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SURFACE VEHICLE RECOMMENDED PRACTICE

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Tire Pressure Monitoring Systems— For Medium and Heavy Duty Highway Vehicles

RATIONALE

Not applicable.

FOREWORD

Today the world of mobility is served extensively by tires which are pneumatic in design. To function correctly these tire designs need pneumatic pressure to derive their performance characteristics – optimum tread wear, fuel economy, ride quality, or fatigue life – hence the value of keeping the retained pressure at design levels ranks high.

While periodic inspection and the periodic action of adjusting the inflation pressure while a vehicle is at rest has been the norm for maintaining pressure, the need to hold tire inflation pressures closer to their design targets over time, and the need to make the driver aware of the status of tire pressures in real time, even while operating his vehicle on the open road at highway speeds, becomes apparent. The performances recommended below support these needs.

Within the trucking industry, the value of knowing and keeping tire inflation pressure to its specified level is well known. The suppliers to the trucking industry have responded by developing various tire pressure systems which continue to increase the efficiency and operating safety of these vehicles. Over time, operators will come to rely on these systems as their first indication of pressure loss or pressure discrepancies relative to the specified service pressure. It is therefore important that all marketed systems provide an adequate level of performance to assure continued, and progressing, in-service safety.

Tires and wheels are integral components of tire pressure systems. The system attributes for tire pressure systems described herein assume an appropriate fitment of tire and wheel for each application, and that these tire pressure systems are not dependent on the performance or physical characteristics of the tire or wheel components. The substitution of one tire/wheel assembly for another tire/wheel assembly of another configuration, appropriate for the vehicle system, so long as it provides a pneumatic chamber for the inflation gas, shall not render the tire pressure system inoperative.

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1. SCOPE

This SAE recommended practice defines the system and component functions, measurement metrics, testing methodologies for evaluating the functionality and performance of tire pressure systems, and recommended maintenance practices within the known operating environments.

This document is applicable to all axle and all wheel combinations for single unit powered vehicles exceeding 7257 kg (16 000 US lb) gross vehicle weight rating (GVWR), and multi-unit vehicle combinations, up to three (3) towed units, which use an SAE J560 connector for power and/or communication, or equivalent successor connector technology, or which use a suitable capacity wireless solution.

Examples of included single chassis vehicles would be – utility and delivery vans, tow trucks, rack trucks, buses, recreational vehicles, fuel trucks, trash trucks, dump trucks, cement trucks, and tractors. Examples of combination vehicles using an SAE J560 or successor connector would be – enclosed van trailers, liquid tanker, platform trailer, logger trailers, auto transit trailers, and their associated and compatible towing power units. For combination vehicles including two or more trailers, the dollies are also included. The included vehicles can be newly manufactured vehicles or existing vehicles.

These systems are recommended to address all tires in service as originally installed on a vehicle by the OEM and/or specialty vehicle manufacturer, including the vehicle mounted spares, and, for the aftermarket (including replacement or spare parts) are recommended (but optional) to address all tire/rim combinations installed after initial vehicle sale or in-use dates.

This document will focus on tire pressure systems of the monitoring type.

NOTE: The following systems are not being addressed in this edition of the document. The management system types and more mature/complex versions of maintenance and management types, to include on-board reporting/storage/retrieval data capabilities for both, will be addressed separately by future changes/additions to this document series.
1] Tire Pressure Maintenance Systems – (typically known as ATIS – Automatic Tire Inflation Systems) systems which sense pressure directly or indirectly and maintain tire pressure above a minimum specified threshold, and inform the driver of the system's activity.
2] Tire Pressure Management (adjustment) Systems (typically known as CTIS – Central Tire Inflation Systems) – systems which sense pressure, plus other pertinent parameters (i.e., vehicle load and speed, tire temperature, etc.) directly or indirectly, and adjust or sustain the pressure at a the level appropriate for the conditions, and inform the driver of the system's activity.

1.1 Purpose

The systems for the monitoring of tire pressure defined herein are vehicle systems. The design approach taken is expected to support the purpose and performance objectives of a monitoring type system, and to function within the operating environment and design configuration of the vehicle itself. Since many of the vehicles included in the scope of this document are combination vehicles, already using standardized mechanical or electronic interfaces, it is essential that the connection, communication, and data link interfaces of these tire pressure systems also use these standardized interfaces.

The tire pressure MONITORING system is intended to communicate to the driver or vehicle maintainer – 1) a warning of the loss of inflation gas in the tire/wheel assembly based upon the sensed level of pressure in the tire/wheel assembly, or the sensed parameters which directly correlate to the actual loss of inflation gas in the tire/wheel assembly, and 2) an indication when the system itself is not capable of providing a warning concerning the loss of inflation gas.

MONITORING systems are bounded by their sensing, analyzing, and communicating capabilities. These systems have no requirement or capability to alter the tire pressure itself. The maintenance function remains the sole responsibility of the driver/ vehicle maintainer.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of each publication shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J551/1 Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)

SAE J560 Primary and Auxiliary Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable

SAE J1113/1 Electromagnetic Compatibility Measurement Procedures and limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz)

SAE J1113/2 Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft)—Conducted Immunity, 15 Hz to 250 kHz—All Leads

SAE J1113/3 Conducted Immunity, 250 kHz to 400 MHz, Direct Injection of Radio Frequency (RF) Power

SAE J1113/4 Immunity to Radiated Electromagnetic Fields—Bulk Current Injection (BCI) Method

SAE J1113/11 Immunity to Conducted Transients on Power Leads

SAE J1113/12 Electrical Interference by Conduction and Coupling—Capacitive and Inductive Coupling via Lines Other than Supply Lines

SAE J1113/13 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Part13—Immunity to Electrostatic Discharge

SAE J1113/21 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Part 21—Immunity to Electromagnetic Fields, 30 MHz to 18 GHz, Absorber-Lined Chamber

SAE J1113/22 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Part 22—Immunity to Radiated Magnetic Fields

SAE J1113/24 Immunity to Radiated Electromagnetic Fields; 10 kHz to 200 MHz—Crawford TEM Cell and 10 kHz to 5 GHz—Wideband TEM Cell

SAE J1113/25 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Immunity to Radiated Electromagnetic Fields, 10 kHz to 1000 MHz—Tri-Plate Line Method

SAE J1113/26 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Immunity to AC Power Line Electric Fields

SAE J1113/27 Electromagnetic Compatibility Measurements Procedure for Vehicle Components—Part 27—Immunity to Radiated Electromagnetic Fields—Mode Stir Reverberation Method

SAE J1113/42 Electromagnetic Compatibility—Component Test Procedure—Part 42—Conducted Transient Emissions

SAE J1211 Handbook for Robustness Validation of Automotive Electrical/Electronic Modules

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J1587 Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications

SAE J1939 Recommended Practice for a Serial Control and Communications Vehicle Network

SAE J2334 Laboratory Cyclic Corrosion Test

SAE J2402 Road Vehicles—Symbols for Controls, Indicators, and Tell-Tales

SAE J2657 Tire Pressure Monitoring Systems for Light Duty Highway Vehicles

2005-01-3517 Concerns Related to FMVSS No. 138 “Tire Pressure Monitoring Systems” and Potential Implementation of a Similar Standard on Commercial Vehicles (Greenly/Beverly – Jan. 2005)

2.1.2 ASTM Publication

Available from American Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 117 Salt Spray (Fog) Testing

2.2 Related Publications

The following publications are provided for informational purposes only and are not required as part of this document. Unless otherwise specified, the latest issue of the publications shall apply.

2.2.1 Tire and Rim Association Publication

Available from The Tire and Rim Association, Inc., 175 Montrose West Avenue, Suite 150, Copley, OH 44321, Tel: 330-666-8121, www.us-tra.org.

Tire and Rim Association Year Book

2.2.2 ETRTO Publication

Available from European Tyre and Rim Technical Organisation, Secretariat, Av. Brugmann, 32/2, B-1060 Brussels, Belgium, Tel: +32-2-344-40-59, www.etrto.org.

ETRTO Standards Manual

2.2.3 JATMA Publication

Available from the Japanese Automobile Tire Manufacturers Association, Inc., No. 33 Mori Bldg. 8th Floor, 3-8-21 Toranomon, Minato-Ku, Tokyo, Japan 105-0001, Tel: 81-3-3435-9094, www.jatma.or.jp.

JATMA Year Book

2.2.4 ISO Publications

Available from ANSI, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.iso.org.

ISO 7000 Graphical symbols for use on equipment—Index and synopsis

ISO 2575 Road Vehicles—Symbols for controls, indicators and tell-tales

ISO CAN 11992 (specified TPMS messages for tractor / trailer communication)

ISO/IEC 2575:2004 Road vehicles. Symbols for controls, indicators and tell-tales

2.2.5 ATA Publication

Available from American Trucking Association Headquarters, 950 North Glebe Rd., Suite 210, Arlington, VA 22203-4181, Tel: 703-838-1700, www.truckline.com.

ATA/TMC RP-235A Guidelines for Tire Inflation Pressure Maintenance (2008)

2.2.6 Federal Publications

Available from the Federal Motor Carriers Safety Administration, United States Department of Transportation, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-800-832-5660, www.fmcsa.dot.gov.

FMCSA-PSV-04-002 Commercial Vehicle Tire Condition Sensors (Dec. 2003)

FMCSA-PSV-007-001 Tire Pressure Monitoring and Maintenance Systems Performance Report (Jan. 2007)

Available from the Federal Communications Commission, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-888-225-5322, www.fcc.gov.

FCC Part 15

Available from the Federal Register, National Highway and Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-888-327-4236, www.nhtsa.dot.gov.

Title 49 Code of Federal Regulations Federal Motor Vehicle Safety Standards

3. DEFINITIONS

3.1 Terms

3.1.1 Baseline Temperature

The temperature condition when the tire’s contained air, the tire’s interior structure, and the adjacent ambient air temperature are the same

3.1.2 Standard Tire Mounting

The action of assembling a tire and its specified wheel by button-holing the tire’s beads over the wheel’s flanges using a mechanized, rotating bead bar, or manual mounting tools.

3.1.3 Specified Service Pressure (SSP)

The ‘cold’ pressure level for a tire/wheel assembly defined by the vehicle manufacturer or tire manufacturer for the intended service conditions (load, speed, etc.) of a given vehicle.

3.1.4 Operational Service Pressure (OSP)

The actual pressure level of the tire/wheel assembly at any point during service whether at ambient or at elevated temperature due to rolling under load.

3.1.5 Self Diagnostic

A device function by which an analysis of system readiness can occur resulting in a positive or negative outcome.

3.1.6 Tire Pressure System

A group of interacting components whose purpose is to measure and/or maintain, directly or through other parameters which correlate to pressure, the pressure level of the tire/wheel assembly.

3.1.7 Tire Pressure Monitoring System

A tire pressure system fitted to a vehicle which 1) senses pressure directly or indirectly, and possibly temperature, or able to evaluate the variation of pressure over time, 2) does not restore the measured pressure to its specified level, and 3) signals when the threshold(s) has (have) been exceeded, and passes this information along to the driver.

3.1.8 Low Pressure Threshold

A change of pressure (▲P) indicating an actual loss of inflation gas from the tire/wheel assembly, or a change in parameter(s) which directly relate(s) to the actual loss of inflation gas, which serves as a trigger for issuing a warning in tire pressure monitoring systems.

3.1.9 Minimum Activation Pressure (MAP)

A gauge pressure reading below the SSP which serves as a trigger for issuing a warning in tire pressure monitoring systems.

3.1.10 Human Machine Interface (HMI)

The device(s) which serve to bring about an understanding or communication between a human and a machine concerning the status of the monitored parameter(s).

3.1.11 Warning (TPMS)

Any indication to the driver to inform him that one or more tire/wheel assembly(s) of the vehicle is now in a situation where an immediate corrective action is necessary concerning pressure.

3.1.12 Cold Tire Inflation Pressure

Tire pressure at the prevailing ambient temperature, in the absence of any pressure build-up due to tire usage.

3.1.13 Quasi-Stationary

Vehicle creeping forward at very low speed, causing at least one full revolution of each installed tire/wheel assembly.

3.1.14 Gross Vehicle Weight Rating (GVWR)

Means the value specified by the manufacturer as the loaded weight of a single motor vehicle.

3.1.15 Gross Combination Weight Rating (GCWR)

Means the value specified by the manufacturer as the loaded weight of a combination (articulated) motor vehicle. In the absence of a value specified by the manufacturer, GCWR will be determined by adding the GVWR of the power unit and the total weight of the towed unit and any load thereon.

3.2 Symbols and Abbreviations

3.2.1 DUT

Device Under Test

3.2.2 EMC

Electromagnetic Compatibility

3.2.3 TPMS

Tire Pressure Monitoring System

3.2.4 EMI

Electromagnetic interference

3.2.5 SSP

Specified Service Pressure

3.2.6 OSP

Operational Service Pressure

3.2.7 HMI

Human Machine Interface

3.2.8 MAP

Minimum Activation Pressure

3.2.9 FMVSS

Federal Motor Vehicle Safety Standards

3.2.10 FMCSA

Federal Motor Carrier Safety Administration

4. TIRE PRESSURE MONITORING SYSTEMS

4.1 General System Requirements

4.1.1 The tire pressure system should be a powered system normally “ON” in the case of the power unit, the trailer unit, or the dolly, and may use vehicle power, self-power, or a combination of both.

4.1.2 Upon turning the ignition to the “ON” or “RUN” position, or upon conducting an interrogation of the system, the Tire Pressure System should perform a check of the system and a reset of the system for the current ambient temperature level. The telltale(s) should illuminate indicating that the associated system function is active.

4.1.3 The tire pressure system should be capable of warning the driver of a low pressure condition whenever the vehicle ignition is ‘ON’, or the system is powered – vehicle quasi-stationary or rolling at speed.

4.1.4 The tire pressure system should contain a self-diagnostic function to alert the driver in case of system malfunction, i.e., no transmission between pressure sensor and its receiving antenna, altered transmission frequency from one wireless box, computational failure, or a tire/wheel assembly installed that is incompatible with the TPS, whenever the vehicle ignition is “ON”, or the system is powered – vehicle quasi-stationary or rolling at speed.

4.1.5 The tire pressure system should be capable of use with all axle and all wheel combinations for single unit powered vehicles exceeding 7257 kg (16 000 US lb) gross vehicle weight rating (GVWR), and combination vehicles (power unit plus trailer), up to three (3) towed units, which use an SAE J560 connector for power and/or communication, or equivalent successor connector technology, or which use a suitable capacity wireless solution.

4.1.6 The tire pressure system sampling rates and sensor capabilities should be sufficient for comparative analysis of all tires, or axle end combinations, on each vehicle or vehicle combination, and support the communication requirements at the HMI.

4.1.7 The tire pressure system of each powered unit capable of towing a trailer should have the added capacity to accept the low pressure and malfunction warning transmission from each included trailer, and to display this information on the dashboard.

4.1.8 The tire pressure system (monitoring) of each trailer, when self contained, should be capable, at a minimum, of generating a signal indicating a low pressure and malfunction warning which can be accepted by the powered unit; when not self contained, should be capable of generating a signal indicating the pressure level of each tire/wheel assembly, or axle end combination, which can be used by the power unit control module to determine and signal the low pressure and malfunction warning.

4.1.9 The tire pressure system of each trailer, which could be used in conjunction with a dolly should be capable of receiving the signal from the tire pressure sensor of each dolly axle assembly, or axle end combination, and incorporating this signal into the system type installed – self contained or not self contained.

4.1.10 The communication link between a power unit and trailer(s) can be wired or wireless. Should a wired link be selected to carry this signal, it should be carried across the standard wired link between powered towing unit and trailer, or trailer and trailer (SAE J560 or successor connector).

4.1.11 Should a wireless link be selected to carry the warning signals between a power unit and trailer, the tire pressure system should be capable of continuous, robust transmitting and receiving of signals, at a signal strength which conforms to FCC Regulations (47 CFR Part 15), and at the frequency and protocol of the applicable national or international standard as specified by the requesting customer, and/or suitable to meet the requirements of the tire pressure monitoring system application.

4.1.12 The tire pressure system link between sensor and control module should have sufficient signal security, and encryption measures to insure identification of each tire/rim assembly or axle end combination, and b) prevention measures for unauthorized tire pressure system electronic tampering or data compromise. This link should be at a signal strength which conforms to FCC Regulations (47 CFR Part 15), and at the frequency and protocol of the applicable national or international standard as specified by the requesting customer, and/or suitable to meet the requirements of the tire pressure monitoring system application.

4.1.13 The tire pressure system assembly, or axle end combination, identification capability should be 100% accurate.

4.1.14 The tire pressure system (when appropriate) should be designed and constructed to insure that “EMI” (electromagnetic interference) is managed under FCC rules – 47 CFR Part 15 (Section 231(e)).

4.1.15 The tire pressure system should be backwards compatible with SAE J1939 (Recommended Practice for Serial Control and Communications Vehicle Network), current and subsequent versions applicable at the time of manufacture, or the corresponding US FCC regulation.

4.1.16 The tire pressure system should be sufficiently robust and ‘hardened’ by design per SAE J1455.

4.1.17 The tire pressure system should have the capability to take into consideration the effect of temperature, attributable to in-use conditions or shifts in ambient, and determine the actual loss of inflation gas without temperature effect. The correction algorithm could be based on equations of state, such as "Boyles Law, or Ideal Gas Law or Real Gas Law", and/or other correction factors.

4.1.18 The specified service pressure (SSP), or reference pressure, is determined in cooperation with the vehicle OEM or specialty manufacturer and the tire manufacturer, based on the vehicle capacity, the maximum applied axle or wheel position loads, and operating conditions. An industry accepted method for determining the appropriate specified service pressure has been documented in the American Trucking Association’s TMC RP-235: Guidelines for Tire Inflation Pressure Maintenance.

4.1.19 The tire pressure system should have the capability and function to allow the input and adjustment of the SSP value in the field by authorized personnel.

4.1.20 The tire pressure system overall pressure accuracy should be not less than that of the least accurate measuring device in the system. All pressure devices should have an accuracy which does not exceed ± 2% of full scale or ± 2 psi of reading, whichever is greater.

4.1.21 The temperature measuring devices employed should have an accuracy which does not exceed ± 2% of reading, or ± 3 °C (± 5 °F) , whichever is greater in the normal operating temperature range -20 to +85 °C (–4 to +185 °F).

4.1.22 The tire/wheel assembly mounted sensor system should not alter tire performances, i.e., tire/wheel balance, or tire fitment to or dismounting from the wheel.

4.1.23 The system should have the flexibility of design or programming such that the removal or replacement of a tire/wheel assembly, nor the failure of a single sensor, will not render the system inoperative.

4.1.24 The typical operational conditions and configurations for which tire pressure systems should function properly (during either the calibration or the detection mode) are outlined below:

a. Speed – The tire pressure system should function installed in a vehicle operating at any vehicle design speed.

b. Road Surfaces – The tire pressure system should function installed in vehicles operating on all improved road surfaces.

c. Maneuvers – The tire pressure system should function during all driving maneuvers.

d. Loading – The tire pressure system should function properly across the full loading range of the power vehicle, and the full loading range of the trailer unit(s) per the vehicle manufacturers' recommended limits.

e. Temperature – The tire pressure system should function properly installed in vehicles operating in ambient temperatures ranging from –40 °C (–40 °F) to 55 °C (131 °F), and under the full range of system operating temperatures.

4.2 Component Performance Requirements – Environmental Conditions and Associated Laboratory Bench Test Methods

As electronics have been in vehicles for many years, the details of the effects of the environmental conditions on electronic equipment are widely known.

4.2.1 Environmental

It is the intent that electronic device(s) that are mounted in/on the tire/wheel environment should be capable of successfully completing all the tests – thermal cycling, thermal shock, humidity, altitude, mechanical shock, drop, mechanical vibration, and combinations of these conditions.

The recommended test method for these conditions is defined in SAE J1455. The functionality of the device under test (DUT) should be verified before and after testing. Additionally, each DUT should be visually inspected for damage after testing. Unless otherwise specified, the DUT shall be at ambient atmospheric pressure and relative humidity as well as standard operating pressure and relative humidity (if applicable) for each test.

4.2.2 Corrosion

The identification of potential physical contaminates, and the mitigation/elimination of their corrosive effects is critical to both performance and longevity of all tire pressure systems and related hardware. Depending on system type, the following design and performance considerations must be addressed in regards to potential system contamination: power connections; sensing; component attachment points/locations; inflation supply and source; and the use of integral, stand-alone, and balance and vibration performance enhancers, i.e., liquid and powders, and tire/wheel mounting lubricants.

The recommended test methodology for physical contaminates is to apply the laboratory conditions for corrosive events and cycles, and the chemical mixtures (solutions) defined in SAE J2721 or its successor document.

4.2.3 Proof Pressure

Though the application for most tire pressure systems is as specified on the tire placard, there are instances when the device can be exposed to pressure levels above those listed. For pressure sensing devices placed inside the tire/wheel cavity, it is important that these devices continue to function even after exposure to elevated pressures. For pressure sensing devices which are mounted externally, it is important that these devices can continue to function after exposure to elevated pressures, and that the device itself does not fail compromising the ability of the tire/wheel assembly to hold pressure.

A recommended test method is to mount the DUT in a pressure vessel (for those devices installed inside the cavity of the tire/wheel assembly), or attach the DUT to a pressure vessel (for those devices attached to a port on the tire/wheel assembly). Pressurize the vessel to the greater of 800 kPa (116 psi) or 150% of the DUT’s maximum operating pressure. Maintain the applied pressure for 30 minutes, then release to ambient atmospheric pressure.

4.2.4 Rapid Deflation

Within some tire pressure system devices, there is a pressure sensor that measures the pressure within the tire/wheel assembly. There could be effects on the sensor when there is rapid deflation of the tire/wheel assembly.

The DUT should be exposed to a pressure of 150% of the DUT’s maximum operating pressure for a minimum of 16 hours. Taking proper precautions, subject DUT to depressurization to atmospheric pressure within 1 second.

4.2.5 Centrifugal

The centrifugal forces exerted on a device mounted in/on the tire/wheel can be significant. Not all vehicles operate over the same speed range. When developing a test procedure, consideration should be given to the maximum speed the vehicle can operate and the time spent at that speed over the life of the vehicle.

The DUT shall be mounted in a fixture that can rotate the DUT in the same orientation as the tire/wheel. The DUT shall be exposed to a minimum 1500 G centrifugal force for eight hours at an ambient temperature of 65 °C (149 °F). It is not required that the fixture/DUT be pressurized.

4.2.6 Electromagnetic Compatibility (EMC) and Signal Contamination

If the DUT is an electronic device, it can be affected by electromagnetic fields or be a source of electromagnetic radiation. As with other electronic devices on the vehicle, this device is expected to operate to a specified level for – signal strength and integrity, including encryption and/or coding – when exposed to EMI, and conversely, not adversely affect other electronic devices.

The recommended test methods for EMC are specified in the various SAE J1113 documents, with test procedures specified in SAE J1113/42. As not all SAE J1113 documents may be applicable, the designer shall determine which portions apply and then test the DUT accordingly.

5. TIRE PRESSURE MONITORING SYSTEM – HUMAN MACHINE INTERFACE CHARACTERISTICS AND RESPONSE

The tire pressure monitoring system should employ a design-for-use approach to make the operation as automatic as possible other than initial hook-up to the download point(s), if so equipped. In other words, the human-machine-interface envelope should require as little human/operator inputs as may be economically viable within state-of-the-art technology, in order to mitigate or eliminate the potential for intentional and unintentional errors and/or vehicle operator/maintainer-induced damage.

As Operators (Drivers) rotate from power vehicle to power vehicle, it is important that the interface between the Operator and the dashboard retain a common, recognizable, and understandable appearance and functionality in its basic form. It is also important that the information provided relates directly to the action to be taken, and urgency associated with the action.

5.1 HMI Characteristics and Response

5.1.1 The minimum configuration of the HMI should be an optical telltale(s) which when activated is (are) illuminated in the color amber or yellow (in accordance with SAE J2402) and of sufficient brightness to be recognized by day or by night.

5.1.2 The optical telltale(s) should be positioned in the driver's forward field of vision, unobstructed by other dashboard controls.

5.1.3 The optical telltales, or combination telltale, should be used as an indication to the driver of a low pressure level on the powered unit or trailer(s), as well as system malfunction conditions.

5.1.4 A label or symbol, containing the standardized symbol for tire pressure monitoring systems per ISO/IEC 2575 or FMVSS 101, adjoining or integrated with the telltale, should be available to clearly indicate the telltale's purpose, and action to be taken.

5.1.5 The low pressure warning telltale signal to the driver should activate, on or before the tire pressure reaches the low pressure threshold or minimum activation pressure (whichever is greater), in the presence of minimal EMI interference, whenever the vehicle ignition is 'ON', or the system is powered – vehicle "quasi-stationary" or rolling at speed.

5.1.6 The low pressure threshold is expressed as a ▲P and applied as follows: [See Appendix A and B]

a. The low pressure threshold is defined as a ▲P below the tire operational service pressure (actual pressure), indicating an actual loss of inflation gas from the tire/wheel assembly, or as a change in a parameter(s) which directly relate(s) to the pressure reading.

b. The ▲P low pressure threshold should not exceed 20% of the specified service pressure. The ▲P system value should be set considering the variability of the least accurate measuring device in the system.

c. The minimum activation pressure (MAP) value of the system is the specified service pressure (SSP) less ▲P.

5.1.7 The low pressure warning telltale should remain illuminated (as long as the vehicle ignition is 'ON') until the tire/wheel assembly(s), or axle end combination, with low pressure has (have) been raised to a pressure level equal to or greater than the operational service pressure (OSP), at temperature. At this point, the telltale must extinguish itself.

5.1.8 The malfunction telltale signal to the driver should activate no later than 20 minutes following the system's failure to perform its specified function, in the presence of minimal EMI interference, whenever the vehicle ignition is 'ON', or the system is powered – vehicle "quasi-stationary" or rolling at speed.

5.2 Controls, Symbols, Switches

5.2.1 If separate switches or buttons are required for reset, activation, or calibration, a standardized TPMS symbol should accompany these devices.

5.2.2 If the use of a TPMS switch or button requires the driver to first consult his owners manual, a sticker should accompany the device directing him accordingly.

5.3 Owner’s Manual Information

5.3.1 For each system installed, it is essential that a full set of instructions and explanations be made available to the Operator in the Owners Manual. This information should include – type of system applied to each unit (tractor or power vehicle), its function, how to interpret the dashboard display, and necessary maintenance actions. This information should be specific to and accompany each vehicle, or trailer unit.

6. TIRE PRESSURE MONITORING SYSTEMS: TEST PROCEDURES

The three test procedures defined below are structured to 1) validate that the system as designed can sense a loss of inflation gas at the specified threshold, or respond to the MAP, and consistently send a signal which can be displayed at the HMI, 2), and 3) validate that upon developing a fault in the system, the system will respond to the malfunction condition and transmit a signal which can be displayed at the HMI.

6.1 #1 – Low Pressure Sensing Test – Warning Threshold Response

This system test may be conducted as a bench test or as a vehicle test. The system test measures whether the system design meets the defined response characteristics of this specification.

Regardless of test methods used, appropriate safety procedures and safety equipment must be utilized.

6.1.1 Bench Test Option (for System Design)

A pressure-temperature bench test, or a setup which supports the parameters selected which correlate to pressure loss, is needed to demonstrate the design performance of the sensing device, and its associated computing system. The bench test, if used, must be capable of containing the pressure levels of the applicable tire/wheel assemblies, at elevated temperature, and generating thermal environments between 0 °C (32 °F) and 93 °C (200 °F). Both pressure and temperature must be controlled independently. Each designed tire pressure system must be subjected to the test cycle conditions described below.

At the moment the system transmits a signal which could be used to illuminate a dashboard telltale indicating the delta P threshold has been exceeded, record the pressure value.

TABLE 1 - BENCH TEST

Starting Conditions			Temperature Cycle		Pressure Reduction Cycle	
Cycle	OSP (PSI) [% of SSP]	Temperature C (F)	Temperature Rise [C (F)/minute]	Clock Time (min)	Pressure Decrease (PSI/minute)	Clock Time (min)
1	100	7 (45)	1.4 (2.5)	0 – 30	5	30 to warning
1			0.14 (0.25)	30 to end		
2	100	27 (80)	1.4 (2.5)	0 – 30	5	30 to warning
2			0.14 (0.25)	30 to end		
3	82	27 (80)	1.4 (2.5)	0 – 30	5	2 to warning
3			0.14 (0.25)	30 to end		
4	100	27 (80)	1.4 (2.5)	0 – 30	0.5	30 to warning
4			1.4 (0.25)	30 – 40		
4			0.03 (0.05)	40 to end		
5	82	7 (45)	1.4 (2.5)	0 – 30	0.5	15 to warning
5			0.14 (0.25)	30 – 40		
5			0.03 (0.05)	40 to end		

6.1.2 Vehicle Test Option (for System Design)

6.1.2.1 Power Unit Test Setup

a. The test vehicle(s) should be in a partially to fully loaded condition not less than 50% of the GVWR or GCVWR.

b. Set the tire pressure to the <u>operating service pressure</u> for the vehicle under test per Test#1 of Table 2. Condition the vehicle for one hour outdoors – stationary, and tires shaded. The ambient temperature should not vary more than 20 °F (11.11 °C) over the test interval.

c. Reset the tire pressures. Consider the tire stabilized if within ± 1 psi after 10 minutes.

d. If applicable, conduct a reset of the Tire Pressure System in accordance with the instructions specified in the vehicle owner's manual.

e. With the vehicle stationary and beginning with the ignition locking system in the "Lock" or "Off" position, turn the ignition to the "On" or "Run" position. The monitoring system should perform a check of the system and the function of the indicator(s) as specified.

6.1.2.2 Power Unit Test

a. Perform the vehicle warm-up phase by driving for the accumulative time per Test #1 of Table 2 at speeds between 60 to 100 km/h (37 to 62 mph). The drive route may be a stretch of highway or a test track, but must keep a balance between right and left hand turns. Then bring the vehicle to a stop. Engine running.

b. Begin releasing pressure from one tire/wheel assembly per axle, or axle end combination, to the test condition of Test #1 of Table 2.

c. Resume driving the vehicle at a speed between 60 to 100 km/h (37 to 62 mph).

d. If no alert is signaled at a ▲P of 20%, or the MAP, discontinue this test phase.

e. If the dashboard telltale is illuminated, record the ▲P of each assembly under test.

f. Return the vehicle to its base of operations. Stop the vehicle.

g. Turn the ignition to the "Off" position.

h. Wait for three minutes. Turn the ignition to the “On” position.

i. Verify that the dashboard telltale continues to be visible on the dashboard as specified.

j. Keep the vehicle stationary, tires shaded, and with the engine turned off for two hours.

k. Adjust the previously selected tire/wheel assemblies, or axle end combination, to the specified service pressure.

l. Start the engine. Determine whether the dashboard telltale has been de-activated.

NOTE: If necessary, drive the vehicle within the 60 to 100 km/h (37 to 62 mph) speed range. If after 5 minutes the dashboard telltale remains on, discontinue the test.

m. Repeat this test sequence – Setup followed by Test – for test condition #2 of Table 2 using the same combination of assemblies.

n. Repeat this test sequence – Setup followed by Test – using an alternate assembly, or axle end combination on each axle and each of the conditions of Table 2.

o. Repeat this test sequence – Setup followed by Test – using the right front steer axle assembly only, and the conditions of Table 2.

p. Repeat this test sequence – Setup followed by Test – using the left front steer axle assembly only, and the conditions of Table 2.

TABLE 2 - VEHICLE TEST

	Starting Conditions		Warm-up	Pressure Reduction after Warm-up	
Test #	OSP (% of SSP)	Temperature (F)	Drive Time (minutes)	Pressure Release Rate (psi/ minute)	Initiation Point
1	100	Ambient	30	1.0 to 2.0	Immediately following warm up
2	82	Ambient	10	1.0 to 2.0	

6.1.2.3 Trailer Test Setup

a. The test vehicle(s) should be in a partially to fully loaded condition not less than 50% of the GVWR or GCVWR.

b. Set the tire pressure to the <u>operating service pressure</u> for the trailer(s) (and dolly, as applicable) under test per Test#1 of Table 2. Condition the trailer for one hour outdoors – stationary, and tires shaded. The ambient temperature should not vary more than 20 °F (11.11 °C) over the test interval.

c. Reset the tire pressures. Consider the tire stabilized if within ± 1 psi after 10 minutes.

d. If applicable, conduct a reset of the Tire Pressure System in accordance with the instructions specified in the vehicle owner’s manual.

e. With the power unit connected to the trailer(s) (and dolly, as applicable), the vehicle stationary, and beginning with the power system in the “Lock” or “Off” position, turn the power to the “On” position. Program and synchronize the trailer to the power unit. The monitoring system of the trailer should perform a check of its system and transmit a signal which could be used by the dashboard of the power unit to indicate the system is functional as specified.

6.1.2.4 Trailer Test

a. Perform the trailer (and dolly, as applicable) warm-up phase by driving for the accumulative time per Test #1 of Table 2 at speeds between 60 to 100 km/h (37 to 62 mph). The drive route may be a stretch of highway or a test track, but must keep a balance between right and left hand turns. Then bring the vehicle to a stop. Engine running.

b. Begin releasing pressure from one tire/wheel assembly per axle, or axle end combination, to the conditions of Test #1 of Table 2.

c. Resume driving the vehicle at a speed between 60 to 100 km/h (37 to 62 mph).

d. If no signal (for low pressure warning) is transmitted which could be used by the power unit at a ▲P of 20% or the MAP, discontinue this test phase.

e. At the moment the trailer device has transmitted a signal which could be used by the power unit to illuminate a dashboard telltale, record the ▲P of each assembly under test.

f. Return the vehicle to its base of operations. Park the power unit and trailer. Turn off all power to the trailer system.

g. Wait for three minutes. Turn on the power of the trailer unit system.

h. Verify that the trailer device continues to transmit a signal which could be used by the power unit to illuminate a dashboard telltale.

i. Keep the power unit and trailer stationary, tires shaded, and with the engine turned off for two hours.

j. Adjust the previously selected tire/wheel assemblies, or axle end combination, to the specified service pressure.

k. Turn on the power of the trailer unit system. Determine whether the device signal has been deactivated.

NOTE: If necessary, drive the power unit and trailer(s) within the 60 to 100 km/h (37 to 62 mph) speed range. If after 5 minutes the signal remains on, discontinue the test.

l. Repeat this test sequence – Setup followed by Test – for test condition #2 of Table 2 using the same combination of assemblies.

m. Repeat this test sequence – Setup followed by Test – using an alternate assembly on each axle and each of the conditions of Table 2.

6.2 #2 – System Installation Test – Signal Transmission / Signal Strength

This is a vehicle test for the purpose of verifying that wheel mounted devices are able to transmit a signal, and a signal of adequate strength, to the onboard processing system as installed on a power unit or as installed on a trailer for all wheel positions and potential placements of the sensors/sending units. Care must be taken to include the worst case scenario(s) with regard to vehicle maneuvering, e.g., turns, significant increase/decrease in signal blocking due to the variables of vehicle mass/density, and loaded vs. unloaded conditions. While conducting this test, the location being used should be free of significant RF interference external to the test vehicle that might influence measurements. This is a system installation test.

6.2.1 Power Unit Test Setup

a. Condition the vehicle for one hour outdoors, and tires shaded. The ambient temperature should be in the range of 0 to 35 °C (32 to 95 °F).

b. The test vehicle(s) should be in a partially to fully loaded condition not less than 50% of the GVWR or GCVWR.

6.2.2 Power Unit Test

a. With the vehicle stationary and beginning with the ignition locking system in the “Lock” or “Off” position, turn the ignition to the “On” or “Run” position. The monitoring system must perform a check of the system and the function of the indicator(s) as specified.

b. While quasi-stationary, verify the transmission of the signal from the tire pressure sensing device of each tire/wheel assembly, or axle end combination, to its antenna. The field strength of the measured signal must be sufficient for the system, at the chosen frequency (under FCC rules (49 CFR Part 15)), to reliably function.

c. Begin driving the vehicle and bring the vehicle to the highway speed of 100 km/h (62 mph). Again, verify the transmission of the signal from the tire pressure sensing device of each tire/wheel assembly, or axle end combination, to its antenna. The field strength of the measured signal must be sufficient for the system, at the chosen frequency (under FCC rules (49 CFR Part 15)), to reliably function.

6.2.3 Trailer Test Setup

a. Condition the vehicle for one hour outdoors, and shaded. The ambient temperature should be in the range of 0 to 35 °C (32 to 95 °F).

b. The test trailer(s) should be loaded not less than 50% of the GVWR.

6.2.4 Trailer Test

a. With the vehicle stationary, activate the trailer mounted tire pressure system. The monitoring system must perform a check of the system and the function of the indicator(s) as specified.

b. While quasi-stationary, verify the transmission of the signal from the tire pressure sensing device of each tire/wheel assembly, or axle end combination, to its antenna. The field strength of the measured signal must be sufficient for the system, at the chosen frequency (under FCC rules (49 CFR Part 15)), to reliably function.

c. Begin driving the vehicle and bring the vehicle to the highway speed of 100 km/h (62 mph). Again, verify the transmission of the signal from the tire pressure sensing device of each tire/wheel assembly, or axle end combination, to its antenna. The field strength of the measured signal must be sufficient for

6.3 #3 – System Malfunction Test – Warning Response

The test to validate the system's ability to warn the driver when the system is not capable of monitoring the pressure level or of determining that a low pressure threshold has been exceeded should be conducted through a vehicle test. The system test measures whether the system design meets the requirements of this specification for malfunction.

6.3.1 Power Unit Test Setup

a. The test vehicle(s) should be in a partially to fully loaded condition not less than 50% of the GVWR or GCVWR.

b. Set the tire pressure to the specified service pressure for the vehicle under test. Condition the vehicle for one hour outdoors – stationary, and tires shaded. The ambient temperature should be in the range of 0 to 35 °C (32 to 95 °F). This test should be conducted in an area with low EMI interference.

c. If applicable, conduct a reset of the Tire Pressure System in accordance with the instructions specified in the vehicle owner's manual.

d. With the vehicle stationary and beginning with the ignition locking system in the "Lock" or "Off" position, turn the ignition to the "On" or "Run" position. The monitoring system must perform a check of the system and the function of the indicator(s) as specified.

6.3.2 Power Unit Test

a. Simulate a TPS malfunction – no transmission between pressure sensor and its receiving antenna, computational failure, or a tire/wheel assembly installed that is incompatible with the TPS. When simulating a TPS malfunction, the electrical connections for the telltale lamp should not be disconnected. For a given test, introduce only one malfunction at a time.

b. Begin driving the vehicle at speeds between 60 and 100 km/h (37 to 62 mph).

c. If the TPS malfunction indicator does not illuminate after 20 minutes, discontinue the test.

d. If the TPS malfunction indicator illuminates, return the vehicle to its operational base. Stop the vehicle. Turn the ignition to the “OFF” position, stopping the engine.

e. After 3 minutes, turn the ignition to the “ON” position. The TPS malfunction indicator should again signal a malfunction by illuminating the telltale, and remain illuminated as long as the ignition is in the “ON” position.

f. Restore the TPS to its normal operational setup. If necessary, drive the vehicle until the warning signal has been extinguished. If the warning telltale has not extinguished after 20 minutes of driving, discontinue the test.

g. This test sequence should be repeated to simulate the other listed malfunctions, but each test should be limited to the simulation of a single malfunction at a time.

6.3.3 Trailer Test Setup

a. Set the tire pressure to the specified service pressure for the trailer(s) (and dolly, as applicable) under test. Condition the trailer(s) for one hour outdoors – stationary, and tires shaded. The ambient temperature should be in the range of 0 to 35 °C (32 to 95 °F). This test should be conducted in an area with low EMI interference.

b. If applicable, conduct a reset of the Tire Pressure System in accordance with the instructions specified in the vehicle owner’s manual.

c. With the vehicle stationary and beginning with the power system in the “Off” position, turn the power to the “On” position. The monitoring system must perform a check of the system and the function of the indicator(s) as specified, and transmit a signal which could be used by the dashboard HMI.

6.3.4 Trailer Test

a. Simulate a TPS malfunction – no transmission between pressure sensor and its receiving antenna, altered transmission frequency from a wireless box (if applicable), computational failure, or a tire/wheel assembly installed that is incompatible with the TPS. When simulating a TPS malfunction, the electrical connections for the telltale lamp should not be disconnected. For a given test, introduce only one malfunction at a time.

b. Begin driving the vehicle at speeds between 60 and 100 km/h (37 to 62 mph).

c. If the signal which could be used to illuminate a dashboard telltale is not transmitted as required after 20 minutes, discontinue the test.

d. If the signal which could be used to illuminate a dashboard telltale is transmitted, return the vehicle to its operational base. Stop the vehicle. Turn the trailer power to the “OFF” position.

e. After 3 minutes, turn the power to the “ON” position. The signal which could be used to illuminate a dashboard telltale should again be present, and remain present as long as the power is in the “ON” position.

f. Restore the TPS to its normal operational setup. If necessary, drive the vehicle until the signal which could be used to illuminate a dashboard telltale has been extinguished. If the signal has not been discontinued after 20 minutes of driving, discontinue the test.

This test sequence should be repeated to simulate the other listed malfunctions, but each test should be limited to the simulation of a single malfunction at a time.

7. NOTES

7.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

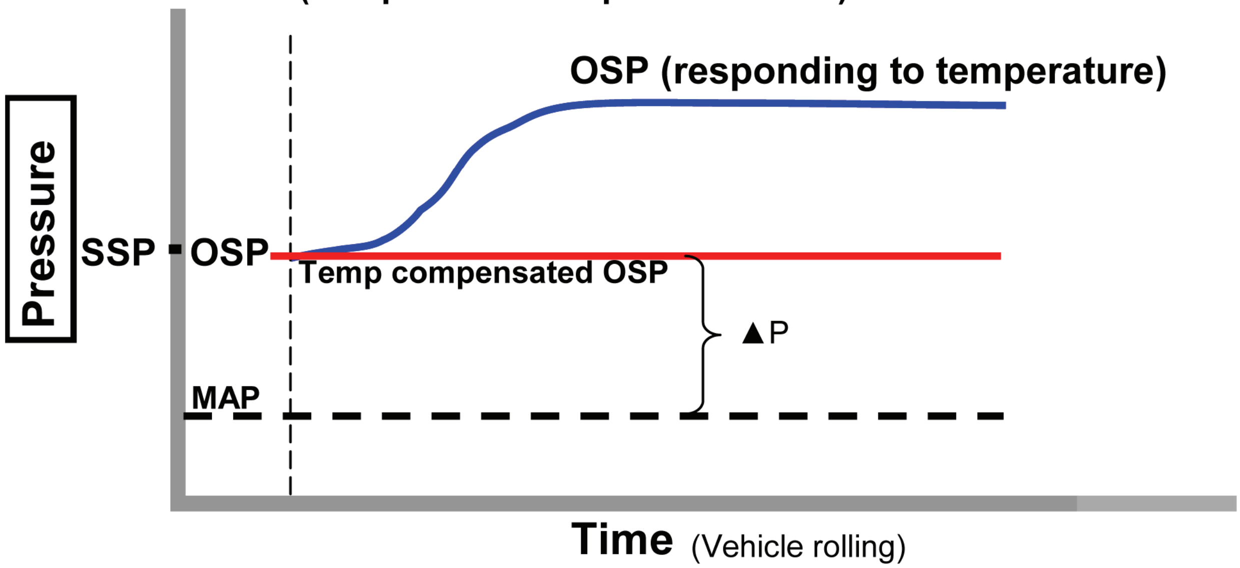
PREPARED BY THE SAE TRUCK AND BUS TIRE PRESSURE MANAGEMENT SYSTEMS COMMITTEE
OF THE SAE TRUCK AND BUS TOTAL VEHICLE ADVISORY GROUP

APPENDIX A

Tire Pressure Monitoring System

Indicating an actual loss of inflation gas

(Temperature compensated OSP)



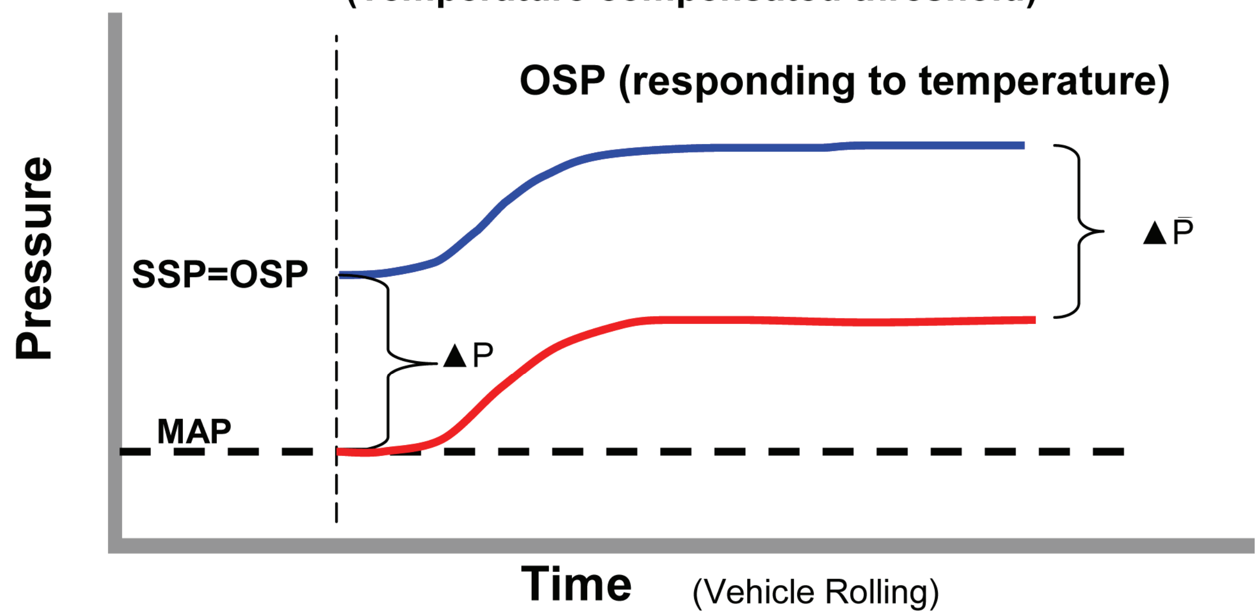
SSP = Specified Service Pressure
OSP = Operational Service Pressure
MAP = Minimum Activation Pressure
▲P = Low pressure threshold
OSP responding to temperature
OSP corrected for temperature

APPENDIX B

Tire Pressure Monitoring System

Indicating an actual loss of inflation gas

(Temperature compensated threshold)



SSP = Specified Service Pressure
OSP = Operational Service Pressure
MAP = Minimum Activation Pressure
▲P = Low pressure threshold
OSP responding to temperature
Threshold pressure corrected for temperature