UN标准中关于声学测量不确定度的技术研讨

Technical Consideration for Measurement Uncertainty of Acoustic Measurement in UN Regulation

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Background

1. Discussion in UN WP29 GRBP

Measurement uncertainty has long history especially in calibration, laboratory accreditation, and metrology services area to provide a basis for the international comparison of measurement results.

UN Regulations are being used globally. Type approval test, conformity of production, and in-use compliance might be conducted in different countries for same type of vehicle. Thus, the knowledge of the measurement uncertainty is important as it provides information about the accuracy of measurements and reliable estimation.

2. Activities in GRBP

GRBP established task force for measurement uncertainty. (GRBP-MU TF)

1st meeting was held in May 2019 and we started discussion for consideration of UN R51-03 (noise)

GRBP will consider below for COP (conformity of production) and in-use conformity.

- 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?

History of Measurement Uncertainty

1977 CIPM

BIPM

1980 WG

1993

ISO
BIPM:
IEC:
IFCC:
IUPAC:
IUPAP:
OIML:
ILAC: (2005～)

2008

In 1977, recognizing the lack of international consensus on the expression of uncertainty in measurement, the world's highest authority in metrology, (CIPM), requested (BIPM) to address the problem in conjunction with the national standards laboratories and to make a recommendation.

CIPM : the Comité International des Poids et Mesures (weight and measurement)
BIPM : the Bureau International des Poids et Mesures

Recommendation INC-1

The basis of the *Guide* is Recommandation INC-1 (1980) of the Working Group on the Statement of Uncertainties. The Working Group was convened by BIPM in response to a request of the CIPM.

Guide to the Expression of Uncertainty in Measurement (GUM)

Publish GUM as ISO/IEC Guide 98-3

IEC: International Electrotechnical Commission
IFCC: International Federation of Clinical Chemistry**
ISO: International Organization for Standardization
IUPAC: International Union of Pure and Applied Chemistry
IUPAP: International Union of Pure and Applied Physics
OIML: International Organization of Legal Metrology
ILAC: International Laboratory Accreditation Cooperation (2005～)

ISO/IEC GUIDE 98-3:2008
Uncertainty of measurement —
Part 3: **Guide to the expression of uncertainty in measurement (GUM:1995)**

1 Scope

1.1 This *Guide* establishes general rules for evaluating and expressing uncertainty in measurement that can be followed at various levels of accuracy and in many fields — from the shop floor to fundamental research. Therefore, the principles of this *Guide* are intended to be applicable to a broad spectrum of measurements, including those required for:

-- maintaining quality control and quality assurance in production;
-- complying with and enforcing laws and regulations;
-- conducting basic research, and applied research and development, in science and engineering;
-- calibrating standards and instruments and performing tests throughout a national measurement system in order to achieve traceability to national standards;
-- developing, maintaining, and comparing international and national physical reference standards, including reference materials.

3.2 Errors and effects

3.2.1 In general, a measurement has imperfections that give rise to an **error** (B.2.19) in the measurement result. Traditionally, an error is viewed as having two components, namely, a **random** (B.2.21) component and a **systematic** (B.2.22) component. NOTE **Error is an idealized concept and errors cannot be known exactly.**

3.2.2 Random error presumably arises from unpredictable or stochastic temporal and spatial variations of influence quantities. The effects of such variations, hereafter termed *random effects*, give rise to variations in repeated observations of the measurand. Although it is not possible to compensate for the random error of a measurement result, it can usually be reduced by increasing the number of observations;.

3.2.3 Systematic error, like random error, cannot be eliminated but it too can often be reduced. If a systematic error arises from a recognized effect of an influence quantity on a measurement result, hereafter termed a *systematic effect*, the effect can be quantified and, if it is significant in size relative to the required accuracy of the measurement, a **correction** (B.2.23) or **correction factor** (B.2.24) can be applied to compensate for the effect. It is assumed that, after correction, the expectation or expected value of the error arising from a systematic effect is zero.

Error;
Result of a measurement minus a true value of the measurand.
Random effect
Systematic effect

We cannot know true value.
We can know only estimate of value of measurand which seems to be closer to true value.

B.2.18
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand
NOTE 1 The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.
NOTE 2 Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information.

Candidates of true value are around estimate of value of measurand.

Uncertainty expresses deviation of average of population, e.g. standard deviation, based on estimate of value of measurand.

Components of uncertainty
-> experimental standard deviations
-> assumed probability distributions

Standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

The combined standard uncertainty $u_c(y)$
is the positive square root of the combined variance $u_c^2(y)$, which is given by

$$u_c^2(y) = \sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2(x_i)$$

Definition of Type A and Type B

3.3.4 The purpose of the Type A and Type B classification is to indicate the two different ways of evaluating uncertainty components and is for convenience of discussion only; the classification is not meant to indicate that there is any difference in the nature of the components resulting from the two types of evaluation.
Both types of evaluation are based on **probability distributions** (C.2.3), and the uncertainty components resulting from either type are quantified by variances or standard deviations.

2.3.2
Type A evaluation (of uncertainty)
method of evaluation of uncertainty by the statistical analysis of series of observations
2.3.3
Type B evaluation (of uncertainty)
method of evaluation of uncertainty by means other than the statistical analysis of series of observations

Type A and T y pe B are defined as two different ways of evaluation uncertainty components for convenience.

Type A;
Analyzing standard deviation by measurement results and estimate of standard deviation of population.

Type B;
Finding estimate of standard deviation of population by knowledges or experiences.

ISO/IEC GUIDE 98-3:2008 (GUM)

4.3 Type B evaluation of standard uncertainty

4.3.1 the standard uncertainty $u(x_i)$ is evaluated by scientific judgement based on all of the available information on the possible variability of X_i .
The pool of information may include
– previous measurement data;
– experience with or general knowledge of the behaviour and properties of relevant materials and instruments;
– manufacturer's specifications;
– data provided in calibration and other certificates;
– uncertainties assigned to reference data taken from handbooks.

How to define probability distribution?

→ Scientific judgement based on available information

4.3.3 If the estimate x_i is taken from a manufacturer's specification, calibration certificate, handbook, or other source and its quoted uncertainty is stated to be a particular multiple of a standard deviation, the standard uncertainty $u(x_i)$ is simply the quoted value divided by the multiplier, and the estimated variance $u^2(x_i)$ is the square of that quotient.

→ Normally 95% coverage probability Normal distribution

4.3.7 If there is *no specific knowledge* about the possible values of X_i within the interval, one can only assume that it is equally probable for X_i to lie anywhere within it (a uniform or rectangular distribution of possible values — see 4.4.5 and Figure 2 a).

→ Rectangular distribution

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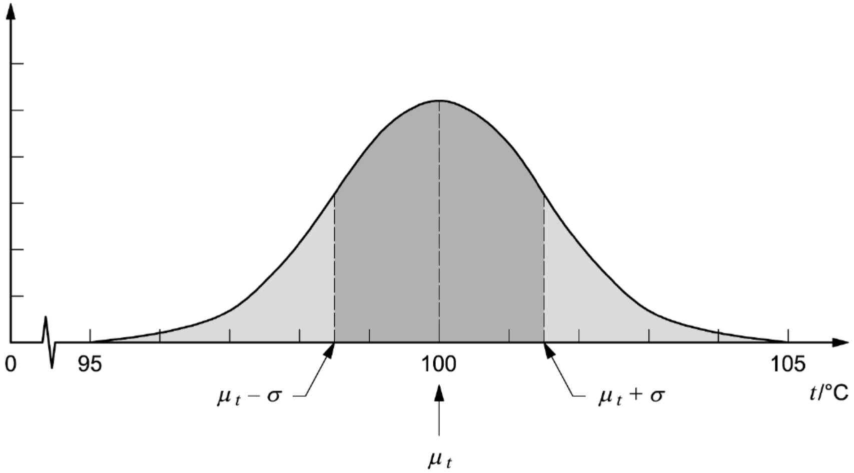
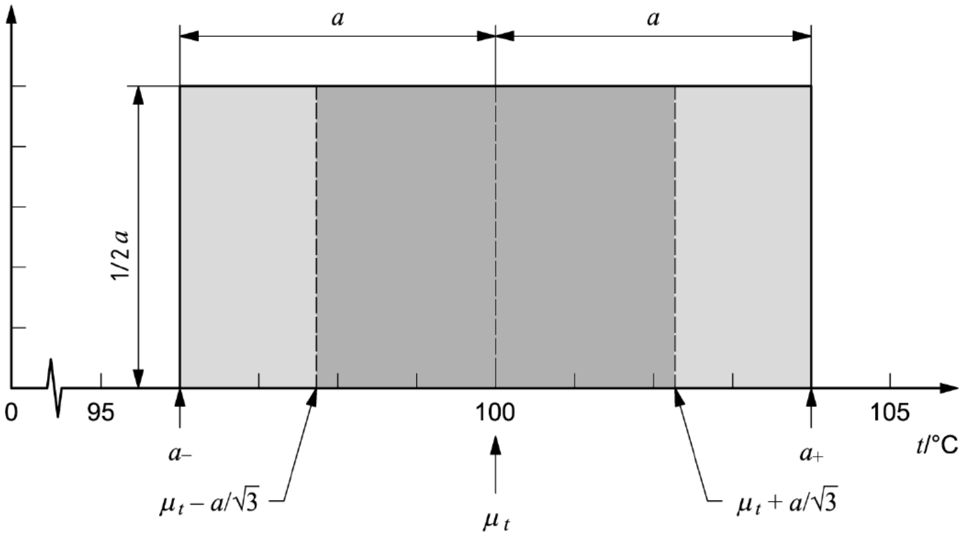
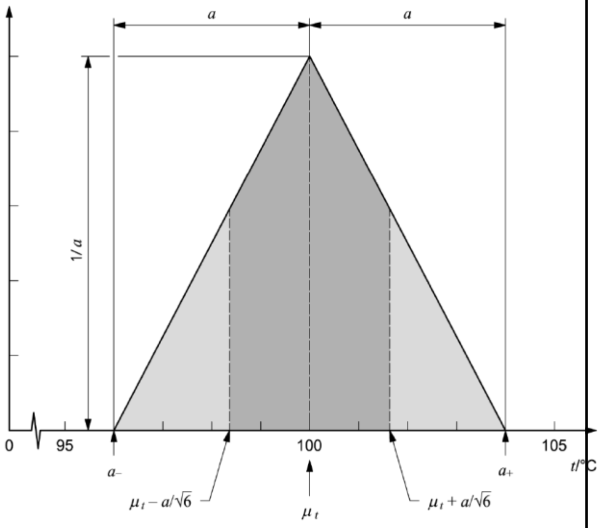
Probability distributions

Normal	Rectangular	Triangular
		
Standard uncertainty u_i **U/k** *U*: extended uncertainty k: coverage factor	Standard uncertainty $\frac{a}{\sqrt{3}}$	Standard uncertainty $\frac{a}{\sqrt{6}}$

ISO/IEC GUIDE 98-3:2008 (GUM)

Uncertainty Budget

Quantity	Estimate	Type	Probability distribution	Divisor	Standard uncertainty u_i	Sensitivity coefficient $\frac{\partial f}{\partial x_i}$	Standard uncertainty $\frac{\partial f}{\partial x_i} u_i$

Temperature
Speed
Accuracy of equipment
·
·

Measured data → Type A → σ

Range Tolerance → Type B → Normal, Rectangular, Triangular → K=2, 3; √3; √6 → u_i

Combined standard uncertainty

$$u_c^2(y) = \sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2(x_i)$$

expanded uncertainty U

$U = k\, u_c$

u_c: combined standard uncertainty

k : coverage factor

2.3.5

expanded uncertainty

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

NOTE 1 The fraction may be viewed as the coverage probability or level of confidence of the interval.

2.3.6

coverage factor

numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

NOTE A coverage factor, *k*, is typically in the range 2 to 3.

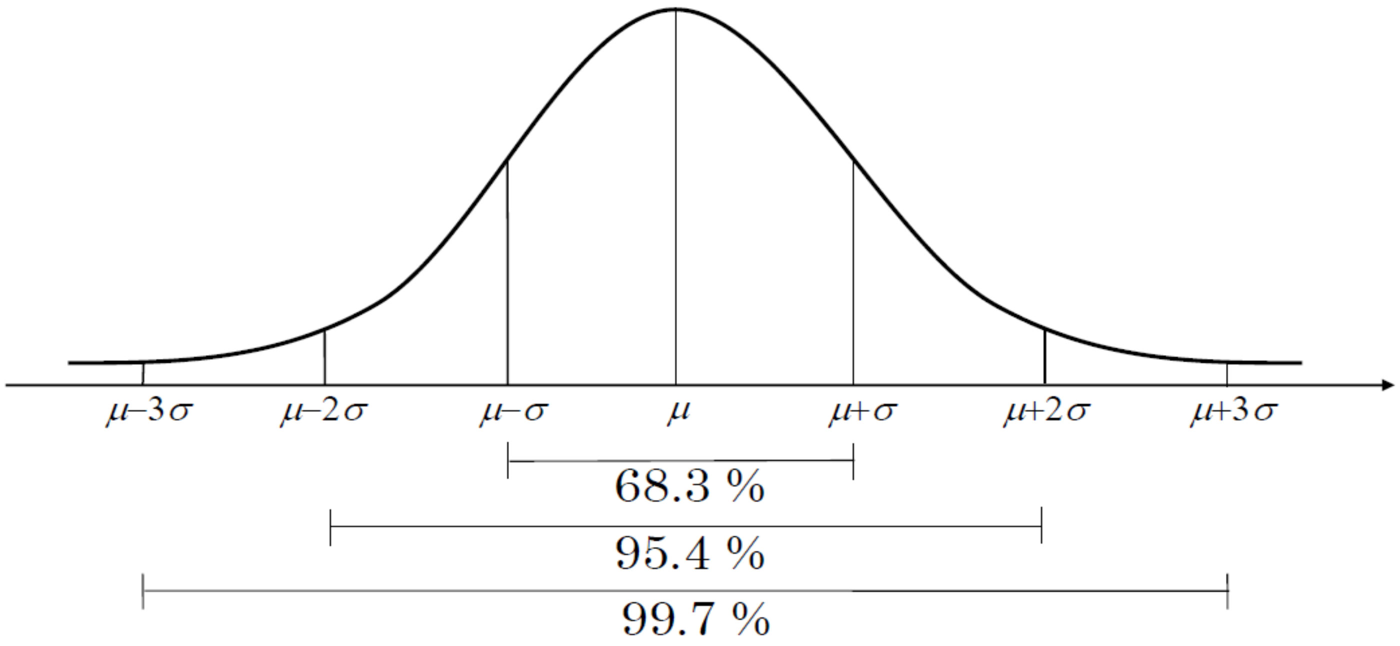
6.3 Choosing a coverage factor

6.3.3

.... However, a simpler approach, discussed in G.6.6, is often adequate in measurement situations where the probability distribution characterized by y and $u_c(y)$ is approximately normal and the effective degrees of freedom of $u_c(y)$ is of significant size. When this is the case, which frequently occurs in practice, one can assume that taking $k = 2$ produces an interval having a level of confidence of approximately 95 percent, and that taking $k = 3$ produces an interval having a level of confidence of approximately 99 percent.

ISO/IEC GUIDE 98-3:2008 (GUM)

Coverage factor and level of confidence



μ±1σ：68.3 %

μ±2σ：95.4 % → 95%

μ±3σ：99.7 % → 99%

Table G.1 — Value of the coverage factor k_p that produces an interval having level of confidence p assuming a normal distribution

Level of confidence p (percent)	Coverage factor k_p
68,27	1
90	1,645
95	1,960
95,45	2
99	2,576
99,73	3

Measurement Uncertainty in ISO 362-1

- UN R51.03 Pass-by tests are based on ISO 362-1.
- Any ISO standard is requested to provide a statement about the measurement uncertainty.
- ISO 362-1:2015 introduces fields of uncertainties:
  - variations expected within the same test laboratory (run-to-run);
  - variations 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.

Table 4 — Variability of measurement results for a coverage probability of 80 % (k=1.3)

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

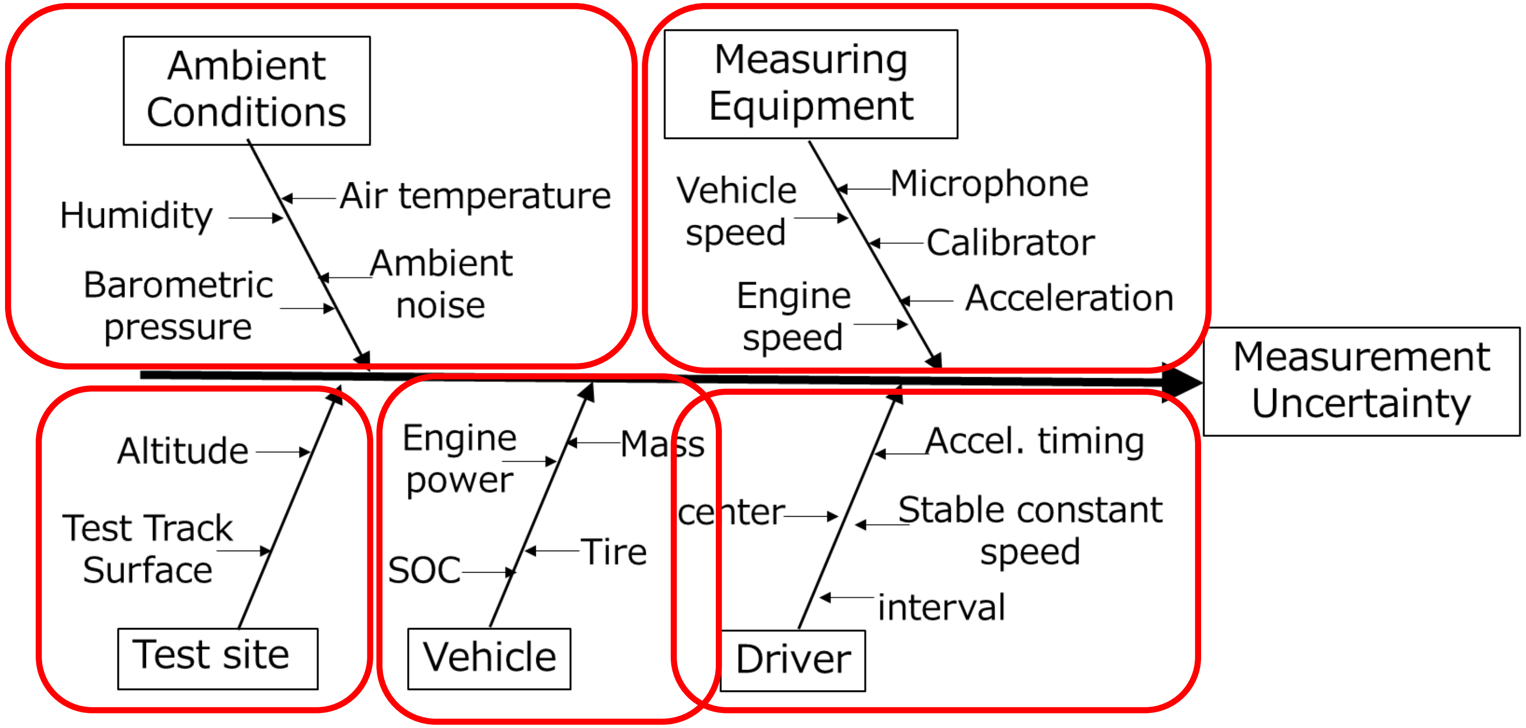
Consideration for R51-03

- Should be reconsidered coverage probability.   (80%, 95%, 99% ?)
- Find correction way for systematic effect to reduce uncertainty
- 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.

Consideration for R51-03

- 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 by driver

Cause-and-effect diagram



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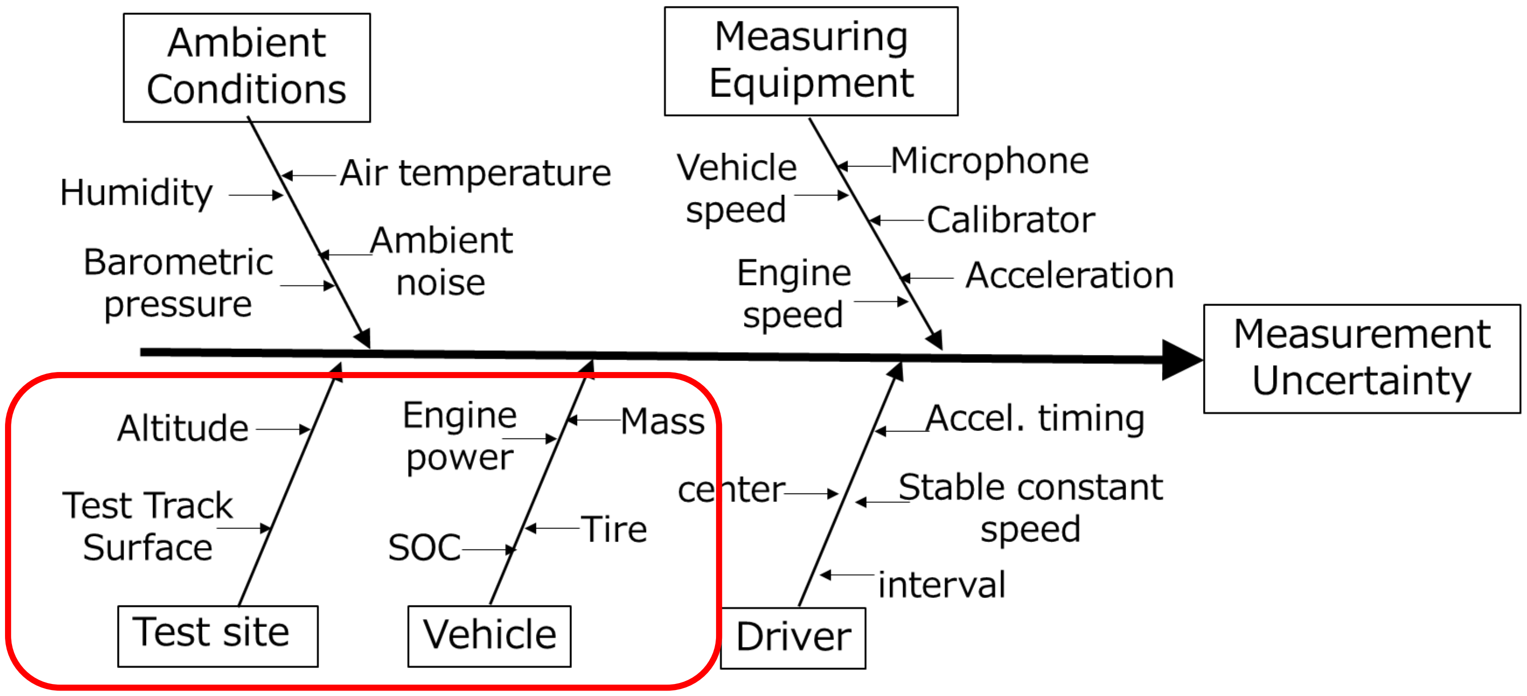
More important uncertainty in COP, in-use compliance



Consideration for R51-03

Examples of factors for Measurement Uncertainty

Categories	Influence Factor	Statistical Effect	Influence on
Effects designated to ambient conditions	Weather dependent Barometric pressure on engine power and propulsion noise. (970-1035 mbar) ==> +/- 30 hPa	Random	Day-to-Day
	Air temperature effect on tyre noise (5-10°C)	Systematic Random	Day-to-Day
	Air temperature effect on tyre noise (10-40°C)	Systematic Random	Day-to-Day Site-to-Site
	Intake air temperature has an effect on propulsion noise	Systematic	Day-to-Day
	Residual humidity on test track surface(Road Surface temperature inclusive heating systems)	Random	Day-to-Day
Test site	Altitude 0-1000 m (probably also barometric pressure)	Systematic	Site-to-Site
	Test track surface; Texture, absorption, gradients, way of use (single direction, bi-directional);	Systematic Random	Site-to-Site
Vehicle	Production Variation of tires (UN R117) ; inclusive variation of tire diameter (UN R30 an UN R54) and tread depth;	Random	Vehicle to vehicle
	Production variation in engine power (see UN R85)	Systematic	Vehicle to vehicle
	Battery state of charge for HEVs (different propulsion source mix)	Random	Vehicle to vehicle
	Production variation of vehicle mass; variation in equipment; variation in body style	Systematic	Vehicle to vehicle

Consideration for R51-03

Measurement uncertainty 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

Summary

- 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.
- Measurement uncertainty should be considered in COP and in-use conformity to adequate evaluation (judgement).
- GRBP has decided to establish task force for measurement uncertainty.

  1st task force meeting was held on 22nd and 23rd May.
- The objectives of the task force are
  - Consideration for R51-03 (Noise regulation) as first step
  - Proposal for the conceptual approach to measurement uncertainty
  - Finding adequate compensation and tolerance to reduce uncertainty
  - Final Proposal to GRBP in 2020.

感谢您的关注

Thank you for your attention