ABSTRACT
Most fleet managers are aware that tires are the second highest vehicle operating cost after fuel. However, many fleet managers may not realize that the number one maintenance challenge facing fleet’s today is proper tire inflation pressure maintenance. As tire and wheels are the second leading cause of roadside inspection citations (according to CVSA), fleets need to gain better control of their tire maintenance in order to prevent receiving fines and being shut down for unsafe operations. TPMS and automatic tire inflation systems can assist fleets in this difficult task and may be well worth the investment.

Most fleet managers are aware that tires are the second highest vehicle operating cost after fuel. However, many fleet managers may not realize that the number one maintenance challenge facing fleet’s today is proper tire inflation pressure maintenance.

Tires are the cause of 53.5 percent of roadside breakdowns, according to statistics compiled by Heavy Duty Trucking magazine. From 2007 to 2009, they were also the second leading cause of roadside inspection citations after brakes, as reported by the Commercial Vehicle Safety Alliance (CVSA).

In 2001, the Technology & Maintenance Council (TMC) surveyed more than 35,000 commercial truck and bus tires and found that:

- Only 44 percent of all tires were inflated within +/- 5 psi of their targeted inflation pressure.
- Twenty-two percent had at least one tire underinflated by 20 psi or more.
- Four percent of all vehicles had at least
one flat tire (50 psi below the targeted inflation pressure)
• About 22 percent of all dual tires had mismatched air pressure with a difference of greater than five psi.
• Approximately seven percent of all tires in truckload and LTL fleets are under-inflated by 20 psi or more.

According to TMC RP 235A, Guidelines for Tire Inflation Pressure Maintenance:
• A constant 20 percent underinflation will increase tread wear by 25 percent and a constant 10 percent overinflation will reduce tread wear by five percent. This is due to uneven abrasion of the tread against the pavement and the development of irregular wear patterns which shortens tread life.
• A constant 20 percent underinflated condition will reduce the life of a tire by 30 percent, and 40 percent underinflation will reduce tire life by 50 percent. Underinflation will increase flexing and heat buildup within the tire components which deteriorate tires and reduces casing life and retreadability. Overinflated tires are more vulnerable to tread surface cutting, impact breaks, punctures, and shock damage which also shortens tire life.
• Improper tire inflation, defined as little as 10 psi low, reduces fuel economy by about one percent. About 30-40 percent of the fuel required to move a vehicle down the highway is spent overcoming tire rolling resistance. When tires are underinflated, the amount of drag created by the tires increases.

In 2003, the Federal Motor Carrier Safety Administration (FMCSA) published a report of a study it conducted that showed:
• Tire-related costs are the single largest maintenance cost item for commercial vehicle fleet operators. National average tire-related costs per tractor-trailer were about two cents per mile, or about $2,375 for an annual 125,000-mile operation.
• For the average fleet operator in the United States, improper tire inflation increases the annual procurement costs for both new and retreaded tires by about 10 to 13 percent.
• Improper tire inflation is responsible for about one road call per year per tractor-trailer combination due to weakened and worn tires.
• Improper inflation increases total tire-related costs by approximately $600 to $800 annually per tractor-trailer combination.

Since 2003, the costs of both tires and fuel have increased substantially from $300 for the average cost of a truck tire and the $1.40/gallon average fuel price used to compute these costs. Today average tire prices are around $400 and fuel is around $3.00 a gallon. These higher costs dramatically increase total tire-related costs calculated in the FMSCA study.

As can easily be seen, improper tire pressure can significantly impact fuel economy, tire mileage, and casing retreadability. It is also primarily responsible for tire-related, enroute breakdowns which are a significant cost to linehaul fleets in not only tire and road service charges but also in lost driver and vehicle productivity (as the average road service down time is 2.5 hours). Improper inflation pressure also changes the tire contact patch which affects stopping and acceleration traction and vehicle handling thereby impacting vehicle safety. Properly maintained and performing tires aid drivers in preventing and mitigating crash situations.

Despite the Department of Transportation (DOT) requirement that commercial drivers conduct pre-trip inspections of their vehicles including the tires on them, tire inflation pressures are still not well maintained. There are many reasons for this:
  a. It takes too long to check tire pressure with a gauge (20 minutes on an 18-wheeler),
  b. checking pressure is a dirty job,
  c. the inside dual is difficult to reach and may be impossible to check if the valve stem is not properly aligned with the hand hole of the outside dual wheel.

Other problems include the use of inaccurate tire gauges, the loss of valve caps which are the primary seal on the valve stem, valve cores that can stick and slowly leak air, and the use of “Tire Billys,” ballpeen hammers or thumpers to check pressure (which only indicate when tires are totally flat).

All new passenger cars and light trucks (under 10,000 lbs. GVWR) sold in the U.S. are required to have some type of tire pressure warning system which the National Highway Traffic Safety Administration mandated in 2007 as required by the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act. All vehicles over 10,000 lbs. GVWR are next to be addressed. FMCSA will conclude studies on tire pressure monitoring systems for commercial trucks and buses this year and is expected to issue a position on their use in 2011.

**USER EXPECTATIONS FOR TIRE PRESSURE MONITORING SYSTEMS**

However, for more than 20 years, the trucking industry has had an interest in tire pressure monitoring systems.
monitoring systems (TPMS) in order to better and more efficiently maintain truck tire pressures. In the early 1990s, TMC developed a Recommended Practice to spell out the requirements and expectations that member fleets had for this technology. The first edition of this RP was RP 228, *Tire Radio Frequency Identification Guidelines*, first published in 1995. Since then, the document has evolved along with technology and is now known as RP 228A, *Guidelines for Wireless Tire Pressure Monitoring Systems for Medium and Heavy Duty Truck Tires*.

Twenty years ago, fleets identified four things that they wanted from TPMS systems:

1. Monitor tire pressure
2. Monitor tire temperature
3. Record tire mileage
4. Maintain a unique identification number for tire record keeping purposes

While most fleets felt it was important for the driver to receive tire alerts, they also thought it would be great for these systems to communicate via satellite or other wireless communications to alert fleet maintenance and operations departments about tire problems, too.

These requirements for TPMS systems haven’t changed much. Today fleets still want tire pressure monitoring systems to capture and communicate tire pressure and temperature information with external devices for tire pressure maintenance purposes. In addition, they desire automatic identification of the tire position, and tire identification, the ability to communicate through telematics devices, and audible/visible alarms to alert users of pressure and temperature problems.

**DIFFERENT TYPES OF TPMS AVAILABLE**

While TMC’s early vision of TPMS hasn’t changed greatly, TPMS technology certainly has. Today there are several different types of TPMS and tire inflation maintenance systems available for carriers to choose from depending upon need and price.

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**a. Tire Pressure Equalizers and Mechanical Tire Pressure Monitoring Systems.**

The first and most basic are Tire Pressure Equalizers and Mechanical TPMS. Tire Pressure Equalizers are designed to maintain the same pressure between two tires of a dual assembly and indicate the state of inflation pressure in the tires. These systems distribute the load evenly between the two tires and reduce irregular tire wear. They also provide a visual indicator (Go/No-Go gauge) of the pressure in the tires and one valve stem through which both tires can be inflated, making tire inflation pressure maintenance easier. If a tire develops a slow leak, the equalizer isolates both tires after a drop of around 10 psi so that the good tire is not damaged. These devices cost about $75 an axle end.

Mechanical TPMS attach to the external end of the valve stem and monitor tire pressure through a mechanical device that works much like an air gauge. They provide visual indicators on the valve stems that provide the status of pressure in the tire. There is no display or alarm in the cab since these devices do not have the capability of transmitting information. These devices are very inexpensive (usually under $10 a piece).
b. Electronic TPMS

Electronic TPMS are much more advanced systems. They use electronic tire pressure sensors to detect inflation pressure. Some sensors also detect the temperature of the air inside the tire which can be used to convert hot tire pressure to cold inflation pressure.

The sensors may either automatically transmit tire data wirelessly to a receiver, or will do so on demand when interrogated by an off-board reader. Some systems provide an in-cab display to alert the driver that may provide either a warning light or tire operating parameters, others use gate readers and/or hand held readers and transmit the data to the fleet, while still other systems are integrated into a wireless network (satellite/cellular/WiFi) and provide tire alerts to the fleet's managers and technicians as well as the driver. Some systems that are integrated into wireless networks also provide advanced analysis of the data, can provide alerts for hot axle ends, torque check reminders after tires are changed, work order and management reports, record tire mileage, and provide vehicle location. These systems may also include a monthly service fee. The sensors for these systems may be located on the tire liner, at the base of the valve stem inside the tire/wheel air chamber, in the wheel.
well, on the external end of the valve stem, attached to the outside of the wheel or attached to the wheel hub.

When choosing an electronic TPMS, fleets must consider their application, the type of data transmission they require, the extent of data analysis that is available from the TPMS being considered, whether they require that cold inflation pressure be reported, and who in their fleet needs to be aware of a developing tire problem. These systems range from around $600-$1,000 per vehicle.

c. Tire Inflation Systems
Tire Inflation Systems are systems that take air that is stored in the air tanks on a vehicle and use it to supply air to the tires. This can be done on demand or automatically triggered through sensors that monitor tire pressure. These systems can be broken down into two types: automatic and variable. Variable systems are operated by the driver who, at a push of button, can raise or lower the inflation pressure in the vehicle’s tires on demand. These systems are extremely expensive but are necessary for fleets that operate off-road in sand and mud such as construction and military vehicles do, and on forest roads as logging fleets do.

d. Automatic Tire Inflation Systems
Automatic Tire Inflation Systems maintain tire pressure at a single preset level and are pneumatically or electronically activated. Electronically activated systems use an ECU to measure tire pressure at regular intervals and inflate the tires as required. Pneumatically operated systems keep tires inflated by maintaining a predetermined air pressure continuously applied to the tires. A warning lamp indicates to the driver when tire or system service is required. All tire inflation systems have a pressure protection valve to ensure a rapid loss of tire pressure will not drain the vehicle air system below a safe pressure required for proper braking. If a significant loss of air should occur in a tire or the inflation system itself, the remaining tires are protected from air loss by check valves in the air hoses. All systems must be vented to prevent wheel end failure that may result from hub pressurization in the event of component failure. Some systems vent air at the wheel ends while others vent remotely.

These systems eliminate the need to manually inflate tires and operate with no involvement from the driver. Most automatic tire inflation systems are designed for trailers and route their plumbing through the hollow trailer axles. The warning light for the driver is usually mounted on the nose of the trailer where the driver can see it in his rear-view mirror. Systems designed for tractors have to be exterior
plumbed and often are subject to damage. As a result, not many fleets use these systems on tractors, although fleet acceptance on trailers with internal plumbing is good.

While all of these systems may reduce tire labor and improve tire inflation maintenance, it is still necessary to periodically inspect tires to ensure they are serviceable (have the proper tread depth and are free from damage), are properly inflated and the systems are working correctly. All of these systems need to be properly installed and maintained and fleet personnel must be trained to read, understand, and react to system alerts in order to deliver the benefits they provide.

The benefits of tire pressure monitoring and inflation maintenance systems are:

- Increased tire mileage
- Increased retreadability
- Reduced tire cost/mile
- Improved fuel economy
- Lower fleet carbon footprint and reduced greenhouse gas emissions
- Reduction in tire-related emergency road calls
- Improved driver and vehicle productivity
- Reduced tire-related labor

The 2003 FMCSA study mentioned previously also found that the return on investment (ROI) for the average fleet that purchases a tire pressure monitoring or inflation maintenance system would be between one and two years. With today’s higher costs of tires and fuel, this period has dropped to under one year.

Currently EPA’s SmartWay Program recognizes that TPMS can be an aid to improving fuel economy, however; these systems are not on the list of approved products since they are dependent upon fleet personnel to react to their alerts. To acquire approval for acceptance of a TPMS under the SmartWay Program, fleets must submit a plan for interacting with these systems so that the EPA can then calculate the savings the fleet can expect to gain in fuel economy. Automatic tire inflation systems are on the SmartWay-approved products list.

The FMCSA’s new safety rating system, CSA 2010, will accumulate all warnings, citations, and vehicle inspection reports to determine whether fleets are operating safely on U.S. highways. As tire and wheels are the second leading cause of roadside inspection citations, fleets need to gain better control of their tire maintenance in order to prevent receiving fines and being shut down for unsafe operations. TPMS and automatic tire inflation systems can assist fleets in this difficult task and are well worth the investment.

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