SP-20
Log 1729

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: October 23, 1985

Forwarded to:

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

SAFETY RECOMMENDATION(S)

A-85-81 through -86

On November 11, 1983, at 1926, e.s.t, Eastern Air Lines (Eastern) flight 836, N812EA, a B-727-225A, with 152 passengers and 7 crewmembers aboard, took off from Miami International Airport, Miami, Florida. The flightcrew stated that the climbout was normal until the flight reached approximately 10,900 feet. At that point a loud bang was heard, followed by illumination of the red DOORS and red RIGHT GEAR warning lights above the landing gear lever. In accordance with prescribed procedures, the first officer moved the landing gear lever from the OFF to the UP position. Following the first officer's actions, the second officer reported loss of fluid and pressure in the A and B hydraulic systems. The primary flight controls reverted to manual operation, and the climb was terminated. 1/

The second officer attempted to view the right main landing gear and wheel well through an inspection port located in the cabin floor. However, because the wheel well lights had been damaged and did not illuminate, he could not see into the wheel well. He then used a flashlight but found that the wheel well side of the inspection port was coated with hydraulic fluid which obscured illumination and vision through the port.

The airplane then was flown over runway 27R at the Miami airport. Eastern observers on the ground reported that the right main landing gear doors were open but that the gear position could not be seen. Eastern flight 511, which was preparing for takeoff, reported to the tower and flight 836 that the right main landing gear doors were not fully open.

The captain decided to lower all landing gear using the emergency manual extension procedures. The second officer first extended the left main landing gear and the green LEFT GEAR light illuminated. He attempted then to extend the right main landing gear and noted that the manual extension system appeared to operate normally. However, the red RIGHT GEAR warning light remained illuminated. The nose landing gear was next extended and the green NOSE GEAR light illuminated. The captain then retarded one of the throttles and the landing gear warning horn activated, indicating that one or more landing gears were not down and locked.

1/ For more information read, Aircraft Accident/Incident Summary--"Eastern Airlines 727-225A, N812EA, Miami International Airport, Miami, Florida, November 11, 1983," (NTSB/AAR-85/01/SUM).

When a second fly-by over runway 27R was made, Eastern observers on the ground reported that the right main landing gear doors were open but the right gear was not extended. The second officer then made additional attempts to manually extend the right gear, and the captain maneuvered the airplane in an attempt to dislodge it. Both actions were unsuccessful.

The captain electrically extended the trailing edge flaps and, using the standby hydraulic system, hydraulically extended the leading edge flaps and slats with the alternate flap extension system. He landed the airplane on the extreme left side of runway 9R and decelerated the airplane using reverse thrust and pneumatic brakes. He attempted to keep the right wing off the runway as long as possible. When the right wing contacted the runway, the airplane veered to the right and departed the runway. The left main landing gear and the lower portion of the nose landing gear separated from the airplane. The nose gear punctured the right wing fuel tank, and fuel spilled out. The airplane stopped about 2,500 feet from the departure end and about 100 feet to the right (south) of runway 9R. One passenger's injury was classified as serious because of a hospital confinement in excess of 48 hours due to a preexisting cardiac condition. There was no fire; the airplane was substantially damaged.

The Safety Board's investigation determined that the No. 3 tire failed explosively in flight while retracted in its wheel well, due to massive ply separations around its crown, severely damaging the hydraulic lines for the A and B hydraulic systems running through the right wheel well. The origin of the ply separations was located along the chafer strip/toe bead area which had extensive previous damage from two sources--abrasion and excessive heat. Damage from either source would have allowed high-pressure nitrogen (approximately 175 psig) to enter the ply system under dynamic conditions, causing ply separation.

Eastern records showed that the No. 3 tire had been retreaded for the fifth time and the crown portion had been examined by holography in September 1983. No abnormalities were found. Sometime after the tire was retreaded and before it was mounted, the bead seat of the tire was sanded along several areas with an abrasive tool. The sanding penetrated the outer chafer strip and four cover plies exposing the plies wrapped around the toe bead. The investigation did not determine who performed the sanding. The sanding was not in accord with the guidelines of Federal Aviation Administration (FAA) Advisory Circular No. 145-4, "Inspection, Retread, Repair, and Alterations of Aircraft Tires," dated September 27, 1982, section 8.a., which describes acceptable industry practices regarding aircraft tire repairs. The Safety Board believes that Eastern should place increased emphasis on the guidelines set forth in FAA Advisory Circular No. 145-4, and that Thompson Aircraft Tire Corporation (TATCO), the retreader, should develop improved procedures for inspecting tire bead seat areas to determine if tires are suitable for retreading.

The bead seat area of the No. 3 tire also was examined for heat damage. Tests showed that the bead seat and chords wrapped around the toe bead had been subjected to excessively high temperatures (above 300 degrees F) for an extended time. This exposure had caused severe deterioration (detritus, reverted rubber, and loss of ply adhesion and tensile strength) of the bead seat and plies wrapped around the toe bead. The tests also indicated that the excessive heat originated from worn brakes and was transferred from the wheel to the tire.

In December 1983, following the accident, other tires in Eastern's B-727 fleet were inspected for ply separation, and three other massive ply separations in tires were found. The ply separations, which were similar to those found in the accident airplane's No. 3

tire, were not noticeable while the tires were inflated but were found after deflation. None of the tires had abrasions along the bead seats. Examinations and tests showed essentially the same deterioration of the toe bead from repeated exposure to excessive heat as was found on the accident airplane's No. 3 tire.

The location of the ply separations in all four tires (i.e., at or near the toe bead) indicates that the routine holography inspections limited to the crown portion of newly retreaded tires are inadequate to detect ply separations at the toe bead and along the sidewall. On January 6, 1984, TATCO and Eastern began a complete bead-to-bead holography inspection of tires in Eastern's B-727 fleet. The results of the program through March 31, 1984, showed a substantial increase in tires rejected for heat-related defects over the same period in 1983.

The most likely source of the excessive heat that damaged the tires was the brakes. New B.F. Goodrich (BFG) brake lining cups were installed by Eastern on its B-727 fleet around June 1983. BFG issued Service Bulletin No. 418 on July 25, 1983, followed by an FAA Notice N8320.288 on September 23, 1983, which stated, in part, that these lining cups caused accelerated brake rotor wear that could result in the rotors becoming worn below minimum thickness. Wear-down of rotors below minimum thickness causes progressively higher brake temperatures for the same energy dissipation. As brake temperatures rise above normal limits, more heat is transferred to the wheels and then to the tire bead seat areas which gradually deteriorate. The deterioration of the tires becomes progressively worse with repeated exposures to higher than normal temperatures.

BFG Service Bulletin No. 418 recommended removal of a sample of affected brakes and measurement of rotor thickness; if the rotor thickness was found to be less than the minimum required, the brakes were to be removed from service. After examining the No. 3 tire on the airplane, the three additional tires found with massive ply separations, and the results of the bead-to-bead holography inspection program following the accident, the Safety Board concludes that these data show that BFG Service Bulletin No. 418 does not provide adequate warning that tire damage is also possible from continued use of the "new" brake lining cups. The service bulletin should require removal of all affected brake lining cups on a priority basis.

The Safety Board believes that the FAA should issue an advisory circular describing the damage that can occur to tires in the event of overheated brakes. It should emphasize the importance of periodically inspecting bead seat areas for heat damage in accordance with Advisory Circular No. 145-4 and the need to perform bead-to-bead holograms in addition to visual inspections. It should recommend that whenever brake linings are suspected of causing faster-than-normal rotor wear or higher-than-normal brake temperatures for any reason, they should be replaced as soon as possible and in the interim braking procedures should be modified to minimize heat damage to tires.

The hydraulic lines for the A and B hydraulic systems running through the right wheel well were damaged severely at several locations by the explosion of the No. 3 tire. Hydraulic fluid and pressure in the B system were lost when the line between the main brake accumulator and the brake pressure switch was severed. Moreover, since this portion of the B system is pressurized continuously at 3,000 psig, the flightcrew could have done nothing to prevent the loss of B system pressure through this line. Since there is a balance line between the B system and A system reservoirs, about half of the volume in the A system reservoir was lost immediately through the B system leak. This left only about 2.5 gallons of fluid remaining in the A system reservoir.

The remaining fluid in the A system was lost through a severed line, which normally pressurizes the main landing gear lock actuator and the wheel retraction brake, when the first officer moved the landing gear from the OFF to the UP position. This line is part of the main landing gear retraction system. When the cockpit gear handle is in the OFF position, hydraulic pressure is relieved on all landing gear hydraulic lines and actuators, and the line is pressurized only when the cockpit gear handle is placed in the UP position. The first officer's action of placing the gear handle in the UP position pressurized all landing gear retraction lines, including the line which was severed. This circumstance resulted in the further loss of fluid and complete loss of pressure in the A system.

The first officer's action of placing the gear handle in the UP position and leaving it there was in accordance with the B-727 Operations Manual which states:

> If landing gear door light illuminates during climb, cruise, or descent, position landing gear lever UP and observe gear door warning light extinguishes. Leave landing gear lever in UP position. If gear door warning light does not extinguish, observe landing gear operating speed limit. Expect performance penalties.

As a result of its investigation of this accident and five similar tire blowout incidents, 2/ the Safety Board believes, in circumstances which point to a tire explosion in a wheel well, that: (1) this procedure is inappropriate; (2) a specific new procedure is needed; and (3) flightcrews should be trained in procedures to extend the landing gear in such a manner as to not jeopardize hydraulic systems which might provide pressure for the primary and secondary flight control systems.

There is nothing to be gained by placing the gear handle in the UP position following the explosion of a tire in a wheel well. The open landing gear doors, if still attached to the airplane, probably would be damaged extensively (i.e., torn from actuator, hinges broken, buckled, etc.) so that they could not be retracted; most likely, based on the accident and the five previous incidents, the doors would be blown off the airplane completely. However, the risk of losing the hydraulics systems is high when the gear handle is moved from the OFF position. Both the A and B hydraulic system lines in the wheels wells are highly vulnerable to being damaged and/or severed by an exploding tire in a wheel well. If the B system already has been lost due to the explosion, as occurred in this accident and one of the previous incidents, the flightcrew encounters an unnecessary risk of losing all hydraulics by moving the gear handle from the OFF position. Normal procedures require that the gear handle be placed in the OFF position after the gear has been retracted in order to isolate the landing gear components of the A system from other critical components powered by the system (i.e., elevators, ailerons, lower rudder, outboard flight spoilers, leading edge slats and flaps, trailing edge flaps, and nosewheel steering). The procedures call for the landing gear components to be isolated because they are more vulnerable to wear and damage and might become the source of a loss of hydraulics.

2/ October 13, 1970, Western Airlines, B-727-200, B2801W; August 8, 1973, Braniff Airlines, B-727-100C, N1728T; May 25, 1974, United Air Lines, B-727-100C, N7415U; November 13, 1976, American Airlines, B-727-100, N1991; and December 22, 1980, Delta Airlines, B-727-200, N535DA.

This accident and the five previous incidents clearly show that no significant loss of airplane stability or controllability occurs when landing gear doors are blown open or severed from the airplane, although there is a loss in performance due to an increase in drag. However, in all occurrences, all the hydraulic lines in the wheel wells were damaged substantially. In this accident and one of the other incidents, both the A and B hydraulic systems ultimately were lost. In both cases, the A system was lost only when the flightcrews followed the Aircraft Operations Manual and put the gear handle in the UP position. The loss of all hydraulic power to the primary flight control system required that the airplanes be flown using the manual reversion flight control system. This substantially reduced the controllability and maneuvering capabilities of the airplanes. Also, the lateral-directional stability of the airplanes was reduced significantly because the yaw damper became inoperative. In all cases where tires have exploded in wheel wells, the associated door was severed from its actuator and was blown open making it impossible for it to be retracted. Therefore, placing the gear handle in the UP position serves no useful purpose and needlessly jeopardizes the integrity of the A hydraulic system.

The Safety Board believes that the safest action for the crew to take immediately following a possible explosion of a tire in a wheel well (i.e., loud bang followed by illumination of red DOORS warning light) is to leave the gear handle in the OFF position. The crew first should assess the airplane's stability and controllability (severed doors may strike and damage control surfaces or engines), then check the condition of the hydraulic systems, and finally check the condition of the landing gear system. During these checks the crew should take every precaution to not jeopardize the availability of hydraulic pressure for the flight controls. If this is done, at least a partial A hydraulic system will be maintained allowing the crew to land at the lower speeds associated with normal landing flaps instead of 15 degrees alternate flaps and to retain the capability of raising the flaps for a go-around if needed. Moreover, even a limited A system would allow a safer configuration in which to land and stop with pneumatic braking due to lower approach and touchdown speeds plus the controllability provided by ground spoilers and nose wheel steering. Flightcrews should be given specific training and procedures on how to check the condition of landing gear extension lines of the A hydraulic system in the wheel well so as to preserve any residual capacity. The training and procedures should be based, in part, on the discussions that follow.

The A and B system reservoir quantity gages indicate about 3.8 gallons and 1.8 gallons, respectively, with the landing gear retracted and with the brake system hydraulic lines in the wheel well intact. In the event of suspected damage, the crew should place the gear handle in the DOWN position and carefully monitor the A system quantity gage. Normally when the gear is extended, the A system quantity gage on the second officer's panel will indicate an increase of about 0.8 gallon. Therefore, if none of the A system hydraulic lines in the wheel well have been severed, the gage would indicate an increase in reservoir quantity as the gear extends. However, if one of the A system gear extension lines has been severed, the gear will not extend and the gage would indicate a decrease in quantity. If a decrease in quantity is seen, the handle should be returned immediately to the OFF position to preserve what is left in the reservoir. The flow rate through a fully open (i.e., not deformed) 1/4-inch A system line would be approximately 20 gallons per minute (0.33 gallon/second). Therefore, the crew would have about 11 seconds when checking the system before the reservoir would be completely depleted.

If the brake system hydraulic lines upstream of the antiskid valve have been severed, as occurred in this accident, then the A and B reservoir quantity gages would indicate about 2.5 gallons and 0, respectively, with the landing gear retracted. The lower A reservoir quantity with the B reservoir empty results from the loss of A system fluid

through the balance line between the two reservoirs. In this case, the crew would have about 7 seconds when checking the A system with the gear lever in the DOWN position before the reservoir would be depleted completely.

If the foregoing check of the A system hydraulic lines for gear extension indicated a leak, then the landing gear would have to be extended using the manual system. This option would, of course, be available to the crew if they decided not to check the A system as discussed above and left the gear handle in the OFF position because of the risk of depleting the reservoir. The damaged gear should be extended first. Limit load factor maneuvering may be required to jar the gear loose so that it can be extended. Therefore, hydraulic power to the primary flight controls is needed in order to achieve the required maneuvering load factors. If the damaged gear could not be extended manually (as occurred in this accident due to structural damage, or as occurred in a previous case due to damage to the manual extension cables) and the crew was unable to dislodge it by maneuvering the airplane, then the option of landing the airplane with the landing gear retracted would still be available.

Examination of the hydraulic, electrical, and control system components in the right wheel well of the accident airplane showed extensive damage which resulted from the exploding tire. As discussed above, hydraulic lines for both the A and B hydraulic systems were bent, deformed, and severed. Some landing gear hydraulic valves were broken from their attachments. Electrical wires, bundles, clamps, and connectors were damaged. One wire was severed. Aileron control cables for the manual reversion system were damaged and a cable guide was broken. The Safety Board believes that the FAA should study the feasibility of shielding critical components in wheel wells from the destructive effects of an exploding tire.

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

> Require operators of B-727 airplanes to establish a training program for flightcrews addressing recognition, assessment, options, and procedures to be followed in the event a tire has exploded in a wheel well. The training program should be based, in part, on the discussion in the letter transmitting this recommendation. (Class II, Priority Action) (A-85-81)
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> Issue an Air Carrier Operations Bulletin, or require additional information in the Aircraft Operations Manual, Abnormal Procedures/Expanded Checklist section and Hydraulic-Alternate Operations section, to provide information and instructions to be followed by a flightcrew after a tire has exploded in a wheel well. The information and instructions should be based, in part, on the discussion in the letter transmitting this recommendation. (Class II, Priority Action) (A-85-82)
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> Review with the Thompson Aircraft Tire Corporation and Eastern Air Lines the provisions of Advisory Circular No. 145-4, "Inspection, Retread, Repair, and Alterations of Aircraft Tires," emphasizing that tire bead seat areas should not be sanded (Section 8.a., "Tire Repairs for Tires Operated Above 120 MPH") and that final inspections of retreaded tires should rigorously follow the guidelines of Section 10., "Nonrepairable Aircraft Tires." (Class II, Priority Action) (A-85-83)

Issue an advisory circular describing the damage to tires that can result from elevated brake temperatures. Emphasize the importance of visually inspecting bead seat areas prior to mounting and the need to perform bead-to-bead holograms for heat damage whenever exposure to higher-than-normal brake temperatures is suspected, including occurrences where there has been faster-than-normal rotor wear. Emphasize the need to replace tires suspected of having been subjected to heat damage and brake linings suspected of causing faster-than-normal rotor wear or higher-than-normal brake temperatures for any reason as soon as possible to minimize heat damage to tires. (Class II, Priority Action) (A-85-84)

Request the B.F. Goodrich Company to amend Service Bulletin No. 418, "Landing Gear, All 727 Models, Main Landing Gear Brakes - Inspection for Excessive Rotor Wear," dated July 25, 1983, to provide adequate warning that tire damage also is possible from the continued use of the "new" brake lining cups and to require the removal of all "new" brake lining cups on a priority basis. (Class II, Priority Action) (A-85-85)

In cooperation with the Boeing Commercial Airplane Company, determine the feasibility of shielding the A and B hydraulic system lines, electrical wiring, and control system cables located in the wheel wells of B-727 airplanes, and of modifying the wheel well lighting systems to make them less vulnerable to damage in the event of a tire explosion within the wheel well. (Class II, Priority Action) (A-85-86)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

By: Jim Burnett
Chairman