

**P R E S E N T A T I O N   O F**



**INTERNATIONAL ORGANIZATION OF MOTOR VEHICLE MANUFACTURERS**

# **Measurement Uncertainties of Sound Emission Measurements According to UN R51.03**

**GRBP – Working Party on Noise and Tyres**

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- Measurements are subject to uncertainties. A measured result must be understood as an approximation to the true result, which by itself is unknown.
  - Two measurements are deemed to be the same if they are within the given uncertainty.
  - Two vehicles are deemed to have the same sound level, if their measurement result is within the given uncertainty.
- Thus, the knowledge of the measurement uncertainty is important as it provides information about the precision and repeatability of measurements.
- The measurement uncertainties be minimized, e.g. by narrowing ambient conditions or by correction.
- Questions:
  - What is the uncertainty for the tests specified by UN R51.03?
  - Are their different uncertainties dependent on the purpose of the test?
  - How can the uncertainty be minimized?

# Measurement Uncertainties within Regulations

- Regulations apply limits and expect that all products put on the market stay under the limits. UN R51.03 provides in some cases conditions or tolerance:
  - **paragraph 6.1.1.** The vehicle, its engine and its sound reduction system shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.
  - **Paragraph 6.1.2.** The sound reduction system shall be so designed, constructed and assembled as to be able to reasonably resist the corrosive phenomena to which it is exposed having regard to the conditions of use of the vehicle, including regional climate differences.
  - **Paragraph 6.2.2.** The sound level measured in accordance with the provisions of Annex 3 paragraph 3.2 to this Regulation, mathematically rounded to the nearest integer value, shall not exceed the [...] limits.
  - **Annex 6 (Conformity of production):** One vehicle shall be chosen and subjected to the tests set out in point 2. If the sound level of the vehicle tested does not exceed by more than 1 dB(A) the limit value prescribed [...], the vehicle type shall be considered to conform to the requirements of this Regulation.
- A general systematic consideration about the measurement uncertainty for the test procedure is not available.
- Upcoming in-use testing will add more uncertainties, thus a general review is needed.

## Measurement Uncertainties Provided by ISO 362:1998

- UN R51.03 Passby tests are based on ISO 362 and ISO 362-1.
- Any ISO standard is requested to provide a statement about the measurement uncertainty.
- The former standard ISO 362:1998 summarizes the nature of uncertainty very well:

Measurements made in conformity with this International Standard result in levels that are influenced by climatic conditions. The climatic conditions can affect the performance of the vehicle powertrain, modify the sound level of the tyres, and disturb the propagation path of the sound. In addition, the use of the asphalt test surface specified in ISO 10844 has reduced, but not eliminated, the variations traditionally encountered from different sites. Tests of a vehicle at the same site, in similar climatic conditions, will result in sound pressure levels that are within  $\pm 1$  dB. However, testing over the entire range of temperature and wind conditions allowed in this International Standard may result in larger variation.

- Unfortunately, ISO 362:1998 describes the measurements uncertainty in a more general way, without providing accurate quantities.

## Measurement Uncertainties Provided by ISO 362-1:2015

- The new standard ISO 362-1:2015 introduces fields of uncertainties:
  - variations expected within the same test laboratory (run-to-run);
  - variation in ambient conditions and equipment properties (day-to-day);
  - variations between test laboratories and road surface conditions (site-to-site)
  
- These data are given in Table 4 for two different vehicle categories. The variability is given for a coverage probability of 80 %. The data express the variability of results for a certain measurement object and do not cover product variation.

Vehicle category	Run-to-run dB	Day-to-day dB	Site-to-site dB
M1, M2 having a maximum authorized mass not exceeding 3 500 kg and N1	0,5	0,9	1,4
M2 having a maximum authorized mass exceeding 3 500 kg and N2, M3, N3	0,5	0,9	1,4

Table 4 — Variability of measurement results for a coverage probability of 80 %

- Measurement uncertainty can be created by many influence factors.
- These factors and their effects can be clustered into:
  - Effects designated to ambient conditions
  - Effects designated to test site
  - Effects designated to measuring equipment
  - Effects designated vehicle data
  - Effects designated run to run variability

# Measurement Uncertainties for ambient conditions

Category	Influence Factor	Statistical Effect	Influence on
<b>Effects designated to ambient conditions</b>	Weather dependent Barometric pressure on engine power and propulsion noise. (970-1035 mbar) ==> +/- 30 hPa	Random	<b>Day-to-Day</b>
	Air temperature effect on tyre noise (5-10°C)	Systematic Random	<b>Day-to-Day</b>
	Air temperature effect on tyre noise (10-40°C)	Systematic Random	<b>Day-to-Day Site-to-Site</b>
	Air temperature effect on tyre noise (10-40°C)	Random	<b>Day-to-Day</b>
	Air temperature effect on propulsion noise	Systematic	<b>Day-to-Day</b>
	Road Surface temperature inclusive heating systems	Systematic	<b>Day-to-Day</b>
	Air humidity	Random	<b>Day-to-Day</b>
	Residual humidity on test track surface	Random	<b>Day-to-Day</b>
	Ambient Noise (Background Noise), Spectra specific	Systematic Random	<b>Site-to-Site</b>
	Dust after longer non-rain period	Systematic	<b>Day-to-Day Site-to-Site</b>

- For each influence factor a peak-to-peak variation can be allocated
- An influence factor can be systematic, random or both
  - Example for a systematic error:  
A test track is on 2000m altitude, while another is on sea level
  - Example for a random error:  
the offset to the CC' line in driving through the test track
  - Example for a random/systematic error:  
Background noise is generally random, but may contain site specific frequency dominated noise from other facilities, such as ventilation systems of test chambers.
- All these effects can be combined finally to a total error. This should be done in a 95% confidential interval.



- The uncertainty statement of ISO 362-1 refer to ONE vehicle subject to testing. The standard does not provide variations for production tolerances, maturation or differences by vehicle variants.
- Influence factors contribute differently to sound emission tests dependent on the nature of testing:
  - Type Approval testing
  - Conformity of Production testing
  - In-Use / In-Service testing
- A cross matrix can visualize which factor to be taken into account for what kind of testing.

# Measurement Uncertainties Extension for In-Use Conformity

- Considering in-use vehicle testing for legal compliance purposes, there are numerous additional factors that need consideration.
- Some of these factors (incomplete list) are:
  - Proper maintenance of the vehicle within the inspection intervals. Service shall be carried out by an accepted service provider.
  - Tyres shall be manufacturer certified tyres in an appropriate condition.
  - Applicable limits shall be correctly determined.
  - The vehicle shall have a use history, representative for normal use.
  - If spare parts, if applicable, shall be Original Equipment Parts.
  - Fuel Quality
- 2018/858/EC Preamble 34 requests:

“The selection of the vehicles that are to be subject to that compliance verification should be based on an appropriate risk assessment which takes account of the seriousness of the possible non-compliance; the likelihood of its occurrence; and other possible indicators [...].”

- OICA members are actually reviewing all effects and welcome an exchange with GRB members to benefit as well for more experts experience.
- It is the goal to achieve a better understanding of measurement uncertainty.
- Adequate action shall be introduced such as application of tolerances, correction or narrow test condition into the regulation for type approval, CoP and in-use conformity checks.
- The uncertainty consideration could be introduced into an individual Annex to UN R51.03.
- The work should be done in a separate working group. However, we fear that work capacity of actual active members do not allow the creation of another working group.
- OICA suggests to have a discussion on this topic within the GRBP group to receive a direction how to handle the subject.