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Acoustics — Temperature influence on tyre/road noise measurement —

Part 1: Correction for temperature when testing with the CPX method

Acoustique — Effet de la température sur les essais de bruit pneu/route —
Partie 1: Mode opératoire de correction sur les essais avec la méthode CPX

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

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

Introduction

Air, tyre and road surface temperatures affect noise emission from the tyre/road interaction, as measured by means of, for example, the close-proximity (CPX) method specified in ISO 11819-2. This method allows 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.

In the CPX method, one or two reference tyres may be used, as specified in ISO/TS 11819-3; consequently, the temperature corrections need to be valid for these reference tyres. Tyre properties like rubber hysteresis and tread rubber hardness are affected by temperature, but the latter may also affect road surface properties. Temperature effects on noise, therefore, depend on both the tyre and the road surface, the temperatures of which are affected by ambient air temperature. To make it more complicated, the temperature probably has different effects on different noise generation mechanisms. Ideally, and whenever possible, temperature corrections shall be tailored to the tested tyre/road combination.

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 tyres or a group of road surfaces. This document makes a distinction to the two reference tyres and to a few major road pavement categories.

Acoustics — Temperature influence on tyre/road noise measurement —

Part 1: Correction for temperature when testing with the CPX method

1 Scope

This document specifies procedures for determining the effect of temperature on tyre/road noise emission. Temperatures considered are tyre, road and ambient air temperatures.

The noise emission for which this document is applicable is measured by means of ISO 11819-2, or similar methods such as the on-board sound intensity (OBSI) method specified in Reference [1]. 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 11819-2, *Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 2: The close-proximity method*

ISO/TS 11819-3, *Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 3: Reference tyres*

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:

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

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

3.1 Acoustics

3.1.1
tyre/road noise
noise generated by the tyre/road interaction

3.1.2
CPX method
close-proximity method
measurement procedure designed to evaluate the influence of road pavement characteristics on vehicle and traffic noise under conditions when *tyre/road noise* (3.1.1) dominates and power unit noise is not very important

Note 1 to entry: The method is specified in ISO 11819-2.

Note 2 to entry: The measurements are made using microphones located close to one or more test tyres which are mounted on a special test vehicle.

3.1.3
CPX level
close-proximity level
L_{CPX}
time-averaged A-weighted sound pressure level (SPL) of the *tyre/road noise* (3.1.1) as determined by the *CPX method* (3.1.2), either broadband or spectral bands, as required

Note 1 to entry: The CPX level is expressed in decibels. In order to provide more information, additional suffixes are used; see ISO 11819-2 where the CPX method is described.

3.2 Tyres and road surfaces

3.2.1
reference tyre
test tyre specified for the purpose of representing certain features in tyre/road sound emission, designed and constructed for use in the *CPX method* (3.1.2) with specified and reproducible standard properties

Note 1 to entry: The reference tyres are specified in ISO/TS 11819-3.

3.2.2
road surface
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 B.

3.3 Temperatures

3.3.1
air temperature
ambient air temperature
temperature of the air surrounding the tyres under test, but measured in such a way that the sensor is exposed to the airflow and protected from direct solar radiation

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

3.3.2
road temperature
road surface temperature
static temperature of the part of the road that is in contact with the tyre(s) rolling on the road, where static means that it is the temperature that changes only with pavement convection, sun radiation and meteorological conditions

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

3.3.3
tyre temperature
general term for the temperature of the *reference tyre* (3.2.1), which influences noise emission

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.

3.3.4
tyre tread temperature
temperature of the surface of the tread of the *reference tyre* (3.2.1)

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

Note 2 to entry: In this document, this is considered the temperature of the centre one-third of the tread width.

3.3.5
reference temperature
T_{ref}
air temperature (3.3.1) of 20,0 °C representing a hypothetical, ideal measurement case, to which actual measurements are normalized

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

3.3.6
temperature correction term
$C_{T,\mathrm{t}}$
term used for correcting the *CPX level* (3.1.3) for temperature T for tyre t

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

3.3.7
temperature coefficient
γ_{t}
coefficient used for correcting the *CPX level* (3.1.3) for the effect of temperature for tyre t

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

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 CPX noise measurements to a reference temperature, 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 air temperature of 20,0 °C. The relationship between noise and temperature has been determined from a compilation of several published investigations, with distinction between the two reference tyres specified in ISO/TS 11819-3, and with speed as an influential factor. It has been found that the relationship depends on the main type of road surface, 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).[2]

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 shall be accepted that the use of an average temperature coefficient for tyres 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 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 CPX measurements due to varying temperature substantially. An analysis of uncertainty is included in this document.

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

5 Temperature measurement equipment

The air and (optional) 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.

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 surrounding the test tyre (mandatory).

— Measurement of road temperature representative of the road surface over which the tyres roll (optional).

— Measurement of tyre temperature (optional).

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

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 exposed to the airflow and protected from direct solar radiation. The latter may be achieved by a shading screen. The sensor shall be positioned 0,5 m to 1,5 m above road surface level. The position of the sensor shall be reported.

NOTE If positioned closer to the road there can be an influence of road surface thermal radiation at low airflows.

6.3 Measurement of road surface temperature (optional)

Position the temperature sensor in order to measure where the temperature is representative of the temperature in the wheel tracks. Collect the measurements approximately simultaneously with the noise measurement. Where portions of the roadway are in full sun and other portions are shaded it is advised to collect the temperature values approximately over the same test section as noise is collected.

6.4 Measurement of tyre temperature (optional)

Position the temperature sensor in order that it measures the tyre tread surface temperature, without interfering with the noise measurement. In order to avoid dirt thrown from the tyre by centrifugal forces, the sensor should not be positioned in the tyre plane but a little outside the tyre plane. If tyre temperature is measured, the measuring position on the tyre shall be reported.

7 Temperature range

7.1 General

In order to reduce the uncertainty, it is recommended that noise measurements be made at air temperatures as close as practical to the reference air temperature (20,0 °C).

7.2 Temperature range within which the correction procedure is valid

The correction procedures in this document shall be applied only if air temperatures are within 5 °C and 35 °C.

NOTE The allowed temperature range is related to local road materials. In the warmer zones, high temperatures are common and bitumen viscosity is adjusted to it, while the same temperature in a cooler climate can cause bleeding of the bituminous mixture. This is known to cause extra stick-snap sound from the rolling tyre.[3]

8 Temperature correction procedure

8.1 Correction to CPX levels, L_{CPX}

Temperature correction shall be applied as follows. Each measured CPX level, L_{CPX}, determined according to ISO 11819-2, shall be corrected by the term $C_{T,\mathrm{t}}$, using Formula (1):

$$C_{T,\mathrm{t}} = -\gamma_{\mathrm{t}} \left(T - T_{\mathrm{ref}} \right) \tag{1}$$

where