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Acoustics — Temperature influence on tyre/road noise measurement —

Part 2: Correction for temperature when testing with the pass-by methods

Acoustique — Effet de la température sur les essais de bruit pneu/route —

Partie 2: Correction de la température lors des essais utilisant les méthodes au passage

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

A list of all parts in the ISO/TS 13471 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Air, tyre and road surface temperatures affect noise emission from the tyre/road interaction, as measured by means of, for example, the statistical pass-by (SPB) method specified in ISO 11819-1 or other pass-by methods. These methods allow the user to make measurements within a wide air temperature range (5 °C to 35 °C) which means that temperature influence on the results may be substantial.

Another common type of measurement where temperature effects on tyre/road noise are significant is for noise tests on tyres most commonly conducted as pass-by on test tracks with a reference surface according to ISO 10844[1]. This case is also considered in this document, with the aim to reduce the uncertainties in such measurements. These are often made for legal purposes, such as type approval or labelling of tyres or vehicles where tyres are the dominant noise source. This is further dealt with in Annex A.

Temperature effects on noise depend on both the tyre and the road surface, the temperatures of which are affected by ambient air temperature. The temperature has different effects on different noise generation mechanisms and when also considering the effect of possible power unit noise mixed with tyre/road noise, the temperature effect becomes even more complicated. Ideally, and whenever possible, temperature corrections shall be tailored to not only the tested tyre/road combination as well as to different tyre and vehicle categories, but also to the type of measurement method. For example, there is also a Technical Specification related to the CPX method (ISO/TS 13471-1[2]).

The approach to the temperature correction in this document is semi-generic, which means that under certain conditions a correction to noise for temperature is made common to a group of vehicles and tyres or a group of road surfaces as it is impossible to do it for each tyre and road surface combination. This document makes a distinction to cars and heavy vehicles and to a few major road pavement categories, and also takes into account local, regional or national conditions.

Acoustics — Temperature influence on tyre/road noise measurement —

Part 2:
Correction for temperature when testing with the pass-by methods

1 Scope

This document specifies correction procedures for the effect of temperature on vehicle noise emission, as influenced by the tyre/road noise contribution. Temperatures considered are road and ambient air temperatures.

The noise emission for which this document is applicable is measured by means of ISO 11819-1, or similar methods such as the American methods SIP and CTIM specified in References [3][4]. It is also applicable to other pass-by measurements conducted without acceleration, such as when testing tyres and vehicles on test tracks with ISO 10844[1] reference surfaces; however, given that tyre/road noise is dominant.

Measurement results obtained at a certain temperature, which may vary over a wide range, are normalized to a designated reference temperature (20 °C) using a correction procedure specified in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11819-1, *Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 1: The statistical pass-by method*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Acoustics

3.1.1
vehicle noise
total noise from an individual vehicle, the two major components of which are *power unit noise* (3.1.3) and *tyre/road noise* (3.1.2)

3.1.2
tyre/road noise
noise generated by the tyre/road interaction

3.1.3
power unit noise
noise generated by the vehicle engine, exhaust system, air intake, fans, transmission, etc.

3.1.4
SPB method
statistical pass by method
measurement procedure designed to evaluate vehicle and traffic noise generated on different sections of road surface under specific traffic conditions

Note 1 to entry: The measurements are taken from a great number of vehicles operating normally on the road. Results obtained using this procedure are normalized to standard speeds according to the category or type of road being considered. The method is specified in ISO 11819-1.

3.2 Measured noise quantities

3.2.1
maximum sound level
L_{Amax}
highest sound pressure level recorded by the measuring instrument during a vehicle pass-by, using frequency weighting A and time weighting F

3.2.2
vehicle sound level
$L_{VEH:U,vref}$
maximum A weighted sound pressure level determined at a reference speed, v_{ref}, calculated for one of the universal vehicle categories (U) defined in 3.3.2

Note 1 to entry: When testing according to ISO 11819-1, $L_{VEH,J,vref}$ is equal to $L_{SPB,J,vref}$

3.2.3
tyre/road sound level
$L_{TR:C,vref}$
maximum A weighted sound pressure level determined at a reference speed, v_{ref}, measured or calculated in conditions where there is no power unit noise (coast-by passing or similar), for one of the tyre classes (C) which can be C1, C2 or C3 defined in 3.3.1

3.3 Tyre and vehicle classes

3.3.1
tyre class
dimensional class of tyres

Note 1 to entry: Tyre classes C1, C2 and C3 are defined in ECE Regulation 117[5].

Note 2 to entry: Essentially, C1 tyres are used on cars and other light vehicles, C2 tyres are used on large SUV:s, vans and small trucks, while C3 tyres are used on heavy vehicles. However, refer to the reference [5] for more precise definitions based on tyre load indices.

3.3.2
vehicle category
universal category of vehicles (U), using a certain class of tyres, that can be either P (passenger cars using C1 tyres), H (heavy vehicles using C3 tyres) or M (a medium category of vehicles using C2 tyres, mostly consisting of large SUV:s, vans and small trucks)

Note 1 to entry: Vehicle categories P and H are defined in ISO 11819-1:-[1)], and tyre classes are defined in 3.3.1. Vehicle category M is not used in ISO 11819-1.

3.4 Road surface

3.4.1
surface course
upper course of the pavement, which is in contact with the tyres

Note 1 to entry: Various main types of road surfaces are described in Annex A.

3.5 Temperatures

3.5.1
air temperature
ambient air temperature
temperature of the air surrounding the traffic flow

Note 1 to entry: The air temperature is expressed in degree Celsius.

Note 2 to entry: Instructions on where and how to measure air temperature are given in 6.2.

3.5.2
road temperature
road surface temperature
temperature representative of the temperature in the wheel tracks of the road surface

Note 1 to entry: The road temperature is expressed in degree Celsius.

Note 2 to entry: Instructions on where and how to measure road surface temperature are given in 6.3.

3.5.3
tyre temperature
general term for the temperature of the test tyres

Note 1 to entry: The tyre temperature is expressed in degree Celsius.

Note 2 to entry: Tyre temperature varies substantially between different parts of the tyre, as well as with the tyre operating conditions. In this document, distinction is not made between these different parts, but the tyre is seen as a unit with a temperature that influences noise emission in a particular way.

3.5.4
reference temperature
T_{ref}
air temperature (3.5.1) of 20,0 °C representing a hypothetical, ideal measurement case, to which actual measurements are normalized

3.5.5
temperature correction term for tyre class t
$C_{\mathrm{T,t}}$
term used for correcting the *tyre/road sound level* (3.2.3) for temperature T for tyre class t

Note 1 to entry: The temperature correction term is expressed in decibels.

1) A revision of ISO 11819-1 where the vehicle categories are defined is currently under preparation.

3.5.6
temperature correction term for vehicle category
$C_{T,U}$
term used for correcting the *vehicle sound level* (3.2.2) for temperature T for vehicle category U

Note 1 to entry: The temperature correction term is expressed in decibels.

Note 2 to entry: This term represents how $C_{T,t}$ is "diluted" by power unit noise of the particular vehicle category (see Clause 9).

3.5.7
temperature coefficient
γ_t
coefficient used for correcting the *tyre/road sound level* (3.2.3), for the effect of temperature for tyre class t

Note 1 to entry: The temperature coefficient is expressed in decibels per degree Celsius.

Note 2 to entry: Tyre t can be classes C1, C2 or C3 (3.3.1).

3.5.9
temperature coefficient
γ_U
coefficient used for correcting the *vehicle sound level* (3.2.2) for the effect of temperature for vehicle category U

Note 1 to entry: The temperature coefficient is expressed in decibels per degree Celsius.

Note 2 to entry: Vehicle category U can be P, M or H (3.3.2).

Note 3 to entry: This coefficient is the version of γ_t taking into account how it is "diluted" by power unit noise of the particular vehicle category (see Clause 9)

4 Principles of the correction procedures

The general effect of temperature is an increase in sound levels with colder temperatures and a decrease in sound levels with warmer temperatures. Based on the empirically determined relationship between tyre/road noise and ambient air temperature, the aim is to normalize all coast-by and pass-by noise measurements (including, for example, SPB measurements) to a reference temperature. This is done from the actual air temperature during the measurement, within a temperature range where the relationship is reasonably linear.

The reference condition has been determined to be a hypothetical measurement of noise at an ambient air temperature of 20,0 °C. The relationship between noise and temperature has been determined from a compilation of several published investigations. It has been found that the relationship depends on the class of tyres and types of road surfaces, and somewhat different relationships are, therefore, necessary to apply based on the road surface type, and to some extent the condition of the surface (porosity)[6].

In this way, measured overall A-weighted levels as well as spectral levels, corrected for the difference between actually measured temperature and the reference temperature using formulae given in this document, are normalized to a common reference condition where air temperature would be 20 °C.

In general, it is advised that measurements be made as close as possible to the reference temperature, in order to avoid large corrections. In cases when one wants to compare, for example, a before–after measurement of some type, the lowest uncertainties will result if such before–after measurements are made at similar temperatures; in particular, if temperatures during measurements are relatively far from the reference temperature.

When using a semi-generic correction procedure, it is accepted that the use of an average temperature coefficient for either tyre/road noise or vehicle noise considered in this document, with a distinction

between a few major road pavement categories, will lead to some over- and under-estimations of temperature corrections for individual tyres, vehicles or pavements. However, the errors of such imperfect corrections are more than balanced by the correction itself as it normalizes the results to a common and comparable scale.

This procedure will reduce the uncertainty in coast-by, SPB and other pass-by measurements due to varying temperature substantially. An analysis of uncertainty is included in this document.

Refer to Annex B for a discussion about the choice of temperature to use for normalization.

5 Temperature measurement equipment

The air, road and tyre temperature measuring instrument(s) shall have a maximum permissible error of ±1 °C, as specified by the manufacturer. Meters utilizing the infrared technique shall not be used for air temperature measurements.

NOTE Obviously, the tyre temperature measurement option is impossible in SPB measurements.

The equipment shall be calibrated in accordance with the manufacturer's specification, in most cases requiring a calibration annually by a laboratory authorized to perform calibrations traceable to appropriate standards.

The type of sensor used shall be reported.

6 Measurement methods

CAUTION — This document may involve hazardous operations when measurements are made on trafficked roads or streets. The personnel and the vehicles present on the measuring site shall be equipped with safety or warning devices in accordance with the regulations in force for work in the traffic flow (if any) on that particular site at that particular time. Otherwise, this document does not purport to address the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6.1 General

The measurements shall comprise at least the first of the following operations.

— Measurement of air temperature representative of the ambient air at the test site (mandatory).

— Measurement of road temperature representative of the road surface of the test site (optional).

— Measurement of tyre temperature (optional).

The thermometer manufacturer's instructions shall be observed. The result is the reading rounded to the first decimal, in °C.

NOTE Regarding the various temperatures considered, a discussion follows in 6.2 to 6.4. See also the discussion in Annex B.

6.2 Measurement of air temperature

Locate the temperature sensor so that it is unobstructed and safe, and in such a way that it is protected from direct solar radiation and heat radiation from road or other surfaces. The protection from solar radiation may be achieved by a shading screen. Heights of 1,2 m to 1,5 m above road surface level are suitable. The position of the sensor shall be reported.

The temperature measurement shall have a duration of at least 15 s of stable temperature.