

Transmitted by the experts of the  
Informal Working Group on  
Measurement Uncertainties (IWG MU)

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## **Proposal for a Supplement 9 to the 03 series of amendments to UN Regulation No. 51**

### **Submitted by the Informal Working Group on Measurement Uncertainties**

The text reproduced below was prepared by the experts from the Informal Working Group on Measurement Uncertainties (IWG MU) with the aim to amend UN Regulation No. 51 with tables showing the measurement uncertainties when performing type-approval, COP or field testing (e.g. market surveillance). The modifications to the existing text of the Regulation are marked in bold for new or strikethrough for deleted characters.

# I. Proposal

Add new *Annex 10*:

## “Annex 10

### **Estimation of the calculation of the expanded measurement uncertainties for sound measurements of Annex 3 for vehicles of category M and N.**

#### **1. Scope**

The method for M1, N1 and M2 < 3.500 kg classes of vehicles (Annex 3) is based on two driving conditions; a constant speed test,  $L_{crs}$ , and a wide-open throttle acceleration test,  $L_{wot}$ , to determine the final type-approval level,  $L_{urban}$ . The uncertainty table in paragraph 2.1 is valid for these categories of vehicles. The uncertainty table in paragraph 2.2 is valid for vehicle classes N2, N3, M2 >3500 kg and M3. Vehicles in these classes are only measured according to the wide-open throttle acceleration test.

#### **1.1 ISO Approach**

Based on the probability distribution, the variance and the standard deviation, the combined standard uncertainty is calculated. For each of the quantities, their contribution to the overall uncertainty (in %) has been calculated and makes it easy to understand the influence of the quantity to the total uncertainty. The percentage is based on the total expanded uncertainty for all for test situations. Some of these quantities can be compensated for, like the influence of temperature and test track variations, while others are of random types, like instrumentation accuracy and cannot be compensated.

#### **1.2 Categories of situation**

The uncertainty is grouped into 4 different categories; Run-to-run, day-to-day, site-to-site and vehicle-to-vehicle. For each of these categories, the uncertainty budget is calculated separately for type-approval, CoP and field testing. For type-approval, the relevant uncertainty is only related to run-to-run variations, while CoP includes vehicle-to-vehicle variations as well.

#### **1.3 Application**

This regulation is only related to type-approval and CoP testing. However, due to the introduction of market surveillance and other types of in-use testing, based on this regulation, it is important to include the uncertainty contribution relating to vehicle-to-vehicle variations.

#### **2. Uncertainty estimation**

The tables 2.1 and 2.2 are based on this regulation up to the Supplement 6. If the regulation is amended, any implication for the measurement uncertainties shall be evaluated and if necessary, the tables in Annex 10 shall be updated.

**Table 2.1:**  
**Estimation of uncertainty per situation for M1, N1 and M2 < 3500 kg**

Situation	Input Quantity	Estimated deviations of the meas. result (peak-peak)		Impact on $L_{urb}$	Probability Distribution	Variance	Standard uncertainty	Share	Comb. stand. uncertainty	Uncertainty Budgets			Expanded uncertainty 95%
		$L_{wot}$	$L_{crs}$							Type Approval	CoP	Field Tests	
Run to Run	Microclimate wind effect	1,60	1,50	1,57	gaussian	0,15	0,392	5,6%	0,53	0,53	0,53	0,53	1,1
	Driver #1: Deviation from centred driving	0,50	0,50	0,50	rectangular	0,02	0,144	0,8%					
	Driver #2: Start of acceleration	0,60	0,00	0,40	rectangular	0,01	0,144	0,5%					
	Driver #3: Speed variations of +/- 1km/h	0,30	0,50	0,50	rectangular	0,02	0,144	0,8%					
	Driver #4: Load variations during cruising	0,00	1,00	0,34	gaussian	0,01	0,085	0,3%					
	Varying background noise	0,40	0,40	0,40	rectangular	0,01	0,115	0,5%					
	Variation on operating temperature of engine (WOT) and tyres (WOT&CRS) => See ISO 362-1 note	0,80	0,80	0,80	rectangular	0,05	0,231	2,0%					
Day to Day	Barometric pressure (Weather +/- 30 hPa)	0,40	0,40	0,40	gaussian	0,01	0,100	0,4%	0,92	0,92	0,92	0,92	1,8
	Air temperature effect on tyre noise (5-10°C)	0,00	0,00	0,00	rectangular	0,00	0,000	0,02%					
	Air temperature effect on tyre noise (10-40°C)	2,20	3,60	2,67	rectangular	0,60	0,772	21,9%					
	Varying background noise during measurement	0,00	0,00	0,00	rectangular	0,00	0,000	0,0%					
	Air intake temperature variation	1,60	0,00	1,06	rectangular	0,09	0,305	3,4%					
	Residual humidity on test track surface	0,90	2,10	1,31	rectangular	0,14	0,377	5,2%					
Site to Site	Altitude (Location of Track) -100 hPa/1000m (fr.1015 to 915 hPa)	0,70	0,70	0,70	rectangular	0,04	0,202	1,5%	1,24		0,62	1,24	2,5
	Test Track Surface	3,40	5,50	4,11	rectangular	1,41	1,187	51,8%					
	Microphone Class 1 IEC 61672	1,00	1,00	1,00	gaussian	0,06	0,250	2,3%					
	Sound calibrator IEC 60942	0,50	0,50	0,50	gaussian	0,02	0,125	0,6%					
	Speed measuring equipment continuous at PP	0,10	0,10	0,10	rectangular	0,00	0,029	0,0%					
	Acceleration calculation from vehicle speed measurement	0,50	0,50	0,50	rectangular	0,02	0,144	0,8%					
Vehicle to Vehicle	Production Variation on Tyres; Aging of Tyres until delivery to customer (1dB after one year)	0,80	1,50	1,04	gaussian	0,07	0,259	2,5%	0,57		0,57	0,57	1,1
	Tyres at minimum tread depth	0,40	0,40	0,40	gaussian	0,04	0,209	1,8%					
	Variation on Tyre Size and Brand (non-OEM)	0,00	0,00	0,00	gaussian	0,00	0,000	0,0%					
	Production Variation in Power, incl. proper break-in of a brand-new engine	0,40	0,40	0,40	rectangular	0,01	0,115	0,5%					
	Battery state of charge for HEVs (3 dB(A))	0,00	0,00	0,00	rectangular	0,00	0,000	0,0%					
	Production Variability of Sound Reduction Components	1,10	0,00	0,73	gaussian	0,03	0,182	1,2%					
Impact of variation of vehicle mass	1,60	1,60	1,60	rectangular	0,21	0,462	7,8%						

100 %

<b>Overall Combined Uncertainty +/-</b>	<b>Overall Expanded uncertainty (95%) +/-</b>
<b>1,73</b>	<b>3,46</b>

Expanded uncertainty (95%) +/-		
<b>Type Approval</b>	<b>CoP</b>	<b>Field Test</b>
<b>2,12</b>	<b>2,71</b>	<b>3,46</b>

**Table 2.2:**  
**Estimation of uncertainty per situation for N2, N3, M2 >3500 kg and M3**

Situation	Input Quantity	Estimated deviations of the meas. result (peak-peak)		Impact on $L_{urb}$	Probability Distribution	Variance	Standard uncertainty	Share	Comb. stand. uncertainty	Uncertainty Budgets			expanded uncertainty 95%
		$L_{wot}$	$L_{ers}$							Type Approval	CoP	Field Tests	
Run to Run	Microclimate wind effect – head or tail	0	NA	0	gaussian	0,000	0,00	0,0%	0,30	0,30	0,30	0,30	0,59
	Deviation from centred driving	0,50	NA	0,50	rectangular	0,021	0,14	2,0%					
	Speed at BB' – Target vehicle speed (+/- 5 km/h), (target engine speed (+/-2%))	0,40	NA	0,40	rectangular	0,013	0,12	1,3%					
	Varying background noise	0,10	NA	0,1	gaussian	0,001	0,03	0,1%					
	Variation on operating temperature of engine and tyres => See ISO 362-1 note	0,80	NA	0,80	rectangular	0,053	0,23	5,1%					
Day to Day	Ambient temperature influence on sound transmission in air	0,6	NA	0,6	rectangular	0,030	0,17	2,9%	0,46	0,46	0,46	0,46	0,91
	Ambient barometric pressure influence on sound transmission in air	0,9	NA	0,9	rectangular	0,068	0,26	6,5%					
	Ambient humidity influence on sound transmission in air	0,1	NA	0,1	rectangular	0,001	0,03	0,1%					
	Ambient air temperature influence on engine power (based on R85)	1,0	NA	1,0	rectangular	0,083	0,29	8,0%					
	Ambient air temperature effect on ICE vehicles due to tyre noise (5-40°C)	0,4	NA	0,4	rectangular	0,013	0,12	1,3%					
	Barometric pressure effect on engine power (based on R85)	0,4	NA	0,4	rectangular	0,013	0,12	1,3%					
Site to Site	Altitude effect on combustion and sound propagation (Range: 1000 m) (95-105 kPa )	0,9	NA	0,9	rectangular	0,068	0,26	6,5%	0,50		0,50	0,50	1,0
	Test Track Surface	1,3	NA	1,3	gaussian	0,106	0,33	10,2%					
	Microphone Class 1 IEC 61672	1	NA	1	gaussian	0,063	0,25	6,0%					
	Sound calibrator IEC 60942	0,5	NA	0,5	gaussian	0,016	0,13	1,5%					
	Speed measuring equipment continuous at BB	0,1	NA	0,1	gaussian	0,001	0,03	0,1%					
Vehicle to Vehicle	Production Variation on Tyres; Aging of Tyres until delivery to customer (1dB after one year)		NA						0,70		0,35	0,70	1,4
	Tyre – generic dispersion (Normal, tread depth, inflation pressure, model etc)	2,8	NA	2,8	gaussian	0,49	0,70	47,2%					
	Production Variation in Power, incl. proper break-in of a brand-new engine		NA										
	Battery state of charge for HEVs (3 dB(A))		NA										
	Production Variability of Sound Reduction Components		NA										
Test mass – variation as a consequence of the definition		NA											

100 %

<b>Overall Combined Uncertainty +/-</b>	<b>Expanded uncertainty (95%) +/-</b>
<b>1,02</b>	<b>2,04</b>

<b>Expanded uncertainty (95%) +/-</b>		
<b>Type Approval</b>	<b>CoP</b>	<b>Field Test</b>
<b>1,09</b>	<b>1,64</b>	<b>2,04</b>

“

## II. Justification

The measurement uncertainties developed in this Appendix are based on the work of the GRBP Informal Working Group on Measurement Uncertainties. This working group has developed a Document for Reference, which describes a general approach to estimate measurement uncertainties (ECE-TRANS-WP.29-GRBP-2022-09rev2).

The impact of the quantities on the expanded uncertainty has been evaluated separately for run-to-run, day-to-day, vehicle-to-vehicle and site-to-site variations. Some of the different impacts are based on calculations from tolerances in Annex 3, while others are based on experiences.

In general, the display of results in column “Comb. stand. Uncertainty” of tables 2.1 and 2.2 has been improved for easier understanding for regulatory purposes. The “variance” of the different situations has now been combined separately and has not been accumulated from top to bottom anymore (as ISO does in their documents). This has effect on “Uncertainties Budgets” due to “Type approval”, “COP” and “Field Tests”, including the “expanded uncertainty 95%”.

Some values in the column of COP have been reduced, since COP situations could be expected to be under control to a higher extent compared to an arbitrary test situation:

- For the Light Vehicle category of vehicles the uncertainty of the “Site-to-Site” in COP testing situation has been suggested to be half of the uncertainty of an arbitrary situation.
- For the Heavy Commercial vehicles similar principle applies to the “Vehicle-to-Vehicle” situation corresponding to COP testing.