Acoustics'08 Paris
June 29-July 4, 2008
www.acoustics08-paris.org

Experimental approach for reducing uncertainties associated with road vehicle noise according to ISO 362

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This paper proposes an approach for reducing uncertainties related to sound pressure levels measured in accordance with procedures given in ISO 362 for noise emitted by road vehicles under acceleration. This approach is based on an experimental assessing of several disturbing factors that lead to variation in the resulting level observed day to day and site to site for the same vehicle. The assessment of corrections to build the model is based on an independent analysis on each influent factor (test track, noise measuring device and temperature) taking into account of vehicle noise behaviour depending on power unit and tyres.

1 Introduction

The international standard ISO 362 [1] for light vehicle is used to measure noise from road vehicles on partial acceleration. The measurement procedure is affected by several factors (slight variations within a single test series, variations in ambient conditions day-to day and variations between test-laboratories site-to-site) that lead to variation in the resulting level observed for the same subject.

ISO 362 [1] standard suggests estimation of uncertainties using the GUM approach [2] on different situations taking into account such as run-to-run, day-to-day, and site-to-site variations.

This paper proposes an estimation of uncertainties under conditions of repeatability, and reproducibility using ISO 5725 approach [2]. By this way uncertainties are evaluated from precision values

As three main parameters (test track, measuring device and ambient conditions) influences uncertainties, reduction of reproducibility is managed by using correction factors on each parameter.

2 Uncertainties analysis

The analysis developed in this paper is based on the use of the ISO 5725 [2] approach which is best suited for test laboratory measurements because of the intended use of the data to estimate precision values issued from interlaboratories tests. The two approaches outlined in ISO 5725 [2] and GUM [3] are complementary, as mentioned in document ISO TS 21748 [4]. The document ISO/TS 21748 [4] makes it possible to establish the connection between the values of precision and the uncertainties.

The aim of this paper is to show different results obtained for the estimation of the uncertainties of measurements obtained using these standards under several different situations.

Uncertainties are estimated under conditions of repeatability (run-to-run) and intermediate precision. These conditions are linked with factors which are included in the model of the variance analysis.

In this paper, uncertainties will given with coverage factor k equal to 2 for a confidence level of 95 percent.

3 ISO 362 and correction of influents parameters

The ISO 362 [1] testing procedure consists to measure, with a sound level meter, noise of a vehicle running on an ISO 10 844 test track [5] on partial throttle condition. Measurements can be made with ambient air temperature within range 5 °C to 40 °C,

As uncertainties on vehicle noise depend mainly on test track surface, measuring device and ambient conditions, three situations were taken into account independently:

- day-to-day variations
- track-to-track variations,
- sound meter level-to-sound meter level variations.

The method to reduce uncertainties consists to use correction factors on influent parameters:

- Correction on test track is reduced to rolling noise correction according to vehicle noise model,
- Correction on sound measuring device is reduced by using a reference noise source on each device of each site.
- Correction on ambient condition is reduced to air temperature correction on vehicle noise and rolling noise.

4 Vehicle Noise Model

In ISO 362 [1] testing conditions, vehicle noise is a combination of two main noise sources: rolling noise (tyre-road contact) and propulsion noise (engine, intake, exhaust).

To build the vehicle noise model, the energetic sum of rolling noise and propulsion noise is consider to be equal to vehicle noise:

$$L\ veh = L\ prop \text{ “+” } L\ rolling \qquad (1)$$

L veh is the noise emitted by the vehicle on partial throttle.

L prop is the noise emitted by the power unit,

L rolling is the noise emitted by the tyre,

"+" is the energetic sum *L prop* of and *L rolling* expressed in dB(A).

5 Noise measuring device

The A-weighted sound level is measured with a sound level meter or equivalent measurement system meeting the requirements of Class 1 instruments.

These requirements described in NF EN 61672-1 [6] or IEC 651 [7].

To estimate uncertainties, 13 sound level meters were tested on 20 vehicles noises records with 5 repeats for each records.

Estimation of uncertainties is made on data with and without correction. The correction consists to consider one sound meter level as a reference and applied a “device correction” on the others.

The results shown in figure 1 on one sound illustrate the difference between 13 sound level meters with and without corrections.

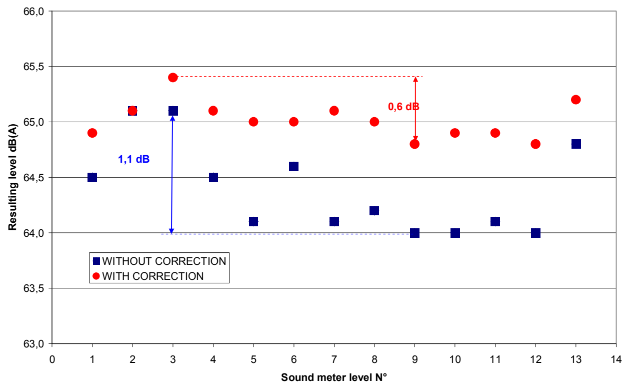

Figure 1: Resulting level on 13 sound level meters on sound 10 with and without correction

By using measuring device correction, uncertainties can be reduced from $U_{sound\_level\_meter}$ = 1.2 dB(A) without correction to $U_{sound\_level\_meter\_corr}$ = 1.1 dB(A) with correction.

5 Temperature

As specify in ISO 362 [1], acoustical measurements can be performed with an air temperature within range 5°C to 40 °C. Temperature affects the vehicle noise emission (rolling and propulsion).

Influence of temperature on rolling noise is specified by [8] which propose 0.1 dB / °C. For vehicle noise, we performed tests on 4 vehicles on different air temperature to estimate a correction value. For light vehicle noise measurement, the correction factor is fixed at 0.08 dB / °C.

Results shown in figure 2 illustrate the difference between vehicle noise with and without corrections on a wide temperature range.

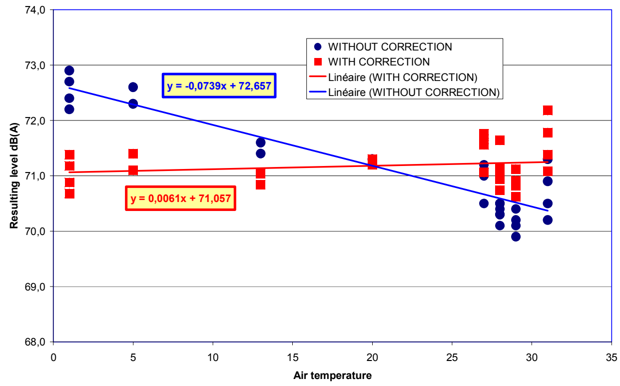

Figure 2: Resulting level one vehicle 2 with and without correction

By using air temperature correction, uncertainties can be reduced from $U_{ambient\_cdt}$ = 1.9 dB(A) without correction to $U_{ambient\_cdt\_cor}$ = 0,8 dB(A) with correction.

5 Test site

Vehicle noise tests are performed on a test site meeting the requirements of ISO 10844 [5].

Road surface parameters affecting noise emission of vehicles are texture and sound absorption.

Rolling noise is affected by texture and sound absorption and propulsion noise is affected by sound absorption.

In order to minimize the variation in rolling and vehicle sound emission measurements, the working group ISO/TC43/SC1/WG42/TT prepares a revision of ISO 10844 including more restrictive specifications of the surface and recommendation for the test track construction process.

As this work is in progress but not finish and new tests tracks will not build soon, we propose to specify a surface correction to minimize the variation in rolling and vehicle sound emission measurements.

To build this correction model, we consider that:

- difference between rolling noise of two different types of tyres tested on two different ISO 10 844 test tracks is quite in the same order.
- propulsion noise is considered by assumption to be independent of test track.

By using rolling noise correction, the uncertainties can be reduced from U_{test_site} = 2,2 dB(A) without correction to U_{test_site} = 1,3 dB(A) with correction.

5 Conclusion

Estimations of uncertainties on ISO 362 [1] measurement procedure made independently on test track, environmental conditions and measurement system variations, with and without correction factor give potential for a global reduction.

Variability expected within a same test laboratory day to day can be reduced by using a correction factor of -0,08 dB / °C on drive-by results and -0,1dB/°C on cruise-by result.

Variations expected between test-laboratories (measuring device and road surface) can be reduced by using a reference tyre. The correction factor given by difference between rolling noise of reference tyre on 2 sites can be applied with vehicle noise model.

This method is an experimental approach to reduce variability on ISO 362 [1] measurement procedure using interlaboratory tests only with one reference tyre.

References

[1] **ISO 362-2007** – Acoustics – Measurement of noise emitted by acceleration road vehicle

[2] **ISO 5725**, part 1 to 6 Accuracy (trueness and precision) of measurement methods and results, 1994.

[3] **NF ENV 13005** Guide to the expression of uncertainty in measurement (GUM), 1999.

[4] **ISO TS 21748** Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation, 2004.

[5] **ISO 10844** Acoustics-Specification of test tracks for the purpose of measuring noise emitted by road vehicles, 1994.

[6] **NF EN 61672** – Electroacoustics – Sound level meters

[7] **CEI 651** – Electroacoustics – Sound level meters

[8] **Norme NF XP S31-145-1** – Acoustique – Caractérisation *in situ* des performances acoustiques des revêtements de chaussées – Mesures du bruit de contact pneumatique / chaussée en continu