



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 13, 1999

In reply refer to: A-99-30 through -31

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 21, 1998, at 1315 Pacific daylight time, Continental Airlines flight 75, a McDonnell Douglas DC-10-10, N68043, en route from Los Angeles, California, to Honolulu, Hawaii, experienced a pitch axis upset while climbing through flight level 310 with the autopilot engaged. Of the 285 passengers, 10 flight attendants, and 3 cockpit crew onboard, 3 flight attendants sustained serious injuries and 5 passengers and flight attendants sustained minor injuries. The airplane was not damaged. Following the upset, the crew dumped fuel, returned to Los Angeles, and landed without further incident.

The captain reported that the upset occurred when the control yoke moved backward without crew input. Immediately after the initial pitch up, the captain disconnected the autopilot. Flight data recorder (FDR) data showed that the airplane then went through four up-and-down pitch oscillations, the most severe of which attained vertical accelerations of +1.84 to -0.12 Gs. The investigation revealed that erroneous control outputs from the No. 1 autopilot resulted in the uncommanded pitch up.

The DC-10 autopilot contains a control wheel steering (CWS) feature that allows the flightcrew to make small adjustments to the airplane's flightpath while the autopilot remains engaged. The autopilot senses the force applied to the control yoke by the flightcrew through CWS sensors. When the control wheel is moved, the sensors provide a voltage signal to the autopilot that is proportional to the magnitude and direction of the applied force (nose up/nose down). If the voltage supplied by the CWS sensor exceeds +/- 3.5 volts, the autopilot will automatically disconnect. Postflight examination of the airplane revealed that the CWS sensor located in the first officer's control column was malfunctioning and sending an erroneous signal to the autopilot computer.

During the subsequent testing of the CWS sensor at the manufacturer's facility (Kulite Semiconductor Products, Inc., Leonia, New Jersey), it was determined that the sensor was providing intermittent uncommanded voltage signals, some of which would have been interpreted by the autopilot computer as valid commands. These uncommanded voltage signals registered from 0.5 to 5.0 volts. Several times during the tests, the sensor provided positive voltage signals below the autopilot disconnect threshold of 3.5 volts for up to 1.5 minutes. Further examination revealed that the uncommanded voltage signals were caused by an intermittent short circuit within the CWS sensor. This short circuit was caused by material contamination that bridged the gap between the two adjacent strain gauge legs within the sensor.

The sensor was further examined at the Safety Board's materials laboratory. Scanning electron microscopic analysis determined that the material contamination in the sensor contained silver, chlorine, and sulfur. The most probable compounds formed from these elements are silver chloride and silver sulfide. Both of these compounds could produce a short circuit. The investigation revealed that the wires connecting the strain gauges with the rest of the sensor were made from gold-plated silver, which is the most likely source of the foreign material's silver component.

For reasons unrelated to a contamination problem, beginning in 1975, Kulite incorporated a series of design changes in the CWS sensor and upgraded the material for the sensor's wire to either pure gold or gold-plated platinum.¹ No reports have been made of foreign material failures of the improved CWS sensors. To prevent further upsets caused by contaminated CWS sensors, the Safety Board believes that the Federal Aviation Administration (FAA) should require the operators of DC-10 airplanes to replace any CWS sensors containing gold-plated silver wires with improved CWS sensors containing pure gold or gold-plated platinum wires.

Review of the FDR data revealed that the four pitch oscillations took place after the captain disconnected the autopilot and the flightcrew took manual control of the airplane. The first, nose-down pitch excursion to -0.2 G occurred immediately after the uncommanded pitch up. Three more complete nose-up and nose-down cycles occurred before the airplane regained level flight. These three oscillations occurred as the flightcrew tried to regain level flight because the peak airplane response lagged behind the peak flightcrew inputs by up to 1 second. This significant lag in airplane response led to an airplane-pilot coupled response in which the flightcrew was continuously out of phase with the airplane's motions. Three oscillations were completed before the flightcrew was able to dampen the airplane's response and return to level flight.

The Safety Board is concerned that the combination of false CWS sensor inputs with a lag in airplane response time during a flightcrew's attempted recovery creates the potential for other upsets of DC-10 airplanes to occur. Until the faulty CWS sensors are replaced, the Safety Board believes that pilots would be better prepared to respond to an upset situation if

¹ Pure gold and gold-plated platinum wires are more resistant to contamination. The materials in the wires were changed to maintain consistency with an unrelated product.

they were made aware of these factors. Therefore, as an interim action, the Safety Board believes that the FAA should issue a flight standards information bulletin to principal operations inspectors requiring that all DC-10 flightcrews are provided with information regarding the potential for airplane attitude upsets caused by faulty CWS sensor input and the potential for overshoots in recovering from those upsets because of the airplane's lag in responding to control inputs at cruise flight conditions.

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

Require the operators of DC-10 airplanes to replace any control wheel steering (CWS) sensors containing gold-plated silver wires with improved CWS sensors containing pure gold or gold-plated platinum wires. (A-99-30)

Issue a flight standards information bulletin to principal operations inspectors requiring that all DC-10 flightcrews are provided with information regarding the potential for airplane attitude upsets caused by faulty control wheel steering sensor input and the potential for overshoots in recovering from those upsets because of the airplane's lag in responding to control inputs at cruise flight conditions. (A-99-31)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman