Automobile Tire Hydroplaning—What Happens*

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WHAT IS TIRE HYDROPLANING?

When driving a car on a wet highway, water may penetrate between the tire and pavement. This penetration results in the formation of water pressure which raises a portion of the tire off the pavement. This pressure increases with increasing speed of the vehicle, supporting more and more of the tire, until at a critical speed, termed the hydroplaning speed, the tire is supported only by the water and loses all contact with the pavement.

WHEN DOES TIRE HYDROPLANING OCCUR?

Tire hydroplaning occurs when the speed of the vehicle, tire inflation pressure, water depth on the road, condition of the pavement surface, and the condition of the tire tread are *combined* in such fashion that the tire loses contact with the pavement.

The combination of factors necessary for hydroplaning to occur are:

(a) *Hydroplaning Speed*

Presuming for the moment that sufficient water is present for hydroplaning to occur, the speed at which a vehicle will hydroplane may be predicted with fair accuracy solely on the basis of *tire inflation pressure.* This can be more easily understood by realizing that the tire is flexible, and deforms under changing loads. It turns out that the ratio of weight carried by the tire

* *Automobile Tire Hydroplaning—What Happens?* is a film prepared by the Bureau of Public Roads with technical advice and assistance from the National Aeronautics and Space Administration. The film may be purchased from the Department of Agriculture Motion Picture Service, Washington, D. C. 20250 for $42 per print. Information on borrowing the film may be obtained by writing to NASA, Code FAD-2, Washington, D. C. 20546.

to the area of tire contact on the pavement remains about the same, and this ratio of weight to area will always be very near the tire inflation pressure.

Based on hydrodynamic theory, a simplified equation has been developed to predict the hydroplaning speed of a pneumatic tire; namely, $Vp = 10.2\sqrt{p}$, where Vp = hydroplaning speed in miles per hour and p = tire inflation pressure in pounds per square inch. For example, a tire pressure of 16 pounds gives a hydroplaning speed of 41 mph; 24 pounds, 50 mph; and 32 pounds, 59 mph.

A note of caution—these speeds, which are well within legal speed limits, are speeds at which total hydroplaning occurs with total loss of traction for steering or braking. Partial loss of traction owing to partial support of the tire by the water may occur well below hydroplaning speed and result in critical loss of traction for a given maneuver at speeds well below those predicted.

(b) *Water Depth on the Pavement*

The equation given above presumes sufficient water on the pavement for hydroplaning to occur. The actual water depth needed in a particular situation depends upon the size and number of "escape channels" present, which allows the escape of the water from beneath the tire and delays the buildup of water pressure. These escape channels may be provided by the *pavement surface,* through surface unevenness and grooves, or by an effective *tire tread pattern.* Research has shown that smooth or badly worn tires will hydroplane on a smooth surface in less than 0.04 inch water! Good tires will hydroplane at the predicted speed when the water depth is greater than the depth of the tread on the tires, and the grooves in the tires become "choked" with water. Since it is difficult to judge the depth of water on the pavement from a moving automobile, a good rule of thumb is that when you can see patches of standing water, or the water is deep enough to cover pavement unevenness, you should assume there is enough water present for hydroplaning.

WHAT ARE THE CONSEQUENCES OF TIRE HYDROPLANING?

The most serious consequence of tire hydroplaning is the loss of traction which is necessary for safe steering and braking. This may be a partial loss of traction due to partial hydroplaning, or total loss of traction at total hydroplaning speeds. The loss in braking capa-

bility due to partial hydroplaning is illustrated in a chart shown in the movie.

The losses here are due to partial hydroplaning, since the tires on the test automobile were inflated to 24 psi, giving a hydroplaning speed of 50 miles per hour. Note that good treads were reasonably effective in providing good tire traction in the test water depth of 1/10 inch.

The driver must remember that losses in traction not only result in increased stopping distance, but in decreased steering control. This may leave insufficient steering capability to hold the road, especially on a curve or a crowned road. Side winds could also result in loss of steering control.