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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 10, 1987

In reply refer to: A-87-16 through -21

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
Washington, D. C. 20591

The Safety Board has investigated four recent Boeing 727 incidents involving structural failures in the landing gear due to corrosion. The first two incidents, which occurred in Denver, Colorado and Norfolk, Virginia, concern stress corrosion failures discovered in the main landing gear (MLG) actuator support link assembly. The third incident, which occurred in Memphis, Tennessee, involved failure of the MLG shock strut outer cylinder. The fourth incident, which occurred in Miami, Florida, involved the nose landing gear (NLG) uplock actuator rod end.

Main Landing Gear Actuator Support Link Assembly

On September 29, 1985, Ports-of-Call Flight 3196D, a Boeing 727-100, experienced a main landing gear (MLG) failure prior to landing at Denver. During gear extension for landing, the flightcrew reported hearing a loud "thud." Shortly thereafter, the flightcrew observed that a part of the MLG had torn a hole in the upper surface of the right wing. The captain declared an emergency and landed the airplane without further incident. 1/

The Safety Board's investigation of this incident disclosed a failure of the right MLG actuator support link, Boeing Part No. (P/N) 65-19657-5. The link failure permitted the outboard end of the MLG actuator beam to punch through the upper wing panel. In the process, a hydraulic line was severed and the "A" hydraulic system was lost. The "A" hydraulic system operates, among other things, the trailing edge flaps, leading edge flaps and slats, lower rudder, and half of the ailerons and elevators. The "B" hydraulic system was undamaged, even though "B" hydraulic lines run adjacent to the "A" lines in this area.

Less than 4 months later, on January 16, 1986, at Norfolk, Virginia, Eastern Air Lines Flight 366, a Boeing 727, experienced a similar MLG support link failure upon gear extension. 2/ The failure of the support link P/N 65-19657-8 also resulted in the puncture of the upper wing skin panel. However, the hydraulic systems were not damaged and the airplane was landed safely.

1/ NTSB Field Incident Report: DEN-85-IA-250. Incident Brief: File No. 5087.
2/ This occurrence was not a reportable incident and it was not fully investigated by the Safety Board. Therefore, there is no incident report or brief on this occurrence.

Investigators found discrepancies in the maintenance records of the incident airplanes described above. The operators' records mistakenly indicated that the airplanes involved were equipped with the newer -11 link assemblies. Consequently, the required repetitive inspections specified in AD 68-17-01 for the -5 and -8 link assemblies on the airplanes were not performed and the stress corrosion cracking went undetected until the link failed.

The MLG actuator support link assembly has a long history of maintenance problems. Over 17 years ago, on August 19, 1968, Airworthiness Directive (AD) 68-17-01 was issued as a result of support link failures on the Boeing 727 MLG. The AD, which was amended on June 15, 1971, required the support link assemblies P/N 65-19657-4, -5, -8, and -13 to be ultrasonically inspected for cracks every 1,000 hours or replaced with a newer -11 assembly.

On January 25, 1972, AD 71-26-01 was issued requiring the inspection and rework of P/N 69-19167-1 and -2 and P/N 69-44388-1 MLG support link shafts. The AD, which was amended on February 4, 1972, was to reduce the possibility of complete fatigue fracture of the support link shaft. A shaft failure would produce damage similar to that of a failed support link. AD-71-26-01 made mandatory Boeing Service Bulletin (SB) 727-32-196, which had been issued on September 16, 1971. The SB was again revised on October 21, 1977, to clarify inspection requirements of the support link shafts, to expand accomplishment instructions, and to add corrosion protection sealing requirements to shaft installation. The revised AD also required that the MLGs be inspected for chrome plate and that those found with chrome plate or cracks be either reworked or replaced with new P/N 69-19167-3 or P/N 69-44388-2 shafts as applicable.

Boeing also issued two Notices of Status Change to SB 727-32-196, one on May 19, 1978, and another on August 11, 1978. The May notice required additional rework, i.e., the use of wet sealant, to minimize stress corrosion of the shafts of some 727-100 airplanes and all 727-200 airplanes. The August notice also dealt with wet sealant installation of the link shaft.

On March 26, 1982, Boeing issued Service Bulletin (SB) 727-32-306, to improve the corrosion protection of the MLG support link assembly. The SB recommended that operators remove from service and discard all P/N 65-19657-4, -5, -8, and -13 support link assemblies. These assemblies were to be replaced with reworked P/N 65-19657-11, -15, and -16 assemblies, which would be designated as -18 link assemblies. Corrosion protection for these reworked link assemblies was improved by adding lubrication fittings and lubricated bushings. Furthermore, the newer support links were made from the more corrosion-resistant 7075-T73 aluminum alloy instead of the 7079 alloy. These improvements were recommended to eliminate the cracks and corrosion found on the MLG support link shafts resulting from the accumulation of water in the recessed bores of the support link assembly.

Service Bulletin 727-32-306 and AD 71-26-01 affect about 1,800 Boeing 727 airplanes, about 1,100 of which are of U.S. Registry. Many of these airplanes may be operating with the old support link assemblies, which are less stress corrosion resistant. In fact, Eastern Air Lines, which has 127 affected airplanes, was not aware of SB 727-32-306 prior to the incident in Norfolk. Nevertheless, Eastern now intends to comply with the service bulletin and estimates that the rework, to be done during landing gear overhauls, will take from 8 to 10 years to complete.

Although the failure to perform required maintenance caused the two link failures described above, the Safety Board believes that mandatory compliance with SB 727-32-306 and the revisions to SB 727-32-196 would significantly reduce the potential for such support link or link shaft failures to occur due to stress corrosion. This action would reduce the potential for a more serious accident by eliminating the older, less corrosion-resistant link assemblies with their need for repetitive inspection, and by providing added corrosion-protective sealing requirements to the link shaft installation.

Main Landing Gear Shock Strut Outer Cylinder

On January 9, 1986, a Boeing 727-232, operated by Delta Air Lines, experienced a collapse of the left MLG during a landing rollout at Memphis, Tennessee, while on a scheduled domestic air carrier flight. The airplane sustained minor damage and none of the 7 crew members or the 31 passengers were injured. An examination of the airplane after the incident revealed that the left MLG shock strut outer cylinder was broken near the top of the cylinder, about 5 1/2 inches below the trunnion centerline. 3/

The first leg of the flight, which originated at Little Rock, Arkansas, earlier in the morning, was uneventful, as was the scheduled start, taxi, and takeoff from Memphis. However, when the landing gear was retracted following takeoff from Memphis, there was an unsafe indication for the left MLG, as well as an illuminated landing gear door warning light. The captain decided to return to Memphis and execute a precautionary landing. When the gear was extended for landing, all three gears indicated down and safe and the Memphis Tower confirmed that the landing gear appeared to be down. However, after touchdown the left MLG collapsed, allowing the left wing to settle to the ground.

The broken shock strut from the left MLG was metallurgically examined at the Delta facility in Atlanta and at the Boeing Commercial Airplane Company facility in Renton, Washington. These examinations showed that fracture of the strut stemmed from an area of stress corrosion cracking that initiated on the outer diameter of the outer cylinder, beneath a stainless steel standoff clamp for the wheel brake hydraulic line. Fretting and corrosion pitting were found on the surface of the cylinder in the area contacted by the clamp.

Three other 727 aircraft MLG shock strut outer cylinders have developed stress corrosion cracks. Two of these cylinders were from the same airplane, a 727-200 series airplane operated by Trans Brazil. The cracks in these outer cylinders were discovered in 1981 during scheduled maintenance of the airplane, which had experienced a hard landing about three months before discovery of the cracks. The location of the stress corrosion cracking on both of these outer cylinders was very similar to the location of the stress corrosion cracking on the outer cylinder of the airplane involved in the Memphis incident. However, the finish on these two outer cylinders had been stripped prior to examination, removing evidence of possible fretting or damage to the cadmium and paint layers normally covering the surface. The third outer cylinder with stress corrosion cracks was from another airplane that had experienced a hard landing about 3 years before discovery of the cracked condition. Opening this crack revealed a shear lip directly adjacent to the outside diameter surface of the cylinder, with stress corrosion cracking features beneath the shear lip. Most likely, the shear lip had occurred during the hard landing and the stress corrosion cracking had progressed intermittently since that time.

3/ NTSB Field Incident Report: ATL-86-IA-054. Incident Brief: File No. 5002.

The Safety Board is concerned that the MLG shock strut outer cylinders on Boeing 727 airplanes are susceptible to stress corrosion cracking when the surface protection layers are damaged. It is interesting to note that mylar is used beneath the hydraulic line standoff clamps on the outer cylinders of the MLG of Boeing 747 airplanes to prevent damage to the protective surfaces which could lead to stress corrosion. Since cracking may lead to failure of the outer cylinder and to a serious accident, additional measures, such as the use of mylar, are necessary to ensure that the surface protection layers are not damaged by the standoff clamps.

Nose Landing Gear Uplock Actuator Rod End

On March 16, 1986, an Eastern Air Lines (EAL), Boeing 727-200 series airplane landed with the nose landing gear (NLG) up at Miami International Airport. 4/ The flight originated at New York, LaGuardia Airport, the previous night, March 15, 1986, and was uneventful until arrival in the Fort Lauderdale, Florida area. At that time, the flightcrew reported problems with the right MLG. The flight was diverted to Miami International Airport and circled for an hour while attempting to remedy the right MLG unsafe indication by manually cycling the right MLG. After the flightcrew manually lowered the right MLG for the final time, an unsafe NLG was indicated. The captain then elected to land due to the low fuel condition (4000 lbs.) with the NLG retracted and the NLG doors closed. He did not attempt to lower the NLG manually. The captain was apprehensive that he might compromise the MLG position by placing the landing gear handle in the neutral position with the "A" hydraulic system off. The aircraft sustained minor damage and one passenger reported minor injuries.

Interviews with the flightcrew after the incident and readout of the cockpit voice recorder (CVR) revealed that the right MLG may have extended on the first attempt even though an unsafe indication was present in the cockpit. However, the flightcrew indicated that they did not visually check the MLG position indicator beneath the floor in the passenger cabin before attempting to manually lower the right MLG. It was subsequently determined that the unsafe gear indication in the cockpit did not reflect an actual unsafe condition of the right MLG but was caused by an electrical failure of the logic resolution circuitry of the landing gear system.

Examination of the NLG assembly indicated that the rod end on the unlock actuator was broken, which prevented hydraulic release of the NLG from the up and locked position. After the incident, the airplane was raised and the NLG manually lowered from the cockpit. This procedure, if done in flight, would have had no effect on the MLG position. Therefore, it appears likely that the crew could have manually extended the NLG prior to landing.

Metallurgical examination of the failed NLG uplock actuator rod end, P/N 69-30537-4, disclosed that the rod end separation was the result of severe corrosion on the threaded shank of the rod end; heavy corrosion was also found on the mating threads of the uplock actuator.

Like the MLG support link assembly, the NLG uplock actuator rod end has a long history of maintenance problems. Almost ten years ago, on June 9, 1976, EAL had a similar failure of an NLG uplock actuator rod end, P/N 69-30537-3, on airplane N8825E. The failure was the result of stress corrosion cracking in the rod end threads.

4/ NTSB Field Incident Report M1A-86-IA-088. Incident Brief: File No. 5008.

Less than 3 months later, Boeing issued a Service Letter (SL) that addressed the problems associated with failures in NLG uplock actuator rod ends P/N 69-30537-1, -3 and -4. In SL 727-SL-32-7, dated September 3, 1976, Boeing recommended that all operators replace -1, -3, and -4 NLG uplock actuator rod ends with the improved -7 rod ends. The new improved -7 rod ends incorporated a larger thread relief diameter and rolled threads, to increase the fatigue life of the rod end, and a new bearing to improve the service life. Revision A of this SL, released on November 22, 1985, reiterated the original SL recommendation and modified the rod end installation torque values.

Between October 1980, and April 1986, there were 53 Service Difficulty Reports (SDR) on NLG uplock actuator problems. Twelve of the SDRs specifically cited problems with the actuator rod ends. Of these, seven reported rod ends to have failed or broken. Two other reports cited corrosion of the rod end threads. The Safety Board believes that corrosion has contributed to more rod end separations than any other cause, even in the absence of SDRs specifically citing corrosion as the cause of the failure.

Failure of the uplock actuator rod end in itself does not prevent manual extension of the NLG. When combined with a flightcrew's lack of knowledge of the hydraulic system, however, failure of the rod end can endanger the safety of the passengers. Since many of the older rod ends are still in service, and corrosion of the rod end threads has not been adequately addressed, the Safety Board believes that further action is required.

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

> Issue an Airworthiness Directive requiring the replacement of all P/N 65-19657-4,-5,-8, and -13 main landing gear support link assemblies with -18 assemblies on Boeing 727 airplanes in accordance with Boeing Service Bulletin 727-32-306, "Main Landing Gear Actuator Beam Support Link Replacement or Rework," dated March 26, 1982, by a specified date. (Class II, Priority Action) (A-87-16)
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> Amend Airworthiness Directive 71-26-01 to clarify inspection instructions, add corrosion protection sealing requirements for link shaft installation, and require the replacement of cracked link shafts with P/N 69-19167-3 or 69-44388-2 shafts where necessary as prescribed in Revision 2 of Boeing Service Bulletin 727-32-196, "Main Landing Gear Actuator Beam Support Link Shaft Inspection and Rework," dated October 21, 1977, by a specific compliance date and include all Notices of Status Change to the service bulletin. (Class II, Priority Action) (A-87-17)
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> Issue a Maintenance Alert Bulletin to all operators of Boeing 727 airplanes, informing them of instances and causes of cracked main landing gear shock strut outer cylinders, so that the operators can take appropriate action to ensure the integrity of the landing gears on their airplanes. (Class II, Priority Action) (A-87-18)
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> Require that the manufacturer develop and prescribe measures to reduce the potential for stress corrosion of the Boeing 727 main landing gear shock strut outer cylinder caused by contact with hydraulic line standoff clamps and require that the Boeing 727 maintenance manual be revised to include these prescribed measures. (Class II, Priority Action) (A-87-19)

Issue an Airworthiness Directive to require that all installed 69-30537-1, -3, and -4 nose landing gear rod ends on Boeing 727 airplanes be replaced with the 69-30537-7 rod end assembly at the next letter check inspection and to require recurrent inspection of the threaded area of all nose landing gear uplock actuator rod ends for evidence of corrosion and removal from service of any rod end found to be significantly corroded. (Class II, Priority Action) (A-87-20)

Notify the foreign governments with operators of Boeing 727 airplanes of the circumstances of the Ports-of-Call incident in Denver, Colorado on September 29, 1985, the Eastern Air Lines incident in Norfolk, Virginia on January 16, 1986, the Delta Air Lines incident in Memphis, Tennessee on January 9, 1986, and the Eastern Air Lines incident in Miami, Florida on March 16, 1986, and inform them of any action taken as a result of these incidents. (Class II, Priority Action) (A-87-21).

BURNETT, Chairman, GOLDMAN, Vice Chairman, and LAUBER and NALL, Members, concurred in these recommendations.

By: Jim Burnett
Chairman