

Check Your Air, Mister?

# SERVICING TIRE PRESSURE MONITORING SYSTEMS

BY DAVID HOBBS

As a once-familiar gas jockey greeting passes into history, now-mandatory TPMSs have made it easier for drivers to monitor tire pressures. Servicing these systems is somewhat more complicated than operating a tire pressure gauge.

**M**yth abound when it comes to tire inflation. For instance, owners tend to believe they don't have to check their tires once a month. Technicians sometimes believe they're a better judge of how much pressure a tire should hold than the engineer who designed it. I'm probably in good company admitting that I check tire pressures on my personal vehicles only when I change oil—unless, of course, a tire *looks* low. Whenever I'm too busy to change my own oil, the tech at the shop I patronize lowers the tire inflation from the specified 36 psi to 32 psi.

Recently, there was a slow leak in my left front tire. After a cold snap, guess what? The tire pressure monitoring system (TPMS) light came on. If not for that light, I would never have known there was a problem with one of my tires until it leaked down to around 15 psi, which is where even a procrastinator like me recognizes that a tire looks low enough to check the air pressure. Thanks to the light, I aired up my tires and went about my business without incident. Unfortunately, that wasn't a typical scenario

just a few years ago for most vehicle owners, and a few paid the ultimate price for believing those myths about not checking tire pressures regularly.

## Legislative Background

In September 2000, following several tragic accidents involving tire inflation, tire failure and vehicle rollover, a bill called the Transportation Recall, Enhancement, Accountability and Documentation Act (TREAD) was pushed through Congress in an amazing 18 hours and signed into law by President Clinton soon after that. Next, the task fell to the National Highway Traffic Safety Administration (NHTSA) to require automakers to implement the provisions of the new law by writing Federal Motor Vehicle Safety Standards (FMVSS) Standard 138.

The heart of the law affecting drivers and those of us in the service business is the section involving mandated systems to alert drivers to underinflated tires. Underinflated tires run hotter and have increased rolling resistance, which can factor into tire tread separation or blowouts. Phase-in for the TPMSs began in the fall of 2005 to mid-2006, with



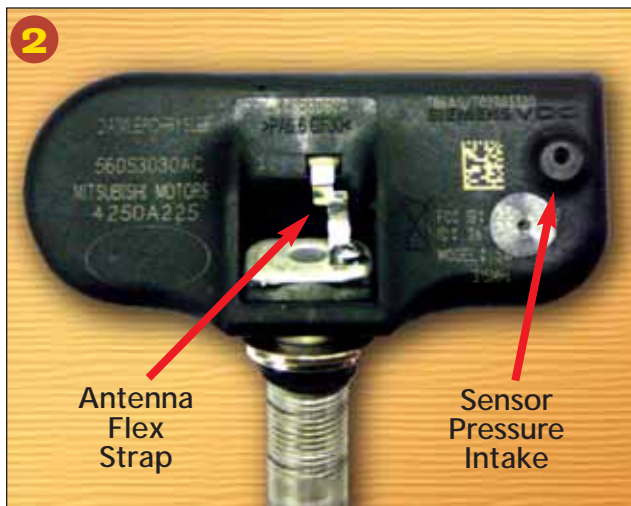


Photoillustration: Harold A. Perry; photos: General Motors

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Photo courtesy Freescale, Inc.



Photos: David Hobbs

100% compliance by the fall of 2007. (Vehicles over 10,000 lbs. GVWR, pickups with dual rear wheels and motorcycles are exempt.) Since this law was written and passed so quickly, there was no time for standardization within the industry, and the result has been a challenge for technicians.

## Tire Pressures & Temperature

Although overinflated tires have their own set of problems, if your customers' tires are as little as 4½ psi lower than specs, their tread life (outside wear) is decreased by 25%, and fuel economy goes down 2%. Those numbers can double if the pressure is down by another pound and a half. Along with decreasing pressure comes decreased weight-bearing ability. Temperature has a big effect on tires as well. The lower the air pressure in the tire, the higher the tire's temperature. Hot tire temps equal a greater risk for a blowout.

Cold ambient temperatures lower the pressure in a tire. For every 10°F drop in temperature, a tire can lose 1 psi. This means that if you get a cold snap one evening that drops the temperature 50°, your tires will be 5 psi lower. In a recent TSB, GM actually suggested adding 3 to 4 psi over the spec on the tire placard if you're adjusting pressure in a warm shop and expect to send the vehicle into a cold environment. A special mention on tire specs: The maximum cold inflation pressure on the sidewall is *not* the recommended

inflation pressure. It's a maximum limit for the tire only. Check the tire placard/label (usually in the driver's door jamb) or the owner's manual.

About 85% of all tire leaks are like the leak on my minivan—very slow. According to the new TREAD Act/FMVSS rulings, a 25% pressure drop in tire pressure *must* turn on a tire warning light to alert the driver. A 25% drop in tire pressure is not easy to detect visually.

## TPMS Sensors

There were two types of systems for detecting tire inflation prior to the phase-in of mandated TPMSs—indirect and direct. The *indirect* TPMS uses no special sensors to check for a low tire, only enhanced software in the ABS module reading wheel speed sensors to determine tire inflation. A tire that's underinflated is smaller in diameter, so it spins faster than a properly inflated tire. Because a tire on one side of a vehicle normally spins faster when the vehicle is turning, this software uses an average of the left front and right rear compared to the average of right front and left rear wheel speed sensors to determine if any tires are underinflated.

On the surface, these systems seemed like a good idea, but they weren't without their disadvantages. This type of system can't determine which tire is underinflated. In fact, if all four tires are underinflated, the system may not alert the driver at all. Also, with the indirect system, space-saver tires and even tires that are slightly mis-

matched in diameter or different from the factory size can trigger false TPMS warning lights.

The *direct* system was the other type of pre-TREAD Act system. These systems, which do use special tire pressure sensors, date back several years and are the type mandated by the new federal regulations. They use a small radio transmitter, most often mounted under the valve stem (photo 1 above), which communicates with a receiver in the vehicle. Two frequencies are used—315 and 434MHz. Each sensor broadcasts a unique ID, much like a cell phone's electronic serial number (ESN). TPMS sensors come in numerous shapes and sizes. All are small, lightweight micro-electromechanical sensor (MEMS) devices that contain sensor elements on an integrated circuit and contain a built-in non-serviceable lithium-ion battery that lasts seven to ten years.

Most sensors start to operate at speeds between 7 and 20 mph and sense within a 24- to 39-psi range. Their main job is to report a 25% or greater loss in specified tire pressure. TPMS sensors weigh about an ounce (28 grams), so doing a tire balance shouldn't be a big deal. Most use aluminum valve stems at the end of the sensor. GM is one of the few automakers currently using rubber-stemmed TPMS sensors. There are almost as many brands and styles of sensors as there are vehicles. For example, Schrader/Bridgport makes sensors for Ford, Chrysler, GM and Nissan/Infiniti; Beru makes them for Audi/VW, BMW,

Land Rover, Mercedes-Benz and Porsche; Pacific builds sensors for most Toyota and Lexus models.

Toyota has two physical styles of sensors—a 20° bend for aluminum wheels and 40° bend for steel wheels. Some Ford vehicles use a long hose clamp or band that encircles the inside of the wheel to hold the TPMS sensor in place, typically 180° from the valve stem to aid in wheel balancing. You may see the term *banded* applied to the Ford sensors, although many Ford sensors are the more common stem-mounted style.

TPMS sensors operate in different modes, depending on their commanded state and what the vehicle is doing (or not doing). They'll be less active when the vehicle is not being driven, to save battery life. This mode is called *stationary* or *park mode*. The sensor will sample pressure only every 30 seconds on some models and may not send a signal at all to the ECU unless it senses pressure loss. Another mode—*rolling* or *drive mode*—occurs once the sensors detect movement. The sensors sense pressure every 30 seconds and transmit that information every 60 seconds in rolling mode. If a sensor detects a change in pressure of more than a pound or so, this sampling rate is increased.

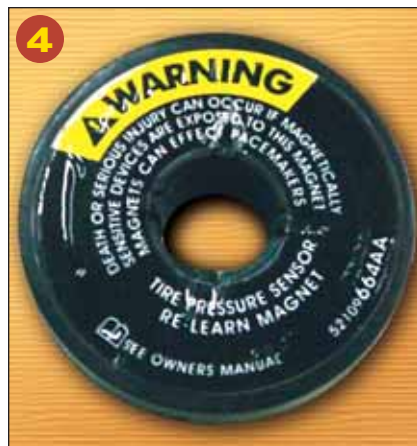
If you disconnect the battery cable, the ECU will remember which sensor was in which location, but will forget the pressure values. This can lead to misdiagnosis if you're looking at sensor pressures on a scan tool. Default pressure values read with some scan tools via the TPMS ECU are often a ridiculously low or high number until the ECU sees a valid information update after a loss of battery power. Just drive the vehicle above 20 mph for two to ten minutes and the ECU will have the correct tire pressure jotted down in volatile RAM.

Another TPMS sensor mode is called *sleep mode*. Vehicles built overseas may have their sensors in this mode prior to new-car dealer prep. Replacement sensors may also come in this mode and will need to be activated. Always write down the seven- or eight-digit ID from the TPMS sensor *before* installing it in



the wheel. On the systems that require a factory scan tool to register the sensors, you may need this info.

Using tire sealant in a wheel with a TPMS sensor is a sure way to ruin it. There's a small hole for sampling pressure and temperature that could very easily fill with sealant. If sealant gets in there, don't wait for a failure, just replace the sensor. Just as sensors have antennas (photo 2) built in to transmit, TPMS electronic control units have antennas to receive. Toyota puts the TPMS ECU antenna and receiver in the roof of the vehicle. On the Toyota Land Cruiser, the TPMS ECU antennas are mounted in the outside rearview mirrors. GM uses the rear defogger grid as an antenna for its TPMS ECU antenna. They've had problems with micro-arcing across tiny breaks in their defogger grids, causing a frequency very close to that of the TPMS. The resulting RFI can turn on



the TPMS light when the rear heated defogger grid is used.

Since most sensors use wake-up circuitry that uses technology based on centrifugal force, TPMS sensors must be mounted properly. If you get a sensor flipped upside down inside the wheel (and some will let you mount them that way), it may not receive the right centrifugal force on its accelerometer to wake it up, resulting in an illuminated warning light. Pay close attention to how sensors come out of a known-good wheel and you won't find this out the hard way.

Another less common type of accelerometer is directional in relation to the position of the sensor on the wheel itself. You might wonder how this could be installed incorrectly, since most sensors mount to the stem and the stem can go in only one place. Of course, that's right, and you'd never see a problem on any of the four wheels mounted on the vehicle because they rotate. It's the matching full-size spare tire using a TPMS sensor that could present a problem. On Mitsubishi SUVs, if you mount the spare tire on the tire carrier with the sensor/valve stem positioned straight down at the bottom, the sensor's roll switch may turn on and keep the sensor powered up. This will convince the TPMS ECU that the spare is actually a rolling wheel. Mitsubishi advises mounting the spare tire with the sensor at or near the 12-o'clock position.

## Instrument Panel Displays

All 2008 and newer models have TPMSs. On older vehicles, if it's not a Ford and there are no aluminum valve stems, the system may be the indirect type (ABS wheel speed sensor-based). Look at the instrument panel cluster (IPC) to determine if the vehicle even has a tire pressure monitoring system. When you turn on the ignition, check for an amber low tire pressure light. Typically, if the vehicle is a deluxe model such as a GMC Denali, it will be able to communicate to the driver which tire is low. If the vehicle is a basic model, the driver will see only the icon on the IPC indicating that one or more tires are underinflated.

## SERVICING TIRE PRESSURE MONITORING SYSTEMS

Always look at the displays on the dash or console (upper and lower) for a TPMS light or message during the first minute of driving. A TPMS light that stays on steady indicates a tire with low pressure. A flashing light indicates a problem with a sensor or the system. The flashing may last only one minute, then go back to a steady light, and will repeat at each ignition cycle. Keep in mind that a blinking TPMS indicator light does not always indicate a fault. Some will blink when the sensors are in sensor training or learn mode.

### TPMS ECUs

Okay, so I've got a sensor that can detect a leaky tire and a display that tells my customer that either a tire is low (light on steady) or the system has a problem (light blinks for the first minute or so of each key cycle). How does all this connect together and work? Basically, TPMS sensors in the wheels send radio signals to a TPMS ECU, which, if there's an underinflation issue,



then signals the cluster to turn on the warning light. A more specific answer varies with each manufacturer.

GM actually has one of the simplest systems. The TPMS sensors send radio signals with information that includes an ID unique for each sensor, and the radio signals are picked up by an ECU.

The same ECU is also used to receive radio signals for the vehicle's keyless entry system. The Remote Keyless Entry (RKE)—or Remote Function Actuator (RFA), in GM lingo—sees each sensor's unique radio ESN and sends that data via the GMLAN (CAN) single-wire low-speed data bus to the in-

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strument cluster to turn on a TPMS warning light.

At the other end of the scale, Chrysler has some systems that take a far more complex approach. The 2006 Grand Cherokee, for example, has three “middlemen” between the four TPMS sensors and the main tire pressure ECU. These middleman ECUs are transponders at three out of the four wheel wells—left front, right front and right rear. These modules receive the short-range radio signal from the TPMS sensors located inside all four wheels, then communicate info like tire pressure and sensor ESN via a single-wire LIN data bus that’s connected to a wireless control module (WCM).

Only three middleman transponders are needed. The strategy goes like this: If signals from three out of four TPMS sensors are received and identified, the fourth signal must be the left rear wheel. The WCM in the Grand Cherokee’s case is the keyless entry/theft deterrent module, which Chrysler calls the sentry key remote entry electronic module (SKREEM). The SKREEM is the module that surrounds the ignition key lock cylinder and now is the main TPMS ECU as well. The module then puts the TPMS info on a CAN B two-wire medium-speed data bus to be monitored by the IPC/DIC, so the driver will know that a tire is low. Sound like a complicated system just to turn on a low tire pressure light? Yes, but no more so than many body electronics systems that use multiple networks to do a simple task like activating a trunk release.

### New Sensors and Tire Rotations

Extinguishing a steady low tire pressure light typically requires putting air in the tire (of course) and a little driving. Toyotas have a button (photo 3 on page 41) to reset the tires after correcting an air pressure problem. Servicing these systems beyond adjusting air pressure, installing sensors in the wheels or doing tire rotations is a task for the above-average tech who’s willing to make the investment in training and tools. Tire rotations are simple if the system is the basic version with a warning light and *not* an enhanced system with a message

display that tells the driver which tire is low. Just rotate the tires as usual.

If a vehicle with an enhanced system comes into your shop, your work will be a little more challenging. The ECU will think the left rear is still the left front, and so on. To prevent customer confu-

sion and comebacks after a tire rotation, you’ll need to put the sensors into the learn (training) mode. This is where it can start to get fun. Just like everything else I’ve mentioned so far that varies from one OEM to the next, learn mode procedures are no exception.

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On some GM models, you have to push the brake pedal and turn the headlamp switch off and on repeatedly. On some Fords, it's a combination of brake pedal activation and the correct sequence of ignition cycling. Some GM models have driver info center prompts as you press buttons on the IPC. Some Toyota SUVs even have a second tire set switch in the glove box for the driver to select a totally different set of tires (winter, off-road, etc.) to install and introduce to the ECU. Swap the tires, press the button and a second set of sensors is already registered with the vehicle's TPMS ECU to eliminate the need to run a completely new TPMS sensor registration/relearn procedure. Some vehicles must be driven above 15 mph for up to 10 minutes as part of the relearn procedure, while others, like Toyota, require a factory scan tool.

All the factory service info websites and most aftermarket service information sites cover TPMSs very thoroughly. Some TPMS tool manufacturers even include a printed manual with information on how each system works and how to handle extinguishing the TPMS light.

### Electronic Tools: Wake Up & Talk to Me

Performing the learning function first requires that the sensors be awake and active. Some TPMS sensors need only a magnet to "ping" them into waking up in preparation for ECU learning. Every TPMS tool I've seen had one of these magnets (photo 4 on page 41) in the kit with the electronic tool. After looking up the procedure for a vehicle on how to put the ECU into learn mode, simply place the magnet next to or around the valve stem (not Ford banded models) and the sensor will wake up and send out a signal for the ECU to interpret. On most models, when the procedure is completed for each wheel you'll hear the horn honk, signaling it's time to go to the next wheel.

Be aware that most systems don't allow a lot of time to get the procedure completed. This means that on some models, if there's a spare tire equipped with a TPMS sensor, you'll need to gain access to it first before performing the



learn procedure. Do your reading *before* doing the procedure. More often than not on newer systems, the sensors require some sort of electronic signal.

Some of the less expensive tools on the market do a "hunting" procedure that pings both frequencies of sensors that are in production as well as run various LF (Low Frequency - 125kHz continuous wave) and RF (Radio Frequency that's pulse modulated) to wake up the sensor. These are the tools that typically have no display—only a few buttons and LEDs. Low cost and simplicity are advantages, but the disadvantage with some of these basic testers is that they won't allow you to connect to a PC to download sensor information and they won't show you the sensor's electronic ID or read out pressure/temperature and battery condition if applicable. Full-featured testers (such as the two shown in photo 5 on page 42) have menu-driven displays that allow you to scroll through a list of vehicles and select the vehicle/sensor

type that pertains to that car, then sends enough of the right energy to ping the wheel you're testing.

When using a TPMS tool, place the tool's head or antenna against the sidewall of the tire next to the valve stem. The sensor signals won't travel through metal. On banded-type sensors used on Ford (rubber valve stem), place the tester up to the sidewall 180° away from the valve stem, which is where the TPMS sensor should be. If you run into a sensor that does not respond when activated by the tool, try activating another sensor. This will help you determine if the tool is able to activate the sensor or if you have a problem with that particular sensor. Bartec offers a TPMS tool that not only activates sensors but can work with the vehicles in need of a factory scan tool to put the ECU into learn mode. It comes with a cable and connector for the OBD II-style DLC (photo 6 above).

Keep in mind that checking for a bad TPMS sensor or prepping the sensors for a relearn are all these tools do. If the dashboard light is blinking due to a problem with the ECU, a serial bus problem or a bad transponder (Chrysler), you'll still need a scan tool that can look at TPMS trouble codes and PIDs to diagnose the rest of the system. This is the same as any other electronic system on the vehicle.

### Mechanical Tools & Spare Parts

The valve cores inside TPMS sensor stems are nickel plated to prevent corrosion. Putting the old-style brass valve core into the newer aluminum TPMS





## TPMS TOOL SOURCES

<b>ATEQ</b>	.....	<a href="http://www.tpms-tool.com">www.tpms-tool.com</a>
<b>Bartec</b>	.....	<a href="http://www.bartecusa.com">www.bartecusa.com</a>
<b>Cornwell Tools</b>	.....	<a href="http://www.cornwelltools.com">www.cornwelltools.com</a>
<b>K-Tool International</b>	.....	<a href="http://www.tipstool.com">www.tipstool.com</a>
<b>Mac Tools</b>	.....	<a href="http://www.mactools.com">www.mactools.com</a>
<b>Matco Tools</b>	.....	<a href="http://www.matcotools.com">www.matcotools.com</a>
<b>Omitec</b>	.....	<a href="http://www.omitec.com/us">www.omitec.com/us</a>
<b>OTC</b>	.....	<a href="http://www.otctpms.com">www.otctpms.com</a>
<b>Plews/Edelmann</b>	.....	<a href="http://www.plews-edelmann.com">www.plews-edelmann.com</a>
<b>Schrader</b>	.....	<a href="http://www.schrader-bridgeport.com">www.schrader-bridgeport.com</a>
<b>Snap-on Tools</b>	.....	<a href="http://www.snapon.com">www.snapon.com</a>
<b>Spectrum Composites</b>	.....	<a href="http://www.spectrumcomposites.com">www.spectrumcomposites.com</a>

sensor stem is a no-no. After the dissimilar metals cause corrosion, the tire will begin to leak, not to mention the difficult time you'll have removing the valve stem core down the road for tire service or replacement. Remember, a valve stem replacement is now anywhere from \$25 to \$150 or more instead of a couple of bucks, due to the TPMS sensor incorporated into the valve stem.

Also related to aluminum TPMS valve stems and the potential for corrosion and/or leakage is the valve stem cap. Those fancy chrome caps stand a good chance of corroding and seizing on the aluminum stem. Use only plastic or nickel-plated caps. A true TPMS valve stem cap will have a rubber seal in the top to seal out moisture. Don't worry; customizers are already coming out with really cool valve caps that are compatible with TPMS valve stems.

Being kind to TPMS sensors and valve stems includes heeding the amount of torque that's applied to the valve stem core. We've never had to worry about this before, but now we must protect those expensive sensors. The stem torque tool I use looks like a screwdriver handle with a valve stem core tool end on the bottom. You can't tell by looking at it but it's a torque wrench; once you hit a safe torque level, the tool makes the familiar torque wrench clicking sound.


Also, check the specs on the 11mm nut that holds the TPMS sensor in the wheel and torque it in place with an inch-pound torque wrench. Whenever a

TPMS sensor is removed, always use new hardware when reinstalling either the old unit or a new sensor. The seal, threaded nut and associated metal washers come in inexpensive packages that are available from most parts stores either individually or as part of a kit that's worth considering as a part of your shop's TPMS arsenal (photo 7). Most manufacturers stress not reusing hardware, as the seals can have a memory that doesn't allow alignment on reinstallation, causing a leak and an illuminated TPMS warning light down the road.

No doubt we'll continue to see an abundance of sensors broken as techs learn hard (and expensive) lessons on how to mount and dismount tires with TPMS sensors. Most of the TPMS tool companies and the Tire Industry Association ([www.tireindustry.org](http://www.tireindustry.org)) have plenty of training available on these systems, including how to mount tires in a way that's gentle to TPMS sensors. Common errors are breaking the bead right on the valve stem/sensor and not being careful with the sensor as you run the dismounting procedure. There's a simple and inexpensive tool that suspends the TPMS sensor down into a safer area of the wheel as the machine does the dismounting (photo 8). A tip for mounting new tires: Grab your TPMS tool and ping the sensors as soon as the vehicle shows up at your shop. If three out of four wheels respond but the fourth does not, you can quote the customer a price for a new sensor *before* you get blamed for breaking it!

## Costs & Future Concerns

All these new parts and processes can add up to some costly repairs. Some shops are already going overboard. I recently heard about an owner of a TPMS-equipped vehicle who priced a new set of tires and was told he'd have to see his dealer for new sensors. The dealer then told him it would cost \$100 per sensor and another \$200 to install and program. Yipes! What about a simple flat tire? Can it really cost \$120 to fix a flat? A friend of mine who's an avid fisherman in Florida recently found himself out that much after saltwater accumulated in his Toyota Highlander's TPMS sensor valve stem during frequent boat launches, causing valve stem corrosion.

High vehicle mileage will take us on new adventures as we service these systems. We've all seen collapsed brake hoses and calipers that hold the pads on, making rotors glow red, pads wear out super fast and valve stem caps melt. What could that kind of heat do to a TPMS sensor? No doubt we'll see all kinds of new twists to old problems with TPMSs as these vehicles rack up the miles. So as these systems keep evolving, we'll all have to keep learning the latest tire pressure monitoring system service procedures. 

This article can be found online at [www.motormagazine.com](http://www.motormagazine.com).