After studying Chapter 22, the reader will be able to:

1. Explain why a tire-pressure monitoring system is used.
2. Discuss the TREAD Act.
3. List the two types of TPMS sensors.
4. Describe how to program or relearn TPMS sensors.
5. List the tools needed to service a tire-pressure monitoring system.
KEY TERMS

- Active mode
- Alert mode
- Cold placard inflation pressure
- Delta pressure method
- Initialization
- Relearn
- Sleep mode
- Storage mode
- Transmitter ID
- TREAD Act
- Tire-pressure monitoring system (TPMS)
NEED FOR TIRE PRESSURE MONITORING

BACKGROUND

- A tire-pressure monitoring system (TPMS) is a system that detects a tire that has low inflation pressure and warns the driver.
  - Because a run-flat tire is designed to be driven a limited distance and at limited speed after it loses air pressure, a method of alerting the driver had to be found.
- There were two systems used, indirect and direct, until the 2008 model year when the use of direct-reading pressure systems was required by law.
NEED FOR TIRE PRESSURE MONITORING
LOW TIRE PRESSURE EFFECTS

• Low-tire inflation pressures have led to all of the following:
  • Reduces fuel economy due to increased rolling resistance of the tires—3 PSI below specifications results in an increase of 1% in fuel consumption
  • Reduces tire life—3 PSI below specifications results in a decrease of 10% of tire life
  • Increases the number of roadside faults, which have been estimated to be 90% related to tire issues
  • Reduces handling and braking efficiency
  • Hundreds of deaths and thousands of personal injuries are due to problems associated with low-tire inflation pressure.
NEED FOR TIRE PRESSURE MONITORING
COLD PLACARD INFLATION PRESSURE

- The term **cold placard inflation pressure** is used in service information to indicate the specified tire inflation pressure.
- The “placard” is the driver’s side door jamb sticker that shows the tire size and the specified tire inflation pressure.
- The pressure stated is measured when the tires are cold or at room temperature, which is about 70°F (21°C).
NEED FOR TIRE PRESSURE MONITORING
COLD PLACARD INFLATION PRESSURE

FIGURE 22–1 The tire pressure placard (sticker) on the driver’s side door or door jamb indicates the specified tire pressure.
### Need for Tire Pressure Monitoring

#### Cold Placard Inflation Pressure

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Tire Pressure (PSI)</th>
<th>Change from Cold Placard Inflation Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>122°F (49°C)</td>
<td>37</td>
<td>+5</td>
</tr>
<tr>
<td>110°F (43°C)</td>
<td>36</td>
<td>+4</td>
</tr>
<tr>
<td>100°F (38°C)</td>
<td>35</td>
<td>+3</td>
</tr>
<tr>
<td>90°F (32°C)</td>
<td>34</td>
<td>+2</td>
</tr>
<tr>
<td>80°F (27°C)</td>
<td>33</td>
<td>+1</td>
</tr>
<tr>
<td>70°F (21°C)</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>60°F (16°C)</td>
<td>31</td>
<td>−1</td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>30</td>
<td>−2</td>
</tr>
<tr>
<td>40°F (4°C)</td>
<td>29</td>
<td>−3</td>
</tr>
<tr>
<td>30°F (−1°C)</td>
<td>28</td>
<td>−4</td>
</tr>
<tr>
<td>20°F (−7°C)</td>
<td>27</td>
<td>−5</td>
</tr>
<tr>
<td>10°F (−12°C)</td>
<td>26</td>
<td>−6</td>
</tr>
<tr>
<td>0°F (−18°C)</td>
<td>25</td>
<td>−7</td>
</tr>
<tr>
<td>−10°F (−23°C)</td>
<td>24</td>
<td>−8</td>
</tr>
<tr>
<td>−20°F (−29°C)</td>
<td>23</td>
<td>−9</td>
</tr>
</tbody>
</table>
• Indirect tire-pressure monitoring systems do not measure the actual tire pressure. Instead, the system uses the wheel speed sensors to detect differences in the speed of the wheels.
• The indirect system uses the wheel speed sensors to check the rolling speed of each of the tires.
• If a tire is underinflated, the following occurs:
  • A tire that is underinflated will have a smaller diameter than a properly inflated tire.
  • An underinflated tire will rotate faster than a properly inflated tire.
FIGURE 22–2 A tire with low inflation will have a shorter distance (radius) between the center of the wheel and the road and will therefore rotate faster than a tire that is properly inflated.
INDIRECT TPMS
COMPENSATION FOR CORNERING

- When a vehicle turns a corner, the outside wheels rotate faster than the inside wheels.
  - To compensate for this normal change in wheel rotation speed, the indirect tire-pressure monitoring system checks the diagonally opposed wheels.

**FIGURE 22–3** The speeds of the diagonally opposed wheels are added together and then compared to the other two wheels to check if one tire is rotating faster.
Advantages for using the indirect system include:

- This system does not require additional components, such as tire-pressure sensors.
- This system is easily added to existing vehicles that were equipped with four-wheel speed sensors.
- It is low cost.
• Disadvantages for using the indirect system include:
  • System cannot detect if all four tires are underinflated.
  • Use of a space-saver spare tire may trigger the warning light.
  • Cannot detect if more than one tire is low.
  • Does not meet the Federal Highway Traffic Safety Standard (FMVSS) 138, which requires the system to be able to detect if any tire is underinflated by 25%.
The diagnosis of an indirect tire-pressure monitoring system includes the following steps:

- Verify the fault.
- If the system has detected low tire pressure, check and adjust the tire pressure to that listed on the door pillar placard or factory specifications as stated in the owner’s manual or service information.
- Determine and correct the cause of the underinflated tire.
INDIRECT TPMS  
RELEARN (RESET) PROCEDURES

- After checking that all four tires are the same size and condition, the system may require resetting, also called **relearn** or **initialization**.
- Check service information for the exact steps to follow, which could include driving the vehicle over an extended period of time.
- The procedure usually includes the following:
  - Inflate all four tires to the placard inflation pressure.
  - Depress and hold the reset switch for 3 seconds.
  - Drive the vehicle so the ABS controller can learn the new “good” values.
FIGURE 22–4 The indirect tire-pressure monitoring system has a reset switch that should be depressed after rotating or replacing tires.
The **Transportation Recall Enhancement, Accountability and Documentation (TREAD) Act** requires that all vehicles be equipped with a tire-pressure monitoring system that will warn the driver in the event of an underinflated tire.

- This act was passed due to many accidents that were caused at least in part to underinflated tires.
- These accidents resulted in many deaths.
The FMVSS 138 specifies that the driver must be warned of a low-tire inflation pressure by turning on an amber warning lamp.

The warning lamp must also come on during a bulb check.

The spare tire is not required to be monitored, but many vehicle manufacturers do equip full-size spare tires with a pressure sensor.

- If the TPMS warning lamp is on at start-up, the system has detected a tire with low inflation pressure.
- If the TPMS warning lamp is flashing for 60 to 90 seconds, a system fault has been detected.
The TREAD Act specifies that the driver be warned if any tire inflation pressure drops by 25% or more from the cold placard pressure.

<table>
<thead>
<tr>
<th>Cold Placard Inflation Pressure (PSI)</th>
<th>Warning Light Pressure (−25%)</th>
<th>PSI Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>30.0</td>
<td>10.0</td>
</tr>
<tr>
<td>39</td>
<td>29.3</td>
<td>9.7</td>
</tr>
<tr>
<td>38</td>
<td>28.5</td>
<td>9.5</td>
</tr>
<tr>
<td>37</td>
<td>27.8</td>
<td>9.2</td>
</tr>
<tr>
<td>36</td>
<td>27.0</td>
<td>9.0</td>
</tr>
<tr>
<td>35</td>
<td>26.3</td>
<td>8.7</td>
</tr>
<tr>
<td>34</td>
<td>25.5</td>
<td>8.5</td>
</tr>
<tr>
<td>33</td>
<td>24.8</td>
<td>8.2</td>
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<tr>
<td>32</td>
<td>24</td>
<td>8.0</td>
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<tr>
<td>31</td>
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<td>30</td>
<td>22.5</td>
<td>7.5</td>
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<tr>
<td>29</td>
<td>21.8</td>
<td>7.2</td>
</tr>
<tr>
<td>28</td>
<td>21</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Check Tire Pressure and Do Not Rely on the Warning Light

TECH TIP

- Industry experts think that 25% is too low and that this generally means that a tire has to be lower by about 8 PSI to trigger a warning light. All experts agree that tire pressure should be checked at least every month and kept at the specified cold placard inflation pressure.
IDENTIFYING A VEHICLE WITH TPMS

- All vehicles sold in the United States since the 2008 model year must be equipped with a tire-pressure sensor.
- If the tire/wheel assembly has a tire-pressure monitoring system (TPMS) valve-type sensor, it can usually be identified by the threaded portion of the valve stem.

**FIGURE 22–5** A clear plastic valve-stem tire-pressure monitoring sensor, showing the round battery on the right and the electronic sensor and transistor circuits on the left.
IDENTIFYING A VEHICLE WITH TPMS
RUBBER TIRE VALVE STEMS

• Some TPMS sensors are black rubber like a conventional valve core but it uses a tapered brass section and a longer cap.

• If the cap is short then it does not have a stem-mounted tire pressure sensor.

• However, the wheel may be equipped with a wheel-mounted sensor, so care should still be taken to avoid damaging the sensor during service.
IDENTIFYING A VEHICLE WITH TPMS
RUBBER TIRE VALVE STEMS

FIGURE 22–6 A conventional valve stem is on the right compared with a rubber TPMS sensor stem on the left. Notice the tapered and larger brass stem. The rubber TPMS sensor also uses a longer cap that makes it easy for a technician to spot that this is not a conventional rubber valve stem.
IDENTIFYING A VEHICLE WITH TPMS
ALUMINUM TIRE VALVE STEMS

• If the vehicle has an aluminum tire valve stem, it is equipped with a direct tire-pressure monitoring system.

• The valve stem itself is the antenna for the sensor.
Use TPMS-Friendly Replacement Tires

TECH TIP

• Some replacement tires use steel body plies and could therefore block the low-level radio frequency signal sent from the tire-pressure sensor. Before installing replacement tires, check that the tires are safe and recommended for use on vehicles equipped with a direct-type tire-pressure monitoring system.
TPMS PRESSURE SENSORS
TYPES

• All direct TPMS sensors transmit tire inflation pressure to a module using a radio frequency (RF) signal.
• There are two basic designs used in direct pressure-sensing systems.
• These sensors are manufactured by a variety of manufacturers, including:
  • Beru
  • Lear
  • Pacific
  • Schrader
  • Siemens
  • TRW
Each sensor uses a 3-volt lithium ion battery that has a service life of 7 to 10 years.

- Valve stem-mounted sensor
- Banded sensor

FIGURE 22–7 The three styles of TPMS sensors most commonly found include the two stem-mounted (rubber and aluminum, left and top), and the banded style (right).
TPMS PRESSURE SENSORS
MODES OF OPERATION

- Tire-pressure sensors operate in three modes of operation:
  - Active mode
  - Sleep mode
  - Alert mode
TPMS SENSOR OPERATION

- Depending on the type and manufacturer, tire-pressure monitoring sensors can be any of several different designs.

- The TREAD Act does not specify the type or operation of the pressure sensors, only that the system must be capable of measuring tire inflation pressure and light the TPMS warning lamp.

- The types of sensors include:
  - Continuous-wave-type sensor
  - Magnetically-triggered-type sensor
  - Pulse-width-modulated-type sensor
Check the TPMS Sensors Before and After Service

TECH TIP

- It is wise to check that all of the tire-pressure monitoring system sensors are working before beginning service work. For example, if the tires need to be rotated, the sensors will have to be reprogrammed for their new location. If a tire-pressure monitoring sensor is defective, the procedure cannot be performed. Use an aftermarket or original equipment tire-pressure monitoring sensor tester.
Check the TPMS Sensors Before and After Service

**FIGURE 22–8** A typical tire-pressure monitoring system tester. The unit should be held near the tire and opposite the valve stem if equipped with a wheel-mounted sensor, and near the valve stem if equipped with a valve-stem-type sensor.
Does a TPMS Sensor Work before Being Installed?

FREQUENTLY ASKED QUESTION

- No. New tire-pressure warning sensors (transmitters) are shipped in **storage mode**. This mode prevents the battery from becoming discharged while in storage. When the transmitter is installed in a wheel/tire assembly and the tire is inflated to more than 14 PSI (97 kPa), the transmitter automatically cancels storage mode. Once a transmitter has canceled storage mode, it cannot enter this mode again. Therefore, once a sensor has been installed and the tire inflated above 14 PSI, the clock is ticking on battery life.
TPMS RECEIVER

• The wireless TPMS receiver is housed in one of the following locations, depending on the vehicle:
  • Remote keyless entry (RKE) receiver
  • Body control module (BCM)
  • Door module
  • Individual antennas near each wheel well.

FIGURE 22–9 Some vehicles display the actual measured tire pressure for each tire on a driver information display.
DIRECT TPMS DIAGNOSIS

WARNING LIGHT ON

• If the TPMS warning light is on and not flashing, the system has detected a tire that has low inflation pressure.

• If the TPMS light is on, perform the following steps:
  • Check the door placard for the specified tire inflation pressure.
  • Check all tires using a known-accurate tire-pressure gauge.
  • Inflate all tires to the specified pressure.
FIGURE 22–10 A tire-pressure warning light can vary depending on the vehicle, but includes a tire symbol.
DIRECT TPMS DIAGNOSIS

WARNING LIGHT FLASHING

• If the TPMS warning lamp is flashing on and off, the system has detected a fault in the system.

• Faults could include:
  • Defective wheel sensors, such as a sensor with a dead battery.
  • A fault in the receiver, such as in the remote keyless entry module.
Check the Spare Tire

TECH TIP

Many vehicles equipped with a full-size spare tire also have a TPMS sensor. If the inflation pressure decreases enough, the system will trigger the TPMS warning light. This is confusing to many vehicle owners who have checked all four tires and found them to be properly inflated. This fault often occurs during cold weather when the tire inflation pressure drops due to the temperature change. Most 2008 and newer vehicles equipped with a full size spare tire will come equipped with a TPMS sensor in the spare.
When installing a new pressure sensor either because it failed or was damaged, the new sensor has to be relearned.

This process is usually done with either:

- A scan tool
- A TPMS tester
Scan tools can be used for TPMS service if the scan tool is an original equipment tool for the vehicle make or if an aftermarket scan tool has original equipment compatible software to access the chassis or body functions of the vehicle.

A scan tool is used to perform the following functions:

- Register TPMS sensors
- Perform initialization
- Monitor sensor values
FIGURE 22–11 The parts of a typical stem-mounted TPMS sensor. Notice the small hole used to monitor the inflation pressure. The use of stop-leak can easily clog this small hole.
FIGURE 22–12 When replacing a TPMS sensor, be sure to record the sensor ID because this needs to be entered into the system through the use of a tester or scan tool.
TPMS SENSOR ACTIVATIONS
ACTIVATING THE SENSOR

• A tire-pressure monitoring system sensor needs to be activated to verify that the sensor actually works.
• This should be performed before any tire or wheel service is performed.
• There are three methods used to activate a TPMS sensor to cause it to send a signal that can be captured to verify proper operation.
• These activation methods include:
  • Using a magnet
  • Changing inflation pressure
  • Triggered by a handheld TPMS tester
FIGURE 22–13 A magnet is placed around the valve stem to reprogram some stem-mounted tire-pressure sensors.
Whenever servicing a tire/wheel assembly that has a direct TPMS system, certain items are needed.

When a stem-mounted sensor is removed, the following items are needed:

- Information
- Digital tire-pressure gauge
- Tire valve core torque wrench
- Tire valve nut torque wrench
- Sensor service kit
FIGURE 22–14 Always use an accurate, known-good tire-pressure gauge. Digital gauges are usually more accurate than mechanical gauges.
FIGURE 22–15 A clicker-type valve core tool ensures that the valve core is tightened to factory specifications.
FIGURE 22–16 An assortment of service parts that include all of the parts needed to service a stem-mounted TPMS sensor being installed after removal for a tire replacement or repair.
All TPMS Sensors Will Fail

TECH TIP

- All TPMS pressure sensors will fail because they contain a battery that has a service life of 7 to 10 years. What does this mean to the service technician? This means that if new tires are being installed on a 5- or 6-year-old vehicle equipped with tire-pressure sensors, then the customer should be notified that the TPMS sensors could fail almost anytime.
Can TPMS sensors be switched to new wheels?

**FREQUENTLY ASKED QUESTION**

- Maybe. It depends on the style of the new or replacement wheels as to whether the sensors will fit or not. Some vehicles are designed to allow for a second set of sensors such as for winter tires. Many Lexus vehicles can be programmed to use set #1 or set #2. It is best to check before purchasing new wheels. Another set of TPMS sensors could be a major added expense.
SUMMARY

1. Low-tire inflation pressure can cause a decrease in fuel economy, reduced tire life, and increase the chance of tire failure.

2. The designated tire inflation pressure is stated on the driver’s side door jamb placard.

3. Tire inflation pressure drops 1 PSI for every 10 degrees drop in temperature.

4. The indirect tire-pressure monitoring system uses the wheel speed sensors to detect a low tire.
5. The TREAD Act, also called the Federal Motor Vehicle Safety Standard 138, specifies that all cars, trucks, and vans under 10,000 pounds gross vehicle weight rating (GVWR) must be equipped with a direct pressure-sending tire-pressure monitoring system after September 1, 2007 (2008 model year vehicles).

6. The two basic types of TPMS sensors include:
   - Valve stem-mounted
   - Banded

7. After a tire rotation, the sensors need to be reset or relearned.

8. Special tools are recommended to relearn, activate, or service a tire-pressure monitoring system.
REVIEW QUESTIONS

1. How does the use of wheel speed sensors detect a tire with low inflation pressure?
2. What is the difference between faults when the TPMS warning lamp is on compared with when it is flashing?
3. What is the percentage of vehicles that each vehicle manufacturer must equip with TPMS?
4. TPMS pressure sensors can be made by what manufacturer?
5. What are the three modes of sensor operation?
6. What information is sent to the TPMS controller from the sensor?
7. After removing a stem-type pressure sensor to replace a tire or perform a tire repair, what should be replaced?
CHAPTER QUIZ

1. A tire with lower than specified inflation pressure could lead to what condition?
   a. Reduced fuel economy
   b. Reduced tire life
   c. Increased chances of roadside faults or accidents
   d. All of the above
2. Which tire inflation information should be checked to determine the proper tire inflation pressure?
   a. Cold placard inflation pressure
   b. The maximum pressure as stated on the sidewall of the tire
   c. 32 PSI in all tires
   d. Any of the above
3. Two technicians are discussing tire pressure and temperature. Technician A says that tire pressure will drop 1 PSI for every 10 degrees drop in temperature. Technician B says that the tire pressure will increase as the vehicle is being driven. Which technician is correct?

a. Technician A only
b. Technician B only
c. Both Technicians A and B
d. Neither Technician A nor B
4. Two technicians are discussing the indirect tire-pressure monitoring system. Technician A says that it was used by some vehicle manufacturers on vehicles before the 2008 model year. Technician B says that it uses the speeds of the RF and LR tires and compares the rotating speeds of the LF and RR tires to detect a low tire. Which technician is correct?

a. Technician A only
b. Technician B only
c. Both Technicians A and B
d. Neither Technician A nor B
CHAPTER QUIZ

5. The FMVSS 138 law requires that the driver be notified if the tire inflation pressure drops how much?

a. 30%
b. 25%
c. 20%
d. 15%
6. The two basic types of direct TPMS sensors include __________.
   a. Rubber stem and aluminum stem
   b. Beru and Schrader
   c. Stem-mounted and banded
   d. Indirect and direct
CHAPTER QUIZ

7. What mode does a direct pressure sensor enter when the vehicle is stopped?
   a. Sleep mode
   b. Storage mode
   c. Alert mode
   d. Active mode
8. To activate or learn a direct pressure sensor, what does the service technician need to do?

a. Enter learn mode and use a magnet
b. Enter learn mode and decrease inflation pressure
c. Use a handheld tester
d. Any of the above depending on the vehicle and system
9. What does the “delta pressure method” mean?
   a. Change the inflation pressure
   b. Activate the sensor so it broadcasts the pressure to the scan tool
   c. Inflating the tire to the specified pressure
   d. Using a handheld tester to read the pressure as reported by the sensor
10. What type of valve core is used in stem-mounted sensors?
   
a. Brass
b. Nickel plated
c. Steel
d. Aluminum