

HYDROPLANING ON HIGHWAYS



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MICHIGAN DEPARTMENT OF  
STATE HIGHWAYS AND TRANSPORTATION

**HYDROPLANING ON HIGHWAYS**

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**Michigan State Highway Commission  
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### What is tire hydroplaning?

Automobiles experience two types of hydroplaning: viscous and dynamic. Viscous hydroplaning results from thin-film lubrication of a smooth pavement surface. The wet sliding coefficient of friction, as measured by the Department's skid test equipment, provides an indication of the ability of a pavement surface to support viscous hydroplaning. Since even a heavy dew on a smooth pavement surface can create a condition where viscous hydroplaning can occur, that type of hydroplaning is most common on highways, roads, and streets.

Dynamic hydroplaning, a phenomenon not recognized until the late 1950's, results when a wedge of water progressively penetrates a tire-pavement interface. As the wedge of water begins to penetrate, a hydrodynamic pressure increases until the tire can completely lose contact with the pavement surface. Dynamic hydroplaning is the subject of this paper, and henceforth the term "hydroplaning" will be intended to mean "dynamic hydroplaning."

### When does hydroplaning occur?

The friction that provides vehicle traction is due to tire-pavement surface contact. On wet pavements, friction is provided when water is squeezed from beneath the rolling tire and the rubber makes contact with the pavement surface. As the tire rolls faster, there is less time for squeezing water from beneath the tire and, as the time for water removal becomes shorter, all the water will not be removed and the tire will begin to lose contact with the pavement. If the speed is further increased, the tire will gradually but completely lose contact with the pavement and will be entirely supported on a wedge of water.

Horne and Dreher (1) developed a simplified and subsequently proven equation for predicting critical hydroplaning speeds:

$$V = 10.35 \sqrt{p}$$

where V = the speed in mph where a tire is totally hydroplaning  
p = tire inflation pressure, psi

The preceding equation describes the condition where depth of surface water is greater than the depth of tire tread. This water depth may be less than 1/10 in. depending upon tire tread depth. Partial hydroplaning occurs below the speeds shown by the preceding equation. Stopping distances shown in Figure 1, were made during joint FHWA - NASA tests, and these tests verify the equation.

Hydroplaning can occur at speeds less than that predicted by the Horne-Dreher equation under certain conditions. Some of the factors influencing the occurrence of hydroplaning are:

- a) tire groove design
- b) tire tread width
- c) tire tread depth
- d) water depth
- e) pavement texture
- f) vehicle speed.

The preceding factors can interact to create conditions where hydroplaning can occur for one vehicle but not another. For example, a vehicle traveling at about 45 mph with wide-tread tires would begin to hydroplane in a 0.4-in. layer of water whereas a car with ordinary tires would not (2).

#### Effects on Highway Vehicles

As a highway vehicle begins to hydroplane, either partial or complete control may be lost if hydroplaning is total. Since the front wheels provide some wiping for the rear wheels, steering control may be lost before drive traction, and a driver may not be aware of this until entering a curve.

One of the most insidious features of hydroplaning is that, once a tire begins to hydroplane, vehicle speed must be reduced to a much lower level before tire-pavement contact will again be made. For example, if a car starts to completely hydroplane at 60 mph, it will continue to hydroplane until speed has been reduced much lower than 60 mph; it may have to drop as low as 40 mph before the tire regains contact with the pavement (3).

#### When is hydroplaning likely to occur?

Hydroplaning need never occur on highways if vehicles would reduce their speeds during wet weather and use tires with deep tread. However, studies have shown that, typically, drivers do not appreciably reduce their speed when pavement surfaces are wet; and a statewide survey made by the Research Laboratory in 1971 indicated that over 15 percent of the passenger cars in Michigan had at least one smooth tire. Therefore, hydroplaning will occur if pavement conditions are conducive.

Hydroplaning is likely to occur during a heavy rainfall, and on pavements where surface drainage is poor. Specifically, it would occur where a high berm impounds water on a pavement or where deep ruts create puddles. Another likely condition occurs when entering or leaving a super-elevated curve, where water runs longitudinally or diagonally along a pavement surface instead of directly off to a side.

What can be done to prevent hydroplaning?

Probably the most effective means of preventing both dynamic and viscous hydroplaning is to reduce speeds during wet weather. The prohibition of smooth tires (1/16 in. or less tread depth) would also reduce both types of hydroplaning (Fig. 2) as would pavements with well textured surfaces. Pavements with good surface drainage should cause no dynamic hydroplaning problems. Therefore, berms that are too high to permit pavement drainage should be trimmed off and pavements with deep ruts should be patched or resurfaced. Finally, in problem areas such as curves, pavement grooving has shown spectacular improvements in accident frequencies, although the durability of such treatments depends upon the quality of the aggregates in the surface.

## REFERENCES

1. Horne, Walter B. and Dreher, Robert C., "Phenomena of Pneumatic Tire Hydroplaning," NASA Technical Note D-2056.
2. Martinez, J. E., Lewis, J. M., and Stocker, A. J., "A Study of Variables Associated With Wheel Spin-Down and Hydroplaning," Texas Transportation Institute, Texas A & M University, Presented at 51st annual HRB meeting.
3. "Hydroplaning: No Sport for the Skid Resistance Committee," Materials Research and Standards, April 1972.

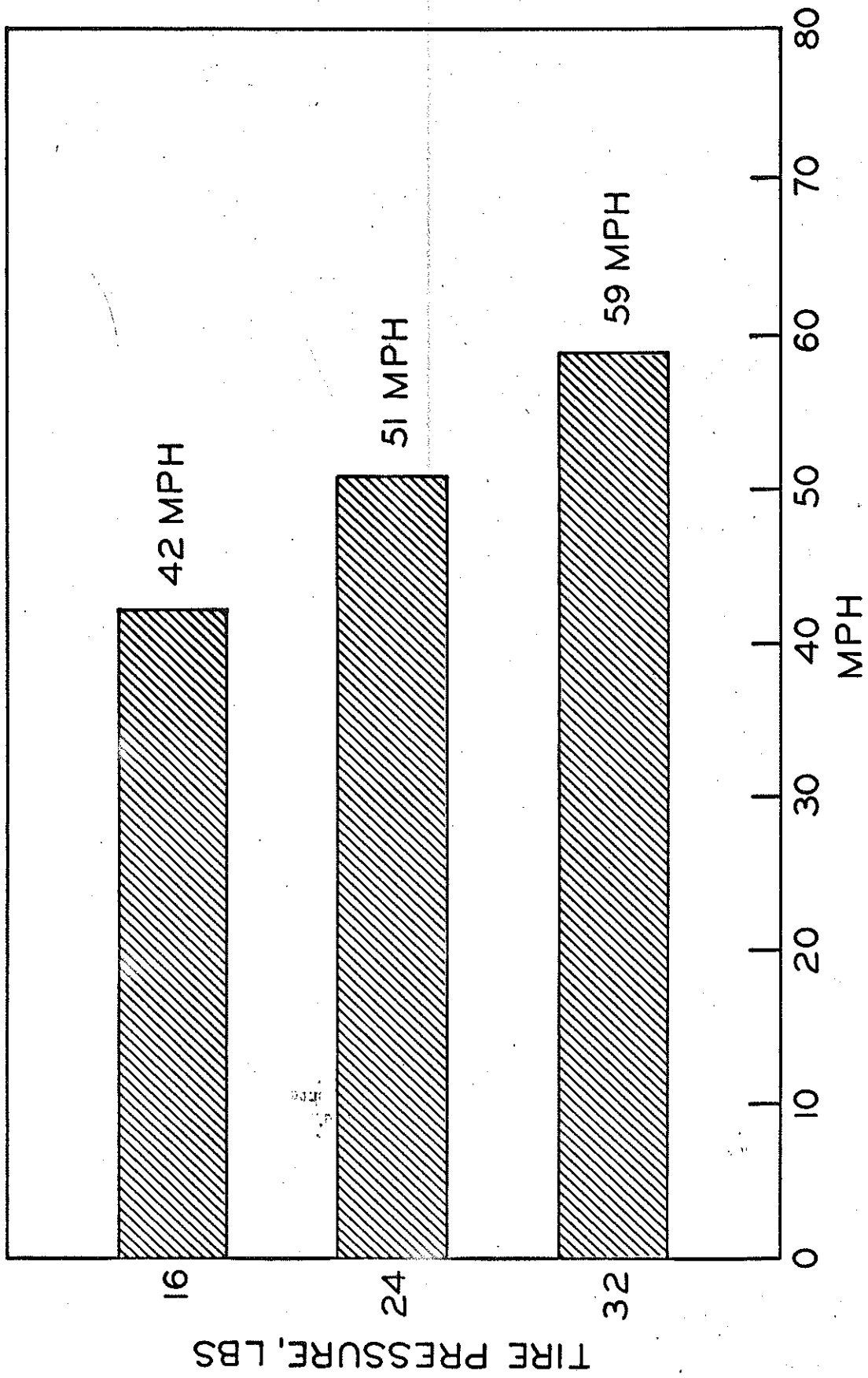


Figure 1. Hydroplaning speeds (new tires on 1/2-in. standing water, smooth tires on 1/10-in. standing water).

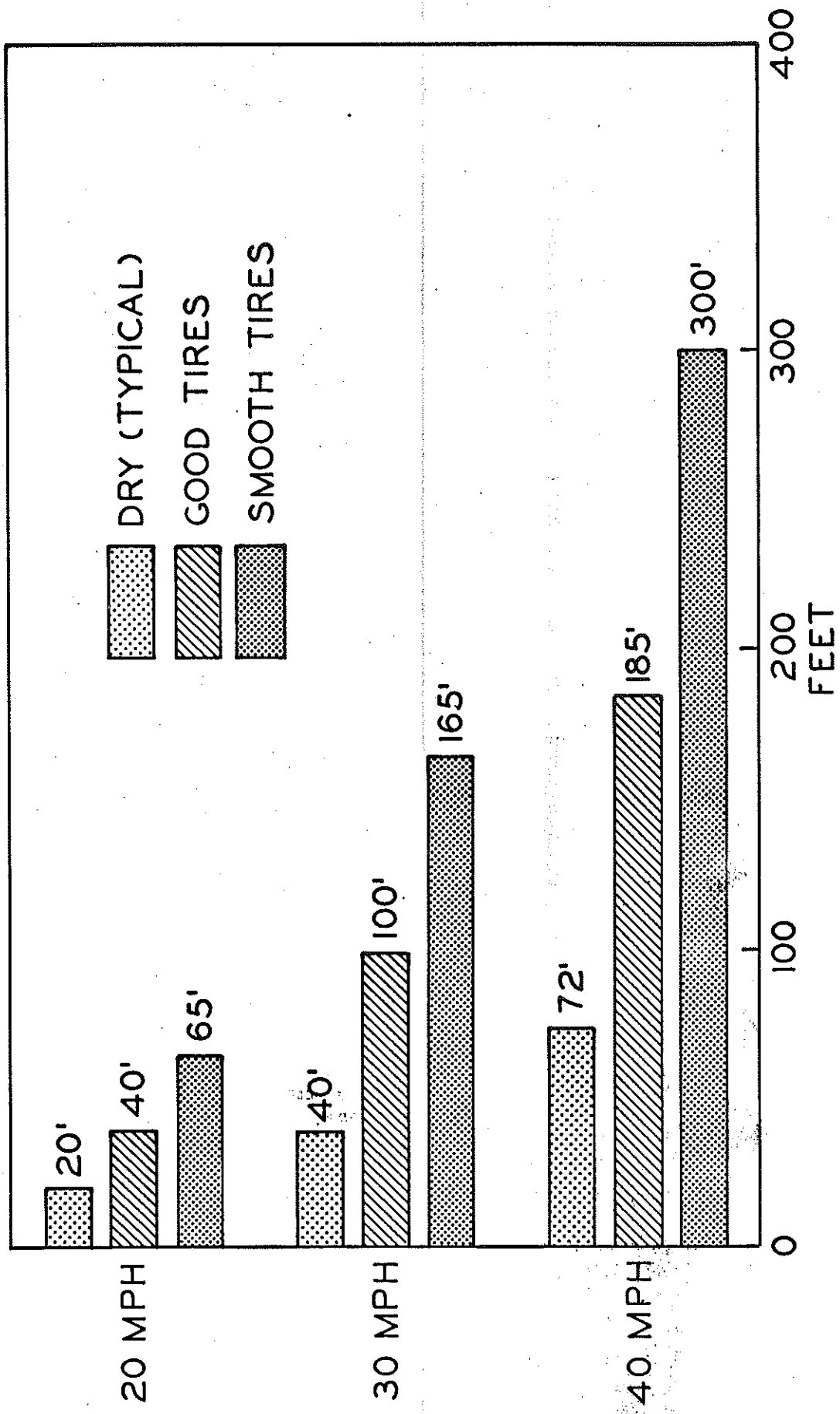


Figure 2. Braking distance on wet, smooth surface with less than 1/10-in. standing water.