GRRF/TPM/TF/D-Prop-Revision 17 draft text after 2nd meeting

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 APPROVAL OF ~~PASSENGER CARS~~ VEHICLES WITH REGARD TO TYRE PRESSURE MONITORING

1. SCOPE

This Regulation applies to the approval of vehicles of category M_1[1/] with regard to their equipment which ~~may~~ includes ~~a~~ tyre pressure monitoring.

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

2. DEFINITIONS

For the purposes of this Regulation

2.0. Tyre Pressure Monitoring Function means XXX (Mr. Hesse to provide proper wording)

2.1. Tyre Pressure Monitoring System (TPMS) means a system fitted on a vehicle, able to ~~[~~evaluate~~/monitor]~~ 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~~.

[Tire pressure monitoring system means a system that detects when one or more of a vehicle's tires is significantly under-inflated and illuminates a low tire pressure warning telltale.] (FMVSS 138)

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

2.3. [Minimum cold tyre inflation pressure means the minimum cold tyre inflation pressure, specified by the tyre standardization bodies for given service conditions.]

[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)

Note: to be included according to necessity in the regulation. This draft however does not use this definition.

2.4. 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. [Tyre Pressure Loss Reminder System (TPRS) is any system fitted on a vehicle, as part of a TPMS, able to give a reminder message periodically to the driver to check and re-adjust the tyre pressure.]

2.6. [~~Warm tyre inflation pressure is the stabilised tyre pressure at ambient temperature, after pressure build-up due to tyre usage.~~]
[In service operating pressure is the inflation pressure elevated from the cold pressure by temperature effects during vehicle usage] (ISO definition)

3. 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.

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 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.

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 system (TPMS) fitted on a vehicle shall comply with the requirements of Regulation N°10 on electromagnetic interferences.

5.2. ~~Deflated~~ Tyre pressure detection for incident-related pressure loss

When tested according to paragraph 6, the TPMS shall illuminate the warning signal described in paragraph 5.5 not more than 10 minutes after the warm tyre inflation pressure in one ~~or two~~ of the vehicle's tyres is reduced by 25% or to 150 kPa , whatever is higher.

Notes:

- *Request of written comments from organisations having a mandate at UNECE, if compromise considered not suitable*
- *Compromise: 10 min and 25% or 150kPa whatever is higher.*

5.3. ~~Deflated~~ Detection for a tyre pressure level significantly below the ~~optimum~~ recommended pressure for optimum performance (~~for~~ including ~~good~~ fuel consumption and tyre intergrity)

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 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 [30kPa]/[25%] [a value between those two values].

Notes:

- *This paragraph aims CO2 emission reduction.*
- ***Time**: Schrader, Continental support 30 minutes time to warning*
- ***Threshold**:*
  - *30kPa: ~~ETRTO~~, Schrader, Beru, NL.*
  - *25%: OICA, Dunlop Tech-Sumitomo, Nira, Bosch*
  - *Range 30kPa-25% : Continental (w/o tyres)*
  - *According to technical capabilities: UK, J, TRW*
  - *No position: F*
- ***Temperature**: take into account T° effects (Warm tyres) in the test procedure,*

5.3.2 As an alternative the 5.3.1, vehicles may be fitted a TPRS. In this case, the following shall apply:

5.3.2.1. 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.

Note: limit and test method to be decided.

5.3.2.2. 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.

Note: 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.

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

5.3.2.4. 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.

5.4. Malfunction detection

When tested according to paragraph 6.2, the TPMS shall illuminate the warning signal described in paragraph 5.5. not more than [20] / [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.

Note: ETRTO position: 10 minutes + extension for external influence (ISO recommendation – "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.

5.5.4. 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

Note: could be in an annex

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, the distribution of the mass among the axles being 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.

6.1.4.2 Vehicle speed

The vehicle's TPMS shall be calibrated and tested at a speed between [50 km/h and 100 km/h] / [25 km/h and 130 km/h] / [up to 160 km/h].
[The whole speed range shall be covered during the test.]
For vehicles equipped with cruise control, the cruise control shall not be engaged during testing.

Notes:

- *OICA position:*
  - *Good fuel economy: 60 to 90 km/h*
  - *Dangerously low pressure: 50 km/h to 130 km/h*
- *ETRTO position: between 25 km/h and 130 km/h*
- *Schrader position: Schrader asks for a maximum test speed of 160 km/h*

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.

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 loading conditions.

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. Learning phase.

6.2.4.1. Drive the vehicle for up to 15 minutes of cumulative time (not necessarily 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 of 20 minutes (including the time in 6.2.4.1, and not necessarily continuously).

6.2.5. Deflation phase

6.2.5.1. [Deflate one of the vehicle's tyres, up to a total of two tyres on the same vehicle side, until it is at [7 kPa below] the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal.]

6.2.5.2. [Deflate at least one of the vehicle's tyres, up to a total of four tyres, until the deflated tyre(s) is (are) at [7 kPa below] the inflation pressure at which the tyre pressure monitoring system is required to illuminate the low tyre pressure warning signal.]

Note:

- *OICA, Dunlop Tech Sumitomo, Nira: paragraph 6.2.5.1. for dangerously low pressure level (5.2), paragraph 6.2.5.2. for pressure level significantly below the optimum pressure for good fuel economy (5.3.).*
- *UK, NL, ETRTO, Continental, Beru: If the provisions for optimum pressure for good fuel consumption (see 5.4.1) are met for 4 tyres, the provisions for dangerously low pressure level can address 1 tyre at the time only. If not, the provisions for dangerously low pressure level shall address up to 4 tyres at the time.*

6.2.6. Low tyre pressure detection phase

6.2.6.1. Procedure for detection of pressure level significantly below the optimum pressure for good fuel economy (5.3.).

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.

6.2.6.2. Procedure for systems aiming prevention of dangerously low pressure level (5.2.).

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.

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

6.2.7. If the low tyre pressure telltale illuminated during the procedure in paragraph 6.2.6., 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.

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

6.2.9. 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.

6.2.10. Repetition of the deflation phase

The test may be repeated, using the test procedures in paragraphs 6.2.1 to 6.2.9, 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 or more TPMS malfunction(s) 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 15 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 20 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 20 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.