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"Hazards of TIRE HYDROPLANING to Aircraft Operation"

A TECHNOLOGY UTILIZATION FILM REPORT

produced by
Langley Research Center, NASA

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Hazards of TIRE HYDROPLANING to Aircraft Operation....

Every aircraft pilot – business, private, airline, or military – has made or may at some time make a landing on a rainswept airfield!

The National Aeronautics and Space Administration prepared the accompanying motion picture, based on tire studies conducted at The Langley Research Center, to identify and draw particular attention to a wet runway hazard which is not yet fully appreciated.

The hazards of tire hydroplaning, the potentially dangerous phenomenon explained in the film, can be minimized only if hydroplaning is properly understood.

Facts concerning TIRE HYDROPLANING-

What is TIRE HYDROPLANING?

When pneumatic tires of aircraft (or of highway vehicles as well) roll over water-covered or flooded pavements, hydrodynamic pressures develop between the tire footprint and the pavement. The pressures grow larger as the ground speed increases. At a critical speed, hydrodynamic lift resulting from the built-up pressure under a tire will equal the weight riding on the tire. When this occurs, hydroplaning speed has been reached. Any increase in ground speed above this critical value lifts the tire completely off the pavement, leaving it supported by the fluid alone. The result is called total tire hydroplaning.

When does TIRE HYDROPLANING occur on pavements?

Research thus far indicates that total tire hydroplaning will not occur on most runways or roads until the paved surface is flooded or heavily puddled with water or slush. Most runways and roads are designed with a crown to drain water away readily. Such crowned pavements should not become flooded unless very heavy rain is falling or deep slush accumulates.

However, a note of caution follows:

(1) Tire hydroplaning research indicates that tires require less fluid depth to hydroplane on smooth surfaces than on rougher paving.
(2) Bald or smooth tread tires tend to hydroplane in more shallow fluid depths than tires with ribbed or patterned treads.
(3) NASA studies show that a smooth tire will hydroplane on a very smooth pavement if only 1/10 inch of water is present.
(4) Ribbed treads on rough textured pavement may hydroplane in 2/10 or 3/10 inch of water.

At what speed does total TIRE HYDROPLANING occur?

Tire research shows that for flexible pneumatic tires, changes in the vertical load acting on a tire produce corresponding changes in the tire-ground contact area so that the ratio of tire load to contact area remains constant at a value approximating the tire inflation pressure. This result makes it possible to define *TOTAL TIRE HYDROPLANING SPEED* in terms of the *TIRE INFLATION PRESSURE* by means of the simple relation $V_H = 9\sqrt{p}$, where V_H = tire hydroplaning speed in knots and p = tire inflation pressure in pounds per square inch. (The equation is valid for smooth tires or for grooved tires where fluid depth exceeds tread groove depth.) For example, an operating tire pressure of 100 pounds per square inch would give a total hydroplaning speed of 90 knots.

Consequences of TIRE HYDROPLANING –

At ground speed above the total hydroplaning speed, V_H, the tire lifts off the pavement surface and tire-ground friction forces drop to insignificant values because the fluid cannot develop large shear forces. In addition, hydrodynamic lift acting between the tire and ground tends to shift the vertical ground reaction on the tire in a way that produces a spin-down tendency on the tire. These two major effects combine to produce the following consequences of tire hydroplaning:

(1) Pneumatic tires on free rolling or unbraked aircraft or automobiles can spin down to a complete stop at ground speeds near or above the total hydroplaning speed V_H.
(2) Tires suffer nearly complete loss of braking traction and cornering capability. This loss can result in severe vehicle skidding under action of only small external side forces on the vehicle.
(3) Even at lower speeds in deep fluids, partial hydroplaning can occur, so that both tire-to-ground friction coefficients and cornering ability are reduced.

Associated hazards of tire hydroplaning to aircraft operation are greatly increased stopping distances and potential loss of ground directional stability. Of importance with regard to these hazards are:

(1) Crosswinds during take-off and landing operations on flooded runways, which may greatly increase the possibility of aircraft skidding.
(2) When landings must be made on very wet runways, operational techniques such as minimum "safe" touchdown speed, early runway contact, early use of spoilers and, possibly, wheel brakes, and reverse thrust should be employed to decrease the aircraft landing roll. Of course, reverse thrust and wheel brakes should be used with caution since asymmetrical thrust or drag on the aircraft for these slippery runway conditions will be difficult to control.
(3) Use of smooth or excessively worn patterned tread tires should be avoided on aircraft subject to wet runway operation.

The motion picture develops the subject of tire hydroplaning from first principles and discusses its various manifestations and hazards to vehicles. Actual operational procedures to minimize hazards of hydroplaning are not described but these should be specified by the agency operating the particular aircraft. Film running time: 15 minutes.