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Light vehicles: Regulations Nos. 68 (Measurement of the maximum speed, including electric vehicles), 83 (Emissions of M_1 and N_1 vehicles), 101 (CO_2 emissions/fuel consumption) and 103 (Replacement pollution control devices)

Proposal for a new Supplement to the 03, 04, 05, 06 and 07 series of amendments to UN Regulation No. 83 (Emissions of M1 and N1 vehicles)

Submitted by the expert from the International Organization of Motor Vehicle Manufacturers*

The text reproduced below was prepared by the expert from the International Organization of Motor Vehicle Manufacturers (OICA) to modify the Constant Volume Sampling system temperature sensor time response requirement. The modifications to the current text of the Regulation are marked in bold for new or strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2018–2019 (ECE/TRANS/274, para. 123 and ECE/TRANS/2018/21 and Add.1, Cluster 3), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

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I. Proposals

A. A new Supplement to the 03, 04 and 05 series of Amendments

Appendix 5 of Annex 4, paragraph 2.3.3.2., amend to read:

"2.3.3.2. A temperature sensor shall be installed immediately before the volume measuring device. This temperature sensor shall have an accuracy and a precision of ± 1 °C and a response time of ~~0,1~~ ~~**less than**~~ **1.0** second~~s~~ or less at 62 per cent of a given temperature variation (value measured in water or silicone oil)."

B. A new Supplement to the 06 and 07 series of Amendments

Appendix 2 of Annex 4A, paragraph 1.3.5., amend to read:

"1.3.5. Volume Measurement in the Primary Dilution System

The method of measuring total dilute exhaust volume incorporated in the constant volume sampler shall be such that measurement is accurate to ±2% under all operating conditions. If the device cannot compensate for variations in the temperature of the mixture of exhaust gases and dilution air at the measuring point, a heat exchanger shall be used to maintain the temperature to within ±6K of the specified operating temperature.

If necessary, some form of protection for the volume measuring device may be used e.g. a cyclone separator, bulk stream filter, etc.

A temperature sensor shall be installed immediately before the volume measuring device. This temperature sensor shall have an accuracy and a precision of ± 1 °C and a response time of ~~0,1~~ ~~**less than**~~ **1.0** second~~s~~ or less at 62 per cent of a given temperature variation (value measured in water or silicone oil).

The measurement of the pressure difference from atmospheric pressure shall be taken upstream from and, if necessary, downstream from the volume measuring device.

The pressure measurements shall have a precision and an accuracy of ±0.4kPa during the test."

II. Justification

1. The current response time of 0.1 seconds at 62% measured in silicone oil is beyond the capability of most readily available temperature sensors. The sensors that can meet this response time – namely exposed junction thermocouples – introduce several disadvantages of their own such as greater challenges with meeting calibration accuracy, greater susceptibility to electromagnetic interference and a lower robustness against moisture and the chemical components of diluted exhaust gas.

2. Given that the accuracy of the total dilute exhaust volume is constrained to ± 2 per cent under all operating conditions, specifying a response time for the temperature sensor could be argued as an unnecessary, further, constraint which, under commonly encountered conditions, has only a small effect on flow rate accuracy. For a critical flow venturi CVS system, flow rate (Q) depends on upstream pressure (P) and upstream temperature (T) and a calibration constant (Kv):

$$Q = K_v \frac{P}{\sqrt{T}}$$

The error propagation due to error in temperature measurement can be shown to be:

$$\frac{\sigma_Q}{Q} = \frac{1}{2}\left(\frac{\sigma_T}{T}\right)$$

3. Owing to the presence of the factor of 0.5, the contribution of an error in temperature measurement on the error in flow rate is halved. In effect, the flow rate is desensitized from the error in temperature measurement. Further, for bag analysis, the flow-weighted error in total CVS flow across the test is important, and not the error in flow rate at a single point in time. Table 1 shows the results of two example WLTP (4-phase) tests analysed using two different methods to simulate the effects of thermocouple response time on total CVS flow. Case 1 sets the CVS flow rate to a constant value which represents a temperature sensor with infinite response time. This effect was simulated twice by setting the CVS flow rate to a constant equal to the maximum and minimum flow rates observed across the WLTP test. The total flow across the test was recalculated and compared to the value obtained when considering the fluctuating temperature signal from the temperature sensor. The second test case down-samples the 10Hz CVS flow rate data to 1Hz, representing a temperature sensor with a slower (but not infinite) response time and again compares the recalculated total flow with the original value. Even in the worst-case (constant flow rate throughout the test set equal to the minimum flow rate observed), the error in total CVS flow is -1.29%.

Table 1: total CVS flow error for two test cases.

Test case		Total diluted CVS flow (m^3 at 1 atmosphere and 0C)	error in CVS flow (%)
Constant flow rate	Baseline WLTP (4-phase)	490.2545	(-)
	flow rate set equal to maximum observed during the WLTP	493.3287	**+0.65**
	flow rate set equal to minimum observed during the WLTP	483.8529	**-1.29**
Down-sampling	Baseline WLTP (4-phase)	491.1044	(-)
	10Hz → 1Hz	491.4950	**+0.08**

4. Whilst under conditions commonly found during light-duty vehicle testing, CVS flow temperature only fluctuates gently and the CVS flow remains within the +/- 2% accuracy requirement (as exemplified above), there are two reasons for maintaining a response time requirement:

(a) Under some test conditions, with a dilution system of low thermal inertia, the importance of maintaining a fast time response remains;

(b) A standardised system specification is important to ensure comparability of emissions data across different measurement systems.

Therefore, it is proposed to specify a response time requirement of less than 1.0 second at 62% of a given temperature variation as measured in silicone oil.