Submitted by the representative of OICA

Informal document No. **WP.29-148-02**
(148th WP.29, 23-26 June 2009,
Agenda item 3.6.1)

A. BACKGROUND

At its last session, GRRF drafted uniform provisions concerning the type-approval of vehicles with regard to Tyre Pressure Monitoring Systems (TPMS), see document GRRF-65-40. Whereas the experts already agreed on the provisions for the "puncture test", they were unable to agree on two specific issues of the "diffusion test". In consequence, the Chairman of GRRF has requested guidance from WP.29, see document ECE/TRANS/WP.29/2009/81. In the present document, OICA presents and explains its position on the two open issues.

B. PROPOSAL (amendments refer to document GRRF-65-40)

Paragraph 5.3.1., delete the 30 minutes option, adopt the 60 minutes option, to read:

"5.3.1. When tested according to paragraph 6.2.6.2., the TPMS shall illuminate the warning signal described in paragraph 5.5. within not more than ~~30~~ **60** minutes of cumulative driving time after the in-service operating pressure in one of the vehicle's tyres, up to a total of four tyres, has been reduced by 20 per cent."

Paragraph 6.2.5.3. amend to read:

"6.2.5.3. In both cases above, in order to compensate for inaccuracies of the measuring equipment **and thermal effects due to the test procedure**, the value P_{test} shall be reduced by a further ~~[5] kPa~~ **value depending on the recommended cold inflation pressure P_{rec} as follows:**

P_{rec}	**Total reduction of P_{test}**
<200 kPa	**15 kPa**
≥ 200 kPa and <250 kPa	**18 kPa**
≥ 250 kPa and <300 kPa	**22 kPa**
≥ 300 kPa	**25 kPa**

"

Paragraph 6.2.6.2.1., delete the 30 minutes option, and adopt the 60 minutes option, and amend to read:

"6.2.6.2.1. Drive the vehicle along any portion of the test course **for approximately 20 minutes after which the vehicle shall be brought to a complete standstill at least once with the engine switched off and only restarted after at least 1 minute has elapsed, but before 3 minutes has expired and the test resumed.** The sum of the total cumulative drive time shall be the lesser of ~~30~~ **60** minutes or the time at which the low tyre pressure telltale illuminates."

C. JUSTIFICATIONS

The current proposal of GRRF, which requires a TPMS warning when the hot in service tyre pressure has decreased by 20%, is a completely new requirement, which is more severe than any existing regulation worldwide. OICA accepts this proposal of GRRF in its constant wish of taking its part in the reduction of the global CO_2 emissions.

As the GRRF proposal is a very ambitious requirement, which makes necessary the redesign of all actual vehicle models included in the scope of the regulation, we believe that the **specific test procedure for type approval** must be **technology neutral** and must **not introduce any unnecessary severity**.

Any type approval test procedure must be designed to be repeatable and must reliably check the vehicle compliance with the requirements. In consequence, physical effects, which are only due to the test procedure, have no influence on the real world performance of the vehicle and must be compensated by appropriate measures.
The current GRRF proposal contains two parameters that are still in square brackets. Please find below the justifications for the OICA-answer to this open issues.

1. Diffusion test with a TPMS warning at the latest 60 minutes after the step-wise deflation

In contrast to the "puncture test" (paragraph 5.2.), which simulates an incident-related pressure loss (safety issue), the "diffusion test" (paragraph 5.3.) simulates a user-negligence of the tyre pressure maintenance for a long period. This is the main reason for long-term underinflations, which increase the tyre rolling resistance and hence increase the CO_2 emissions of a vehicle.

Starting from the recommended tyre pressure, it will typically take 6 months or more until a tyre with an average natural air diffusion rate has reached the TPMS warning threshold of 20%.

As this threshold may be reached for very short durations during transitional phases due to random changes in some key parameters (temperature, altitude, driving style, etc.), the system (whether direct or indirect) needs redundant information to provide a robust alert to the driver. In addition, a sudden step change of 20% of the tyre pressure is not a real world diffusion scenario. As TPMS warning strategies are designed for real world use and not just to satisfy a specific type approval test, a robust system will first check the plausibility of the given situation before taking the risk to give an unjustified alert to the driver which is due to transitional influences.

Should the alert delay be reduced to less than 60 minutes, the TPMS manufacturers would have to design their system according to the test method rather than the reality. This would jeopardise the real world benefit.

The proposed 60 minutes are CUMULATED DRIVING TIME. To emphasize this, OICA has added in its proposal the requirement that the engine shall be stopped at least once during the diffusion test. In consequence, even for vehicles which are only driven for e.g. 10 minutes journeys, the system must warn at the latest just before 60 minutes total driving. In addition, safety and environmental benefits of 30 minutes instead of 60 minutes detection time are negligible (6 months + 30 minutes = 6 months + 60 minutes from all practical aspects).

A requirement for a maximal 60 minutes CUMULATED DRIVING TIME is neither detrimental to the safety nor to environment, but rather beneficial to the TPMS credibility.

We recall that this amendment to the Regulation N°64 was elaborated under the wish of the European Union to make the installation of TPMS mandatory for all M1 vehicles in its Member States. In this context, an important fact is that the European Union has decided that the technical requirements for TPMS shall "allow for a technology-neutral and cost-effective approach in the development of accurate Tyre Pressure Monitoring Systems".

Decreasing the requirements from 60 minutes to 45 or 30 minutes could exclude certain technologies and hence multiply by factor 4 to 6 the price for the system without improving the real world benefit and in the same time affect the TPMS credibility. It would divide the TPMS cost-effectiveness by factor 4 to 6.

2. Compensation of physical effects due to the test procedure

In the current test procedure, there are at least three sources of inaccuracy, which should be taken into account in order to avoid biased, unreliable results:

1) Pressure measuring equipment
2) Pressure increase due to exchange of heat with tyre/rim assembly subsequent to cooling of gases when the tyres are abruptly deflated
3) Heating of the tyre due to increased rolling resistance after deflation

The current GRRF draft proposal foresees a measuring equipment tolerance of [5kPa] for point 1). However, as this value is in square brackets it needs to be validated. The other two points are not considered. Please find below an analysis of the three sources of inaccuracy.

2.1 Pressure measuring equipment
The manufacturers of pressure measuring equipment indicate measurement accuracies in their commercial documentation for certain environmental conditions. The accuracy depends on the chosen scale (see the two examples below):

Manufacturer 1) The accuracy of the measuring device is

- **5 kPa** (0.05 bar) for a pressure range 0 - 800 kPa and
- **10 kPa** (0.1 bar) for a pressure range 800 - 1000 kPa.

Measurement Range (kPa)	Measurement Accuracy(kPa)		(Ref.) Min. Scale (kPa)
	0-800(kPa)	800-1000(kPa)	
0-1000	±5	±10	1

Manufacturer 2) The accuracy is 0.2% of the maximum scale. In the case of pressures above 300 kPa, the maximum scale is 3000 kPa, which means an inaccuracy of **6 kPa** (0.06 bar).

As this commercial information, which varies between the different suppliers, can hardly be the base for a regulatory requirement, we believe that an appropriate reference would be the European Standard EN 12645 "Apparatus for inspection of pressure and/or inflation of tyres for motor vehicle". This standard requires a maximum permissible error of **8 kPa** for a maximum scale of 400 kPa. This in a temperature range from 15°C to 25°C. As the test procedure of the current GRRF proposal foresees an ambient temperature between 0 and 40°C, the temperature range given in EN 12645 is exceeded by 15°C (either below 15°C or above 25°C) . For these cases, EN 12645 admits an additional tolerance of 6 kPa. In consequence, the total tolerance for the current TPMS test procedure would be **14 kPa** (= 8 + 6).

In addition, it must be considered that these requirements are valid at the time when the measuring device is manufactured and calibrated. Depending on the national calibration legislation, these tolerances can be exceeded during the normal life of the measuring device, for instance in the case of Germany by **factor 2 i.e. by 28 kPa** (= 14 kPa x 2).

2.2 Pressure increase due to exchange of heat with tyre/rim assembly subsequent to cooling of gases when the tyres are abruptly deflated
If the pressure in any tyre is reduced rapidly by 20%, the temperature of the air in the tyre will decrease due to the decreased pressure. The thermal inertia of the tyre/rim assembly will then start to heat up again the air in the tyre to the same temperature as before the deflation. This means that the pressure will automatically rise in the tyre after the stepwise deflation. This effect can be easily shown in a static test.

The US National Highway Traffic Safety Administration had admitted a 2 psi margin (14 kPa) to compensate this effect - see the establishment of FMVSS138 (Federal Register, Vol. 70, No. 67, Friday, April 8, 2005, Final Rule, page 18136). However, this effect depends also on the tyre pressure and volume of the tyre/rim assembly. Depending on these factors, it will provoke inaccuracies between **3 and 14 kPa**.

2.3 Heating of the tyre due to increased rolling resistance after deflation

A tyre deflation of 20% from the hot in service pressure after the learning phase (paragraph 6.2.4.) will increase the rolling resistance of the tyre during the test phase (paragraph 6.2.6.). This additional mechanical resistance is transformed in thermal energy and will heat up the tyre during the test phase. The tyre heat-up provokes a pressure increase during the test phase so that the alert will already be required for a smaller underinflation, e.g. 17% instead of 20%: an additional and not intended severity. Practical measurements on typical vehicles with a medium recommended inflation pressure have shown an increase of 5 kPa during the test phase which are due to this effect. Depending on the recommended inflation pressure, this effect will typically provoke inaccuracies between **3 and 7 kPa**.

2.4 Conclusions for compensation of physical effects due to the test procedure

The three sources of inaccuracies mentioned above depend on the inflation pressure and will lead to unreliable test results. In order not to discriminate a vehicle, which fulfils the ambitious regulatory requirements for TPMS but which is penalized by unavoidable inaccuracies of the test procedure, OICA believes that it is appropriate to compensate these effects accordingly. This means a total reduction of the test pressure P_{test} depending on the recommended cold inflation pressure (see table in paragraph 6.2.5.3 of this proposal) between 15 and 25 kPa. Even, if this reduction does not cover the worst case for all three effects and does not take into account the pressure sensors' accuracy of direct systems (typically +/-10kPa), it is considered as a reasonable compromise.

As this compensation is only due to the effects of the type approval test procedure, it will not change the real world benefit of TPMS for safety and CO_2 emissions. However, it permits to improve the robustness of the system, which is necessary to convince the driver that TPMS is not just a regulatory burden or an unreliable electronic gadget but a real added value for his vehicle.

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