

A Statistical Study of Tire Pressures on Road Going Vehicles

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ABSTRACT

Published information on studies of something so critical to safety as passenger vehicle tire pressures can be found [1, 2]; however, they only account for rolling tires. Studies related to spare tire pressures are lacking. This paper is the result of measurements on 150+ vehicles and the most surprising results are presented regarding the influence of Tire Pressure Monitoring Systems (TPMS) and the new spare tire locations and use. A statistical study was performed on the collected data to determine the correlation between tire pressures, vehicle age and TPMS. One particular topic of investigation was the relationship between various factors that influence spare tire pressure. Some newer models, particularly some mini-vans, have placed the spare tire in an unusual and inconvenient place for regular maintenance. Based on the data collected, TPMS has a positive influence on rolling tires but not on spare tires. The results support the need for TPMS to also monitor spare tire pressures.

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INTRODUCTION

For something as critical to passenger vehicle safety as spare tire pressures, public information is seriously lacking. This paper is the result of measurements on more than a hundred vehicles and the most surprising results are presented regarding the influence of TPMS and the new trend toward spare tire locations and use.

Gathering this data is notoriously difficult due to the psychological hurdles involved in gaining access to a trunk that can be embarrassingly cluttered and the time required to measure a tire buried under floor boards. One key observation is that spare tires are often left unchecked or overlooked in between regular vehicle maintenance resulting in safety issues for drivers.

The vehicles sampled ranged from full-sized pick-up trucks to compact cars. The study included vehicle model years from 1965 to 2015 (50 year range). The sampling was performed at the University of North Carolina at Charlotte campus as well as at local tire shops. The tire pressures were measured, recorded, and typically corrected to the manufacturer recommended pressures.

A statistical study was performed on the collected data to determine the correlation between tire pressures versus vehicle age, etc. One particular topic of investigation was the relationship between spare tire location and spare tire pressure. Some newer models, particularly some mini-vans, have placed the spare tire in an unusual and inconvenient place for regular maintenance. Based on the data collected, older vehicles were more likely to have lower spare tire pressures than their newer counterparts, regardless of the ease of access to the spare tire and TPMS has a positive influence on rolling tires but not necessarily spare tires.

THE TEMPORARY SPARE TIRE

On higher end vehicles, there is a trend towards more "Run-Flat" tires. These tires cost more, the vehicle ride is harsher and requires more compensation, and they will not be useful if there is rim damage. With stiffer sidewalls, run flat tires need a TPMS system to determine if there is air loss. Also, they have limited range once they are flat. They can only be safely driven for fifty miles at speeds less than fifty miles an hour [3, 4]. Even then, they can be damaged and need replacement. For these reasons, spare tires are still the norm.

While some vehicles equipped with a spare tire carry full-size spare tires, most now carry temporary spare tires. Temporary spares are smaller in size and construction from the main tires and wheels on the vehicle and typically request 60 pounds per square inch (psi) inflation pressure and maintain the full size tire diameter. However, they are smaller in volume than the main tires to lower the vehicle's weight, and save space for a larger storage compartment. As a result of their rare need and to reduce costs, they are often made to a lower quality standard.

Because the spare tire serves as an essential part to the reliability and safety of a road vehicle, regular maintenance is crucial to efficient performance of the spare tire. However, temporary spare tires have lower internal volume so a small air loss results in a greater lowering of the pressure. In addition, air loss is a function of pressure and since the temporary spare almost always requires 60 psi, it loses air faster than a tire with less pressure. Typical tires lose air about 1 psi per month [5] whereas we have measured temporary spare tire lose at over twice this rate. This higher pressure and lower volume make the temporary spare more vulnerable to under-inflation.

TPMS AND THE TREAD ACT

In the Department of Transportation (DOT), the National Highway Traffic Safety Administration (NHTSA) implemented the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act in April of 2005. In this, a mandate was made for vehicles to have a Tire Pressure Monitoring System (TPMS) which warned the driver of a low tire pressure.

Complaints about TPMS on spare tires included:

1. Spare tire TPMS would cause low pressure faults with spare tire use.
2. Requiring spare tire TPMS would motivate manufacturers to eliminate spare tires.
3. Spare tires are difficult to monitor on wheel speed systems.
4. Battery powered spare tire TPMS systems would require three million additional batteries in the environment.

Unfortunately, after much discussion regarding the impact of spare tire TPMS on the discontinuity of spare tires, the TREAD Act does not require monitoring of the spare tire.

DIFFICULTIES IN CHECKING THE TEMPORARY SPARE TIRE PRESSURE

Despite the TREAD Act requirement that a statement is added to owner's manuals that "Each tire, including the spare (if provided), should be checked monthly" [6], there is a risk for spare tire under-inflation.

Vehicle manufacturers are finding that the spare tire is in a very useful location for storage. To maximize this space, they have made several changes that make it difficult to check the spare tire pressure.

- Temporary spares stored in the trunk are installed valve stem down to free up wheel cavity space.
- On pickup trucks and SUV's, spare tires are stored up under the back of vehicles with the valve stem up.
- Temporary spares on many mini-vans have started moving them to up under the vehicle between the front seats and with the valve stem up.

The last two require assembling a hand crank and then winching the tire down to gain access.

On a positive note, one sample vehicle, a MINI Cooper, the spare was attached to a hose which provided a pressure tap for a TPMS system and a 'T' out to a remote valve stem near the rear bumper. It was easy to check and inflate, allowed the TPMS to keep tabs on the spare tire, and disconnected easily from the spare for removal.

The spare tire should be checked for punctures and cracks and inflated regularly. However, spare tires are often overlooked or left unchecked between regular vehicle maintenance resulting in a safety issue for drivers. This omission can be attributed to difficulty of

access, such as having to empty the contents of one's trunk, and reliance on road-side assistance in the event of a damaged or flat tire.

MEASURING TEST VEHICLES

Three general locations were used for gathering tire pressure data. The first was a "free air" pump on the campus of the University of North Carolina at Charlotte. In order to measure tire pressures we found that considerable psychological effort was needed to convince people to allow us the opportunity. About half the spare tires were in trunks that were half filled with items that would be best described as 'clutter' and these drivers did not want us to even see into the messy trunk. Many older cars either contained no spare or had no way of allowing the tire removal. Several vehicles that require assembling a crank to access the spare did not have the crank mechanism. On our first experience with the central storage location, the driver of a newer mini-van wouldn't allow us near the spare tire as he knew the time penalty involved.

The second location was the Firestone tire store on North Tryon St. in Charlotte, NC where the generous manager allowed us access as a research project (Thank you). We found the same rate of "junk in the trunk" and missing tools. However, as a rule, if you bring a car in for tire work, they have legal access to your trunk. Half of the tire pressure measurements were made this way and we worked hard to not get in the way of any tire technicians.

The third location would best be described as at "friends and family". About a dozen mechanical engineering students took calibrated pressure gages with them and measured pressures at their apartments and while on break. These students were recruited from a senior level "Tire Mechanics" course as extra credit. The students worked in pairs, used calibrated gages, and as needed, used little air pumps and replaced missing valve caps (black, gray and green).

EXPERIMENTAL CHECK SHEETS

Check sheets were used to record vehicle information. We recorded the name of the person measuring; the date, time, and temperature. We also recorded the vehicle type, make, model, and year. On the tires, we recorded the brand and size recommendations. If the values were in a safe range, the tire pressures were set to the driver preferred values. The safe range lies between the vehicle manufacturers suggested set point and maximum inflation pressure as noted on the sidewall of the tire. The pressures were always set closer to vehicle manufactures recommended pressure.

EXPERIMENTAL SET-UP

Most of the pressure data presented in this paper was collected between 10 am and 4 pm on mostly sunny days, with an average temperature between 21 and 32°C (70 and 90°F) to keep the effect of temperature variance in check. Tires will rise about 0.1 bar (1.5 psi) for every 10°C (18°F) of air temperature change [1, 7]. In accordance with the findings of [1], tire pressures were set to a higher value depending on the running and time of day.

