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Road vehicles — Safety enhancement in conjunction with tyre inflation pressure monitoring

Véhicules routiers — Renforcement de la sécurité conjointement avec le contrôle de la pression de gonflage des pneumatiques

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21750 was prepared by Technical Committee ISO/TC 22, *Road vehicles*.

Introduction

A pneumatic tyre is a flexible component which is deflected when loaded. A tyre needs to be sufficiently inflated in order to be used at a limited deflection adapted to carry the wheel load as part of an axle load at a given speed and to transmit the expected longitudinal and transversal forces. The deflection is at the origin of the fatigue of a pneumatic tyre. Repeated excessive deflection may lead to tyre failure.

In real driving conditions, the physical parameter that most correlates to the tyre deflection is the tyre inflation pressure.

Therefore, the inflation pressure surveillance of pneumatic tyres for road vehicles has been identified as a major way to increase the active safety of the vehicles in service and to reduce the risks for the users.

The inflation pressure of pneumatic tyres for road vehicles shall be set by the vehicle users according to the car manufacturer's recommendations in coherency with the tyre standards which apply. The vehicle user is responsible for setting the correct tyre inflation pressure and its maintenance.

One or more significantly under-inflated tyres reduce the vehicle performances, especially the behaviour related to safety. Tyre pressures outside of the range recommended by the tyre or the vehicle manufacturer for the intended service may permanently alter the tyre characteristics up to a sudden pressure loss.

This International Standard does not imply that the tyre will resist under all circumstances before an alert is delivered by a Tyre Pressure Monitoring System (TPMS) described by this International Standard.

The primary objective of a TPMS is to alert the driver when an unsafe condition related to incorrect tyre inflation pressure is detected.

This International Standard contains proposals for the definition of terms used in both standardization working groups dealing with TPMSs and extended mobility systems.

Both working groups are invited to make comments and proposals, the goal being to finally share these definitions.

Each International Standard should contain the definitions which are typical to its subject and refer to the other International Standards for the other definitions.

Road vehicles — Safety enhancement in conjunction with tyre inflation pressure monitoring

1 Scope

This International Standard deals with electronic Tyre Pressure Monitoring Systems (TPMS) for tubeless tyres in association or not with an extended mobility system, with a reference pressure lower or equal to 375 kPa, fitted in single formation on four wheeled vehicles. The systems are able to survey all tyres in use but not necessarily those in temporary use and provide information to the driver.

This International Standard establishes overall performance guidelines for the systems and their components, independently of the physical principles and the technological solution which have been selected to monitor the tyre pressure, to compute the difference to the requested level and to deliver a relevant information to the driver if the pressure of one, several or all tyres needs corrective action for the intended service conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

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

IEC CISPR 22, *Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement*

IEC CISPR 24, *Information technology equipment — Immunity characteristics — Limits and methods of measurement*

ASTM B 117–73, *Standard Method of Salt Spray (Fog) Testing*

European Tyre & Rim Technical Organization, *ETRTO Standards Manual*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
tyre wheel assembly
assembly consisting of a wheel (rim and disc) fitted with a tyre, a valve, etc.

3.2
tyre
flexible component of the tyre wheel assembly made of rubber and reinforcing materials

NOTE Inflating the tyre with compressed gas enables it to carry the wheel load as part of an axle load and to transmit longitudinal and transversal forces. In the unloaded condition, the inflated tyre is essentially toroidal.

3.3
normal tyre
tyre designed for use in an inflated state

NOTE "Conventional tyre" under the SAE means is defined by the ETRTO Standards Manual as a synonym of "diagonal tyre" and should not be used in the sense of "usual, standard tyre".

3.4
spare unit
tyre wheel assembly intended to be exchanged for a tyre wheel assembly already fitted on the vehicle that has lost some functional efficiency

3.5
Spare Unit Substitutive Equipment
SUSE
equipment intended to maintain or restore, not replace, the basic tyre functions of a tyre in case of a tyre wheel assembly failure

3.6
extended mobility system
assembly of specified functionally dependent components including, but not limited to, a tyre and a flat tyre warning system, which together provide the specified performance granting "extended mobility" to a vehicle thus equipped

NOTE A single component or several independent components, functionally interacting with other elements of the vehicle do not in and of themselves constitute an "extended mobility system". In addition, the assembly of components, otherwise suitable to compose a system, but which do not completely follow the specifications of a "systems manager", does not constitute an "extended mobility system".

3.7
Tyre Pressure Monitoring System
TPMS
any system fitted on a vehicle, able to evaluate the pressure of the tyres or the variation of the pressure over time and to transmit corresponding information to the user while the vehicle is running

NOTE A TPMS is functionally composed of:

— sensing devices;

— information channel hardware;

— central information processing unit (CPU); and

— human machine interface (HMI).

3.8
Tyre Pressure Alerting System
TPAS
system and process of measuring the tyre inflation pressure and eventually internal temperature, or (a) parameter(s) that directly correlate(s) to the pressure and delivering an information to the driver that a tyre has reached a level of inflation pressure that requires a corrective action

NOTE TPAS may also include a run-flat warning function.

3.9
Tyre Pressure Warning System
TPWS
TPAS also able to provide useful information, at least the actual relative tyre pressure condition of each tyre, to the driver

3.10
Tyre Leak Alerting System
TLAS
system and process for detecting that the inflation pressure of one of the tyres in service has significantly changed in comparison to the others and to the initial state, requiring a corrective action

3.11
Intelligent Tyre Pressure Management System
ITPMS
system which is able to monitor the pressure and the internal temperature of the tyre, to adapt the pressure by increasing or decreasing the actual pressure in dependence on the real service conditions and to restore the correct pressure in case of pressure loss

3.12
false information
information provided to the user which is not consistent with the system's specifications

3.13
learning phase
working condition where necessary values for TPMS/TLAS (data, parameter) are recognized, measured, and respectively verified to a sufficient statistical probability

NOTE The learning phase can include active and passive sections. During the learning phase the alerting/warning sensibility increases from “zero” to target.

3.14
inflated mode
normal working state of a tyre, inflated at the cold inflation pressure recommended by the vehicle (or the tyre) manufacturer for the intended service

3.15
flat tyre running mode
state of a tyre, part of an extended mobility system operating at an inflation pressure lower than 70 kPa

3.16
cold tyre inflation pressure
tyre pressure at ambient temperature, in absence of any pressure build-up due to tyre usage

3.17
minimum cold tyre inflation pressure
minimum cold tyre inflation pressure, specified by the tyre standardization bodies for given service conditions

3.18
recommended cold tyre inflation pressure
P_{rec}
pressure recommended for each tyre position by the vehicle and/or the tyre manufacturer for the intended service conditions of the given vehicle

NOTE P_{rec} is the same or higher than the minimum cold tyre inflation pressure.

3.19
set of recommended cold tyre inflation pressure
recommended cold tyre inflation pressure for the tyres of the front and the rear axle of a vehicle

3.20
pressure reserve
difference, for each tyre position, between the recommended cold tyre inflation pressure and the minimum cold tyre inflation pressure

3.21
normal load on a tyre
load applied on an individual tyre by distributing to each axle its share of “kerb mass”, “accessory mass” and the “normal occupant mass”

3.22
maximum vehicle load on a tyre
share of the maximum axle load allowed by the vehicle manufacturer which applies on an individual tyre

3.23
tyre load reserve
for a given tyre at a given pressure, the difference between the maximum load allowed by the tyre manufacturer’s standards and the maximum vehicle load on the tyre

3.24
warning
any indication to the driver to inform him that one element of the vehicle is no longer within the normal service conditions, and that a corrective action is recommended

3.25
alarm
any indication to the driver to inform him that one element of the vehicle is now in a situation where an immediate corrective action is necessary

3.26
nuisance status indication
justified status indication that occurs at a frequency that distracts or annoys the vehicle operator and which could cause the vehicle operator not to take action when necessary

3.27
false warning or alarm
anomaly of the system leading to an unjustified warning or alarm

3.28
tyre intended service conditions
maximum expected load, speed and camber of a tyre in service for a given vehicle

3.29
wheel fitted component
WFC
enclosed device that measures physical parameters and conveys information to (downlink) a central unit fitted in the car body

NOTE A WFC may also be equipped with an uplink channel which could carry the pressure on demand inputs or elsewhere.

3.30
external car body fitted component
EFC
enclosed device mounted on the body structure of the vehicle outside of the passenger compartment or boot which supports specific features of a TPMS and exchange information with WFC and/or IFC

NOTE EFC may perform signal processing.

3.31
internal car body fitted component
IFC
enclosed device mounted on the car body structure of the vehicle inside the passenger compartment or boot which supports specific features of a TPMS and exchanges information with WFC and/or EFC

NOTE IFC may perform signal processing.

3.32
run-flat warning function
possible additional function for a TLAS allowing it to warn the driver in the case where the vehicle is fitted with an **extended mobility system** (see 3.6) and this system is in the extended mobility mode

4 Symbols and abbreviations

CPU — Central Processing Unit

EFC — External car body Fitted Component

EMC — Electro-Magnetic Compatibility

FS — Full Scale

HMI — Human Machine Interface

IFC — Internal car body Fitted Component

ITPMS — Intelligent Tyre Pressure Management System

RF — Radio Frequency

TLAS — Tyre Leak Alerting System

TPAS — Tyre Pressure Alerting System

TPMS — Tyre Pressure Monitoring System

TPWS — Tyre Pressure Warning System

WFC — Wheel Fitted Component

5 Technical requirements and test procedures for system

5.1 General

Any of the mentioned TPMS shall monitor the tyre pressures at speeds exceeding 25 km/h after a successful learning phase if it does exist.

This learning phase will have a maximum duration of 30 min of cumulative driving above 25 km/h. In the case it is not successful, the driver shall be warned by the malfunction tell-tale or optical indicator.

The learning phase shall be activated only after the system reset (new tyre fitting, pressure adjustment).

For all the tests, the TPMS shall be in their normal working state.

Any of the mentioned TPMS shall avoid false warnings or alarms. A warning or an alarm felt as unjustified by the user cannot necessarily be considered as a false warning or alarm. It may be interpreted incorrectly by the user. Therefore, the TPMS shall have a sufficiently clear human/machine interface to allow a correct interpretation to maintain confidence in the system.

Test procedures and system performance are described for tyres according to the car manufacturer's recommendations for any legal tyre tread wear level.

5.2 Tyre Pressure Alerting System (TPAS)

5.2.1 Purpose of the TPAS

The purpose of the TPAS is to avoid driving too often and/or too long distances and/or at too high speed with one, several or all tyres under-inflated/over-deflected by providing the driver with a warning or an alarm.

NOTE A TPAS may also include a Flat-Tyre Warning function.

5.2.2 System performance

5.2.2.1 A TPAS shall be able to give either a warning or an alarm according to the conditions.

5.2.2.2 The alert delivered by a TPAS shall be related to the actual tyre pressure expressed either as an absolute or as a relative pressure of at least one tyre under control. It shall not only be related to pressure differences between tyres or to parameter differences between tyres, even if this parameter directly correlates with the tyre pressure.

5.2.2.3 The alert delivered by a TPAS may be global for all tyres fitted on the vehicle. The identification of the tyre at the origin of the alert is optional.

5.2.2.4 A TPAS should separately take into account the P_{rec} for the tyres fitted on the front axle and for the tyres fitted on the rear axle.

In the case the corresponding minimum cold tyre inflation pressure is higher or equal to the P_{rec} of the second axle, a TPAS which is not able to differentiate both axles shall not be used.

5.2.2.5 If the car manufacturer has decided to adopt more than one set of recommended pressures corresponding to different load/speed service conditions, the following cases may occur:

— The equipment is able to recognize automatically which set of pressure applies in dependence on the actual driving conditions. The P_{rec} and the minimum cold inflation pressures of this set apply for each tyre, whether the set is selected automatically or manually by the driver.

— The equipment is not able to recognize/verify that the right set has been selected in dependence on the actual driving conditions. It is the driver's responsibility to select the relevant P_{rec}, taking into account the tyre size and intended driving conditions.

— The equipment is not able to recognize/verify that the right set has been selected in dependence on the actual driving conditions and has no selection possibility. Then the highest P_{rec} shall be taken into account.

5.2.2.6 A TPAS shall not monitor the tyre pressure of the unfitted normal spare unit.

If the spare unit is in use, the TPAS shall either monitor it in the same conditions as for the other tyres or inform the driver for partial monitoring of the vehicle tyres.

5.2.2.7 A TPAS shall be able to take into account all sensors of the vehicle and only those of the vehicle (learn or auto-learn). The identification of the tyre position on the vehicle is optional (localization or auto-localization).

5.2.2.8 Optionally, a TPAS may also monitor the tyre pressures when the engine is off.

5.2.3 Environmental system performance

A TPAS shall deliver the alert independently on:

— the category of the roads: motorways, highways, city roads, off-road, on bridges, inside tunnels;

— the nature of the roads: straight, bent, sloped, cambered;

— the nature of the road surface: asphalt, concrete, cobblestone, off-road;

— the condition of the road surface: dry, wet, slippery, snowy, icy.

If nevertheless the system is not active or efficient, the user shall be advised (see 5.2.5).

5.2.4 Monitoring strategy

A TPAS shall provide an alert if one or more of the tyres needs a corrective action. The alert conditions (threshold levels, time, interface) shall be related to the criticity of the individual situation to reduce the risk.

5.2.5 Diagnostic

A TPAS shall include a self-diagnostic function delivering information to the user when the system is out of function. The system shall be able to deliver information within 10 min in driving conditions exceeding 25 km/h in case of malfunction.

In case of conjunction of a TPAS malfunction and a puncture, the user may not be informed in time.

5.2.6 Outdoor test procedures

5.2.6.1 General

These tests are defined to check the functionality and accuracy of the system without any link with the future detection thresholds for a specific vehicle.

All tests shall be performed after a successful learning phase.

5.2.6.2 First test for detection

Use a vehicle which has correctly inflated tyres at the recommended cold inflation pressure P_{rec}. Produce on one tyre a gradual pressure loss between 10 kPa/min and 20 kPa/min and check while driving at a speed exceeding 25 km/h that the system delivers an alert at the latest for a pressure drop of 100 kPa.

Repeat this test by doing the same on all four tyres simultaneously and check that the system also delivers an alert under the same conditions.

5.2.6.3 Second test for detection

While the vehicle is stationary, adjust one tyre at a pressure below the threshold within a tolerance of 10 kPa. The system shall deliver an alert within 3 min while driving at a speed exceeding 25 km/h.

Repeat this test by doing the same on all four tyres simultaneously and check that the system also delivers an alert under the same conditions.

5.3 Tyre Pressure Warning System (TPWS)

5.3.1 Purpose of the TPWS

The purpose of a TPWS is to allow the vehicle user to maintain the tyre pressures within the range of pressures for optimized tyre and vehicle performances by providing a warning when corrective action is recommended.

A TPWS shall always be a complement to a TPAS or shall include a TPAS function.

5.3.2 System performance

5.3.2.1 The alert delivered by a TPWS shall be related to the actual tyre pressure expressed either as an absolute or as a relative pressure of at least one tyre under control. It cannot only be related to pressure differences between tyres or to parameter differences between tyres, even if this parameter adequately correlates with the tyre pressure.

5.3.2.2 The alert delivered by a TPWS may be global for all tyres fitted on the vehicle. The identification of the tyre at the origin of the alert is optional.

5.3.2.3 A TPWS shall take into account the different P_{rec} values between front and rear fitted tyres.

5.3.2.4 In the case where the car manufacturer has decided to adopt more than one set of recommended pressures corresponding to different load/speed service conditions, the following cases may occur:

— The equipment is able to recognize automatically which set of pressure applies in dependence on the actual driving conditions. The P_{rec} and the minimum cold inflation pressures of this set apply for each tyre whether the set is selected automatically or manually by the driver.

— The equipment is not able to recognize/verify that the right set has been selected in dependence on the actual driving conditions. It is the driver's responsibility to select the relevant P_{rec}, taking into account the tyre size and intended driving conditions.

— The equipment is not able to recognize/verify that the right set has been selected in dependence on the actual driving conditions and has no selection possibility, in which case the highest P_{rec} shall be taken into account.

5.3.2.5 A TPWS does not survey the tyre pressure of the unfitted normal spare unit.

If the spare unit is in service, the TPWS shall either survey it in the same conditions as for the other tyres or inform the driver for uncompleted survey of the vehicle.

5.3.2.6 A TPWS shall be able to take into account all sensors of the vehicle and only those of the vehicle (learn or auto-learn). The identification of the tyre position on the vehicle is optional (localization or auto-localization).

5.3.2.7 Optionally, a TPWS may also survey the tyre pressures when the engine is off.

5.3.3 Environmental system performance

A TPWS shall deliver the alert independently on:

— the category of the roads: motorways, highways, city roads, off-road, on bridges, inside tunnels;

— the nature of the roads: strait, bent, sloped, cambered;

— the nature of the road surface: asphalt, concrete, cobblestone, off-road;

— the condition of the road surface: dry, wet, slippery, snowy, icy.

If nevertheless the system is not active or efficient, the user shall be advised (see 5.2.5).

5.3.4 Monitoring strategy

A TPWS shall provide an alert if one or more of the tyres need a corrective action. The actual pressure is not necessarily compensated in temperature. The alert conditions (threshold levels, time, interface) shall be related to the criticity of the individual situation to reduce the risk.

A TPWS shall only include the self-diagnostic function of the associated TPAS.

5.3.5 Test procedures

The test procedures are defined by the provider in dependence on the TPWS specifications.

5.3.6 Minimum request for the display

The minimum request for the display is a warning provided by an orange, yellow or amber optical indicator on the dashboard.

5.4 Tyre Leak Alerting System (TLAS)

5.4.1 Purpose of TLAS

A TLAS is a system that monitors the pressure differences between the tyres in use, or a parameter that adequately correlates, and delivers an alert if a significant pressure difference appears. The goal of the alert is to inform the driver to take proper corrective actions as soon as possible.

5.4.2 System performance

5.4.2.1 All tyres positions of the vehicle shall be monitored by the TLAS.

5.4.2.2 The alert delivered by a TLAS may be unique for the set of tyres in use. The identification of the tyre at the origin of the alert is optional.

5.4.2.3 A TLAS does not need to measure directly the pressure of each tyre. The information about tyre pressure may be estimated by comparing all tyres in use. The system shall give an alert if one of four tyres is under-inflated related to the other ones. It may also give an alert if two or more tyres are under-inflated.

5.4.2.4 A TLAS is not required to monitor the tyre pressure of the unfitted tyre wheel assemblies or the spare unit even when fitted.

5.4.2.5 The alert provided by a TLAS may not be related to the minimum cold inflation pressure recommended by the tyre manufacturer's technical standards in relation to service conditions, but to the tyre pressures set by the user when initializing the system. Therefore, a TLAS is not able to deliver an alert at a given minimum absolute pressure threshold.

5.4.2.6 A TLAS may use a reset program to tune the system. After all tyres in use have been inflated, the reset button shall be activated. After a learning phase, the system will be able to detect when the pressure of at least one tyre is below that of the others. The system is not able to detect that a wrong inflation pressure has been set.

5.4.3 Environmental system performance

A TLAS shall deliver the alert independently on:

— the category of the roads: motorways, highways, city roads, on bridges, inside tunnels;

— the nature of the roads: straight, curved, sloped, normal camber;

— the nature of the road surface: asphalt, concrete, cobblestone (with the exception of off-road surfaces);

— the condition of the road surface: dry or wet (with the exception of slippery, snowy and icy conditions).

5.4.4 Monitoring strategy

After completion of the learning phase, a TLAS shall provide an alert within 10 min at a speed exceeding 25 km/h if corrective actions are needed.

5.4.5 Diagnostic

A TLAS shall include a self-diagnostic function delivering information to the user when the system is out of function. The system shall be able to deliver information within 10 min in driving conditions exceeding 25 km/h in case of malfunction.

5.4.6 Outdoor test procedures

5.4.6.1 General

These test procedures are defined to check the functionality and accuracy of the system without any link with the future detection thresholds for a specific vehicle.

Outdoor tests shall be performed after a successful learning phase.

5.4.6.2 Test for detection

Use a vehicle the tyres of which are correctly inflated at the recommended cold inflation pressure P_{rec}. Produce on one tyre a gradual pressure loss between 10 kPa/min and 20 kPa/min and check while driving at a speed exceeding 25 km/h that the system delivers an alert at the latest for a pressure drop of 100 kPa.

6 Technical requirements and test procedures of system components

6.1 General

As described in the scope of this International Standard, the system shall be able to survey all tyres in use, but not necessarily those in temporary use, and provide information to the driver. This clause establishes performance guidelines and test procedures for the components of the system, independently from the technical solution adopted to achieve its main tasks.

Table 1 illustrates typical TPMS system implementations, relating the location of the component to the different functionality of the TPM system:

Table 1

	Sensing	Communication	CPU	HMI
WFC	X	X		
EFC	X	X	X	X
IFC		X	X	X

6.2 Wheel Fitted Component (WFC)

6.2.1 Functionality

WFCs measure physical parameters which are either directly or indirectly correlated with the inflating pressure of the tyre. These parameters are sampled and transmitted according to specific strategies.

6.2.1.1 WFC information reporting strategy

The sensed values shall be reliably reported to a central unit. The WFCs shall be designed in such a way that the information will be transferred reliably within the reaction time required by the system.

Regardless of the technology employed, the communication channel hardware should be designed in such a way to ensure the minimal performance level imposed by the general system requirements given in 5.2.2, 5.2.4, 5.3.2, 5.3.4, 5.4.2 and 5.4.4.

6.2.1.2 Lifetime

WFCs shall be designed to last at least for six years or 100 000 km for the car of application whichever comes first, on the fitted car.

6.2.1.3 Measurement accuracy

WFCs shall be designed in order to ensure that the overall minimal system accuracy is guaranteed, regardless of all tolerances which may come into effect due to the elements which build the pressure information delivered to the final user.

In case of direct pressure measurement, the minimal accuracy required should respect the following criteria:

— ± 2 % FS between 0°C and +70°C, with a maximum of ± 10 kPa,

— ± 5 % FS elsewhere a maximum of ± 25 kPa,

where FS is the full pressure scale.

6.2.1.4 Environmental characteristics

— Temperature: WFCs shall be designed to survive at all temperatures they may be subjected to during their operational life as specified.

— Operational: The temperature range of full operation of WFCs shall be at least between –40°C and +85 °C. The system shall be able to inform the end user of temporary unavailability of pressure information.

— Maximum survival temperature: If temperatures are outside the above described range, a degraded functionality is accepted, as long as normal functionality is resumed whenever conditions return to the operational limits above.

— Maximum vehicle speed/acceleration: WFCs shall operate within the entire speed and acceleration profile of the wheel of application.

— Maximum survival pressure: WFCs shall survive undamaged a pressure value of at least 1 200 kPa applied for at least the time duration of the wheel assembly process.

— Fluid (gas and liquid) and particles contamination resistance: WFCs shall comply with the contamination profile designed for the wheel of application. It is possible to test resistance to contamination in final application mounting conditions.

— Electro-magnetic compatibility (EMC): According to the technology employed, WFCs shall comply with the applicable EMC legislative and regulatory requirements.

— Recycling: According to the technology employed, WFCs shall comply with the applicable recycling legislative and regulatory requirements.

6.2.1.5 Mechanical requirements

The WFCs shall be designed in order to be fully compatible with the application rims and tyres, without compromising wheel balance or vehicle handling. WFCs shall be compatible with the manufacturing process and machinery of the wheel assembly. WFCs shall be designed in order to avoid any damage to themselves or the tyre or any other wheel part during proper tyre mounting and dismounting operations, taking into account the aftermarket tyre fitment practice. WFCs shall not in any way interfere with the mechanical characteristics of the tyre, such as rolling resistance, wet grip, handling, noise, air sealing, etc. A mounting and dismounting procedure shall be clearly identified for the particular WFC of use allowing survivability of the WFC itself.

6.2.2 Test — Work item No. 1 — Minimal test criteria for WFCs

6.2.2.1 General

WFCs shall comply with the application-specific validation test. The validation test shall attempt to represent the lifetime utilization of the device. It shall include test procedures to simulate extreme conditions under all environmental and mechanical constraints. However, the minimal test criteria to be applied should follow the prescription hereafter specified. At the end of every specified test (from 6.2.2.2.4 to 6.2.2.2.14) and at the end of the test sequence, perform a physical examination and a functional test.

6.2.2.2 Test methods and environmental conditions

6.2.2.2.1 Test sequence

For the purpose of verifying compatibility of WFCs with the minimal technical requirements, no particular test sequence need be applied. However, identifying the most appropriate test sequence is not within the scope of this International Standard.

6.2.2.2.2 Functional test

This test verifies that the WFC operates within the parameters defined by the WFC specification.

6.2.2.2.3 Test samples

At least 10 samples shall be used for each test and the same samples shall be used for all tests.

6.2.2.2.4 Temperature

6.2.2.2.4.1 Operational

All components of a TPM system shall remain fully functional when tested at both the upper and lower limits of their operational temperature range for a minimum of 24 h. It is essential to verify functionality of the WFC during temperature exposure.

6.2.2.2.4.2 Thermal cycle

Program the chamber to cycle WFCs according to the profile shown in Figure 1. Place the WFC in the chamber and start. Continue for 100 cycles. After completion, perform the physical examination and functional test. Failure is defined as any WFC exhibiting damage or degradation of performance.

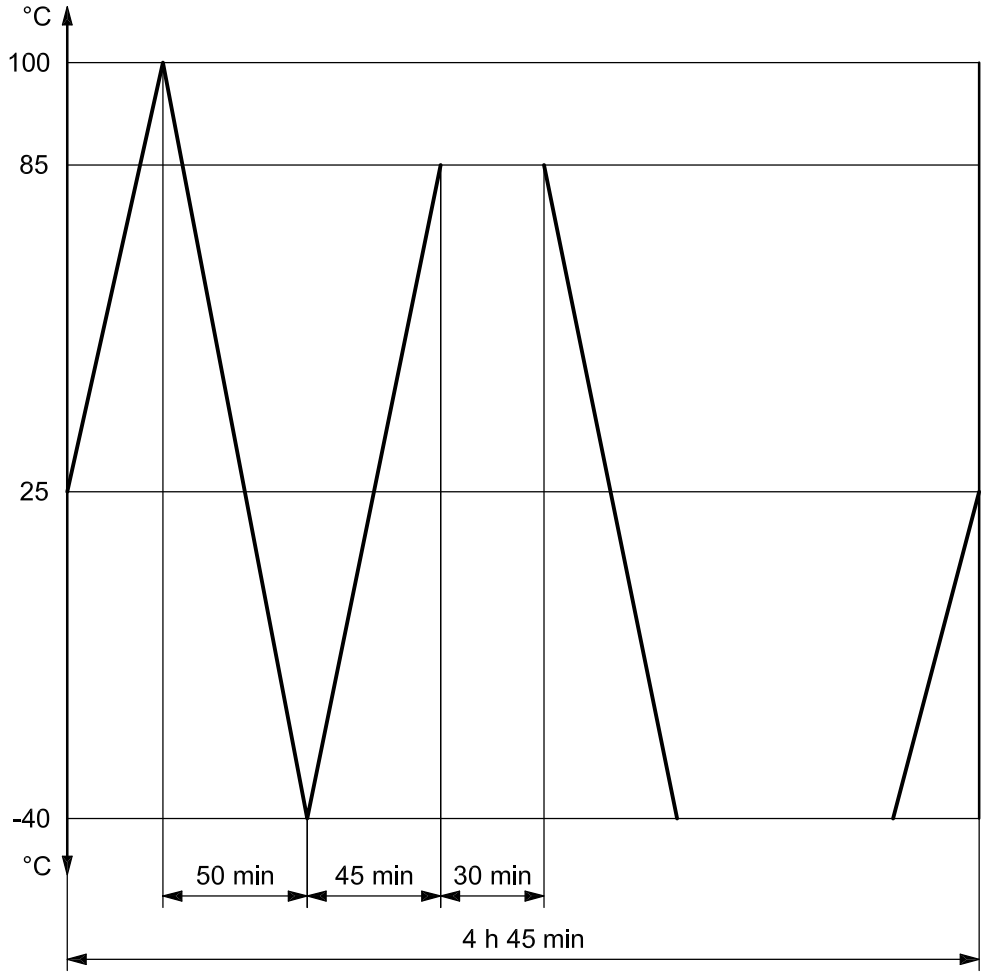

Figure 1 — WFC thermal cycle test

6.2.2.2.4.3 Thermal shock

- Place WFCs in chamber at 85 °C.
- Allow the WFC to soak at 85 °C for 30 min.
- Within 1 min transfer all parts to another chamber at – 30 °C.
- Allow the WFCs to soak at – 30 °C for 30 min.
- transfer to ambient (typically 20 °C) for 30 min.

6.2.2.2.4.4 Survival

Compliance to survival temperature requirement is verified within the thermal cycle test detailed above.

6.2.2.2.5 Acceleration

WFCs shall remain fully functional when subjected to an acceleration of 1 100 g for four hours at 65 °C as mounted in the final application.

6.2.2.2.6 Survival pressure

WFCs shall survive undamaged a minimum pressure of 1 200 kPa applied for minimum time duration of 5 s.

6.2.2.2.7 Humidity

The WFC shall be exposed for 120 hours to 95 % humidity at 65 °C. Humidity testing shall be done at atmospheric pressure. Electrical status of the WFC during humidity testing shall be representative of the WFC during vehicle application. After the completion of the test, the WFC shall function without degradation.

6.2.2.2.8 Frost

The WFC shall be exposed to –40 °C for 8 hours at atmospheric pressure, then moved to +10 °C, 90 % relative humidity or greater for 15 min. Transition time should be less than 1 min. The WFC shall be fully functional at the completion of the test. As a minimum, one such cycle is requested.

6.2.2.2.9 Fluid and particle contamination resistance

The specifications in this subclause need more experience and will be completed at the next revision of this International Standard.

6.2.2.2.10 Dust test

The specifications in this subclause need more experience and will be completed at the next revision of this International Standard.

6.2.2.2.11 Shock/Drop

The WFC shall be able to withstand three 100 g peak acceleration, half sine wave shocks of 20 ms duration along each axis. No damage shall be observed after visual inspection. The WFC shall be fully functional at the completion of the test.

The WFC shall be able to withstand a drop from a height of 1 m onto a solid concrete floor. The drop shall be performed on each face, edge, and corner of the device as applicable, one drop per device. No damage shall be observed after visual inspection. The WFC shall be fully functional at the completion of the test.

6.2.2.2.12 Vibration

Vibration resistance is a relevant factor to be taken into consideration in the design of a WFC. The intensity varies from low severity at smooth engine ideal to extreme severity when traversing rough roads at high speed. Vibration also varies with location. A specifically designed vibration profile shall be used to verify vibration resistance of WFCs. However, the minimum peak energy level shall be 2 g^2/Hz over a frequency of 20 Hz with the centre frequency determined by the application. The duration of the test shall be 10 hours per axis. The vibration frequency shall be randomly distributed across the entire spectrum.

6.2.2.2.13 Salt fog

This procedure, described in ASTM B 117-73, demonstrates the WFC ability to withstand exposure to salt fog or sea breezes. A salt-fog chamber shall be used.

— Prepare the unit for operation with a 5 % neutral salt concentration at 35 °C.

— Arrange exposure of the WFC sensing element in the salt-fog chamber, start the chamber and run for 96 hours.

— Upon completion, remove the WFC and wash in fresh water to remove salt deposits.

— Perform the physical examination and functional test.

The WFC shall be fully functional at the completion of the test.

6.2.2.2.14 Air shipment and extreme altitude

Expose the WFC to 18,6 kPa and –50 °C for 12 hours, either in operational or non-operational mode. Return the WFC to atmospheric pressure at 20 °C. Test for full functionality and visually inspect for damage or degradation. No damage shall be observed after visual inspection. The WFC shall be fully functional at the completion of the test. A procedure should be identified to allow total radio frequency shutdown for airfreight purposes.

6.2.2.2.15 Electromagnetic compatibility

If radio frequency technology is used, WFCs should be designed within the requirements of the worldwide standards IEC/CISPR 22 for radiated emissions and IEC/CISPR 24 for immunity.

6.3 External car body Fitted Components (EFCs)

The specifications in this subclause need more experience and will be completed at the next revision of this International Standard.

6.4 Internal car body Fitted Components (IFCs)

The specifications in this subclause need more experience and will be completed at the next revision of this International Standard.

7 Human Machine Interface (HMI)

7.1 Identification of controls, tell-tales and optical indicators

7.1.1 Symbols and colours

The minimum configuration shall be one alarm optical indicator which shall be red, and a second orange, yellow or amber lamp, for use in case of malfunction and/or other pressure warnings. A bicolour tell-tale may be used.

The following alternative solutions are also possible:

— Adding of some text or vocal message(s), sound(s), other tell-tale(s) to the above configuration.

— Replacement of the proposed minimum configuration by other, clearer, symbols, under the car manufacturer responsibility, if the manufacturer is able to prove that these symbols are in direct relationship with the system and well understood. The colours (red for alarm, orange, yellow or amber for other warnings) shall be kept for optical indicators. In case of a written message, the colour is not relevant.

A vehicle image may be used to indicate which tyre wheel assembly is concerned. The display shall be drawn in accordance with ISO 2575:2004, 4.4.

The tell-tales shall be located in the drive's direct field of vision and shall not be hidden by the steering wheel or any other part of the dashboard or controls.

7.1.2 Switches and buttons

If dedicated switches or buttons are required for reset, and/or calibration purposes, the associated symbol shall be the same as the one chosen for the tell-tale.

No sticker is required, but the car manufacturer may add any sticker or label which may seem necessary for the good use of the system. If a system symbol is used, it shall be the same as the one chosen for the tell-tale.

7.2 Information to the driver

7.2.1 Operational limitations

In case of a learning phase or of an initialization or a calibration phase, or as long as the system hasn't received the necessary data (after an "ignition off" phase, for instance), the driver shall be informed of the limitations, either by the system or by the manual. It is the car manufacturer's decision whether or not to show that the system is not fully operational ("inactive" tell-tale) and/or to write all necessary information in the owner's manual.

7.2.2 Warning duration

The warnings delivered by the system shall be maintained until a corrective action or a manual reset has been detected.

The warnings may disappear automatically, if the reason which was at their origin is no longer present (for example a temporary system malfunction).

7.2.3 Text messages

If the dashboard contains a text display, it shall not have less than 20 characters, if it is not completed with a vehicle image which indicates the involved tyre wheel assembly.

If the pressure value is displayed, it shall be in bar, in., PSI or kPa, according to the country where the car is to be sold, and it shall not be compensated with temperature. It shall be rounded according to ISO 1000.

7.2.4 Priorities

Any alarm (red optical indicator) shall have priority on warnings. In case of different alerts to be shown simultaneously on the same display (multi-functional displays), the different symbols can either alternate automatically or be displayed simultaneously.

7.2.5 Disconnection of the system

In case of temporary or continuous disablement of the system, the driver shall be clearly informed (either by the system itself, or by a special sticker).

7.3 Owner's manual information

The required necessary information shall be as follows:

"When the TPMS warning optical indicator is lit, one or more of your tyres is significantly under-inflated. You should stop and check your tyres as soon as possible, and inflate them to the proper pressure as indicated on the vehicle's tyre information placard. Driving on a significantly under-inflated tyre causes the tyre to overheat and can lead to tyre failure. Under-inflation also reduces fuel efficiency and tyre tread life, and may affect the vehicle's handling and stopping ability. Each tyre, including the spare, should be checked monthly when cold and set to the recommended inflation pressure as specified in the vehicle placard and owner's manual."

The driver should also be informed of the necessity to take the temperature into account to correctly inflate a tyre wheel assembly by a sentence such as:

“Tyre pressure shall be checked on cold tyres; if the pressure is measured when the tyres are warm, please add to the recommended inflation pressure 20 kPa to 30 kPa (2,8 PSI to 4,2 PSI).

NOTE Tyre is deemed “cold tyre” if it has not been heated by long driving (more than 10 min) or if it has nearly the same temperature as the ambient temperature.

7.4 Compatibility with extended mobility systems

In most cases, the use of an extended mobility system allows one to keep on driving, even without air, with some limitations in speed and/or mileage.

In these conditions, the TPMS shall deliver only warnings, instead of alarms, as long as the run-flat limits (speed and/or mileage) have not been exceeded.

When extended mobility systems use is allowed by the car manufacturer, the TPMS shall be able to switch between normal tyres and extended mobility systems monitoring strategies, either automatically or manually (by an accredited dealer or repairman only).

In case of use of both run-flat tyres and normal tyres on the same vehicle, the most severe strategy shall be used.

Another allowed possibility is to switch on run-flat running mode only if four wheels are fitted with run-flat tyres.

8 Recommended inflation pressure limits

The specifications in this clause need more experience and will be completed at the next revision of this International Standard.

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[1] ISO 3877(all parts), *Tyres, valves and tubes — List of equivalent terms*

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