By Tom Austin, IBA Chief Technical Advisor

Tire Pressure Monitoring

MINIMIZING TIME THAT your wheels aren't turning is the key to maximizing the miles you can cover each day while riding a motorcycle. Although most long distance riders don't yet use one, a tire pressure monitoring system (TPMS) is one of the accessories that can increase the time spent riding while simultaneously increasing rider safety.

Because the maintenance of proper tire pressure is a critical safety factor, checking tire pressure before *every* ride is recommended by motorcycle manufacturers and the Motorcycle Safety Foundation. A TPMS eliminates the need for the pre-ride tire pressure checks — which can really be a hassle in bad weather — while simultaneously providing early detection of a slow leak. Early leak detection not only reduces the risk of an accident, it minimizes the chances of being forced to fix a flat in a difficult or unsafe location.

Based on a recent survey of about 200 long-distance riders, only 30% currently use a TPMS. But those riders that already use a TPMS are almost never sorry they spent the $150-$200 it costs for a typical system. Once you use one, you probably won't want to be without a TPMS in the future. The first time you get a warning light while rolling down the freeway at 75 mph and have time to make it to the next exit before the tire goes flat, you will realize that you got a real bargain for the money you spent.

How Likely Are Flat Tires?

IF YOU HAVEN'T had a flat tire while riding a motorcycle, you are probably fairly new to long-distance riding. Based on a survey of IBA members that have ridden least 100,000 miles, only 10% have never had a flat tire. On average, there is one flat tire every 54,000 miles.

About 90% of all flats happen to the rear tire. (It's common for the front tire to run over a nail or screw lying on its side and kick it up so that it can more easily puncture the rear tire.) Some respondents to the survey, including Bob Higdon, have ridden over 1 million miles without ever having a front tire flat.

One flat every 54,000 miles may not sound like much, but you never know when the next flat is going to happen and many riders experience flats more frequently than the average.

How frequently you can expect to have a flat depends on how much construction activity there is in the areas you ride and how frequently you use the roadway shoulder.

Most of the nails and screws that cause flat tires fall out of the beds of pickup trucks driven by carpenters, sheet metal workers, and other tradesmen. As vehicles run over the nail and screws, they bounce around until they are picked up by a tire or eventually make it to the shoulder of the road or the roadway median. (That's why motorcycle officers who frequently use the roadway shoulders get more flat tires. A 13-year veteran California Highway Patrol motorcycle officer reports an average of one flat per 1,000 miles, almost all of which were rear tires.)

Factors Affecting Tire Pressure

To know what your tire pressure should be, it is important to understand how tire pressure is affected by variations in temperature and, to a lesser extent, altitude.

The Temperature-Pressure Relationship: As the temperature of a tire rises, so does the pressure; it's the law, the "ideal gas law." As a tire warms up, the "absolute" pressure increases in proportion to the change in "absolute" temperature. [1]

To keep things simple, Table 1 shows the relationship between gauge pressure and temperature on the Fahrenheit scale. As the table shows, a good rule of thumb is that each 10˚F increase in tire pressure causes tire pressure to increase by about 1 psi. Using the row in boldface type as an example, if the tire pressure is set at 40 psi when the tire is "cold" and the ambient temperature is 60˚F, the pressure will rise to 43.2 psi when the temperature increases to 90˚F. However, that assumes the motorcycle has been parked long enough for the tire temperature to be equal to the ambient temperature.

When the motorcycle is being ridden, the constant flexing of the sidewalls causes a tire to heat up; the higher the speed and load, the higher the temperature. During summertime weather, the air temperature inside the rear tire of a motorcycle running at freeway speeds may be 150˚F or higher. If the tire pressure was set to 40 psi after the bike had been parked overnight at 60˚F, the tire pressure would rise to 49.5 psi when the tire temperature increases to 150˚F. On a heavy touring bike, like a Honda Gold Wing, the rear tire temperature can easily reach 180˚F at freeway speeds on a hot (90-100˚F) summer day. A tire set at 40 psi in the cool of the morning would increase to 52.6 psi. It's difficult to find published specifications on the maximum "safe" tire temperature, but, based on the warning levels used on two different TPMS brands, 176-194˚F is as hot has you would want to run.

Because of the relationship between tire temperature and pressure, optimum tire pressure monitoring requires knowing the temperature of the air inside the tire. Just knowing that the pressure is at or above the set point doesn't mean that the tire isn't leaking. Based on the examples described above, *a loss of 9 psi or more can't be detected without measuring the temperature of the air in the tire and accounting for it.*

Table 1: The Effect of Temperature on Tire Pressure

30°F	60°F	90°F	120°F	150°F	180°F
32.1 psi	35.0 psi	37.9 psi	40.7 psi	43.6 psi	46.5 psi
33.1 psi	36.0 psi	38.9 psi	41.9 psi	44.8 psi	47.7 psi
34.0 psi	37.0 psi	40.0 psi	43.0 psi	46.0 psi	48.9 psi
35.0 psi	38.0 psi	41.0 psi	44.1 psi	47.1 psi	50.2 psi
35.9 psi	39.0 psi	42.1 psi	45.2 psi	48.3 psi	51.4 psi
36.8 psi	**40.0 psi**	**43.2 psi**	**46.3 psi**	**49.5 psi**	**52.6 psi**
37.8 psi	41.0 psi	44.2 psi	47.4 psi	50.6 psi	53.9 psi
38.7 psi	42.0 psi	45.3 psi	48.5 psi	51.8 psi	55.1 psi
39.7 psi	43.0 psi	46.3 psi	49.7 psi	53.0 psi	56.3 psi
40.6 psi	44.0 psi	47.4 psi	50.8 psi	54.2 psi	57.6 psi
41.6 psi	45.0 psi	48.4 psi	51.9 psi	55.3 psi	58.8 psi

The Altitude-Pressure Relationship: Most people recognize that the air is "thinner" at higher elevations. Table 2 presents the relationship between altitude and atmospheric pressure using an equation available from the following location: http://www.engineeringtoolbox.com/air-altitude-pressure-d_462.html

Because a conventional tire pressure gauge measures the *difference* between tire pressure and atmospheric pressure, the gauge reading will increase as altitude increases even if the pressure in the tire is unchanged. As indicated in Table 2, each 1,000 feet of elevation above sea level causes the gauge pressure to increase by about 0.5 psi. A tire pressure gauge should indicate an increase in pressure of about 2.5 psi when a motorcycle is ridden from sea level to Denver, Colorado (elevation about 5,000 feet). So *if you set your tire pressure at 5,000 feet, it should be 2.5 psi higher than the setting you use at sea level* to achieve the same absolute pressure level. However, a pressure monitoring system that uses an internal sensor is actually measuring absolute pressure. The standard sea level pressure of 14.7 psi is subtracted from the absolute pressure so that the pressure displayed will match what a tire gauge would read at sea level.

Table 2: Effect of Altitude on Pressure

Altitude (feet)	Altitude (meters)	Atmospheric Pressure (psi)	Tire Gauge Pressure Change (psi)
0	0	14.70	
1,000	305	14.17	+0.52
2,000	610	13.66	+1.03
3,000	914	13.17	+1.52
4,000	1,219	12.69	+2.00
5,000	1,524	12.23	+2.47
6,000	1,829	11.78	+2.92
7,000	2,134	11.34	+3.36
8,000	2,438	10.92	+3.78
9,000	2,743	10.50	+4.19
10,000	3,048	10.11	+4.59

TPMS Technology

All tire pressure monitoring systems provide a warning to the vehicle operator when the inflation pressure of a tire falls out of the acceptable range. The simplest form of a TPMS is a mechanical device that replaces the valve stem cap and indicates inflation pressure with a pop-up post marked with colored bands. When the green band is showing, the inflation pressure is above the minimum specification. In addition to concerns about their reliability, the mechanical systems are obviously useless once the vehicle is moving.

More advanced systems use a battery-powered transmitter mounted on the valve stem or inside the wheel and illuminate a remotely located warning light when inflation pressure is outside of the acceptable range. Generally speaking, tire pressure monitoring systems are only for tubeless tires. The aftermarket systems with external sensors that replace the valve stem cap will actually work on tube-type tires, but they aren't recommended because the weight of the sensor

1 "Absolute pressure" is pressure read by a tire gauge plus the atmospheric pressure, which is 14.7 psi at sea level. An "absolute temperature scale" is one that defines "0" as the temperature at which all molecular motion stops and all gases are frozen into solids. On the Fahrenheit scale, absolute zero is -459.67˚F. A temperature increase from 50˚F to 100˚F is an increase in absolute "Rankine" temperature of 509.67˚R to 559.67˚R, or 9.8%, so the absolute pressure would increase by 9.8% and the "gauge pressure" would increase by more than that.

increases the risk of a valve stem failure. To minimize the risk of valve stem failure, it is recommended that external sensors only be used on wheels that have been retrofitted with solid metal valve stems.

As described in more detail below, some systems also display the exact inflation pressure of each tire, the temperature of the air inside the tire, and other supplemental information. The features a TPMS may or may not have are described below.

Low Pressure Warning: Except for the cheap mechanical systems mentioned above, tire pressure monitoring systems have a warning light that illuminates when the tire pressure is outside of the acceptable range. Since the availability of a low pressure warning is the whole point of a TPMS, this is a universal feature.

Display of Tire Pressures: The ability to display individual tire pressures is also a common feature of aftermarket systems. It's a nice feature to have because it provides an indication of when tire pressures are getting close to the level at which a warning will occur. It's also a useful feature when you hit an object on the roadway and want the earliest possible indication of whether a leak is occurring.

High Pressure Warning: A high pressure warning is a feature in some systems. The value of this feature is that it can provide an indication of when a tire is overheating.

High Temperature Warning: The more effective way to provide a warning that a tire is overheating is with an actual measurement of the air temperature in the tire. This is a better approach because a tire can overheat without setting off a high pressure warning if it is simultaneously leaking.

Temperature Compensation: As noted above, temperature compensation is necessary to detect a significant loss in pressure in a tire running at 150°F. Without temperature compensation, a low pressure warning may not be displayed until the tire pressure is dropped by more than 30% from where it should be.

Wireless Transmission to Display: Having a tiny radio transmitter integrated into the pressure sensor greatly simplifies the installation of an aftermarket TPMS. Systems without transmitters require a "pickup" sensor to be located so that there is only a small air gap when the pressure sensor passes by the pickup. A pickup mounted in close proximity to the wheel complicates the installation and subjects the pickup to damage from road debris.

Weatherproof Display: It would seem obvious that the display for a TPMS intended for motorcycle use would be weatherproof. Sadly, as discussed below, this is not always the case.

12-Volt Display Power: Some systems have a display powered by a replaceable battery; others are wired into the 12-volt system of the vehicle. A display with its own battery may be easier to install, but the disadvantage is that the battery will need to be replaced frequently, particularly if you want to be able to have the display illuminated continuously when riding at night.

Update Frequency: Ideally, the TPMS display would be updated continuously so that pressure values are always current. However, continuous transmission from the pressure sensor reduces battery life. Several different approaches are used to reduce battery drain, the simplest of which involves the use of periodic updates. As discussed

Table 3: Aftermarket Tire Pressure Monitoring Systems

	SmarTire	Tire Watch	Doran 360M	Kisan tireAlert	Pressure Pro	TireGard
Low Pressure Warning	✓	✓	✓	✓	✓	✓
Display of Tire Pressures	✓	✓	✓	✓	✓	✓
High Pressure Warning	✓	✓	✗	✗	✗	✓
High Temperature Warning	✓	✓	✗	✗	✗	✓
Temperature Compensation	✓	✗	✗	✓	✗	✗
Wireless Transmission to Display	✓	✓	✓	✗	✓	✓
Weatherproof Display	✓	✓	✓	✓	✓	✗
12-Volt Display Power	✓	✗ (CR2450)	✓	✓	✓	✗ (AAA)
Update Frequency	constant	1 sec	6 min./ FastLeak	constant	5 min. or -12.5%	constant
Sensor Battery Life	7-years	5-years	3-4 years	No battery required	4-5 years	2-5 years
Sensor Weight	28 g	27 g	14 g	10-20 g	17 g	13.5 g
Sensor Location	Internal	Internal	Internal or External	External	External	External
Supplemental Capabilities	—	ambient temp., time	—	speed, accel rate	—	—
Price	~~$189~~ *discontinued*	$189	$200	$275-325	$250	$149
Overall Rating	★★★★	★★★☆	★★★☆	★★☆☆	★★☆☆	★☆☆☆

below, the periodic update frequency can range from continuous to once every six minutes. The use of motion-activated transmission is another option; transmissions are stopped when the wheels haven't been turning for a specific period of time.

Sensor Battery Life: The battery life of the TPMS sensors is going to be a function of the update frequency and the size of the battery. Original Equipment Manufacturer (OEM) systems are typically designed to last from 5-10 years. Some aftermarket systems also have long battery life. A shorter life is reasonable if the battery is user replaceable.

OEM Systems

Until recently, the only tire pressure monitoring systems available for motorcycles were produced by aftermarket manufacturers. However a growing number of OEMs are now making systems available on new motorcycles.

> "…a growing number of OEMs are now making systems available on new motorcycles."

BMW now has a TPMS option for virtually all of its street motorcycles equipped with tubeless tires from the F650GS twin to the K1300 series. The option is not available on motorcycles with tube-type tires like the G650GS single and the F800GS. Other manufacturers have a TPMS available on just a few models. For example, Honda has made TPMS standard on the Gold Wing and Kawasaki has a TPMS option for the Concours 14.

OEM tire pressure monitoring systems use sensors mounted on the inside of the wheel rims that incorporate battery-powered transmitters. The non-replaceable battery, which is sealed within the sensor, has a relatively long battery life. It's too early to know what the average battery life will actually be, but based on automotive experience, it should be a minimum of 5-years.

The display on an OEM TPMS is integrated into the instrument panel. Some systems, like the Honda Gold Wing system, only have a warning light to indicate when the tire pressure is outside of the manufacturer's recommended range. They do not display the actual tire pressure. (This may be due to concern about how owners will interpret temperature variations due to changes in tire temperature.) Other OEM systems will also display tire pressure on a multifunction display. For example, the BMW system allows the user to continuously display tire pressures, or ambient

temperature, but not both at the same time. The Kawasaki Concours system also allows the rider to see the actual tire pressures.

Aftermarket Systems

Aftermarket pressure monitoring systems are the only option for most new motorcycles and all existing motorcycles that were not originally equipped with TPMS (OEM systems are not retrofitable.) Some aftermarket systems use sensors mounted inside the wheel that are similar to the sensors used on OEM systems. Unlike the OEM systems, some aftermarket systems that mount inside the wheel have user-replaceable batteries. Also unlike the OEM systems, some of the aftermarket systems use external sensors that replace the valve stem cap.

Table 3 provides a summary of the features available from six different aftermarket tire pressure monitoring systems specifically intended for motorcycles. As shown in the table, all of the systems provide a low pressure warning and all will display tire pressures. However, there are significant differences with respect to temperature measurement and temperature compensation, display power supply, display update frequency, sensor battery life, sensor location, and the availability of supplemental features.

SmarTire: Since May 5, 2004, when the availability of the system was announced, the SmarTire motorcycle TPMS has set the standard against which all other systems should be compared. A sensor that measures both pressure and temperature is attached to the inside of the rim with a stainless steel band. A metal "bridge" is provided to avoid blocking the end of a valve stem located in the center of the rim.

An important feature of the SmarTire system is that it uses the internal air temperature measurement to determine what the pressure reading should be. For example, if the system was initially programmed to monitor a tire set at 40 psi when at 60°F, the SmarTire system will report "-3" if the pressure is measured to be 43 psi when the internal air temperature is 120°F. Even though the pressure has risen from the set point, the system detects that there has been a slight loss of air.


SmarTire Display Mounted on BMW Clutch Reservoir

When pressures are in the normal range, the display just shows two rectangles, as illustrated in the accompanying picture. The top rectangle represents the front tire and the bottom rectangle represents the rear tire. By pressing the little button to the left of the display, the system will cycle through the following readings:

- Front tire pressure
- Front tire pressure deviation from ideal (e.g., "-2")
- Front tire temperature
- Rear tire pressure
- Rear tire pressure deviation from ideal
- Rear tire temperature

When the pressure of either tire is either 15% too low or 15% too high, the warning light above the button will flash and the display will indicate which tire is out of range and how far it is out of range relative to the temperature compensated ideal pressure (e.g., "-7"). A warning is also triggered if the temperature in either tire exceeds 176°F. In this case, the actual tire temperature is displayed along with the flashing warning light.

Physical failures of some of the first generation sensors resulted in a recall under which SmarTire not only replaced the system free of charge, the company covered 100% of the cost associated with having the system replaced at the dealership of the owner's choice (and paid the dealer directly). Since that recall, problems with the system are rarely reported unless a really incompetent tire monkey breaks a sensor during a tire change. (When exercising reasonable care, it is easy to avoid putting any pressure on the internal sensor when either removing or installing a tire. You simply lift the second bead over the sensor before

removing it and, similarly, lift the first bead installed over the sensor before installing the second bead.)

As described above, the SmarTire system has everything you could ask for in a TPMS. Unfortunately, the patents under which the SmarTire system is built were purchased by Bendix Corporation near the end of 2008 and production of the motorcycle version of the system was subsequently terminated. Bendix apparently has no interest in the motorcycle TPMS market. Until recently, replacement sensors used on the passenger car version of the system were available and they work with the motorcycle display. Unfortunately, even the passenger car sensors are now no longer available.

Tire Watch: Tire Watch is a completely wireless system manufactured in France by LDL Technologies. (LDL Technologies also produces OEM sensors, including the sensors used on the Gold Wing TPMS.) Like the SmarTire system, the Tire Watch system measures both pressure and temperature. As sold by the U.S. distributor, the system comes with several adapters to mount the internal sensors to a wide range of motorcycle models. It also has several adapters for mounting the display. The models covered include Honda Gold Wings and STs, Yamaha FJRs, Suzuki V-Stroms, most Triumphs, and pre-2006 BMWs with rim mounted valve stems.

Tire Watch Display and Internal Sensor

Relatively few Tire Watch systems have thus far been sold in the U.S., but two IBA members who responded to my recent survey use the system and haven't had problems with it. Unlike the SmarTire system, the Tire Watch system does

not display a temperature compensated pressure deviation. However, riders who understand the relationship between pressure and temperature can use the information displayed by the Tire Watch system to determine whether a tire is leaking.

The low pressure warning level is user selectable over a range of 20-51 psi. Since the highest pressure displayed by the system is 51 psi, the Tire Watch system will not cover the full range of pressures experience by heavy touring motorcycles like the Honda Gold Wing. However, if you set the high pressure to the maximum 51 psi level, it will *not* trigger a high pressure warning when the true pressure exceeds 51 psi. The temperature measurement capability of the system is an adequate alternative to the display of pressures above 51 psi. A "temperature threshold crossing alert" is pre-programmed at 80°C (176°F) for the front tire and 90°C (194°F) for the rear tire.

Compared to the SmarTire System, the two disadvantages of the Tire Watch system is that the low pressure warning is not temperature compensated and the display is powered by a battery rather than 12-volt power, which means that display batteries have to be periodically changed. However, with limited use of the backlight display, the battery will last for approximately a year and it's easy to change. (A quick press of the left button will turn the backlight on for a few seconds; the warning light is illuminated when necessary regardless of whether the backlight is on.)

The Tire Watch system is available for $189 from Murphskits.com.

Doran 360M: The Doran TPMS is somewhat unique in that the sensors can be installed either externally or internally. Unlike the more sophisticated SmarTire and Tire Watch systems, there is no temperature measurement. As a result, it is more difficult to determine whether a warm tire has experienced a loss in air pressure because the rider has to guess at the tire air temperature. However, this is a more theoretical than practical problem because most leaks are fast enough that a temperature-compensated warning may only be a minute or two sooner.

To conserve battery power, the Doran system normally transmits only once every 6 minutes. This is also a disadvantage relative to the SmarTire and Tire Watch system; however, the Doran system does employ what the company calls "Fast Leak" detection that causes a signal to be transmitted to the display whenever there is 2.8 psi loss in pressure in 12 seconds. In addition, although the information on the company's website isn't clear on this point, Doran tells me that the low pressure alert is immediately triggered when the pressure falls 12.5% from the set value.

From what I've heard from a few IBA members that have experience with the system, it's fairly reliable. There have been a few premature sensor failures reported, but Doran apparently takes care of warranty claims quickly.

The system is available from Doran-mfg.com for $199.99.

Kisan tireAlert: The most complex of the aftermarket TPMS products is the Kisan "tireAlert" system. In addition to measuring pressure and temperature, it records the frequency with which a sensor attached to the wheel is rotating. This allows the system to monitor speed and acceleration.

As explained by Kisan, "Transceivers are installed such that when the wheel-mounted sensor rotates past, the air gap is about a 1/4" (6mm), and it is in radial alignment with the Sensor — the centerline of both are at the same diameter." Although this design eliminates the need for a battery in the sensor, it requires a pickup to be installed. Mounting of the pickup significantly complicates the installation of the system and makes the system vulnerable to damage.

In addition to the sensor and the 12-volt powered display, a separate "power supply" needs to be remotely located (an underseat location is recommended).

Unlike all of the other systems, the Kisan system displays a temperature compensated pressure rather than the true pressure. There is a two stage warning that occurs when the pressures drop by 4 psi and 6 psi from the proper, temperature compensated value.

For the reasons described above, the absolute capabilities of the Kisan system are greater than the other systems available for riders who are willing to live with the additional complexity of the system. Since none of the IBA members I surveyed have used the system, I don't know about its reliability. The system is available from Kisantech.com.

Pressure Pro: The Pressure Pro system is similar to the Doran system in that it only measures pressure (not temperature), it has a weather-resistant 12-volt powered display, and an intermittent display update (once every 5 minutes). As with the Doran system, an alert is apparently triggered immediately if the pressure drops by 12.5% from the set value. Since none of the IBA members I surveyed have used the Pressure Pro system, I have no information regarding its reliability.

The display and the sensors, which are sold separately, are available from Tirepressuremonitor.com.

TireGard: The Show Chrome TireGard system is one of the most popular aftermarket monitoring systems because it is relatively inexpensive and the easiest to install. The sensors mount externally, replacing the valve stem cap. The pressure readings are not temperature compensated but the system does measure both pressure and temperature.

TireGard (top) in RAM Aqua Box with Blackberry

The TireGard display is not designed to be permanently mounted to the motorcycle. It is a small battery-powered "key fob" style device that can be carried in a pocket. A vibrating alarm allows a warning to be detected even if the display is out of sight. Actually using the TireGard display as a key fob for the

Table 4: Pros and Cons of Six Different Systems

	Pros	Cons	Bottom Line
SmarTire	Temperature compensated, excellent display, constant updates	Out of production	The gold standard; unfortunately out of production
Tire Watch	Pressure and temperature, rapid updates	Battery powered display	A good choice if you don't mind periodic battery changes
Doran	Internal or external sensors, fast leak detection, remote warning light	No temperature data, slow updates	A good choice despite lack of temperature measurement
Kisan	Pressure and temperature, supplemental speed and acceleration data	Not wireless, most difficult to install	Installation more complicated and prone to damage
Pressure Pro	Simple	No temperature data, slow updates	Little information regarding reliability
TireGard	Pressure and temperature, easy installation	Reliability issues, Battery-powered display is not weatherproof	Better than nothing

motorcycle is not practical because the display is not waterproof! Some users mount the display inside a waterproof cover designed for a cellular phone so that the display is visible and protected from the weather.

There are numerous reports of problems with the TireGard system, including display failures, failure to read a sensor, and inaccurate tire pressure readings. Not surprisingly, there are some reports of valve stem failures when the system is installed on rubber valve stems. Some owners report having the system replaced three or more times during the 12-month warranty period. (See, for example, owner reviews at http://tiny.cc/aiq86.)

In addition to the lack of a weatherproof display, another disadvantage of the TireGard system is that there isn't sufficient battery power to leave the display illuminated during night riding. The warning light will automatically illuminate when there is a low pressure warning, but only temporary illumination of the display is possible for monitoring tire pressures.

The TireGard system is available from numerous retailers, including Wingstuff.com.

Summary

Since the SmarTire system is no longer available, no other single system stands out as the clear choice, in part because of the limited data on reliability. Although the TireGard system is clearly the most popular, the lack of a waterproof display and the numerous reports of reliability problems are an issue. This Kisan system offers many interesting features, but it's more complicated to install and I really don't like the need for the installation of a pickup right next to the wheel.

Among the remaining systems, Tire Watch is the only system that provides temperature information along with pressure. It also has an advantage over the other systems of updating the pressure display on a second-by-second basis. I would prefer a 12-volt powered display, but the battery is easy to change and seems to have a reasonable life.

Notwithstanding the lack of temperature data and rapid display updates, the Doran system is also worth considering. Detecting a significant leak quickly is the highest priority task a TPMS has to do and the Doran system does that. The reduced maintenance associated with a 12-volt display is also an advantage.

Although the choice of a system may be difficult, any system is better than nothing. Just be sure to install metal valve stems if you decide to use a system with an external sensor.

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