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Improper Installation of Elevator Bolt Causes DC-8 Freighter to Pitch Up Uncontrollably

Absence of the bolt caused the right elevator control tab to become disconnected. The control tab then jammed as the flight crew began a night takeoff. During the crew's attempt to return to the airport, the aircraft struck the ground and was destroyed. All the crewmembers were killed.

FSF Editorial Staff

About 1951 local time on Feb. 16, 2000, a McDonnell Douglas DC-8-71F operated by Emery Worldwide Airlines struck an automobile salvage yard soon after takeoff in night visual meteorological conditions from Sacramento Mather Airport in Rancho Cordova, California, U.S. The three flight crewmembers were killed. The airplane was destroyed.

The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable cause of the accident was "a loss of pitch control resulting from the disconnection of the right elevator control tab. The disconnection was caused by the failure to properly secure and inspect the attachment bolt."

The airplane was being operated as Flight 17, a scheduled cargo flight from Rancho Cordova to Dayton, Ohio. Earlier on the day of the accident, scheduled cargo flights had been conducted in the airplane from Dayton to Reno, Nevada, and from Reno to Rancho Cordova.

Emery's headquarters was in Dayton. At the time of the accident, the company operated 43 DC-8s and two DC-10s. The accident airplane was manufactured as a DC-8-61 in 1968, converted to a DC-8-71 with different engines in 1983 and converted to a DC-8-71F freighter in 1993. Emery purchased the airplane from Aero USA in 1994. At the time of the accident, the airplane had accumulated 84,447 operating hours and 33,395 flight cycles (takeoffs and landings).

The accident crewmembers had flown together on two previous trip sequences in February 2000.

The captain, 43, had an airline transport pilot (ATP) certificate and five type ratings. He earned a DC-8 type rating in August 1998. He had 13,329 flight hours, including 2,128 flight hours as a DC-8 captain.

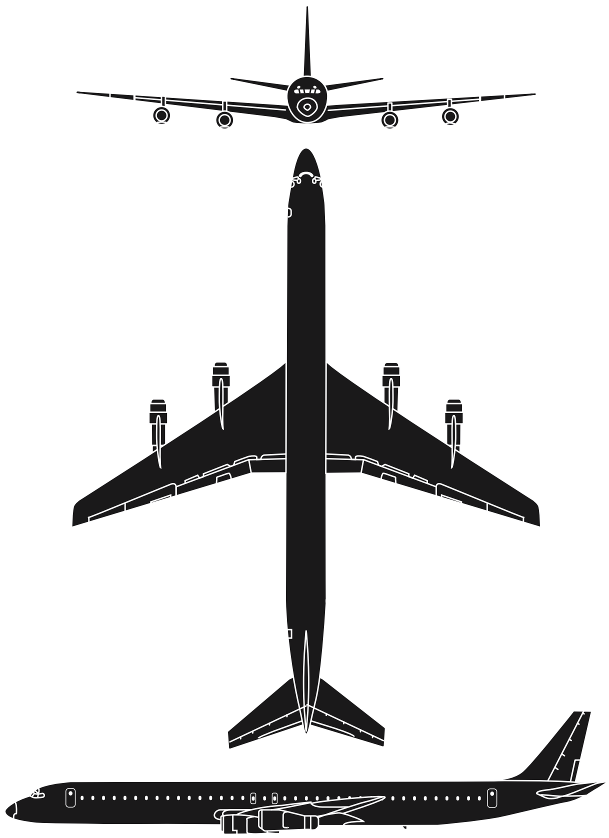
The first officer, 35, had an ATP certificate and 4,511 flight hours, including 2,080 flight hours as a DC-8 first officer.

The flight engineer, 38, had an ATP certificate and a flight engineer rating for turbojet-powered airplanes. He had 9,775 flight hours, including 675 flight hours as a DC-8 flight engineer.

The accident captain was aboard the accident airplane during its two previous flights on the day of the accident; he occupied the flight deck jump seat during the flight from Dayton to Reno, and he served as pilot-in-command during the flight from Reno to Rancho Cordova. The accident flight engineer also was aboard the flight from Reno to Rancho Cordova; he served as the flight engineer. The accident first officer joined the flight crew in Rancho Cordova.

The airplane arrived in Rancho Cordova about 1815, and unloading and loading of cargo was completed at 1930.

"Post-accident interviews with the cargo-loading supervisor, load planner and cargo loaders who worked on the accident airplane indicated that the unloading/loading process on the night of the accident was routine and that the airplane's load was lighter than usual," the report said.



McDonnell Douglas DC-8-71F

Douglas Aircraft Co. began production of its first jet transport, the DC-8, in 1959. The first five versions of the DC-8 — the series 10, 20, 30, 40 and 50 — have the same overall dimensions. The DC-8-61, introduced in 1965, is longer than its predecessors and can carry up to 251 passengers and four crewmembers.

Douglas merged with McDonnell Aircraft Corp. in 1968. In 1981, McDonnell Douglas Corp. introduced the DC-8-71, a re-engined version of the DC-8-61. The series 61's Pratt & Whitney JT3D-3B turbofan engines, rated at 18,000 pounds (8,165 kilograms) thrust, were replaced with CFM International CFM56-2-C1 turbofan engines, rated at 22,000 pounds (9,979 kilograms) thrust.

The DC-8-71F is a freighter version with a cargo capacity of 8,810 cubic feet (247 cubic meters). The airplane has an upward-hinged cargo door on the left side of the forward fuselage and can accommodate 18 pallets measuring 7.3 feet by 10.4 feet (2.2 meters by 3.2 meters).

Maximum takeoff weight (MTOW) is 328,000 pounds (148,781 kilograms). Balanced field length at MTOW is 10,560 feet (3,220 meters). Maximum landing weight is 258,000 pounds (117,029 kilograms).♦

Source: *Jane's All the World's Aircraft*

The airplane was within weight-and-balance limits. Maximum takeoff weight is 328,000 pounds (148,781 kilograms). The airplane's takeoff weight was 279,231 pounds (126,659 kilograms). The aft center of gravity (CG) limit is 33.6 percent mean aerodynamic chord (MAC). The airplane's CG was 28.9 percent MAC.

"Post-accident interviews indicated that while cargo-handling personnel were working, the flight engineer conducted a preflight inspection of the exterior of the airplane," the report said. "Additionally, during this time, mechanics from Emery and a contract maintenance company performed routine maintenance inspections and service items (such as servicing the engines with oil, checking the tires and brakes, and refueling).

"Although the investigation revealed that minor maintenance discrepancies existed (for example, an inoperative-fuel-valve indication and a malfunctioning navigation light), neither the flight engineer nor the mechanics reported observing any significant airplane anomalies during the preflight inspections. Further, the cockpit voice recorder (CVR) did not record any discussion of airplane anomalies while the airplane was on the ground."

The first officer was the pilot flying. At 1927, while conducting a takeoff briefing, he said, "Standard Emery procedures if there's a problem; we'll come back here and land on [Runway 22L]."

The captain said, "Sounds good."

The airport, a former U.S. Air Force base, is about 12 nautical miles (22 kilometers) east of Sacramento, California, and has two parallel runways: Runway 4L/22R, which is 6,040 feet (1,842 meters) long; and Runway 4R/22L, which is 11,301 feet (3,447 meters) long. The airport did not have a control tower at the time of the accident.

The crew started the engines and, about 1940, made a radio transmission on the common traffic advisory frequency (CTAF) that they were taxiing the airplane from the southwest cargo area to Runway 22L.

While taxiing the airplane, the crew conducted a flight control check.

At 1942, the captain said, "Elevator forward … coming back."

The first officer said, "EPI [elevator position indicator] checks."

The DC-8 has two elevators that operate in unison through drive rods and a torque tube. A control tab is on the inboard section of each elevator.

"The [flight crew's] control columns are mechanically linked to the elevator-control tabs, and deflection of the control tabs in flight results in deflection of the elevators, which results in changes in the airplane's pitch attitude," the report said. "Each elevator-control tab is hinged to the inboard trailing edge of the associated elevator surface, then connected by a mechanical linkage (including a crank fitting, pushrod and bellcrank assembly) at the inboard edge of the tab to the flight-control system on that side of the airplane."

Geared tabs outboard of the control tabs reduce control force.

"As the elevators' positions change in relation to the horizontal stabilizer, linkages move the elevator geared tabs in the opposite direction, providing an aerodynamic boost to assist the control tabs in moving the elevators," the report said. "This reduces the amount of control force required from the pilots.

"Dampers are installed in each elevator leading edge at the inboard hinge location and provide an opposing force proportional to the rate of elevator movement to prevent elevator flutter."

The report said that the elevator controls normally operate as follows:

"When a pilot moves the control column forward (commanding an AND [airplane-nose-down] movement), the left and right elevator-control tabs deflect in a TEU [trailing-edge-up] direction, and the resultant aerodynamic forces drive the elevator surfaces in the opposite (that is, TED [trailing-edge-down]) direction, causing the airplane to pitch nose-down.

About the time the airplane reached rotation speed, the first officer began to move his control column forward to counter the unusual pitch-up.

"When a pilot moves the control column aft (commanding an ANU [airplane-nose-up] movement), the left and right elevator-control tabs deflect in a TED direction and the resultant aerodynamic forces drive the elevator surfaces in the opposite (TEU) direction, causing the airplane to pitch nose-up."

The accident airplane's EPI was located on the lower left side of the first officer's instrument panel. The EPI, which is 1.0 inch (2.5 centimeters) in diameter, has markings for "UP," "NEUT" (neutral) and "DN" (down).

The report said that installation of EPIs in DC-8s was required by airworthiness directive (AD) 78-01-15, which was issued by the U.S. Federal Aviation Administration (FAA) in 1978 "as a result of a series of accidents and incidents involving DC-8 jammed or restricted elevator surfaces."[1]

EPI location in DC-8s is not standardized.

"AD 78-01-15 specified that operators install the EPI gauge on the first officer's instrument panel such that full-forward movement of the control column and wheel would not obstruct the first officer's view of the gauge," the report said. "The AD did not comment regarding visibility of the gauge from the captain's seat. As a result, DC-8 operators installed the EPI where they found room for it and where the first officer could see it."

At about 1946, the first officer established radio communication with Sacramento Approach Control and requested release for an instrument flight rules (IFR) flight to Dayton. The controller released the flight and told the first officer to report airborne.

The crew conducted the "Before Takeoff" checklist and made a radio call on CTAF that they were taking off on Runway 22L and would conduct a left-downwind departure. At the time, the automated weather observation system (AWOS) indicated that surface winds were calm, visibility was greater than 10 statute miles (16 kilometers), temperature and dew point both were 46 degrees Fahrenheit (8 degrees Celsius) and that there were scattered clouds at 2,000 feet and a broken ceiling at 7,000 feet.

"According to postaccident interviews with witnesses, the ceiling and nighttime visibility at [the airport] were such that the witnesses could clearly observe the airplane as it taxied from the ramp to the runway, took off, climbed out and turned to return to the airport," the report said.

The crew conducted an "80-knot elevator check" during the takeoff roll. Emery's procedure called for the pilot flying to monitor the EPI for response to control-column movement while moving the control column full-forward and then releasing the control column so that it moves slightly forward of its neutral position.

At 1948:50, the captain said, "Eighty knots."

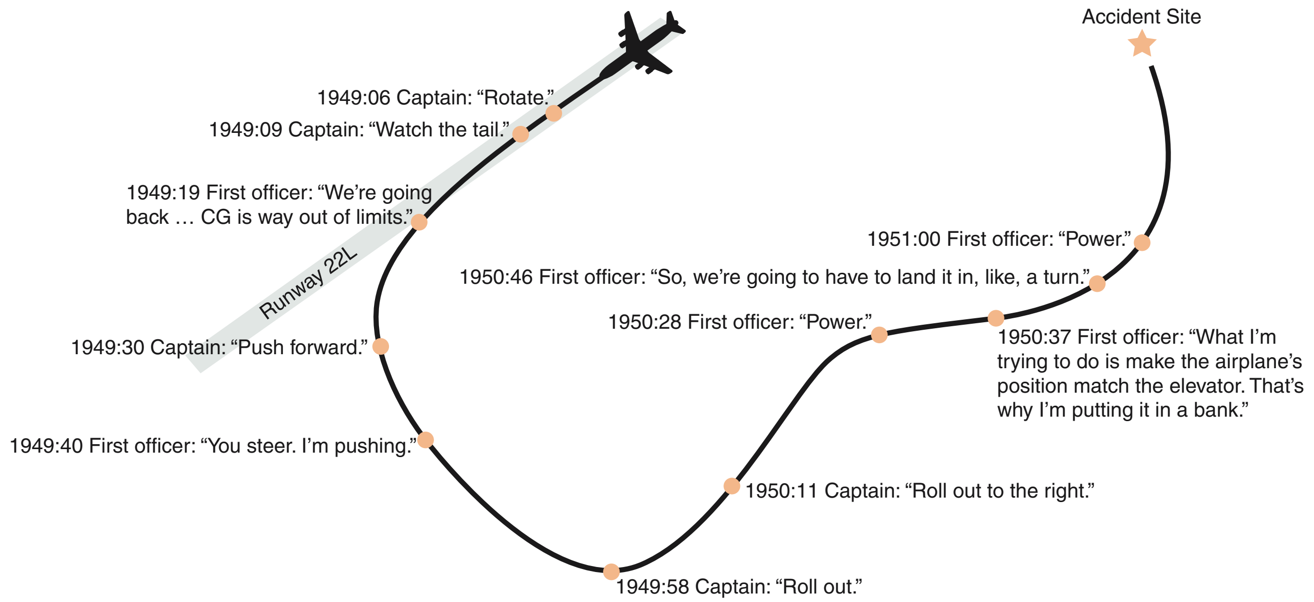
The first officer said, "Eighty knots … elevator checks."

At 1949:02, the captain said, "V one." V_1 (takeoff decision speed) was 126 knots. Four seconds later, he said, "Rotate" (Figure 1, page 4). Rotation speed was 146 knots.

The report said that flight data recorder (FDR) data and CVR data indicate that although neither pilot had moved his control column aft, the airplane began to pitch up before reaching rotation speed. About the time the airplane reached rotation speed, the first officer began to move his control column forward to counter the unusual pitch-up. About four seconds later, the first officer began to apply nose-down stabilizer trim.

FDR data indicated that although nose-down control column pressure and full nose-down trim were maintained throughout

Ground Track and Selected Cockpit Voice Recordings; Emery Worldwide Airlines Flight 17; McDonnell Douglas DC-8-71F; Rancho Cordova, California, U.S.; Feb. 16, 2000



CG = Center of gravity

Source: U.S. National Transportation Safety Board

Figure 1

the flight, the trailing edge of the elevator never moved below the neutral position.

At 1949:09, the captain said, "Watch the tail."

The airplane lifted off the runway about 1949:12 and entered a left turn.

About 1949:13, the captain said, "V two." V_2, the takeoff safety speed, was 158 knots. He then said, "Positive rate."

By this time, the airplane's pitch attitude had increased to 18.3 degrees nose-up.

The first officer said, "I got it."

The captain said, "You got it?"

"Yep," the first officer said.

"All right," the captain said.

Two seconds later, at 1949:19, the first officer said, "We're going back. … CG is *way* out of limits."

By 1949:22, the airplane's left bank had increased to about 35 degrees.

The flight engineer said, "Do you want to pull the power back?" No verbal response was recorded; but two seconds later, the CVR recorded a sound similar to decreasing engine speed and a sound similar to stick-shaker [stall-warning system] activation.

The first officer voiced an expletive.

The captain said, "Push forward."

The first officer said, "You steer. I'm pushing."

Between 1949:30 and 1949:40, the airplane's left bank decreased to about 13 degrees, increased to 25 degrees, then decreased to about 12 degrees. The airplane began to descend from 1,037 feet.

The flight engineer said, "We're sinking. We're going down, guys."

During this time, the captain told the Sacramento departure controller, "Emery seventeen has an emergency … extreme CG problem."

After the controller said "roger," there was no further radio communication between the flight crew and the controller.

"Throughout the accident flight, the airplane rolled and pitched and climbed and descended, as the pilots tried different combinations of flight-control inputs and engine-power settings to counter the airplane's uncommanded pitch-up while they attempted to maneuver back to the runway," the report said.

The landing gear lever was not found after the accident; the report said that CVR information and other information indicate that the landing gear remained extended throughout the flight.

At 1949:46, the CVR recorded a sound similar to increased engine speed and then a ground-proximity warning system (GPWS) warning: "whoop whoop pull up."

The CVR recorded several more GPWS warnings during the accident flight.

The airplane was descending through 679 feet and its left bank was increasing through about 11 degrees at 1949:47, when the first officer said, "Power."

The airplane descended to 601 feet, then began to climb. The airplane was climbing through 625 feet at 1949:52, when the captain said, "All right, all right … all right."

"Throughout the accident flight, the airplane rolled and pitched and climbed and descended …"

The airplane was climbing through 673 feet at 1949:54, when the first officer said, "Push."

As the airplane climbed, its left bank increased. By 1949:56, the bank angle had increased to about 45 degrees.

At 1949:58, the captain said, "Roll out."

The CVR recorded the "sound of strained exhale" twice during the next 10 seconds.

FDR data indicated that about 1950:04, the airplane was at 901 feet and that its bank angle had decreased to about 33 degrees left.

"FDR data indicated that the airplane continued to climb and [that] its bank continued to decrease during the next six [seconds] to seven seconds," the report said.

At 1950:11, the captain said, "Roll out to the right."

The first officer said, "OK … push. Push forward."

"For the next four seconds, the airplane continued to fly on a north-northeasterly heading, approximately parallel to the departure runway at an altitude of about 1,000 feet," the report said. "During the next 10 seconds, the airplane banked right to an east-northeasterly heading, then climbed, reaching 1,087 feet (the maximum altitude obtained for the accident flight) about 1950:18, before it began to descend again."

About 1950:26, the flight engineer said, "You got the trim maxed?"

The first officer said, "Power."

"More?" the flight engineer said.

"Yeah," the first officer said. "We're going to have to land fast."

The airplane's roll attitude changed from a right bank to a left bank, and the captain said, "Left turn."

The first officer said, "OK. … What I'm trying to do is make the airplane's position match the elevator. That's why I'm putting it in a bank."

"All right," the captain said.

"So, we're going to have to land it in, like, a turn," the first officer said.

About this time, the airplane was abeam the threshold of Runway 22L and turning toward the airport.

The airplane was turning through a heading of about 035 degrees at 1950:47, when the captain said, "Bring it around." The CVR then recorded a sound similar to the stick shaker. One second later, the captain again said, "Bring it around."

The airplane was turning through a northerly heading and descending through about 770 feet at 1950:54, when the first officer said, "You got the airport?"

The captain said, "Bring it around."

At 1951:00 and again at 1951:07, the first officer said, "Power." At the time, the airplane was turning through a heading of about 308 degrees and descending through 224 feet.

At 1951:07, the first officer voiced an expletive. One second later, the CVR recorded a sound similar to impact.

The airplane was in a left-wing-low and slightly nose-up attitude when it struck the ground about one nautical mile (two kilometers) east of the runway threshold.

"The accident airplane's left wing tip contacted a concrete-and-steel support column for an overhang attached to a two-story building located adjacent to the southeast edge of the salvage yard," the report said. "The airplane subsequently impacted the vehicles and pavement in the salvage yard; many vehicles in the salvage yard were damaged or destroyed by impact and post-impact fire."

The Sacramento County Coroner's Office found that the captain and the flight engineer died of thermal injuries and traumatic injuries, and that the first officer died of thermal injuries and inhalation of combustion products.

Tissue specimens from the flight crew tested negative for drugs of abuse, prescription medications and over-the-counter medications.

The ground-support personnel who were involved in unloading and loading cargo aboard the airplane were not required to submit to drug/alcohol testing after the accident because they are not included among those defined in U.S. Federal Aviation Regulations (FARs) Part 121 as performing a "safety-sensitive function." (The report said that flight crewmembers, flight attendants, flight instructors, aircraft dispatchers, aircraft maintenance/preventive maintenance personnel, ground-security coordinators, aviation screeners and air traffic controllers are among those defined as performing safety-sensitive functions.)

"Although not required, voluntary drug tests were eventually conducted on eight cargo handlers, a load planner and the ramp supervisor involved with the accident flight," the report said. "Samples were taken from the 10 tested employees between one [day] and six days after the accident; two of the 10 employees [a cargo handler and the load planner] tested positive for drugs and were subsequently relieved of their duties."

The report said that although the performance of the cargo-handling personnel was not a factor in this accident, improper cargo loading has been involved in other accidents.

"The way cargo-handling personnel conduct their duties … can have a significant effect on the safety of flight," the report said.

The bolt, washer and castellated nut that attached the right elevator-control-tab crank fitting to the pushrod were not found. The cotter pin that secured the castellated nut in place also was not found.

"The aluminum control-tab-crank fitting and the aft end of the pushrod were intact and exhibited no evidence of internal damage, indicating that the bolt was not in place at impact," the report said. "By contrast, the aft end of the left control-tab pushrod … showed evidence of damage consistent with the bolt having been in place until impact; it was fractured."

The report said that failure of the castellated nut or the cotter pin was unlikely; therefore, the bolt must have separated because it was not secured properly and inspected properly during the airplane's most recent major inspection or during subsequent maintenance.

Current FARs Part 25 airworthiness standards for transport category airplanes require two separate locking (securing) devices for every fastener used in critical flight control attachments. The DC-8, however, was certified under the earlier airworthiness standards of Civil Aviation Regulations (CARs) 4b, which did not require dual-locking devices.

The report said that the bolt moved out of the right crank fitting and pushrod at some time between the airplane's departure from Reno and its takeoff roll at Rancho Cordova. No longer attached to the pushrod, the control tab deflected TED. As aerodynamic forces increased during the takeoff, the trailing edge of the control tab began to move upward, but the crank fitting contacted the disconnected pushrod, preventing further TEU movement of the control tab.

The DC-8 was certified under the earlier airworthiness standards of Civil Aviation Regulations (CARs) 4b, which did not require dual-locking devices.

"During the accident flight, the aerodynamic forces acting on the extreme TED-deflected right control tab would have driven both elevator surfaces abnormally TEU, resulting in a strong airplane nose-up elevator effect … regardless of the flight crew's inputs," the report said.

The most recent major inspection of the accident airplane was a D inspection conducted by Tennessee Technical Services (TTS) on Aug. 27, 1999, through Nov. 17, 1999. D inspections, which include an overhaul of the airplane, are required every 12 years.

During the D inspection, the airplane's elevators, elevator-control tabs and geared tabs were replaced with overhauled units and installed using hardware from TTS stock. The work card for the installation contained a reference to a section of Emery's DC-8 maintenance manual (MM).

"However, this section of the Emery DC-8 MM did not contain a list of (or other guidance specifically detailing) the required hardware for the proper installation and security of the control-tab crank fitting/pushrod attachment or detailed steps regarding the inspection of this attachment," the report said.

The MM contained a reference to a figure in Emery's DC-8 illustrated parts catalog (IPC).

"This IPC figure then referenced another IPC figure, which identified [by part number] the drilled-shank alloy steel bolt, washer and castellated nut required for this installation but did not identify the cotter pin required to secure the bolt in this installation," the report said.

On May 8, 2002, The Boeing Co., which merged with McDonnell Douglas in 1997, issued temporary revisions to the DC-8 MM, instructing operators to connect the control tab pushrod to the tab crank fitting by installing a bolt, a washer and a nut, tightening the nut and securing the nut with a cotter pin.

Boeing told NTSB that it did not plan to make similar revisions to the DC-8 IPC because the IPC "was not intended to be used for installation and assembly." Boeing said, "The IPC does, however, relate the specific part to the appropriate installation drawing, which is what the mechanic should be using to assemble and/or install components on an airplane."

The report said, "Emery did not list Boeing's DC-8 installation drawings in its DC-8 maintenance policy and procedures manual as a reference document, and TTS stated that Emery did not provide them with Boeing's DC-8 installation drawings."

None of the TTS maintenance technicians or inspectors interviewed by investigators specifically recalled the work they performed on the accident airplane.

One TTS inspector who was involved in installing the right elevator assembly said that the area where the elevator control tab crank fitting is attached to the pushrod would have been inspected at least three times.

"Specifically, he said that TTS mechanics were not allowed to close a panel/fairing unless an inspector was there to inspect the area and witness the closing of that panel/fairing," the report said. "The TTS inspector stated that he would only stamp the work card for the elevator control tab installation after he had touched the cotter pin to ensure proper installation."

"TTS stated that Emery did not provide them with Boeing's DC-8 installation drawings."

During the D inspection, the accident airplane's Loral Fairchild (now L3 Communications) F800 FDR, which originally recorded six data parameters, was upgraded to record 17 data parameters.

Although the data recorded by the FDR during the accident was of good quality, investigators found the following anomalies:

- Whenever electrical power was discontinued, the FDR switched to the first track of its six-track tape. As a result of the anomaly, the FDR, which is designed to record 25 hours of data, provided only eight hours, 11 minutes of data.

- Recorded elevator-deflection data were 11 degrees greater than actual elevator deflections.

Elevator-deflection-data anomalies were found in data from the FDRs in other Emery DC-8s. The report said that Emery conducted a full FDR data correlation for the FDR in only one of its DC-8s, as permitted by Part 121.343(j). The correlation was conducted with the FDR in the accident airplane.

"The correlation for the accident airplane was applied to the rest of Emery's DC-8 fleet as their FDRs were upgraded," the report said. "The actual control-surface positions on those airplanes were not measured."

During a flight in the accident airplane on Nov. 25, 1999, (eight days after the D inspection was completed), a pilot reported that he had to apply more back pressure than normal on the control column to conduct an elevator check before takeoff and to flare the airplane for landing. Emery maintenance technicians found that the elevator dampers were reversed (i.e., the damper for the right elevator was installed on the left elevator, and the damper for the left elevator was installed on the right elevator).

"According to the lead mechanic, maintenance personnel did not check cable tensions, access the elevator control tab pushrod fairing, rig the elevator control or geared tabs, or discover any obstructions to control column movement during the troubleshooting efforts," the report said.

Emery maintenance technicians removed the elevator dampers, reinstalled them in their correct locations, conducted a visual inspection and checked control-column feel. One maintenance technician involved in the work told investigators, "It seems to me that the flight controls, after swapping of the dampers, felt smoother."

On the night of Jan. 21, 2000, a B-2 inspection of the accident airplane was conducted at Emery's facility in Dayton. A B-2 inspection, one of a series of four B inspections conducted at 136-hour intervals, includes inspection of the empennage and lubrication of the flight controls.

One of the work cards for the B-2 inspection stated that maintenance technicians should "visually inspect elevators and tabs for general condition, corrosion, leakage and security of attachment."

"Because of the DC-8 elevator assembly design, the elevator control tab inboard fairing would have to be removed for maintenance personnel to inspect the inboard hinge fitting and crank fitting/pushrod attachment," the report said.

Investigators found that the accident airplane's elevator geared tab crank arms were fractured. An examination of DC-8 elevator-related service difficulty reports (SDRs) submitted during the five years preceding the accident revealed six SDRs on fractured crank arms.

"One of these was detected during an elevator ground check, one was detected in flight, and four were detected during elevator checks during the takeoff roll, resulting in aborted takeoffs," the report said.

Fractured elevator geared tab crank arms also were found after a jammed elevator on a DC-8-71F caused a Tampa Airlines flight crew to reject a takeoff on Dec. 12, 2002. Tampa Airlines personnel believe that the crank arms were fractured before takeoff, when the DC-8 was struck by jet blast from a DC-10.

The report said that in April 1977, McDonnell Douglas Corp. issued Alert Service Bulletin (ASB) 27-262 after fractured geared tab crank arms caused the elevators on several DC-8s to jam. The ASB recommended that the elevator gust locks be engaged when the airplanes are parked to prevent elevator damage caused by wind or jet blast. In July 1977, the company issued Service Bulletin (SB) 27-262 recommending in part that aluminum geared tab crank assemblies be replaced with forged stainless steel assemblies.

AD 78-01-15 required operators to comply with specific recommendations in SB 27-262. The AD, however, did not require the replacement of aluminum crank assemblies with stainless steel crank assemblies.

The report said that DC-8 operators' pilot-training procedures and airplane operating procedures should emphasize the importance of checking the symmetry of the elevators and tabs during preflight inspection.

Emery's DC-8 operating manual required that the alignment and condition of the elevators and tabs be checked during the preflight inspection and said that, with the gust lock disengaged, "elevator should be up, control tabs up and geared tabs down."

The report said that this guidance is accurate but does not emphasize sufficiently the importance of checking the symmetry of the elevators and tabs.

"Although it was not possible to determine what position the control tabs were in during the flight engineer's preflight inspection of the airplane, if the right elevator control tab was disconnected when the preflight inspections were conducted, an asymmetry between the right and left control tabs would likely have existed," the report said.

In June 2001, Boeing issued a flight operations bulletin (FOB) that included the following recommendation:

> The proper functioning of the flight controls should be verified before every flight. If the exterior walk-around is made … with the gust lock released, the elevators and control tabs should be positioned toward UP (symmetrically) and the geared tabs DOWN (again symmetrically).

The report said that the procedures in effect at the time of the accident for the 80-knot elevator check minimized the use of the EPI as a go/no-go tool.

"The 80-knot elevator check provides flight crews with their last chance to detect abnormal elevator performance (which could result from foreign object damage, fractured geared tab arms, mechanical failure … and/or damage to components that might have occurred since the earlier elevator checks) before the airplane lifts off the runway," the report said.

Although Emery's guidance for the use of the EPI during elevator checks was found to be among the most thorough in the industry (five of six other DC-8 operators did not recommend use of the EPI during the 80-knot elevator check), it did not specify what the EPI indications should be during the 80-knot check.

The report said that the procedures in effect at the time of the accident for the 80-knot elevator check minimized the use of the EPI as a go/no-go tool.

The company's DC-8 operating manual said that when the control column is moved full forward during the *ground* elevator check, the EPI needle should point between the neutral mark and the down mark. During the 80-knot check, however, the flight crew is advised only to check that the EPI needle responds to control column movement.

"Postaccident interviews with Emery personnel and FDR data indicate that Emery's pilots used the EPI, but only to confirm elevator response in the proper direction," the report said. "Observation of EPI needle movement below the neutral mark during the 80-knot elevator check would provide a more quantitative determination that the elevator was functioning properly."

The EPI needle likely did not move below the neutral mark during the accident flight crew's 80-knot elevator check.

"The flight crew appeared satisfied with the results of the 80-knot elevator check and continued the takeoff roll," the report said. "However, because the aerodynamic forces acting on the elevator and control tabs would have been significant as the airplane accelerated during the takeoff roll, the abnormal control-tab condition would have prevented the elevator from moving to its full TED position.

"Therefore, under the circumstances of this accident, the EPI needle would not have moved below the neutral mark during the 80-knot elevator check, thus providing an indication that the elevator was not fully operational."

During post-accident tests in an Emery DC-8-71F, investigators found that the EPI in the test airplane was not calibrated properly; when full-down elevator control was applied, the EPI needle moved about 75 percent of the distance between the neutral mark and the down mark. The report said that EPIs should be calibrated periodically.

The report said that the findings of the investigation were the following:

- "The captain, first officer and flight engineer were properly certificated and qualified and had received the training and off-duty time prescribed by federal regulations and company requirements. No evidence indicated any preexisting medical [conditions] or behavioral conditions that might have adversely affected the flight crew's performance during the accident flight;

- "The accident airplane was certificated, equipped and dispatched in accordance with applicable regulations and industry practices;

- "Cargo loading for the accident flight was routine, and the airplane was operating within prescribed [CG] limits;

- "Weather and air traffic control were not factors in this accident;

- "At some time after the previous takeoff (from Reno, Nevada) and before the accident takeoff roll, the bolt connecting the right elevator control tab crank fitting to the pushrod migrated out of the fitting, allowing the control tab to disengage from its pushrod and shift to a [TED] position;

- "When the aerodynamic forces increased as the airplane accelerated during the takeoff roll, the right elevator control tab crank fitting contacted the disconnected pushrod, restricting that control tab's further [TEU] movement and leaving it in an extreme [TED] deflection;

- "As a result of the right elevator control tab's extreme [TED] deflection, the accident airplane's elevator surfaces were driven to command an extreme [ANU] pitch attitude; despite the large nose-down forces the pilots applied to the control columns, the pilots were unable to overcome the effects of the restricted right elevator control tab;

- "The bolt attaching the accident airplane's right elevator control tab crank fitting to the pushrod was improperly secured and inspected, either during the most recent D inspection or subsequent maintenance; however, [NTSB] was unable to determine when this improper securement and inspection occurred;

- "DC-8 operators' procedures and training should more clearly emphasize that DC-8 flight crewmembers need to verify symmetry between the right[-side] and left-side elevators, control tabs and geared tabs during the preflight inspection;

- "DC-8 operators, including Emery, do not use the [EPI] to confirm elevator movement indications above and below the neutral range during the 80-knot elevator check and, thus, do not take full advantage of the EPI's capabilities to provide pilots with an indication of an abnormal elevator condition;

- "The [EPI] needs to be periodically calibrated to ensure that it provides the most accurate information possible to the pilots;

- "The [EPI] gauge should be readily visible to both pilots;

- "The circumstances of the Emery Flight 17 accident show that the current DC-8 design does not preclude a catastrophic result from a disconnection or failure of the existing control tab crank fitting to pushrod attachment;

- "There may be airplanes that were certificated to [CARs] 4b standards other than the DC-8 on which the disconnection of a critical flight control could have catastrophic results;

- "Replacement of the DC-8 aluminum elevator geared tab crank arms on DC-8 airplanes with stainless steel elevator geared tab crank arms would likely eliminate the possibility of a jam resulting from fractured geared tab crank arms;

- "DC-8 elevator rigging procedures should be fully addressed in a separate work card that specifically lists required inspection items, including verifying the security of elevator control tab attachments after the rigging is completed;

- "All DC-8 work cards related to critical flight controls should identify required inspection items as discrete tasks with individual inspection-signoff requirements;

- "All air carrier operators should provide maintenance personnel with more detailed information regarding the steps or actions that are necessary to satisfactorily accomplish a maintenance task;

- "The use of outdated, incomplete or otherwise unsuitable reference materials by maintenance personnel during the installation and/or assembly of airplane components can occur and is a potentially unsafe practice;

- "The use of a single airplane's [FDR] parameter correlation for all airplanes of the same type is inadequate to ensure accurate correlations for older airplanes that have been retrofitted to record additional FDR parameters;

- "Loral Fairchild Model F800 [FDRs] with unaddressed or unidentified track-switching anomalies may currently be in operation; [and,]

- "The current regulatory definition of safety-sensitive functions is too narrow for the issue of post-accident testing because it does not include cargo handlers, load planners and ramp supervisors, all of whom have a demonstrated potential to affect the safety of a flight."

Based on these findings, NTSB made the following recommendations to FAA:

- "Require all DC-8 operators to train DC-8 flight crewmembers to look for symmetry between the right-[side elevators] and left-side elevators, control tabs and geared tabs during preflight inspection, consistent with Boeing's June 2001 flight operations bulletin guidance;

- "Require the development of DC-8 80-knot elevator-check procedures that will ensure that pilots are clearly made aware of whether the elevator is functioning properly before the airplane lifts off, then require all DC-8 operators to incorporate these procedures into their training and normal operations. The procedures should contain specific guidance regarding an expected range of [EPI] needle movement (including EPI needle movement well below the neutral mark with forward control column movement) and specific criteria for aborting a takeoff as a result of an inadequate elevator-movement indication;

- "Require all DC-8 operators to incorporate periodic [EPI] calibration inspections into their maintenance programs to ensure that the EPI indications observed by pilots accurately represent the condition of the elevator;

- "Require DC-8 [EPIs] to be located and sized so that they are visible and usable for both the captain and first officer;

- "Require Boeing to redesign DC-8 elevator-control-tab installations and require all DC-8 operators to then retrofit all DC-8 airplanes with these installations such that pilots are able to safely operate the airplane if the control tab becomes disconnected from the pushrod;

- "Evaluate airplanes, other than the DC-8, certificated to [CARs] 4b standards to evaluate whether disconnection or failure of critical flight control systems could have catastrophic results and, if so, require that they also be redesigned and retrofitted and/or equipped with dual-locking devices to preclude such catastrophic results;

- "Require all DC-8 operators to replace all DC-8 aluminum elevator geared tab crank arms on their DC-8 airplanes with stainless steel elevator geared tab crank arms;

- "Require all DC-8 operators to create or revise DC-8 work cards to ensure [that] they specifically include a post-rigging inspection of the elevator assembly, including verifying the security of elevator-control-tab attachments;

- "Require all DC-8 operators to review their work cards related to critical flight controls and [to] revise them as necessary to ensure that appropriate tasks are identified as discrete tasks with individual inspection-signoff requirements;

- "Require all [FARs] Part 121 air carrier operators to revise their task documents and/or work cards to describe explicitly the process to be followed in accomplishing maintenance tasks;

- "Require all air carrier operators to either:

  – "Provide all pertinent maintenance personnel with the manufacturer's current installation drawings for pertinent airplanes, update those installation drawings as needed and require use of those drawings during installation and/or assembly of that airplane's components; or,

  – "List the IPC on that operator's operation specifications, provide maintenance personnel with up-to-date IPCs for reference, continue to update those IPCs as needed and require maintenance personnel to use the pertinent updated IPCs during installation and/or assembly of an airplane's components;

- "Require operators of airplanes manufactured before August 18, 2000, that have been retrofitted with additional [FDR] parameters in compliance with federal requirements and for which an operator maintains a common correlation document for that airplane type to conduct a full correlation of all such airplanes' FDR parameters at the airplanes' next required FDR maintenance inspection to verify accurate FDR system documentation and sensor function;

- "Require all operators of airplanes equipped with Loral Fairchild Model F800 [FDRs] to comply with Loral Fairchild Field Service Bulletins [DFR] 011 and DFR 027 for recorders with applicable part numbers and installed component numbers;

- "Require overhaul facilities that service Loral Fairchild Model F800 [FDRs] to monitor those recorders to determine whether abnormal track switching is occurring and to report any such findings to the [FAA] and the manufacturer; [and,]

- "Modify the list of safety-sensitive functions described in [FARs] Part 121, Appendixes I and J, to include all personnel with direct access to the airplane and a direct role in the handling of the flight, including cargo handlers, load planners and ramp supervisors."

[As of Oct. 15, 2003, NTSB was awaiting FAA response to the recommendations.]

The report said that in January 2000, about a month before the accident, FAA placed Emery under a "heightened state of oversight" because of numerous apparent violations of the FARs. During the next year and a half, FAA conducted several special inspections of the company and found more than 100 violations of the FARs, including:

- "Improper/inadequate repairs to mechanical irregularities, including numerous repetitive pilot write-ups of the same problem on the same aircraft over extended time periods;
- "Unapproved aircraft installations/alterations;
- "Operating unairworthy aircraft;
- "Not following the policies and procedures in their manuals;
- "Inadequate record keeping; [and,]
- "Failure to distribute and use current manuals."

In August 2001, Emery signed a letter of interim agreement with FAA, stating that it would cease operations until is resolved the safety issues identified during the FAA investigations. Subsequently, Emery told FAA that it did not wish to resume commercial air carrier operations and that it intended to dispose of its airplanes. In December 2002, the company returned its operating certificate to FAA.♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board Aircraft Accident Report NTSB/AAR-03/02: *Loss of Pitch Control on Takeoff; Emery Worldwide Airlines, Flight 17; McDonnell Douglas DC-8-71F, N8079U; Rancho Cordova, California; February 16, 2000*. The 124-page report contains illustrations and appendixes.]

Note

1. On Sept. 8, 1970, a Douglas DC-8-63F that was being operated on a ferry flight by Trans International Airlines rotated to an abnormally nose-high pitch attitude during takeoff from John F. Kennedy International Airport in Jamaica, New York, U.S. The airplane was between 300 feet and 500 feet above the ground when it rolled right, then rolled left to an inverted attitude and struck the ground. All 11 crewmembers were killed. In its final report on the accident (NTSB/AAR-71/12), the U.S. National Transportation Safety Board (NTSB) said that the probable cause was "loss of pitch control caused by the entrapment of a pointed, asphalt-covered object between the leading edge of the right elevator and the right horizontal spar web access door in the aft part of the stabilizer." The report said, "The restriction to elevator movement, caused by a highly unusual and unknown condition, was not detected by the crew in time to reject the takeoff successfully. However, an apparent lack of crew responsiveness to a highly unusual emergency situation, coupled with the captain's failure to monitor adequately the takeoff contributed to the failure to reject the takeoff."

   Among NTSB recommendations generated by the accident investigation was that the U.S. Federal Aviation Administration (FAA) should consider a requirement to install elevator position indicators (EPIs) in all DC-8s. In its reply to NTSB, FAA said that "the usefulness and value of [an EPI] would not justify the large cost and complexities of this installation."

   On March 5, 1975, McDonnell Douglas Corp. issued Service Bulletin (SB) 27-254, which recommended installation of EPIs in DC-8s. The NTSB report on the Emery Worldwide Airlines Flight 17 accident said, "[The company] indicated that the SB was released because of two instances of insufficient or abnormal elevator travel that were discovered by flight crews during preflight checks."

   FAA Airworthiness Directive (AD) 78-01-15 became effective on June 1, 1978. The AD required DC-8 operators to install EPIs in the airplanes within 18 months, unless EPIs already were installed in accordance with SB 27-254.

Further Reading From FSF Publications

FSF Editorial Staff. "Failure of Stabilizer-trim System Blamed for Crew's Loss of Control of MD-83." *Accident Prevention* Volume 60 (February 2003).

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FSF Editorial Staff. "Cargo Airplane Strikes Building During Rejected Takeoff." *Accident Prevention* Volume 57 (January 2000).

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