Determining Vehicle Speeds From Skid Marks

by James O. Harris

This work is very basic, it does not address many of the factors involved in determining vehicle speeds from skids that are addressed by a professional traffic accident reconstructionist in calculating vehicle speeds. It is intended to give the reader an understanding of how vehicle speeds are determined from skid marks and some of the limitations of the calculations. This work is limited to determining speeds from cars. Trucks, cars pulling trailers, and motorcycles have a number of factors involved that are not addressed and this material should not be applied to situations involving those types of vehicles.

For ready reference, a table of average skid distances at various speed on various surfaces, is provided at the end of this article.

First, let's define a skid mark. A skid mark is a tire mark on the road surface produced by a tire that is locked, that is not rotating. A skid mark typically appears very light at the beginning of the skid getting darker as the skid progresses and comes to an abrupt end if the vehicle stops at the end of the skid. There are other types of tire marks including scuffs, scrubs and yaw marks. These must not be confused with skidmarks. A skid mark is left when the driver applies the brakes hard, locking the wheels, but the car continues to slide along the road. Steering is not possible with the front wheels locked. Skid marks are generally straight but may have some curvature due to the slope of the road.

A car skids 60 feet. How fast was it going? The answer is, "It depends." Several things must be determined before you can determine the vehicle's skid speed. You must know the skid distance, a drag factor for the road surface and the braking efficiency of the vehicle.

Measuring skid marks:

The skid speed is the speed of the vehicle at the beginning of the visible skid mark. This will be a conservative value as the wheels do not lock-up instantly. There is some "shadow skid," a light mark produced as the wheels begin to slow and just before they achieve full lock. Shadow skid and clearly visible skid should be considered as one continuous mark for any given tire. Cars have four tires, two in the front followed directly by the two in the rear. The wheels on most cars, assuming the brake system is functioning correctly, will tend to lock at nearly the same time. Current brake design includes pressure limiters that prevent the rear wheels from locking before the front wheels lock.

If all four wheels lock at the same time, and the vehicle is skidding in a straight line, the marks from the rear wheels will overlap the marks from the front wheels. Rear wheel skid marks can be identified by the dark center while skid marks from the front wheels can be identified by two distinct thin lines on the outer edges.

If four distinct skid marks can be found, they should be measured individually. To get the average skid distance for the vehicle, add the four measurements together and divide by four. This is the "average skid distance." If three skid marks are found, add the three together and divide by three to get the average skid distance. The same applies to two marks. If only one mark is found, measure the entire length and use this as the skid distance.

If two skid marks are found, but it cannot be determined where the front wheel skid marks begin due to being overridden by the rear wheel skid marks, measure the entire length of the two skid marks, subtract one-half the wheelbase of the vehicle from the total and divide by two. The result is the average skid distance.

Drag factor:

A drag factor is the term for the tire/road surface interface when determining vehicle speeds. There are several ways to find the drag factor but the most accurate is to conduct a series of test skids with an exemplar vehicle equipped with a recording accelerometer and chalk bumper gun. Unless you have formal training in conducting skid tests, it is not recommended that you attempt skid tests.

To provide some examples of drag factor values, drag factor ranges for various typical road surfaces are:

Portland Cement: 0.55 to 1.20

Asphalt: 0.50 to 0.90

Gravel: 0.40 to 0.80

Ice: 0.10 to 0.25

Snow: 0.10 to 0.55

Third, braking efficiency:

Each wheel on a car provides a certain amount of the total brake force available. If all four wheels are braking evenly, leaving four distinct skid marks, then braking efficiency is 100%, or 1.00. If the rear brakes are not functioning at all, then 40% of the brake force is not available, leaving a braking efficiency of 0.60 for the car as it was skidding. For rear wheel drive cars, the brake force can be assumed to be 30% for each of the front wheels and 20% for each of the rear wheels.

With the above, you have the three variables required to complete the minimum skid speed formula:

$$S = \sqrt{30 \bullet D \bullet f \bullet n}$$

Where –

S = Speed, in miles per hour.
30 = A constant value used in this equation.
D = Skid Distance, in decimal feet and inches.
f = Drag factor for the road surface.
n = Braking efficiency as a percent.

An example:

A car skids to a stop, leaving four skid marks with an average length of 60 feet. The road is asphalt. Skid tests reveal a drag factor of 0.75. Since all four wheels were braking, the braking efficiency (n) is 100% or 1.00. The value for "D" is 60. The value for "f" is 0.75. Insert the values into the formula and a speed of 36.7 miles per hour is determined (S = 36.7).

It is important to understand this is a MINIMUM speed for the vehicle at the beginning of the skid. It is not possible to find all of the skidmark given it starts out as a light shadow becoming progressively darker. And this formula assumes the vehicle comes to a stop at the end of the skid without hitting anything, like another car or tree or bridge abutment.

If there is a speed value at the end of the visible skid, as when the car strikes something, the residual speed value must be combined with the calculated minimum skid speed. You must not add a residual speed to the calculated minimum speed.

For example, a car skids 73 feet on an asphalt surface and then strikes another car broadside at 28 miles per hour. A drag factor of .85 is determined and braking efficiency is 1.00. The minimum skid speed is determined as 43.14 miles per hour. To combine this speed with the impact speed:

$$Sc = \sqrt{S_1^2 + S_2^2}$$

That is, "Sc" is "Speed Combined". "S1" is the speed of the vehicle at impact and "S2" is the calculated speed lost during the skid. The minimum speed of the vehicle at the beginning of the skid, considering the impact speed at the end of the skid, is 51.4 miles per hour.

There are many factors and situations that these basic formulas will not fit. What has been provided here would apply to the most simple of situations. Vehicle speeds can be determined from a number of variables, including fall distance, vault distance, yaw marks, crush and momentum. If an analysis of vehicle speed is desired, it is recommended that a qualified traffic accident reconstructionist be retained.

How far a car will skid on various road surfaces from different initial speeds –

Speed (mph)	Asphalt f = 0.75	Concrete f = 0.90	Snow f = 0.30	Gravel f = 0.50
30	40'	33'	100'	60'
40	71'	59'	178'	107'
50	111'	93'	278'	167'
60	160'	133'	400'	240'

Notes on this table: The terms used to describe the road surface (asphalt, concrete, snow, gravel) and the associated drag factors (f), are very general. They do NOT apply to all roads. These values were selected as representative, not absolutes. For any accident case where skid speed is at issue, a skid test should be conducted, if practical, to determine the actual drag factor.

All distances are rounded up to the nearest whole number.

These skid distances are for cars only with all four wheels locked. Significantly different values apply to trucks, buses, motorcycles and vehicles pulling trailers. For cars with anti-lock brakes on all four wheels, deduct 10% from the skid distances listed above.

Perception/Reaction Distance

Skid distances do not include perception-reaction time distances. This is the distance a vehicle will travel during the time period a hazard first becomes visible to a driver and the driver takes action, such as stepping on the brake pedal, to avoid the hazard. A perception-reaction time of 1.4 seconds for a nominal hazard, with an alert driver may be used for some situations.

At 30 mph, a car will travel 61.57 feet in 1.4 seconds.
At 40 mph, a car will travel 82.09 feet in 1.4 seconds.
At 50 mph, a car will travel 102.62 feet in 1.4 seconds
At 60 mph, a car will travel 123.14 feet in 1.4 seconds.

The total stopping distance, which includes the perception-reaction travel distance, and the skid distance, is found by adding the applicable perception-reaction distance and the applicable skid distance.

For example, a car skids to a halt leaving 111 feet of visible skid marks. The speed of the car at the onset of the skid is found on the table as 50 mph. At 50 mph, with a reaction time of 1.4 seconds, the vehicle traveled 102.62 feet.

Adding the 102.62 and the 111 feet of visible skid reveals the driver first saw the hazard when the car was 213.62 feet from the hazard.

Skid mark Evidence

by James O. Harris

It is generally known that a vehicle's speed can be determined from skid marks. But whenever you hear a traffic accident investigator or reconstructionist talk about speed from skid marks, they use the term "minimum" or "at least" when quantifying the calculated speed. There is a reason for this. It is very likely the police officer that investigated the accident scene, while all the evidence was fresh and in place, could not see the entire length of the actual skid or the skid mark he could see does not reveal the entire distance the car traveled while the brakes were being applied. In short, the car was braking for a distance greater than the visible skid distance and the calculated speed from the skid marks must be lower than the speed the car was really going when the driver applied the brakes.

You may hear terms like "impending skid, "shadow skid" or "visible skid" in conjunction with the minimum skid speed terms. These descriptions of skid marks are important.

For the case at hand, assume a car is proceeding along a four lane, undivided road in an industrial area. The road surface is a concrete asphalt mix. The road is level, no major surface defects and dry at the time of the accident. As the car was proceeding in the right lane, a bicyclist entered the road from a driveway to the driver's right. The driver saw the bicycle entering his lane of travel and applied the brakes hard in an attempt to avoid a collision.

Unfortunately, the car was unable to stop in the available distance and a collision occurs. The speed limit in the area is 35 mph. The bicyclist claims the driver was going well in excess of the speed limit. The driver says he was not speeding.

The police are called and an investigation is conducted of the scene. The investigating officer is presented with a scene as in Photo 1. The car is at the position of rest after striking the bicycle. Skid marks are visible from the car going into the collision. They can be clearly seen leading up to the wheels of the car. The officer measures each of the skid marks. Based on the length of the skid marks, he uses the basic skid speed formula, after having conducted skid tests to determine a drag factor, and reports he has calculated a speed of 34.5 mph for the car when the skid begins.

Photo 1

In Photo 1, you can clearly see the skid marks begin just past a seam in the pavement. To the left is a skip center line dividing the two right lanes of the four lane road. The officer has measured the skid marks as you see them in this photo. But is this really where the car began braking? If the distance the car traveled while the brakes were being applied, wouldn't the speed be higher than the distance measured by the police officer?

Yes. A skid mark does not necessarily show the entire "braking distance," that is the full distance the car traveled while the brakes were slowing the car down. There very often is a distance of "shadow" or "impending" skid where the car is slowing but the wheels have not completely stopped rotating or the tires are not yet leaving a visible mark. To see this, examine Photo 2.

Photo 2

Photo 2 is the same as Photo 1. For Photo 1, the tape measure, orange cones and a chalk shot mark were digitally removed. This was done to present the skid marks as they are normally found in accident scenes. In reality, the skid marks were produced as part of a skid test with the vehicle equipped with a chalk bumper gun. With this device, we can see where the car was when the brakes were first applied and where the skid marks become visible.

In Photo 2, in the lower left corner, is the end of a tape measure. To the right of this tape measure, and slightly past the end, there is a bright, orange chalk spot. Orange traffic cones have been placed at ten foot intervals, beginning with end of the tape measure nearest the bottom of the photo. Two orange lines to the left of the tape measure show the positions of each axle when the brakes were applied. The chalk mark was produced by the chalk bumper gun. The gun hangs on the side of the test car and fires a small piece of chalk to the ground when a pressure switch on the brake pedal is depressed as the brakes are applied. This provides a reference mark on the road, that can be measured to the gun's position on the car and the actual braking, or skid, distance can be measured. Notice the visible skid marks do not become visible for a considerable distance beyond the point where the brakes were applied. The end of the tape measure is set to the position of the rear wheels at the moment the brakes were applied while the chalk bumper gun was near the center of the car.

Photo 3

Photo 3 is of the car with the bumper gun installed. The bumper gun is just behind the driver's door.

Photo 4

Photo 4 is the bumper gun. A .25 caliber rifle chalk load cartridge is held in a metal block just below the center of the device. The "hammer" is released by a solenoid inside the blue housing. The wires provide a ground, connect to the vehicle for electrical power and to the pressure switch attached to the brake pedal. At the instant the driver's foot depresses the brake pedal, the chalk cartridge is fired, leaving a distinct mark on the pavement as seen in Photo 2.

What happens during braking is that the wheels do not lock up instantly. There is a short time period, even during a panic brake application, when the wheels are slowing but not quite locked. And it takes time for the contact patches of the tire to achieve a high enough temperature to begin leaving a visible skid. This time period, or distance, varies according to the type of road surface and sometimes to the composition of the tires. During this period, the car is slowing, just not leaving a distinct skid mark that can be found by the investigating officer.

The on-scene investigator must work with what he can see, that is, the visible skid mark.
Over the distance of the shadow or impending skid, the car is losing speed. Since the amount of speed lost during this period cannot be readily quantified at the accident scene, the calculations

to determine a speed from the skid marks is a minimum speed. This is to say the car was going at least this fast since it could not have left a skid mark of this length had it been going slower. It almost certainly was going faster than this.

By performing skid tests at the scene, resulting in visible skid marks of the same length as found at the accident scene, and using a chalk bumper gun to record the actual skid distance and speed during the tests, it can be shown with great certainty how fast the car was actually going to leave visible skid marks of that length.

If you have a case where the calculated speed from skid marks is at issue, contact Harris Technical Services. We can perform a skid speed demonstration for use at trial with photographs and videotape as part of the reconstruction.