Motorcraft TIRE PRESSURE MONITORING SYSTEMS

TPMS 101

Tire Pressure Monitoring Systems, or TPMS as they are typically referred to, use an instrument panel warning light to alert the driver to low tire pressure.

Truck fleets have used TPMS for a number of years. But with the advent of the NHTSA-administered TREAD Act (see sidebar), tire pressure monitoring became mandatory with the 2008 model year for all cars and light trucks. (Industry-wide compliance was phased in starting with the 2006 model year, though Ford Explorers and Mercury Mountaineers began using them as early as 2002).

Two Types of TPMS: Direct and Indirect:

There are currently two competing TPMS technologies in use; ***Direct*** and ***Indirect***. Ford and most other OEM's use the Direct system. Though current Ford products no longer use the Indirect method, you should be aware of the basic methodology behind it.

Indirect TPMS Technology

Indirect systems do not require additional hardware if equipped with a four-wheel antilock Brake System. They simply measure wheel speed and translate that data into tire pressure psi.

Software programmed into the antilock (ABS) control module measures wheel speed from the ABS sensors. A tire low on pressure will measure smaller in diameter and in turn rotate at a faster speed than the others.

The ABS system "learns" the average speed at which each wheel rotates when traveling straight at a constant velocity. It can then tell if a tire is low by comparing the relative wheel speeds to one another.

Indirect systems have limitations. While they can easily measure air pressure differences between the four tires, they cannot identify a problem if all four tires are equally low.

Consequently, if four tires are equally low they will not trigger the warning light. Also, after checking and inflating all tires to proper levels, the system must be reset to again "relearn" the rotation rate of the tires. If the system is reset when the tires are low, the system will recognize these incorrect levels as "normal".

In addition, a tire typically has to lose anywhere from 8-14 psi before there's enough of a difference in diameter to be detected by the wheel speed sensors. The exact psi loss required to detect a problem varies depending on several factors, including tire type, diameter, and aspect ratio, as well as the sensitivity of the ABS system.

For example, low profile tires that have short stiff sidewalls will change diameter less than tires with taller aspect ratios and more flexible sidewalls. As a result, a loss of 10 psi in a low profile tire only changes the diameter of the tire less than one mm (.040 inches). Most ABS-based TPM systems cannot detect changes smaller than one mm, so in this example the warning light would not be triggered.

TREAD Act – Know the Law

Congress passed the Transportation Recall Enhancement, Accountability and Documentation (TREAD) Act in 2000. Its intent was to address concerns centering on recalls of alleged defective or improperly inflated tires.

Specifically, the TREAD Act was designed to address the dangers of low tire pressure which can cause serious problems such as poor vehicle stability and braking ability, along with reduced steering control.

Based on their conviction that many consumers do not check their tire pressures on a regular basis and that other climate, road hazard, and driving conditions lead to tire inflation issues as well, Congress mandated tire and vehicle manufacturers take steps to address this issue.

The resulting legislation was the TREAD Act which required vehicle manufacturers to equip all passenger cars and light trucks with tire pressure monitoring systems (TPMS) by the start of the 2008 model year. These systems are required to alert the driver if tire pressure falls 25 percent below the manufacturer's recommended pressure.

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Direct TPMS Technology

The second method of monitoring tire pressure, and the one currently used by Ford and most other OEMs, is the Direct method. Direct-style sensors are very accurate, usually within 2 lbs. or less, and come in one of three designs, Banded, Valve Mounted Bolt-On, or Valve Mounted Snap-In for Ford, Lincoln, and Mercury applications.

Banded Sensors

Banded sensors, also referred to as Rim Mounted, are mounted on a steel band in the drop center of the wheel.

Valve Mount Bolt-On Sensors

Valve Mounted sensors (also referred to as Schrader Valve style) are mounted on the inside end of the valve stem. Ford initially used one-piece “bolt-on” Valve Mounted sensors where the sensor and valve stem were molded together. The fastening process included an external hex nut to secure the valve stem securely. Ford engineers eventually migrated to a Banded style sensor.

Valve Mounted Snap-In Sensors

Beginning with select 2009 models (Escape and F-150) the latest design features a two-piece “snap-in” Valve Mounted sensor where the sensor and valve stem are separate pieces bolted together. They are referred to as “snap-in” because they use a more traditional rubber valve stem for fitment and no longer require the hex nut fastener. This style eliminates the need for an expensive stainless steel band and cradle. The valve stem is rubber and does not need a hex nut or o-ring. The sensor is also much smaller than the banded version, as well as lighter and less of a demand on wheel balancing.

Direct sensors work this way: A small pressure sensor with a built-in battery and transponder is mounted inside each tire. The sensor sends a radio signal at pre-determined intervals to a control module in the vehicle. The control module identifies the signal from each wheel and tracks pressure. If the air pressure drops below the predetermined threshold the control module turns on the warning light on the instrument panel.

When the vehicle begins to move, a centrifugal switch inside the sensor activates the pressure measurement and signal-sending functions. At about 20 mph, the sensor begins measuring the pressure every 30 seconds and transmits the results once each minute to the control module. This so-called “electronic handshake” keeps the wheels in touch with the control module.

Specifically, Motorcraft sensors complete an electrical connection either by a roll switch (imagine a tilt-mechanism from a pinball machine) or an accelerometer. (The roll switch was used on the Valve Mounted bolt-on design on the 2003-2006 Aviator, Explorer/Mountaineer, and Expedition/Navigator. All others use the accelerometer.)

Note that the different types of sensors (bolt-on and snap-in Valve Mounted as well as Banded) are not compatible with one another. (This means, do NOT mix and match sensors on a vehicle).

Under most operating conditions, if the tire pressure drops below the minimum setting, the module will turn on the warning light. The warning light will not indicate which tire is low so all tires need to be checked with an accurate tire pressure gauge. Even though the under-inflated tire may appear to be visibly evident, all the tires should be checked.

The sensors transmit their pressure data to the control module at 315 Mhz (some earlier sensors on Expedition/Navigator used 433 Mhz)

Each wheel sensor has a unique ID code so the control module can recognize it. When the vehicle is parked and has not moved for 15 minutes, the sensors stop transmitting. This is done to prolong the sensor’s internal battery.

After inflating the tires to the correct pressure, the vehicle must be driven to 20 mph or more. The warning light will then go off after a few minutes if the pressure is correct. (Note: Some Heavy Duty applications (called split-placard) require the system to be retrained after tire rotation due to the two different air pressures between front and rear axles).

Ford and Lincoln Mercury vehicle sensors need to be reset using one of two reset tools. (Tool #204-363 can be used for all three types of sensors. The older style bolt-on Valve Mount sensor can also use tool #204-324.)

Refer to the accompanying TPMS graphics for more information on replacing and resetting sensors.

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Banded (or Rim Mounted) Sensors:

The sensor is mounted to a steel band which is secured around the inside drop center of the wheel.

Care must be taken in removing or installing the tire as they can be easily damaged by the tire changing machine.

In addition these sensors must be mounted in a specific position, 180° relative to the valve stem.

Valve Mounted (or Schrader Valve) Sensors:

Motorcraft has also employed the strategy of attaching the sensor onto the valve. The sensor/transmitter unit is mounted at the inside end of the valve stem, with the valve stem functioning as an antenna.

Earlier styles were one-piece with the sensor molded onto the valve stem. These used grommets for sealing and an external hex nut for secure fastening.

New styles beginning in the 2009 model year are two-piece with the sensor bolted to the valve stem. This “snap-in” valve stem more closely resembles a traditional tire valve and does not require additional grommets or hex nuts.

The older one-piece bolt-on Valve Mounted sensors require mounting kits which must be used with each sensor. These kits include grommets, valves, caps and hex nuts for proper sealing.

In addition, a new mounting kit should be used every time a tire is taken off and replaced on the rim.

Additional care must be used in removing and replacing tires on any vehicle equipped with a TPMS.

Beware of Aerosol Tire Sealers and TPMS

Aerosol tire inflator/sealers are popular products in the aftermarket. Typically they are applied through the air valve to stop a puncture or slow leak.

But, aerosol sealants may clog the TPMS sensor inside the wheel and prevent it from reading normally.

Consequently, Ford Motor Company strongly recommends that if a customer uses these products to temporarily repair a flat tire, they should replace the TPMS sensor as soon as a permanent repair or tire replacement is performed.

Most aerosol inflator/sealer products include a warning stating they should NOT be used in wheels that contain TPMS sensors.

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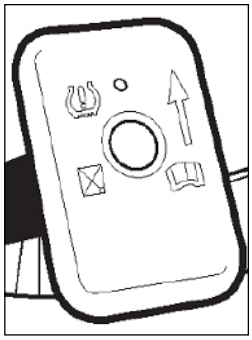
Things You Should Know About TPMS

Whether the vehicle you are working on uses ***Banded*** or ***Valve Mounted bolt-on*** or ***snap-in*** applications, there are several things you should be aware of.

Batteries … All Direct sensors (Banded or Valve Mounted) contain a small battery to power the sensor and transponder. These batteries are designed to have an estimated life of 10 years or 150,000 miles at which point the batteries will go dead and the entire sensor will need to be replaced. As battery voltage gets to the low limit, it may cause the TPMS control unit to generate a diagnostic trouble code. If any tire work is performed as the vehicle nears the 10-year/150,000-mile mark, good preventive maintenance suggests replacement of all the sensors.

ID … Additionally, each sensor has an identification code which signals its ID to the control module. (This also tells the control module that it's reading the right tire signal and not one from a nearby TPMS-equipped vehicle.)

Reset … The TPMS needs to keep track of which wheel is which. This means, for example, when the tires are rotated on a "split placard" vehicle – generally a heavy duty application with different front and rear tire pressures – the system must be reset to allow the control module to learn the new position of each sensor.



The reset tool instructs the sensor to send its ID code – with its unique "address" - to the control module so it can recognize the sensor and identify its location. The control module learns where each tire is by the sequence that the sensors are programmed. A reset tool is supplied with split placard vehicles and can be found in the glovebox or in the Owner Information kit. (Motorcraft TPMS-19).

Cold weather … A drop in temperature during cold weather will cause tire pressure to drop as the air inside contracts. This may cause the TPMS warning to light so tire pressure needs to be adjusted accordingly. Tire pressure drops 1 psi for every 10° drop in ambient temperature. (For example setting pressure inside a warm shop at 68F and driving the vehicle outdoors into an ambient temperature of 28F will result in a 4 psi drop.)

Tire Gauge …Always use an accurate, high-quality, and properly calibrated tire gauge.

Tire Rotation … Tire rotation requires that all tires be "re-calibrated" with the TPMS control module on vehicles with split placards.

Tire Changers … Tires should always be mounted using a tire changer to guarantee proper fit and to prevent damage to the sensor.

Filling Tires … While the air supply source should be clean and dry for any tire, this is especially true for TPMS applications. Sediment or moisture can affect the precision inner workings of the sensor and transmitter. Take care to blow off the area around the valve stem to remove any dirt or dust.

New Tires … Changing to tires that are not the same as the originals may affect the operation of the TPMS depending on the new tire's pressure range.

Mounting Tires to Wheels … Special care must be taken when removing or mounting tires on wheels with bolt-on Valve Mounted sensors, as the sensors can be easily damaged if direct leverage is applied to the sensor. On these wheels, the tire should be deflated and the valve pushed down into the tire before breaking the tire bead away from the wheel. (Refer to accompanying graphics or to the vehicle shop manual.)

Aerosol Inflators with Sealant …And as pointed out earlier, tire inflator/sealants should only be used for emergencies, and with the awareness that TPM sensors can be damaged by the use of these products. The gummy sealant will clog up the valve and the pressure-sensing port of the sensor. The warning light will go off and the sensor will need to be replaced.

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Tires are designed to operate within a specific range of air pressure. The recommended inflation pressure is printed on a decal in the driver's door jamb, and is designed to give the best combination of comfort, load carrying capability, and rolling resistance.

Over time tires lose air pressure naturally – generally about 1.5 psi per month. Decreasing inflation pressure makes the tire softer and reduces the tire's ability to carry weight. It also increases rolling resistance (which hurts fuel economy).

Increased rolling resistance and the resulting flexing in the tread scrubs away tread and causes the tire to wear faster. Eventually the tread is worn down to the wear bars. Once the wear bars are flush with the surface of the tread, the tire needs to be replaced.

When a tire is under-inflated it runs hotter than normal from increased friction in the tread and the sidewall. This may create a potentially dangerous situation depending on a variety of factors such as: how low the tire is, how fast the vehicle is moving and how heavily it is loaded, as well as the ambient temperature.

The lower the tire, the more heavily loaded the vehicle, the higher the speed, and the hotter the weather are all factors contributing to a greater risk of a blowout.

Tire pressure should be checked monthly as recommended in the Owner's Manual because all tires lose pressure over time. Air slowly seeps out through microscopic pores in the tires, tiny leaks in the bead seal, and even through porosity leaks in alloy wheels.

A tire's inflation pressure cannot be judged by appearances alone. For example, often, by the time a low profile radial tire looks low, it may be 10 to 15 psi underinflated.

Over the years independent studies have confirmed that many motorists rarely check the inflation pressure in their tires, or if they do, they check it incorrectly. Tire pressures should be checked when the tires are cold because driving generates friction and heat that increases the pressure inside the tires. Checking inflation pressure also requires an accurate tire gauge as some inexpensive tire gauges can be off by as much as several psi right out of the package.

Tips For Changing Tires

When using a tire machine, service personnel must be more careful as well as more knowledgeable than in the past so as to not inadvertently damage the TPMS system. A tire-changing machine can do unintended damage if not used carefully.

- When dismounting a tire, it's important not to drag the tire bead against the sensor. This is a common cause of sensor damage.
- If the tire has a bolt-on Valve Mounted-style sensor, allow the sensor to fall into the tire before removing the tire from the rim. When installing the tire, put both beads onto the rim, then insert the sensor. Be sure to use a new grommet and torque the retaining nut.
- When using a tire changer to break the bead from the wheel, position the bead-breaker 90 degrees away from the valve stem. This prevents the bottom side of the tire bead from hitting the sensor.
- TPMS bolt-on Valve Mounted sensors use a nickel-plated core. This helps reduce corrosion between the core and the sensor's aluminum stem. When servicing TPMS be sure the valve caps are in place and are made of plastic. (This reduces the possibility of the caps becoming "frozen" on the stem.)

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QUICK REFERENCE: TPMS Q&A

Q: How does TPMS work?

A: A vehicle's TPMS continuously monitors tire pressure through sensors located in the tires (called a Direct System) or through the ABS sensors to measure wheel speed (called the Indirect System).

The data collected by the sensors is sent to a control module that interprets the sensor signals and warns the driver when tire pressure is below the minimum acceptable level (25% below the manufacturer's recommendation) by turning on a warning lamp.

Q: What is the TREAD Act?

A: The TREAD Act, as administered by the National Highway Traffic Safety Administration, requires that all passenger cars, light trucks, and vans (Gross weight less than 10,000 pounds) be equipped with TPMS starting in model year 2008 (specifically September 1, 2007). Incomplete vehicles under 10,000 GVW have until September 1, 2008. The program was phased-in starting in the 2006 model year with 20% of new vehicles, increasing to 70% in 2007, and going to 100% in 2008.

Q: What's it mean if the TPMS warning lamp comes on?

A: When the TPMS warning light on the instrument panel lights it means the system has detected at least one tire with pressure below the accepted minimum psi for that vehicle. All the tires should be inspected and the tire pressure checked as soon as possible. The lamp will go out after the tires are properly inflated.

Q: What's it mean if the warning lamp goes on and off?

A: The warning lamp may light for a short period of time and then go out on cold mornings. This is generally caused by marginally low tire pressure that drops below the warning threshold overnight but rises to an acceptable level as the tires heat up either through vehicle operation or increased ambient temperature. (Note: Every 10 degree drop in ambient air temperature results in a one degree drop in tire pressure). Nonetheless, the tires should be inspected and the tire pressure checked.

Q: What's it mean if the warning lamp flashes on and off and then stays lit?

A: TPMS are designed to warn the driver when the system is not working properly. A system malfunction is indicated by a flashing of the TPMS warning lamp for 60 to 90 seconds. The warning lamp will stay lit after the flashing ends. This sequence repeats every time the vehicle is started up until the problem is corrected. (Note: Prior to September 2007, the Ford system would flash and then go OFF to signal a fault.)

Q: Why's proper tire inflation important?

A: Proper tire inflation is important for safe vehicle operation. Vehicles with properly inflated tires exhibit the optimum in ride and handling characteristics, tire life, as well as fuel economy.

Q: Why does tire pressure change?

A: Tire pressure drops about one psi for every 10 degree F drop in ambient temperature. In addition, tires lose as much as 1.5 psi per month as air escapes naturally from the porosity of the tire and rim. (For those interested in the science behind this, it's PV=nRT.)

Q: What's the TPMS warning lamp look like?

A: There are two different style icons approved by the TREAD Act as low tire pressure warning indicators. Ford and Lincoln Mercury vehicles use an image of a cross-section of a tire with an exclamation mark inside. (Some OE designs employ the alternate icon; an image of a top-down view of a vehicle showing all four tires.)

Q: Can low tire pressure be easily detected visually?

A: Under-inflated tires are hard to detect with the eye. Consequently, tires should be inspected and checked monthly with an accurate tire gauge. Note: TPM systems are not designed to be a substitute for regular tire maintenance. Drivers should be encouraged to review their Owner's Manual for additional information on tire care and TPMS.

For additional information on Motorcraft® branded products and other technical resources, visit our website at **www.motorcraft.com**.

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