be examined regarding the integrity of spoiler, rudder, and aileron cables on airplanes greater than 12,500 pounds.

The Safety Board is also concerned that the Boeing 737-100 Operations Manual lacks appropriate operational guidance in the event of an abnormal flight control failure. The B737-100 Operations Manual discusses "jammed" aileron control systems. The Flight Controls section, which provides information on abnormal flight controls, states:

ABNORMAL FLIGHT CONTROLS

JAMMED, STICKY, OR FAULTY SYSTEM -- OVERPOWER/TRIM

Do not turn off any Flight Control Switches unless the faulty control is positively identified.

The manual contains no procedures for the loss of aileron control or the use of flaps if control of an aileron fails. The Safety Board believes that action should be taken to provide B737 flightcrews with proper operational guidance for the best landing configuration in the event of such a failure.

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

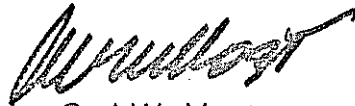
Issue an Airworthiness Directive (AD) to operators of Boeing 727 and 737 airplanes requiring periodic inspection of the aileron cables for both internal and external wear, and for broken wires, with particular attention to the area of the cable contacting the pulleys. The inspection should include releasing cable tension to better detect cable wear and wire breakage and establishing a maximum allowable reduction in cable diameter where pulley contact occurs. Based on the inspections,

develop specific flight hour intervals for replacement of the cables.
(Class II, Priority Action) (A-94-64)

Require that the Boeing Company examine the consequences of a 737-100 aileron cable failure, and provide appropriate flightcrew operational guidance for the best landing configuration in the event of such a failure.
(Class II, Priority Action) (A-94-65)

Conduct a comprehensive study to determine the frequency of spoiler, rudder, and aileron cable failures on airplanes weighing 12,500 pounds or greater. Where the study reveals flight control inspection procedures to be inadequate, require appropriate revisions to those inspection procedures and/or issue Airworthiness Directives to mandate service life limits to assure greater reliability of those control cables.
(Class III, Longer Term Action) (A-94-66)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HAMMERSCHMIDT, and HALL concurred in these recommendations.



By: Carl W. Vogt
Chairman