ADOPTED: 2/27/90

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation 2219

Date: March 21, 1990

In reply refer to: A-90-25 through -36

Honorable James B. Busey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 21, 1988, a McDonnell Douglas Corporation DC-10-30 overran runway 35L during a rejected takeoff (RTO) at the Dallas-Fort Worth International Airport, Texas. No fire occurred, but the airplane was damaged beyond economical repair. Of the 254 persons on board, 2 sustained serious injuries and 6 sustained minor injuries.

The captain of the airplane executed the RTO following the sounding of a takeoff warning horn and the illumination of the slat disagree light. The warning occurred almost simultaneously with the V1 (takeoff decision speed) call, and the crew responded immediately to reject the takeoff. Although the V1 speed was slightly exceeded at the initiation of the RTO, airplane accelerate-stop data in the FAA Approved Flight Manual indicated that the airplane was capable of stopping on or near the end of the runway.

In response to the RTO procedures followed by the flightcrew, the airplane decelerated normally for 5 to 6 seconds, slowing from a 178-knot maximum groundspeed to about 130 knots groundspeed. The deceleration then decayed rapidly, and the loss of decelerative force resulted in the airplane departing the end of the runway at about 97 knots. The nose gear collapsed in soft ground, and the plowing action of the nose slowed the airplane to a stop about 1,000 feet beyond the end of the runway.

The National Transportation Safety Board determined that the cause of the accident was total brake failure in 8 of the 10 wheel brakes as a result of inadequate certification and test procedures. The brakes had been certified to FAA-approved procedures, yet failed at only 36 percent of the design requirement.

As a result of this accident, the Safety Board conducted a special investigation of DC-10-30/40 brakes. The investigation found that the procedures for certifying DC-10-30/40 brakes and determining accelerate-stop distance data were inadequate. Although the special investigation was specifically directed to the DC-10-30/40 brake performance, the Safety Board believes that the concerns expressed about the adequacy of the certification process may apply to the certification of all transport category airplanes.

The safety issues relevant to brake certification procedures and AFM accelerate-stop safety margins and the basis for the subsequent recommendations issued by the Safety Board are discussed in detail in the special investigation report.1/ Copies of the report are enclosed.

The safety issues include:

Brake wear replacement limits.--Current Federal regulations do not require the setting of proper brake wear limits based on the amount of remaining brake friction material necessary to assure continuous braking capability during a maximum energy RTO.

Inadequate dynamometer testing.--Worn brake dynamometer tests are not required. Dynamometer tests of DC-10-30/40 brakes prior to the accident utilized only new brakes and innappropriate brake force test curves. In addition, the stopping ability of new brakes are required to be verified without credit for the use of reverse thrust. Subsequent to the accident, dynamometer tests have been less demanding on worn brakes because credit for the use of reverse thrust has reduced the amount of energy required to be demonstrated by the brakes. Therefore, the ability of brakes at the current wear replacement limit to stop an airplane from a maximum kinetic energy RTO without the use of reverse thrust has not been verified.

Inadequate runway testing.--Runway tests of new DC-10-30/40 brakes were conducted from a landing, which limited the amount of energy absorbed by the brakes and limited the time while the brakes were at the maximum energy absorption rates. In addition, the friction material on the DC-10-30/40 brakes will be depleted during a high energy RTO if the brakes are at or near the replacement limit at the initiation of the RTO. The depletion of the friction material results in the braking force being generated by the rubbing of the rotating and stationary steel disks, a steel-on-steel condition. Although the FAA has typically required runway testing of new brake designs, the steel-on-steel condition has never been tested on the runway, a test that would be more demanding and realistic than dynamometer tests because of runway roughness and dynamic interactions between the airplane, landing gears, tires, and brakes.

Brake energy capacity.--The maximum demonstrated brake energy capacity for new and worn brakes on the DC-10-30/40 is consistent only with a maximum airplane kinetic energy of 840 to 860 million foot-pounds although the airplane is certified to operate at 898 million foot-pounds.

1/ National Transportation Safety Board. 1990. Special investigation report: Brake performance of the McDonnell Douglas DC-10-30/40 during high speed, high energy rejected takeoffs. NTSB/SIR-90-01. Washington, DC. 34 p.

Accelerate-stop distance and approved flight manual safety margins.--The Safety Board believes that, for turbojet transport category airplanes, the accelerate-stop distance data in the AFM should be consistent with a complete stop on the runway. Full allowances should be made for the turn-on alignment distance, worn-brake distance penalties, and an adequate distance safety margin to account for in-service variations of pilot RTO actions. Because the RTO safety margins are very small, the FAA should not allow the use of distance credits or energy benefits attributed to reverse thrust.

As a result of its special investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require McDonnell Douglas to demonstrate with sufficient additional tests, including runway tests if necessary, the safety of the steel-on-steel condition that develops when the DC-10-30/40 brake friction material is depleted during a maximum kinetic energy rejected takeoff (RTO) with brakes at the wear replacement limit before the start of the RTO. For the demonstration, simulate runway roughness and dynamic interactions between the airplane, landing gears, tires, and brakes. (Class II, Priority Action)(A-90-25)

Issue an airworthiness directive to reduce the DC-10-30/40 maximum kinetic energy takeoff limit to a limit that is consistent with the brake energy capacity demonstrated for brakes worn to the replacement limits without credit for reverse thrust. (Class II, Priority Action)(A-90-26)

Require McDonnell Douglas to conduct tests and analyses to determine the increase in the stopping distance attributed to the difference between the use of new brakes and the use of brakes worn to the replacement limits for DC-10-30/40 airplanes without credit for the use of reverse thrust. (Class II, Priority Action)(A-90-27)

Require McDonnell Douglas to determine by tests, simulation, and/or analyses the accelerate-stop distances for the DC-10-30/40 airplane as required by 14 CFR 25.109 (pre-amendment 42) using demonstrated certification stopping performance data from worn brakes and current procedures prescribed for rejected takeoffs. Account for demonstrated pilot reaction times and for deceleration device reaction times, such as engine spool-down time and brake force ramp-up time, in the determination of accelerate-stop distances and add a distance safety margin for in-service variations as described in Advisory Circular 25-7 (chapter 2, paragraphs 11.c.12.iv and vii) to be equivalent at least to a distance traveled in 2 seconds at an appropriate brake-on speed or V1 speed. (Class II, Priority Action)(A-90-28)

Require McDonnell Douglas to revise, as appropriate, the accelerate-stop distances in the DC-10-30/40 FAA Approved Airplane Flight Manual to include the increase in stopping distance attributed to worn brakes (determined in accordance with Safety Recommendation A-90-27) and to include the proper application of safety margins for in-service variations (determined in accordance with Safety Recommendation A-90-28). (Class II, Priority Action)(A-90-29)

Require the appropriate airplane and brake manufacturers to verify, by conducting tests and analyses, that all turbojet transport category airplanes meet the maximum energy requirement of 14 CFR 25.735(f) for wheel brake assemblies at the "maximum brake wear" limits; if the requirement is not met, reduce the maximum kinetic energy takeoff limit. In conducting this verification, use dynamometer brake test curves for demonstrating energy capacity that are consistent with runway-demonstrated braking forces during a maximum kinetic energy rejected takeoff. The test curves should replicate the brake's high energy absorption rate that occurs at the initiation of a maximum kinetic energy rejected takeoff. Note: This recommendation supersedes Safety Recommendation A-88-76. (Class III, Longer Term Action)(A-90-30)

Require airplane manufacturers to conduct tests and analyses to determine the increase in the stopping distance for all turbojet transport category airplanes currently in service attributed to the difference between the use of new brakes and the use of brakes worn to the replacement limits without credit for the use of reverse thrust. (Class II, Priority Action)(A-90-31)

Require the appropriate airplane manufacturers to determine by tests, simulation, and/or analyses the accelerate-stop distances for all turbojet transport category airplanes currently in service as required by 14 CFR 25.109 (pre-admendment 42) using demonstrated certification stopping performance data from worn brakes and current procedures prescribed for rejected takeoffs. Account for demonstrated pilot reaction times and for deceleration device reaction times, such as engine spool-down time and brake force ramp-up time in the determination of accelerate-stop distances and add a distance safety margin for in-service variations as described in Advisory Circular 25-7 (chapter 2, paragraphs 11.c.12.iv and vii) to be equivalent to at least a distance traveled in 2 seconds at an appropriate brake-on speed or V1 speed. (Class II, Priority Action)(A-90-32)

Revise, as appropriate, the accelerate-stop data in the approved flight manuals of all turbojet transport category airplanes currently in service to include the increase in stopping distance attributed to worn brakes (determined in accordance with Safety Recommendation A-90-31) and to include the proper application of safety margins for in-service variations (determined in accordance with Safety Recommendation (A-90-32). (Class II, Priority Action)(A-90-33)

Require that the operators of large turbojet transport category airplanes add the distance required for runway turn-on and takeoff alignment to the field length distances as determined from data in the approved flight manuals. (Class II, Priority Action)(A-90-34)

Revise 14 CFR 25.109 to require that the stopping distance capabilities of brake assemblies at the allowable "maximum brake wear" limit are included in the requirement for determining the accelerate-stop distances for certification of new airplanes without credit for the use of reverse thrust. (Class II, Priority Action)(A-90-35)

Revise certification procedures for new airplanes to require: (1) the airplane manufacturer to determine that the dynamometer brake drag force test curves used for certification are consistent with the brake forces and energy absorption rates that can be developed during a maximum kinetic energy rejected takeoff; (2) the airplane and brake manufacturers to record the brake wear during maximum kinetic energy brake certification tests to determine the onset time and rate of the brake wear during the stop, and then to use these data in the development of in-service brake wear limits; and (3) the airplane and brake manufacturers to consider the variance and distribution of brake wear during a rejected takeoff and to use this factor to develop brake wear replacement limits. (Class II, Priority Action)(A-90-36)

KOLSTAD, Chairman, COUGHLIN, Acting Vice Chairman, LAUBER and BURNETT, Members, concurred in these recommendations.

By: James L. Kolstad
Chairman