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## Tyre sound emission test — Methods of drum

*Essai d'émissions acoustiques de pneumatique — Méthode avec un  
tambour*

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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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 31, *Tyres, rims and valves*.

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](http://www.iso.org/members.html).

## Introduction

The external sound emission of a tyre is one out of a multitude of requirements that need to be considered by manufacturers during design and development of tyres. For health and environmental protection reasons, the sound emission should be reduced under all relevant driving conditions. To meet all these demands, an efficient test site is needed that can be operated the whole year round independent of weather conditions or other outside factors. In many countries, the meteorological conditions are so adverse that outdoor testing on a classical proving ground is only possible in a very limited timeframe. Furthermore, performing sound emission tests on various test tracks highly increases the uncertainty and multiplies the workload for a manufacturer.

This document gives specifications for an indoor noise test bench and a test procedure that delivers precise results for indoor testing, comparable to a certified type approval test track. The results are intended to be within the run-to-run variation of the actual valid exterior noise test described in ISO 13325, which is the test standard used for type approval of tyres. An indoor test bench requires tight specifications for the equipment and set up, such as the acoustical treatment of the walls and the ceiling, the microphone array, the roller bench, the adjustment of the tyre load on the roller bench. Special treatment needs to ensure that all rolling sound components of the tyre are comparable to the rolling sound on a road surface as specified in ISO 10844 and as applied in type approvals. This document provides all necessary specifications and procedures to ensure comparability between today's common and well accepted testing on outdoor test tracks with future indoor facilities. It incorporates all relevant International Standards for equipment, measurement uncertainty and test procedures.

The current outdoor method (described in ISO 13325) requests the vehicle to move at various speeds in between two microphones. This imposes to the tyre a high rotation speed which is at the source of sound emission, by creating tyre parts movements, slip and shocks against the track surface. As a vehicle, movement is not possible in a semi-anechoic room, the rotation of a drum is used to create tyre rotation similar to the one observed on track. In order to create excitation similar to the one created on the track, the drum is coated with a surface similar to the one of the tracks. Finally, the vehicle trajectory between the microphones is simulated by a line of microphones, signals of each microphone being used to estimate the noise level of the car moving between microphones.

The results are intended to be within the run-to-run variation of the actual valid exterior noise test described in ISO 13325.

# Tyre sound emission test — Methods of drum

## 1 Scope

This document specifies methods for measuring tyre-to-road sound emissions from tyres fitted on rig that applies the tyre on a rotating drum under coast-by conditions (i.e. when the tyre is in free-rolling, non-powered operation).

The specifications are intended to achieve a correlation between results of testing the exterior noise of tyres in a semi anechoic chamber and outdoor testing as described in ISO 13325.

This document is applicable to passenger cars and light commercial vehicles tyres as defined in 3.1. It is not intended to be used to determine the sound contribution of tyres applying a torque, nor for the determination of traffic sound nuisance at a given location.

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

ISO 3745:2012/Amd 1:2017, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 4000-1, *Passenger car tyres and rims — Part 1: Tyres (metric series)*

ISO 4209-1, *Truck and bus tyres and rims (metric series) — Part 1: Tyres*

ISO 4223-1:2017, *Definitions of some terms used in the tyre industry — Part 1: Pneumatic tyres*

ISO 10844, *Acoustics — Specification of test tracks for measuring sound emitted by road vehicles and their tyres*

ISO 13325:2019, *Tyres — Coast-by methods for measurement of tyre-to-road sound emission*

ISO 26101-1, *Acoustics — Test methods for the qualification of the acoustic environment — Part 1: Qualification of free-field environments*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

IEC 61672-3, *Electroacoustics — Sound level meters — Part 3: Periodic tests*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4223-1 and the following apply.

ISO and IEC maintain terminology 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**  
**class of tyre**

type of tyres intended to be used on similar vehicles

Note 1 to entry: The various types of class of tyre are named and defined as follows:

- passenger car tyre: tyres conforming to ISO 4000-1;
- light commercial vehicle tyre: tyres conforming to ISO 4209-1 and identified by a load index in single configuration lower or equal to 121 and speed symbol higher or equal to “N”.

**3.2**  
**tyre category**

group of tyres intended to be used for similar purpose

Note 1 to entry: The various types of tyre category are named and defined as follows:

- normal tyre, as defined by ISO 4223-1, 3.1.1;
- snow tyre, as defined by ISO 4223-1, 3.1.3;
- severe snow use tyre, as defined by ISO 4223-1, 3.1.5;
- traction tyre, as defined by ISO 4223-1, 3.1.8;
- special use, as defined by ISO 4223-1, 3.1.2.

**3.3**  
**load index**

**LI**  
numerical code associated with the maximum load a tyre can carry at the speed indicated by its speed symbol under the service conditions specified by the tyre manufacturer

Note 1 to entry: In cases where the LI consists of two numbers, reference shall be made to the first number. For tyres where the load index is not available, reference shall be made to the maximum load marked on the tyre sidewall.

**3.4**  
**rig**

device applying a load to tyre and measuring it during the test

**4 Symbols and abbreviated terms**

All symbols used in this document and that are used in the test report are described in [Table 1](#).

**Table 1 — Symbols used and corresponding clauses**

Symbol	Unit	Sub-clause	Description
$a$		<a href="#">9.2.5</a>	Slope of the regression line $L_i$ versus $v_{*i}$
$\alpha_{array}^+, \alpha_{array}^-$		<a href="#">6.2.3</a>	Angles spanned by the circular array in the $xy$ -plane in positive and negative $x$ -directions, respectively
$\alpha_{array}$		<a href="#">6.2.3</a>	Angles spanned by the circular array in the $xy$ -plane in positive and negative $x$ -directions, respectively
$\alpha_{array \text{ min}}$		<a href="#">6.2.3</a>	Minimal acceptable value of $\alpha_{array}^+$ and $\alpha_{array}^-$
$\alpha_m$		<a href="#">6.2.3</a>	Signed angle between projection of the microphone number $m$ of the circular array onto the $xy$ -plane and the $y$ -axis
$C_t$		<a href="#">9.2.4</a>	Coefficient for tyre impact on sound propagation



Table 1 (continued)

Symbol	Unit	Sub-clause	Description
$C_v$		<a href="#">9.2.4</a>	Coefficient for vehicle impact on sound propagation
$D$	m	<a href="#">6.3</a>	Largest expected size of acoustic source on the tyre
$Dd$	mm	<a href="#">7.2.1</a>	Diameter of drum including the surface
$\Delta L(x_m)$		<a href="#">6.5</a>	Relative sound pressure level decay at microphone number $m$ with respect to the central microphone
$\Delta x$	m	<a href="#">6.2.2</a>	Spacing of linear array microphones in $x$ -direction NOTE It is the reference distance for definition of coordinates of circular array microphones.
$\Delta x_{\max}$	m	<a href="#">6.2.2</a>	Maximum allowed value of $\Delta x$
$Hd$	mm	<a href="#">7.2.3</a>	Height of the drum top point above the floor
$\bar{L}$	dB(A)	<a href="#">9.2.5</a>	Mean value of representative SPLs
$l_{\text{array}}^+$	m	<a href="#">6.2.2</a>	Lengths of linear microphone array in positive $x$ -directions
$l_{\text{array}}^-$	m	<a href="#">6.2.2</a>	Lengths of linear microphone array in negative $x$ -directions
$l_{\text{array min}}$	m	<a href="#">6.2.2</a>	Minimal acceptable value of $l_{\text{array}}^+$ and $l_{\text{array}}^-$
$L_{\text{CBY}}$	m	<a href="#">6.2.2</a>	Reference distance for definition of $l_{\text{array min}}$ and $\alpha_{\text{array min}}$
$L_f$	dB(A)	<a href="#">9.2.5</a>	Final test result
$L_i$	dB(A)	<a href="#">9.2.4</a>	Representative SPL (test result) at speed $v_i$
$L_R$	dB(A)	<a href="#">9.2.5</a>	Interpolated value of SPL at the speed $v_{\text{ref}}$
$L_{R \text{ aligned}}$	dB(A)	<a href="#">9.2.6</a>	Interpolated value corrected for lab alignment with outdoor
$L_{\text{SP}}$		<a href="#">6.5</a>	Sound pressure level
$L_v$		<a href="#">9.2.5</a>	Interpolated value of SPL at a speed $v$
$\lambda_{\min}$	m	<a href="#">6.3</a>	Wavelength of sound wave in the air at the highest frequency of concern
$m$	m	<a href="#">6.2.1</a>	Number of a microphone
$M$		<a href="#">6.2.1</a>	Total number of the microphones in the array
$M_s$		<a href="#">11.3</a>	Slope of the regression line $L_{R \text{ track } i}$ versus $L_{R \text{ drum } i}$
$M_{\text{negative}}$		<a href="#">6.2.1</a>	Number of array microphones in negative $x$ -directions
$M_{\text{positive}}$		<a href="#">6.2.1</a>	Number of array microphones in positive $x$ -directions
$n$		<a href="#">9.1.4</a>	Number of test speeds
$P_A(x_m)$	Pa <sup>2</sup>	<a href="#">9.2.1</a>	Mean square value of $p_{mA}(t)$
$P_A^{\text{corr}}(X_m)$	Pa <sup>2</sup>	<a href="#">9.2.2</a>	Distance corrected mean-square pressure of the microphone $m$
$P_{FA}^{\text{corr}}(X_m)$	Pa <sup>2</sup>	<a href="#">9.2.3</a>	Distance-corrected mean-square pressure of the microphone $m$ with emulation of fast time weighting through exponential weighting in $X$
$p_m(T)$	Pa	<a href="#">9.2.1</a>	Time-signal of the $m$ -th microphone
$p_{mA}(T)$	Pa	<a href="#">9.2.1</a>	A-filtered time signal of the $m$ -th microphone
$P_0$	Pa	<a href="#">9.2.4</a>	Reference acoustic pressure for dB scale
$P_r$	kPa	<a href="#">9.1.2</a>	Reference pressure
$P_t$	kPa	<a href="#">9.1.2</a>	Test inflation pressure
$Q$		<a href="#">11.3</a>	Shift at origin of the regression line $L_{R \text{ track } i}$ versus $L_{R \text{ drum } i}$
$Q_r$	N	<a href="#">9.1.1</a>	Reference load, corresponding to max load associated with tyre load index
$Q_t$	N	<a href="#">9.1.1</a>	Test load for the tyre

**Table 1 (continued)**

Symbol	Unit	Sub-clause	Description
$r_0$		<a href="#">6.5</a>	Distance from the acoustic source to the central microphone of the array
$R^2$		<a href="#">11.3</a>	Correlation coefficient of the regression line $L_{R \text{ track } i}$ versus $L_{R \text{ drum } i}$
$r_{\text{array}}$	m	<a href="#">6.2.3</a>	Radius of the base circle of the circular microphone array
$r_m$		<a href="#">6.5</a>	Distance from the acoustic source to the $m$ -th microphone of the array
$T$	s	<a href="#">9.2.1</a>	Averaging time for mean square calculation
$\bar{v}_*$		<a href="#">9.2.5</a>	Mean value of $v_{*i}$
$v_{*i}$		<a href="#">9.2.5</a>	Decimal logarithm of the test speed $v_i$
$v_i$	km/h	<a href="#">9.1.4</a>	Value of the $i$ -th test speed
$v_{\text{ref}}$	km/h	<a href="#">9.2.6</a>	Reference speed for test results interpolation
$x, y, z$	m	<a href="#">6.2.1</a>	Axis of Cartesian coordinate system
$X_m$	m	<a href="#">9.2.2</a>	Distance-corrected $x$ -coordinate of the microphone $\square$
$x_m, y_m, z_m$	m	<a href="#">6.2.1</a>	Coordinates of the microphone number $m$
$y_{\text{array}}$	m	<a href="#">6.2.2</a>	Distance from linear microphone array to the vertical tyre mid-plane
$Y_{\text{CBY}}$	m	<a href="#">6.2.2</a>	Distance from microphone to track centre (as defined in ISO 13325) NOTE It is the reference distance for sound pressure level correction in this document.
$z_{\text{array}}$	m	<a href="#">6.2.2</a>	Height of linear microphone array above the tyre contact patch centre (drum top)
$Z_{\text{CBY}}$	m	<a href="#">6.2.2</a>	Height of microphones above the ground (as defined in ISO 13325) NOTE It is the reference height for definition of array microphones height in this document.

## 5 Instrumentation

### 5.1 Instruments for acoustical measurement

The sound pressure level meter or equivalent measuring system (including microphone and acquisition system), shall meet the minimum requirements of a Class 1 instrument in accordance with IEC 61672-1. Alternatively, IEC 60651 may be used.

The measurements shall be made using the “A” frequency weighting.

The calibration of the sound pressure level meter shall be checked and adjusted in accordance with the manufacturer’s instructions or with a standard sound source (e.g. pistonphone) at the beginning of the measurements and rechecked and recorded at the end of them. The calibration device shall meet the requirements of Class 1 in accordance with IEC 60942.

If the sound pressure level meter indications obtained from these calibrations differ by more than 0,5 dB during a series of measurements, the test shall be considered invalid. Any deviations shall be recorded in the test report.

NOTE The tests of IEC 61672-3 cover only a limited subset of the specifications in IEC 61672-1 for which the scope is large (temperature range, frequency requirements up to 20 kHz, etc.). It is economically not feasible to verify the whole IEC 61672-1 requirements on each item of a computerized data acquisition systems model.

### 5.2 Microphones

The microphones setup is described in [6.2](#). In the vicinity of the microphones, there shall be no obstacles that could influence the acoustical field.

## 5.3 Temperature measurement

### 5.3.1 General

For air temperature measurement, the measuring instrument shall have an overall accuracy of at least  $\pm 1$  °C. Meters utilizing the infrared technique shall not be used for air temperature measurements.

Continuous registration through an analog output may be employed. If such an option is not available, single values shall be measured.

Measurements of air temperature are mandatory and shall be made in accordance with the instrument manufacturer's instructions.

Temperature measurements shall correspond reasonably over time with sound measurements. Alternatively, the average of the temperature at the beginning and the end of the set of tests may be used.

### 5.3.2 Room temperature

One should position the temperature sensor in an unobstructed location close to the microphone array. The sensor should not be positioned higher than the height of the microphone array (see [6.2](#)).

### 5.3.3 Calibration

At the beginning and at the end of every measurement session (typically one day of measurement), the entire sound measurement system shall be checked by means of a sound calibrator as described in [5.1](#). Without any further adjustment, the difference between the readings shall not exceed 0,5 dB. If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

## 5.4 Conformity with requirements

At intervals of not more than two years, the sound pressure level meter shall be verified with the requirements of IEC 61672-1. Alternatively, IEC 60651 may be used. At intervals of not more than one year, the calibration device shall be verified with the requirements of IEC 60942.

When no general statement or conclusion can be made about conformance of the sound level meter model to the full specifications of IEC 61672-1, the apparatus used for measuring the sound pressure level shall be a sound level meter or equivalent measurement system meeting the compliance requirements of Class 1 instruments as described in IEC 61672-3.

All conformity testing shall be conducted by a laboratory which meets the requirements of ISO/IEC 17025.

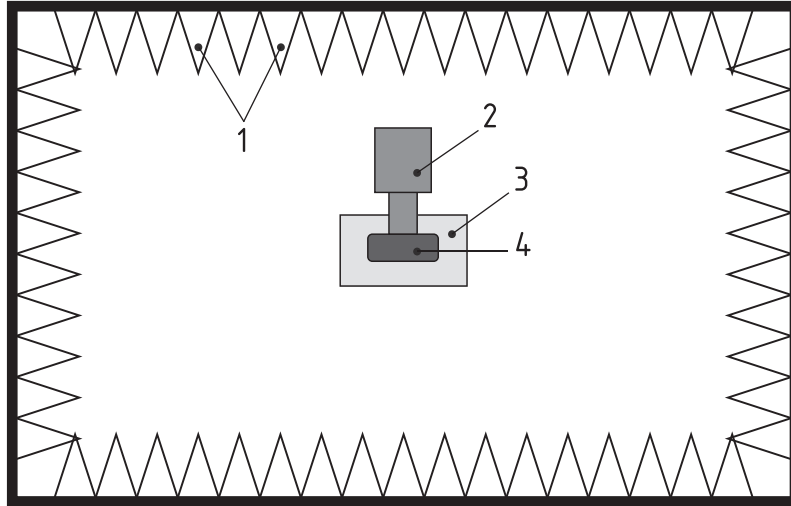
## 6 Test room requirements

### 6.1 General

One of the principal criteria of ISO 13325 for tyre sound emission measurement is testing in an acoustic free field.

To reproduce this acoustic criterion in a laboratory, the room design shall be able to provide the same effective propagation characteristics as an open space over a reflecting surface (see specifications in [6.5](#)).

One solution is a semi-anechoic chamber with absorptive materials. Several techniques are available for this purpose. An example of a test room is shown in [Figure 1](#).



- Key**
- 1 absorbing elements
  - 2 rig
  - 3 drum
  - 4 tyre

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**Figure 1 — Room example**

**6.2 Microphone array setup**

**6.2.1 General**

There are two possible microphone array setups described in [6.2.2](#) and [6.2.3](#).  
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In both setups:

- Position of each microphone is proportionally simulating a relative position of the tyre contact patch and the microphone position used in ISO 13325.
- All microphones of the array shall be located in the far field zone of the tyre noise acoustic field (see [Figure 2](#)).
- Microphones of the array shall be placed at a distance from the walls of the room at least equal to quarter-wavelength of the sound wave in the air at the lowest frequency of concern.

Origin of the coordinate system used to define microphone coordinates in both setups is the projection of tyre centre onto the drum. Axes of the coordinate system are directed as follows:

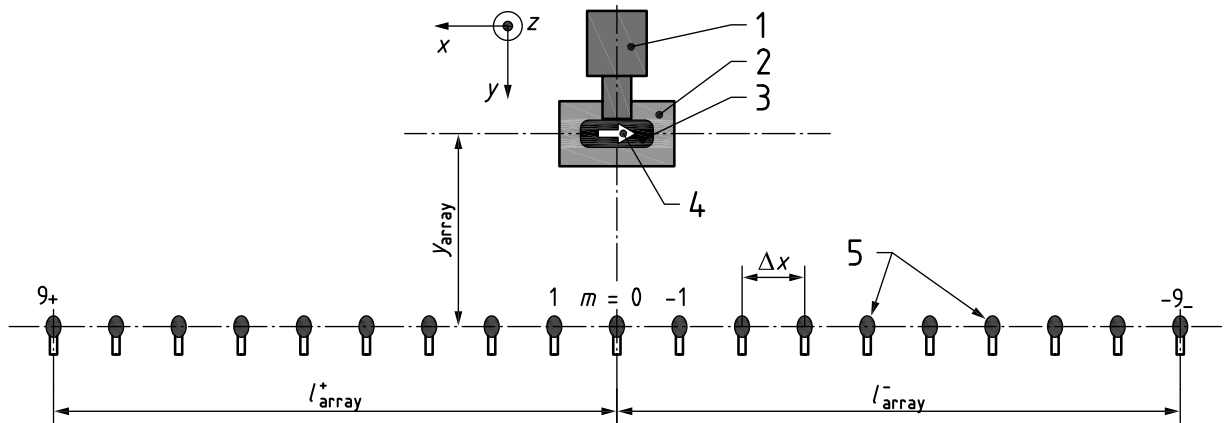
- x-axis is directed opposite to the tyre rotation direction;
- y-axis is directed along the tyre rotation axis towards the microphone array;
- z-axis is directed vertically upwards.

The microphones of the array are numbered as follows. The microphone with  $x = 0$  has number  $m = 0$ . The microphones in the positive  $x$ -direction have numbers  $m = 1, 2 \dots 9_+$  and the microphones in the negative  $x$ -direction have numbers  $m = -1, -2, \dots, -9_-$ . The total number of microphones is 19 and  $M$  is equal to 0 in all clauses.

Microphone coordinates shall be accurate to  $\pm 1$  cm.

6.2.2 Linear array

A linear array of microphones will be set on a straight line perpendicular to the tyre rotation axle at a distance  $y_{array}$  (see Figure 2). The distance  $y_{array}$  should be chosen so that all microphones are in the far field zone of the tyre noise acoustic field (see 6.3). Microphone array facing the tyre as shown in Figure 2 shall then respect the following constraints:



Key

- 1 rig
- 2 drum
- 3 tyre
- 4 rotation direction
- 5 microphones

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Figure 2 — Linear microphone array setup

<https://standards.iteh.ai/catalog/standards/sist/bcb89c4c-cf48-4d0f-af89-3574e1fc3c00/iso-20908-2023>  
All microphones of the array shall have the same  $y$ -coordinate:

$$y_m = y_{array}, \quad m = -M_- \dots M_+ \tag{1}$$

All microphones of the array shall have the same height with respect to the tyre centre (drum top) which is scaled by the distance as

$$z_m = z_{array} = Z_{CBY} \times \frac{y_{array}}{Y_{CBY}}, \quad m = -M_- \dots M_+ \tag{2}$$

With  $Z_{CBY} = 1,2$  m, as in ISO 13325 and  $Y_{CBY} = 7,5$  m is the reference distance defined in 9.2.2.