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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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Forwarded to:

Honorable Langhorne M. Bond
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)

A-78-84 through -89

On March 1, 1978, a Continental Airlines DC-10 crashed off the end of runway 6R at Los Angeles International Airport after two tires suddenly blew out on the left main gear at an airspeed slightly below V_1. Although the crew promptly rejected the takeoff before V_1 was attained and used all of the available deceleration devices, the aircraft overran the end of the wet, grooved 10,285-foot runway at 68 knots.

The Safety Board believes that this accident illustrates a number of shortcomings in the certification of aircraft and in the training of aircrews to effectively accomplish rejected takeoffs under the most critical conditions of speed, weight, runway condition, and the reasons for initiating rejected takeoffs.

14 CFR 25, "Airworthiness Standards: Transport Category Airplanes," defines the certification requirements for normal and rejected takeoffs (RTO). The associated takeoff speeds and accelerate-stop distances are predicated on recognition of an engine failure at V_1 on a smooth, dry, and hard-surfaced runway. These requirements do not address the accident conditions of failed tires and wet runway surfaces, each of which may add a considerable stopping distance increment to that presently required to be demonstrated during certification.

In contrast to the dry runway RTO certification stopping requirement, 14 CFR 121 provides an operational safety stopping margin for landings on wet runways. A landing aircraft is required to stop on a dry runway within 60 percent of the effective runway length. The runway length used for this calculation is increased by 15 percent for wet or slippery conditions. In effect, Part 121 establishes a wet runway length that is more than twice the distance demonstrated for stopping the aircraft during dry runway certification tests. However, even though Part 121 provides for corrections to takeoff weights, distances, and flightpaths

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required by density altitude, wind, and runway slope during normal and rejected takeoffs, it does not similarly require corrections for the added stopping distance required by rejected takeoffs initiated by engine or tire failures on wet or slippery runways.

A 1977 FAA report 1/ indicates that 87 percent of rejected takeoffs were caused by some failure or malfunction of tires, wheels and brakes. These data show that the engine failures have not been the dominant cause for some time. The stopping distance required for the aircraft will increase significantly as a result of tire, wheel, or brake failure wherein the ability to develop or transmit braking torque to the runway surface is reduced. Thus, although 87 percent of RTO's are a result of such failures, no consideration is given to their effect on stopping distance. The FAA report cites wet or slippery runway involvement in three major RTO accidents 2/ between 1964 and 1975. The FAA report recommends that "The increased accelerate-stop distance required on wet/slippery runways be taken into account in takeoff calculations and the necessary changes to airplane flight manuals, procedures, and regulations be incorporated to accommodate this." The Safety Board has determined that no FAA actions had been taken before the Continental accident concerning this recommendation.

In 1962, the British Civil Aviation Authority (CAA) changed the British Civil Airworthiness Requirements (BCAR), counterpart of Part 25, to account for the increased accelerate-stop distance necessitated by wet runways under engine-out conditions. The BCAR's define a wet runway reference surface that is used during landing and rejected takeoff certification testing. This standard represents an average wet, well-soaked surface which typifies the condition of runway 6R at the time of the Continental accident. There is no FAA counterpart to the BCAR wet runway standard, although U.S. manufacturers have been testing under the BCAR wet requirements in order to certificate airplanes in foreign countries. The V_1 data for wet runway conditions are determined from these tests and provided to foreign flightcrews. The BCAR procedures reduce the dry runway V_1 decision speeds so that an RTO initiated at the lower wet V_1 speed will allow the aircraft to stop on the wet runway as long as the actual surface condition is no worse than the reference surface. The BCAR also reduced the wet runway screen height requirement

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1/ Jet Transport Rejected Takeoffs, Final Report, February 1977, Flight Standards Services, FAA.

2/ Trans World Airlines, Inc., B-707, N769TW, Fumicino Airport, Rome, Italy, November 23, 1964.
Capitol International Airways, Inc., DC-8-63F, N4909C, Anchorage, Alaska, November 27, 1970.
Overseas National Airways, Inc., Douglas DC-10-30, N1032F, John F. Kennedy International Airport, Jamaica, New York, November 12, 1975.

from 35 feet, the current FAA standard, to 15 feet. The BCAR, however, retained the requirement for the 35-foot screen height for takeoffs on dry runways. The screen height is the vertical distance above the runway where the takeoff safety airspeed (V_2) is reached with a failed engine. This reduction in screen height allows the wet runway length to be essentially the same as the dry length and, for the DC-10 type aircraft, imposes no weight penalty on the operator. The Safety Board did not attempt to evaluate the adequacy of the CAA approach, but we recognize that lower V_1 speeds or lower takeoff weights, or both, for wet runway conditions will improve aircraft stopping performance.

During the investigation of the Continental accident, the Safety Board learned that one DC-10 operator at Los Angeles has routinely and voluntarily accounted for the added wet runway stopping distance for over 5 years by reducing DC-10 V_1 speeds and takeoff weights. The reduction in weight is required because of the current FAA 35-foot screen height standard. For the Continental accident case, the wet V_1 speed would have been 149 knots, 7 knots lower than the dry V_1 speed (156 knots), and the takeoff weight would have been reduced by about 10,000 pounds. Under these conditions, a successful takeoff by the Continental DC-10 may have been possible. The operator has also applied wet runway corrections for Boeing 727/737 aircraft during the last 8 years for all airports that it serves.

The Safety Board's investigation of flightcrew training practices regarding RTO's revealed that most training is given in simulators under unrealistic conditions. For example, most simulated RTO's are not initiated at maximum takeoff weights and associated V_1 speeds, and few simulators have the capacity to measure the pilot's braking efficiency. In the latter respect, a simulation test conducted by NASA and Douglas Aircraft Company demonstrated that air carrier pilots who were told to apply maximum braking during simulated RTO's actually achieved this only 60 percent of the time.

The FAA acceptance standards for aircraft simulators used in pilot training are set forth in Advisory Circular 121-14, Aircraft Simulator Evaluation and Approval. This circular contains accuracy criteria for takeoff performance characteristics, but it does not contain deceleration criteria for dry, wet, or slippery runways. Additionally, it does not provide for the measurement of pilot response times or the amount of braking effort applied by pilots and achieved by the brakes to assess how well pilots are attempting to stop aircraft during high-energy RTO's on critical length runways.

Pilot training in actual RTO's requiring maximum energy stops is by necessity limited to discussion and simulation. In some cases, simulator training may provide a false sense of security to the pilot by reflecting airplane performance in excess of that actually available for stopping on wet runways. The Safety Board believes that, where simulators are used for such training, they should demonstrate the actual performance, particularly where visual and acceleration cues are provided by the simulator. Furthermore, all simulators should be equipped with sufficient instrumentation to enable instructors to evaluate the pilot's performance in executing an RTO, particularly the response times in activating stopping devices, and the level of brake application to insure that such performance is compatible with a mininum-distance stop.

The RTO procedures in the Continental DC-10 flight manual specified that brakes should be applied "as required" after retarding the throttles to idle. Reverse thrust is to be applied "as required" following brake application. These procedures do not address an RTO initiated at or near V_1 speed and at maximum takeoff gross weights. In contrast to the Continental procedures, a Douglas DC-10 Newsletter issued in August 1977 discussed the emergency nature of RTO's initiated near V_1 speed and recommended using maximum brake pedal deflection, simultaneously selecting reverse thrust, and applying full reverse thrust as soon as possible.

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

Review and revise the accelerate-stop criteria required to be demonstrated during aircraft certification and used during operations to insure that they consider the effects of wet runway conditions and the most frequent and critical causes of rejected takeoffs. (A-78-84) (Class II - Priority Action)

Evaluate, with industry, the British CAA wet runway normal and rejected takeoff requirements for applicability as a U.S. standard. (A-78-85) (Class II - Priority Action)

Revise Advisory Circular 121-14 to provide guidance on (1) programming aircraft simulators to account for the degradation of aircraft deceleration performance on wet runways during landings and rejected takeoffs and (2) installing instrumentation to enable evaluation of pilot performance during RTO's on critical length runways, particularly the response times in activating stopping devices and the level of brake application to insure that such performance is compatible with a minimum-distance stop. (A-78-86) (Class II - Priority Action)

Insure that pilot training programs include appropriate information regarding optimum rejected takeoff procedures at maximum weights, on wet and dry runways, and at speeds at or near V_1, and for rejected takeoffs which must be initiated as a result of engine or tire failures. (A-78-87) (Class II - Priority Action)

Encourage operators of turbine engine-powered aircraft to include in flight manuals the maximum use of aircraft deceleration devices when an RTO is initiated at or near decision speed (V_1) on wet or dry runways of critical length. (A-78-88) (Class II - Priority Action)

Develop and publish an Advisory Circular, or include in other appropriate documents available to air carrier and other pilots, general accelerate-stop performance data for RTO's on wet runways necessitated by engine and tire failures. Emphasize the need for maximum braking procedures when an RTO is required at high gross weights and speeds. (A-78-89) (Class II - Priority Action)

KING, Chairman, DRIVER, Vice Chairman, McADAMS and HOGUE, Members concurred in the above recommendations.

By: James B. King
Chairman