General notes:

- This draft is proposed in the format of a new regulation. The informal group of GRRF could however decide to present the text as an amendment to an existing regulation or in any other regulatory form.
- The text contains some proposals for Human Machine Interface provisions. This point was however not discussed in detail during the meetings of the Task Force, and is still to be decided.
- Text in square brackets [ ] is subject to further decision by the informal group or the Contracting Parties .
- Notes to the reader are in *italic characters* and in general located below the relevant paragraph/sentence.

PROPOSAL FOR A NEW DRAFT REGULATION:

UNIFORM PROVISIONS CONCERNING THE TYPE-APPROVAL OF VEHICLES WITH REGARD TO TYRE PRESSURE MONITORING SYSTEMS AND DEVICES

1. SCOPE

2. This Regulation applies to:

1.1. ~~This Regulation applies to~~ the type- approval of vehicles of category M_1 /N_1[1/] with regard to their equipment which includes tyre pressure monitoring systems with a cold tyre inflation pressure limit of 350 kpa.

1.2. to the type-approval, as separate technical units of tyre pressure monitoring devices to be fitted in one or more types of motor vehicles of categories M1 and N1[1/] as retrofit or replacement parts with a cold tyre inflation pressure limit of 350 kpa.

Note: GRRF to confirm need for pressure limit and for exclusion of special purpose vehicles.

~~2.~~3. DEFINITIONS

For the purposes of this Regulation

2.1. Tyre Pressure Monitoring Function means a function of a vehicle able to evaluate the inflation pressure of the tyres or the variation of this inflation pressure over time and to transmit corresponding information to the user.

2.2. Tyre Pressure Monitoring System (TPMS) means a system fitted on a vehicle, able to evaluate the inflation pressure of the tyres or the variation of this inflation pressure over time and to transmit corresponding information to the user while the vehicle is running.

[1/] As defined in Annex 7 of the Consolidated Resolution on the Construction of Vehicles (R.E.3) (TRANS/WP.29/78/Rev.1/Amend.2)

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2.3. Tyre Pressure Monitoring Device (TPMD) means a separate technical unit fitted as a retrofit- or replacement part on a vehicle, able to evaluate the inflation pressure of the tyres or the variation of this inflation pressure over time and to transmit corresponding information to the user while the vehicle is running.

2.~~3~~4. Cold tyre inflation pressure means the tyre pressure at ambient temperature, in absence of any pressure build-up due to tyre usage.

2.~~4~~5. Recommended cold inflation pressure means the pressure recommended for each tyre position by the vehicle manufacturer, for the intended service conditions of the given vehicle, as defined on the vehicle placard and/or the vehicle owner's manual.

2.~~5~~6. Tyre Pressure Loss Reminder System (TPRS) is any system fitted on a vehicle, as part of a Tyre Pressure Monitoring Function, able to evaluate the inflation pressure of the tyres over time and to illuminate a low tyre pressure warning tell-tale.

Justification:

- *Need for presence of a definition of TPRS for certain markets*
- *Complies with part of definition of TPM Function*
- *No relevant justification **against** TPRS was presented yet*
- *Optional in UNECE regulation, i.e. some CP can decide to not to mandate it (e.g. EU)*

2.6. Warm tyre inflation pressure means the in-service operating pressure elevated from the cold pressure by temperature effects during vehicle usage.

Justification: definition taken from ISO 21750

~~3.~~4. APPLICATION FOR APPROVAL

3.1 The application for approval of a vehicle type with regard to its equipment with a tyre pressure monitoring system shall be submitted by the vehicle manufacturer or by his duly accredited representative;

3.2 It shall be accompanied, in triplicate, by a description of the vehicle type with regard to the items specified in annex 1 to this Regulation.

3.3 A vehicle representative of the vehicle type to be approved shall be submitted to the type approval authority or the technical service responsible for conducting the approval tests.

3.4 The competent authority shall verify the existence of satisfactory arrangements for ensuring effective control of the conformity of production before type approval is granted.

3.5. The application for approval of a retrofit-, or replacemant part as a separate technical unit shall be submitted by the manufacturer or by his duly accredited representative.

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3.6. For each type of device referred to in paragraph 2.3. for which type-approval is requested, the application for approval shall be accompanied by the following documents in triplicate.

3.6.1. Description of the device comprising all the relevant details, referred to in to this Regulation

3.6.2. Drawings indicating the intended location of the approval mark.

3.6.3. Instruction manual for the device installation on vehicles

3.6.4. End-user service manual

3.7. A sample of the specific device, properly installed in the parent vehicle(s).

~~4.~~ APPROVAL

4.1 If the vehicle submitted for approval pursuant to this Regulation meets the requirements of paragraph 5 below, approval of that vehicle type shall be granted.

4.2 An approval number shall be assigned to each type approved. Its first two digits (at present XXXX for the Regulation in its XXXX) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party may not assign the same number to another type of vehicle. However, variants of a model range which are in separate categories with respect to the criteria of paragraph 2.2 may be covered by the same type approval, provided that the results of the tests described in paragraph XXXX do not show major differences.

4.3 Notice of approval or of extension or of refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement which apply this Regulation by means of a form conforming to the model in annex 1 to this Regulation.

4.4 There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation an international approval mark consisting of:

4.4.1 a circle surrounding the letter "E" followed by the distinguishing number of the country which granted approval;

4.4.2 the number of this Regulation, followed by the letter "R", a clash and the approval number to the right of the circle prescribed in paragraph 4.4.1.

4.5 If the vehicle conforms to a vehicle type approved, under one or more Regulations annexed to the Agreement, in the country which granted approval

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under this Regulation, the symbol prescribed in paragraph 4.4.1 need not be repeated; in such a case, the Regulation and approval numbers and the additional symbols for all the Regulations under which approval has been granted in the country which granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1.

4.6 The approval mark shall be clearly legible and be indelible.

4.7 The approval mark shall be placed close to or on the vehicle data plate affixed by the manufacturer.

4.8 Annex 2 to this Regulation gives examples of approval marks.

~~4.~~5. GENERAL REQUIREMENTS

5.1. General

5.1.1. Subject to the requirements of paragraphs [INTRODUCTORY PROVISIONS] any vehicle fitted with a tyre pressure monitoring system complying with the definition of paragraph 2.1. shall meet the performance requirements contained in paragraphs 5.1 to 5.**5**. of this regulation.

Note:

- *Introductory provisions can be found in document TRANS/WP.29/1044, item II, "GENERAL GUIDELINES FOR PROPOSING NEW REGULATION".*
- *If the route of an amendment to an existing regulation were to be followed, transitional provisions will be elaborated accordingly.*

5.1.2. Any tyre pressure monitoring function fitted on a vehicle shall comply with the requirements of Regulation N°10 on electromagnetic interferences.

5.2. Tyre pressure detection for dangerously low pressure level

When tested according to paragraph 6, the TPMS shall illuminate the warning signal described in paragraph 5.5 not more than 10 minutes cumulative driving time after the warm tyre inflation pressure in one of the vehicle's tyres is reduced by 25% or to 150 kPa, whatever is higher. Driving time shall not accumulate during service brake application and when the vehicle is operating outside the speed range defined in paragraph 6.1.4.2.1.

5.3. Detection for a tyre pressure level significantly below the optimum pressure for good fuel consumption

Justification: this paragraph covers fuel consumption only, as per EC mandate.

5.3.1 When tested according to paragraph 6, the TPMS shall illuminate the warning signal described in paragraph 5.5 not more than 60 minutes cumulative driving time after the warm tyre inflation pressure in at least one of the vehicle's tyres, up to a total of four tyres, is reduced by 25%. Driving time shall not accumulate during service brake application and when the vehicle is operating outside the speed range defined in paragraph 6.1.4.2.2..

5.3.2. Vehicles fitted with a TPRS shall meet the following requirements:

5.3.2.1. The TPRS shall illuminate the warning signal described in paragraph 5.5 in conformity with the vehicle manufacturer provisions, but not more than 10 weeks after the system has been reset in accordance with the vehicle manufacturer's recommendations.

5.3.2.2. However, if the TPRS takes into consideration the variation of the ambient temperature over time, the delay mentioned in paragraph 5.3.2.1 above may be extended to a maximum of 30 weeks.

5.3.2.3. Compliance with the time delays mentioned above shall be demonstrated by a computer simulation which respects the characteristics of the tyres approved for the given vehicle type.

5.3.3. Vehicles fitted with a TPRS shall always be fitted with tyres having a permeation rate of or below [30 kPa/10week], when tested according to Annex 4 of this Regulation.

Justification: with the maximum delay of 10 weeks and a maximum permeation rate of 30 kPa/10 weeks, the alert will appear at the latest at an underinflation of 30 kPa.

5.4. Malfunction detection

When tested according to paragraph 6.2, the TPMS shall illuminate the warning signal described in paragraph 5.5. not more than 10 minutes after the occurrence of a malfunction that affects the generation or transmission of control or response signals in the vehicle's tyre pressure monitoring system. If the system is blocked by external influence (e.g. RF noise), the malfunction detection time may be extended.

5.5. Warning indication

5.5.1. The warning indication shall be by means of an optical yellow warning signal conform to Regulation N°121.

Note: Regulation N° 121 is last amended by documents ECE/TRANS/WP.29/2007/14 and ECE/TRANS/WP.29/2008/45.

5.5.2. The warning signal shall be activated when the ignition (start) switch is in the "on" (run) position (bulb check).

~~5.5.3. The warning signal must be visible even by daylight; the satisfactory condition of the signal must be easily verifiable by the driver from the driver's seat.~~

Justification: this requirement already exists in UNECE R121 (paragraph 5.1.2).

5.5.3. The malfunction indication may be indicated by the same warning signal as the deflated tyre detection. If the warning signal described in paragraph 5.5.1. is used to indicate both a deflated tyre and a malfunction in the TPMS, the

following shall apply: with the ignition (start) switch in the "on" (run) position the warning signal shall flash to indicate a system failure. After a short period of time the warning signal shall remain continuously illuminated as long as the failure exists and the ignition (start) switch is in the "on" (run) position. The flashing and illumination sequence shall be repeated each time the ignition (start) switch is in the "on" (run) position until the failure has been corrected.

6. Tests

6.1. Test conditions.

6.1.1 Ambient temperature.

The ambient temperature shall be between 0° C and 40° C.

6.1.2 Road test surface.

The road shall have a surface affording good adhesion. The road surface shall be dry during testing.

6.1.3. The tests shall be conducted in an environment free of radio wave interferences.

6.1.4. Vehicle conditions.

6.1.4.1 Test weight.

The vehicle may be tested at any condition of load, but the load state shall not be changed during the test procedure. The distribution of the mass among the axles shall be that stated by the manufacturer without exceeding any of the maximum permissible mass for each axle.
However, in the case where there is no possibility to set or reset the system, the vehicle shall be unladen. There may be, in addition to the driver, a second person on the front seat who is responsible for noting the results of the tests.

Justification: For most of the vehicles, load changes during vehicle testing would require pressure adjustments which would jeopardize the overall test procedure.

6.1.4.2 Vehicle speed

For vehicles equipped with cruise control, the cruise control shall not be engaged during testing.

6.1.4.2.1. When tested according to paragraph 5.2 (dangerously low pressure level), the tyre warming-up, the learning phase and the low tyre pressure detection phase shall be conducted at a speed between 90 km/h and 130 km/h.

Justification: performing high speed tests would become difficult and unsafe on open roads

6.1.4.2.2. When tested according to paragraph 5.3 (fuel consumption), the tyre warming-up, the learning phase and the low tyre pressure detection phase shall be conducted at a speed between 40 and 80 km/h.

Justification:

- *Performing high speed tests would become difficult and unsafe on open roads*
- *Performing speed tests below 40 km/h would become technology discriminative. Direct systems with G-switch may not switch on below 40 km/h. G-switches permit to limit the cost of TPMS to the user because they save battery energy*
- *In addition, the tyre warming-up must be performed at the same speed as the test in order to avoid temperature changes due to speed changes, provoking pressue changes.*

6.1.4.2.3. The malfunction detection test (paragraph 5.4) shall be conducted at a speed between 40 and 80 km/h.

Justification:

- *Performing high speed tests would become difficult and unsafe on open roads*
- *Performing speed tests below 40 km/h would become technology discriminative. Direct systems with G-switch may not switch on below 40 km/h. G-switches permit to limit the cost of TPMS to the user because they save battery energy*

6.1.4.3 Rim position.

The vehicle rims may be positioned at any wheel position, consistent with any related instructions or limitations from the vehicle's manufacturer.

6.1.4.4 Stationary location.

The vehicle's tyres shall be shaded from direct sun when the vehicle is parked. The stationary location shall be such that there is no wind liable to affect the results.

6.1.4.5 Brake pedal application.

Driving time shall not accumulate during service brake application and when the vehicle is operating outside the relevant speed range defined in paragraph 6.1.4.2.

6.1.4.6 Tyres.

The vehicle shall be tested with the tyres installed on the vehicle according to the vehicle manufacturer's recommendation. However, the spare tyre may be utilised for TPMS malfunction testing purposes.

6.1.5. Accuracy of measurement equipment

The accuracy of measurement equipment shall be taken into account during the test.

6.2. Test procedure

6.2.1. Inflate the vehicle's tyres to the vehicle manufacturer's recommended cold inflation pressure, in accordance with the vehicle manufacturer's recommendation for the load and speed conditions.

Justification: Recommended pressures can vary according to the speed as well as according to the load.

6.2.2. With the vehicle stationary and the ignition locking system in the ''Lock'' or ''Off'' position, activate the ignition locking system to the ''On'' or (''Run'') position.

The tyre pressure monitoring system shall perform a check of lamp function for the low tyre pressure telltale as specified in paragraph 5.5.2 of this Regulation.

6.2.3. If applicable, set or reset the tyre pressure monitoring system in accordance with the vehicle manufacturer's recommendations.

6.2.4. Tyres warming-up phase

6.2.4.1. Drive the vehicle for up to 15 minutes of cumulative time (continuously) along any portion of the test course.

6.2.4.2 Reverse direction on the course and drive the vehicle for an additional period of time for a total cumulative time between 20 and 30 minutes (including the time in 6.2.4.1).

After this phase, the tyre are considered at warm tyre inflation pressure.

6.2.5. Deflation to the recommended cold inflation pressure

Deflate all tyres in two stages as follows:

- one rough deflation bringing the pressure to the recommended cold inflation pressure, within plus 20 kPa – minus 0 kPa, followed by an interval of two to four minutes;
- fine-tuning steps to adjust the pressure to the recommended cold inflation pressure.

Justification:

- *2-step procedure as recommended by ISO WG12*
- *This method is more accurate than the method currently used in FMVSS138. It is also more severe because it does not bring the 7 kPa security for the TPMS.*

6.2.5.1. If applicable, set or reset the tyre pressure monitoring system in accordance with the vehicle manufacturer's recommendations.

6.2.6. Learning phase.

6.2.6.1. Drive the vehicle for up to 15 minutes of cumulative time (not necessarily continuously) along any portion of the test course.

6.2.6.2. Reverse direction on the course and drive the vehicle for an additional period of time for a total cumulative time between 20 and 30 minutes (including the time in 6.2.6.1, and not necessarily continuously).

6.2.7. Deflation to alert threshold and low tyre pressure detection phase

6.2.7.1. Procedure for detection of dangerously low pressure level (5.2.)

6.2.7.1.1. Deflate one of the vehicle's tyres in two stages as follows:

- one rough deflation bringing the pressure to the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal, within plus 20 kPa – minus 0 kPa, followed by an interval of two to four minutes;
- fine-tuning step to adjust the pressure to the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal.

6.2.7.1.2 Drive the vehicle along any portion of the test course (not necessarily continuously). The sum of the total cumulative drive time shall be the lesser of 10 minutes or the time at which the low tyre pressure telltale illuminates.

Justification:

- *Improved test procedure as proposed by Japan at ISO WG12*
- *Advantages:*
  - *Technology neutral (direct vs indirect)*
  - *Supported by existing data (see annex)*
  - *Eradicates influence of parasite factors (external temperature, tyre warm-up, weather, driving speed, etc.)*
  - *Fits all market conditions*

6.2.7.2. Procedure for detection of pressure level significantly below optimum pressure for good fuel consumption (5.3.)

6.2.7.2.1. Deflate at least one of the vehicle's tyres, up to a total of four tyres, in two stages as follows:

- one rough deflation bringing the pressure to the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal, within plus 20 kPa – minus 0 kPa, followed by an interval of thirty seconds to one minute;
- fine-tuning steps to adjust the pressure to the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal.

6.2.7.2.2. Drive the vehicle along any portion of the test course (not necessarily continuously). The sum of the total cumulative drive time shall be the lesser of 60 minutes or the time at which the low tyre pressure telltale illuminates.

6.2.8. If the low tyre pressure signal did not illuminate, discontinue the test.

6.2.9. If the low tyre pressure telltale illuminated during the procedure in paragraph 6.2.8., deactivate the ignition locking system to the ''Off'' or ''Lock'' position.

After a 5 minute period, activate the vehicle's ignition locking system to the ''On'' (''Run'') position. The telltale must illuminate and remain illuminated as long as the ignition locking system is in the "On" ("Run") position.

6.2.10. Keep the vehicle stationary and shaded for a period of up to one hour with the engine off.

6.2.11. Inflate all of the vehicle's tyres to the vehicle manufacturer's recommended cold inflation pressure. If the vehicle's tyre pressure monitoring system has a manual reset feature, reset the system in accordance with the instructions of the vehicle manufacturer. Determine whether the telltale has extinguished. If necessary, drive the vehicle until the telltale has been extinguished.

6.2.12. Repetition of the deflation phase

The test may be repeated, using the test procedures in paragraphs 6.2.1 to 6.2.11, with the relevant number of tyres on the vehicle under-inflated, in accordance with the provisions of paragraph 5.2. or 5.3., whichever is relevant.

6.3. TPMS malfunction detection

6.3.1. Simulate one TPMS malfunction by disconnecting the power source to any TPMS component, disconnecting any electrical connection between TPMS components, or installing a tyre or wheel on the vehicle that is incompatible with the TPMS. When simulating a TPMS malfunction, the electrical connections for the telltale lamps are not to be disconnected.

6.3.2. Drive the vehicle for up to 5 minutes of cumulative time (not necessarily continuously) along any portion of the test course.

6.3.3. Reverse direction on the course and drive the vehicle for an additional period of time for a total cumulative time of 10 minutes (including the time in paragraph 6.3.2, and not necessarily continuously).

6.3.4. The sum of the total cumulative drive time under paragraphs 6.3.2 and 6.3.3 shall be the lesser of 10 minutes or the time at which the TPMS malfunction telltale illuminates.

6.3.5. If the TPMS malfunction indicator did not illuminate in accordance with paragraph 5.4., as required, discontinue the test.

6.3.6. If the TPMS malfunction indicator illuminated during the procedure in paragraph 6.3, deactivate the ignition locking system to the ''Off'' or ''Lock'' position. After a 5-minute period, activate the vehicle's ignition locking system to the ''On'' (''Run'') position. The TPMS malfunction indicator shall again signal a malfunction and remain illuminated as long as the ignition locking system is in the ''On'' (''Run'') position.

6.3.7. Restore the TPMS to normal operation. If necessary, drive the vehicle until the warning signal has extinguished.

6.3.8. The test may be repeated using the test procedures in paragraphs 6.3.1 to 6.3.7, with each such test limited to simulation of a single malfunction.

7. Modification of vehicle type or tyre pressure monitoring system and extension of approval
8. Conformity of production
9. Penalties for non-conformity of production
10. Production definitely discontinued
11. Names and addresses of Technical Services responsible for conducting approval tests, and of Administrative Departments
12. Introductory provisions

ANNEXES

Annex 1: Communication
Annex 2: Type approval certificate
Annex 3: Arrangements of approval marks

Annex 4: Permeation rate of the tyres

PROCEDURE FOR DETERMINING THE TYRE PERMEATION RATE

1. This annex applies to vehicles fitted with a TPRS conform to paragraphs 2.5. and 5.3. of this Regulation.

Note: the following test method is based on the ASTM F 1112 – 06a (Standard Test Method for Static Testing of Tubeless Pneumatic Tires for Rate of Loss of Inflation Pressure).

2. Scope

2.1 This test method covers the determination of the rate of inflation pressure loss resulting from air diffusion through the structures of tubeless tyres under constant temperature conditions. The testing is done under static conditions, that is non rotating, non loaded tyres.

3. Terminology

3.1 Definitions:

3.1.1 Inflation pressure loss rate: rate of change of normalised inflation pressure, determined from the slope of the linear portion of the log pressure versus time curve.

3.1.2 Measured inflation pressure: gauge pressure of a tyre measured at a given time under ambient temperature and barometric pressure.

3.1.3 Normalised inflation pressure: measured pressure of a tyre adjusted, according to the ideal gas law, to the nominal test temperature and one atmosphere external barometric pressure.

4. Summary of Test Method

4.1 Test tyres are mounted on rims, fitted with calibrated precision pressure measuring devices, inflated to the desired pressure, and, after a period of stabilization, are

monitored for inflation pressure as a function of time under static, constant temperature conditions.

4.2 Measured inflation pressures are normalised to the nominal test temperature and one atmosphere barometric pressure for calculation of pressure loss rates.

4.3 Two or more tyres per tyre specification are tested for pressure loss rate over a period of two to six months. High precision in the equipment and data may allow shortening the test.

4.4 The pressure loss rate is calculated as percent loss per month at the nominal test temperature and one atmosphere barometric pressure (101.3 kPa).

5. (Reserved)

6. Interferences

6.1 Ambient temperature excursions greater than 63°C for several hours may significantly alter both the air diffusion rate through the tyre and the driving force inflation pressure, thereby causing variability in the rate of tyre pressure loss. Some temperature variations can result from inconsistent air currents around the test tyres, or from spatial temperature gradients in static air spaces. The effects can be significant where heat-generating tests such as laboratory road wheels are operating intermittently in the same room.

6.2 Other causes for inconsistent results are minute leaks in the tyre, rim, valve, or pressure measuring device assembly; as well as varied service or other heat history of the test tyres.

7. Sampling and Preparation of Test Tyres

7.1 All of the tyres in a sample should have the desired producing plant and date codes and similar storage and service temperature history.

7.2 Tyres must be free of moulding or other defects, particularly on the bead area and innerliner surfaces.

7.3 New tyres should be used for evaluation of construction or compound variations.

7.4 Minimum recommended sample size is two tyres for each type of tyre or treatment being tested.

7.5 Test tyres are to be mounted on rims of the proper bead seat diameter with clean, smooth surfaces in the bead seat areas, particularly in the vicinity of the weld. Rim flanges must be free of sharp edges or scuffs that could damage the tyre during mounting. Bead seat diameters must be verified using a certified disc tape (a.k.a. ball tape) and be acceptable according to an applicable standard such as the tyre standardisation bodies. Painted steel is the material of choice for the test rims due to the low permeation rates. If another rim material must be used, then precautions are to be taken to insure against air permeation through the rim material.

7.6 A commercial bead-rim lubricant shall be applied to the tyre bead areas and rim before mounting. Vegetable oil or soap-based lubricants are recommended.

7.7 Mount the tyre on the rim according to the practice recommended by tyre standardization bodies. Do not exceed 275 kPa inflation pressure for seating beads. Use of sealants in the bead-flange area should be avoided since it can prevent proper seating.

7.8 The rim shall be outfitted with either two serviceable valves or a single valve to which is then attached a metal “T” adapter that permits permanent attachment of a pressure measuring device (gauge/transducer) to one opening and inflation through the other.

7.9 A sealing tape such as TFE-fluorocarbon or a room temperature curable sealant shall be used on all threaded connections in the valve-adapter-gauge/transducer assembly.

7.10 A pressure-measuring device shall be connected to the adapter (or valve) to continuously measure inflation pressure. The device shall have a resolution of at least 2 kPa and an accuracy of ±1 % of the measured pressure. Devices shall be calibrated before and after each use with a reference device. The pressure-measuring device must maintain this accuracy over the duration of the test. Electronic pressure transducers and data acquisition systems are advantageous due to their accuracy, repeatability, and continuous remote monitoring capability. To ensure their accuracy, these systems must be calibrated as a single, functional unit; transducer, cabling, signal conditioner, and data acquisition device. These systems, along with stable environmental conditions, can enable shorter duration tests producing results comparable to 180-day test results.

7.11 Inflate the tyre-rim assembly outfitted with the pressure gauge or transducer to the desired starting pressure. Test for leaks by submersion in a water tank, up to the base of the gauge or transducer, for at least 30 min or carefully check both beads and fittings for leaks with leak detection fluid. If other than a painted steel rim is used, the entire rim must be checked for leaks.

7.12 After confirming that the tyre-rim assembly is free from leaks, fit the valve or adapter opening with a sealing cap, and keep the tyre in the same orientation to avoid causing new leaks.

7.13 After the leakage check, condition the tyres at the test room temperature for 48 h; then adjust to the starting test pressure. Replace the sealing cap on the valve or adapter. If a pressure drop of more than 3 kPa occurs over the conditioning period, recheck the assembly for leakage according to 7.11 and, if necessary, dismount and remount the tyre.
Greater than 48 h conditioning may be necessary for some tyres such as high-pressure compact spares, whose growth can affect early inflation loss results.

8. Test Chamber

8.1 The test chamber shall be controlled to provide a mean ambient temperature that is within ± 0.6°C of the nominal test temperature and with overall variation within ± 3°C over the course of the test.

8.2 Nominal test temperatures currently in use are: 21, 24, 30, and 38°C.

8.3 Air in the test chamber should be forcibly circulated to minimise spatial temperature gradients.

9. Procedure

9.1 Place the test tyres in the test chamber so as to allow free air circulation around them and easy visual access to the pressure gauges. The tyres shall not be moved during the test.

9.2 Record inflation pressures, concurrent ambient temperatures, and barometric pressures frequently (daily readings are recommended) for two weeks. If using a pressure gauge, tap the gauge lightly prior to each reading. Tyres shall be considered to be satisfactorily conditioned when the slope of the logarithm of the normalised inflation pressure versus time relationship becomes constant.

9.3 The test shall be continued if replicate tyres agree with each other within 6 kPa inflation pressure after two weeks. Otherwise, recheck the suspect assembly for leaks according to 7.11, and restart the test.

9.4 Inflation pressure readings and concurrent ambient temperature and barometric pressure readings shall be recorded at least once per week during the remaining test period. Continuous monitoring of ambient temperature is desirable to ensure that the tyre is at equilibrium temperature when its pressure is measured.

9.5 Correct inflation pressure readings, *P*1, to the nominal test temperature and one atmosphere barometric pressure (101.3 kPa, by using the equation in 10.1.

9.6 A commonly used test duration is 180 days. The test period may be shorter or longer depending on the precision level of the data. More frequent or continuous electronic measurements are recommended if shorter term projections of performance are intended. See also 4.3.

10. Calculation

10.1 Calculate normalised pressures from the formula:

$$P = (P1 + B1)\,(T2/T1) - B2$$

where:
P = normalised inflation pressure, kPa,
P1 = measured inflation pressure, kPa,
B1 = measured barometric pressure, kPa
B2 = reference barometric pressure, kPa (one atmosphere = 101.3 kPa),
T1 = measured temperature, °K, and
T2 = nominal test temperature, °K.

NOTE —Temperature in Kelvin

10.2 Air permeation data fits the model of the following form:

$$P = P_0\, e^{\beta t}$$

where:
P = normalised pressure, kPa,
P_0 = normalised initial pressure, kPa,
β = loss rate per day at the nominal test temperature, and
t = test time, days.

10.3 A least squares fit can be obtained after transformation of the model equation to the following form:

$\ln P = \alpha + \beta t$

where:
$\alpha = \ln P_0$

The model is derived from a relationship that expresses pressure loss as a function of pressure only:

$dP/dt = \beta P$

Thus, pressure loss in absolute units will vary as the actual nominal pressure changes, but a loss rate can be expressed by the constant, β.

10.4 The calculated loss rate constant, β, will be in units of 1/day. This number will typically be a very small decimal; it is convenient, and perhaps more intuitively meaningful, to express loss rate as a percent per month. This is done by multiplying β by 3000 (which is 100 % x 30 days/month).

10.5 Calculations of steady state loss rate and predictions of future pressures can be made from any point in the test (beyond the first 30 days as explained in X1.3). The accuracy of such predictions will depend on the appropriateness of the model as well as the precision level of data obtained that, in turn, will depend on factors such as the following:

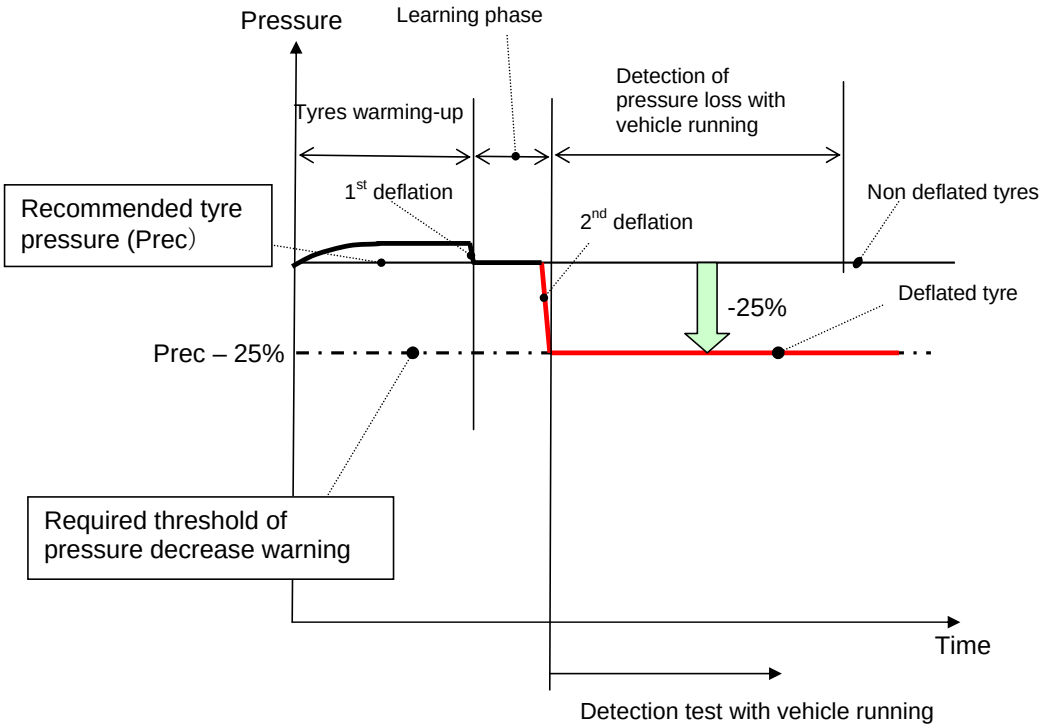
10.5.1 Care in reading pressure gauges,

10.5.2 Resolution and accuracy of pressure measuring devices,

10.5.3 Maintenance of a relatively constant temperature, and

10.5.4 Frequency of pressure measurements.

<u>Explanatory note</u>: scheme of test procedure.



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