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Acoustics — Specification of test tracks for the purpose of measuring noise emitted by road vehicles and their tyres

Acoustique — Spécification des surfaces d'essai pour le mesurage du bruit émis par les véhicules routiers **et des pneus**

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Contents

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10844 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Introduction

Measurements of vehicle noise emission taken in accordance with the procedures described in ISO 362 and ISO 7188 and tyre noise in accordance with ISO 13325, can be significantly influenced by the type of road or test track surface on which the vehicles are run. In general, the road surface parameters affecting the noise emission of vehicles are the texture and sound absorption characteristics. In addition the mechanical impedance or stiffness properties of the surface layer may also influence measured noise levels.

In order to minimise the variation in vehicle and tyre noise measurements made at different testing locations it is, therefore, necessary to specify carefully the materials, design, construction and properties of the test surface.

The principal objective of the previous version of this standard was provide the specification of a surface that minimised the contribution to overall vehicle pass-by noise of the tyre/road interaction. However the reproducibility of noise measured on surfaces constructed in accordance with the previous standard was ultimately reduced as the other sources of vehicle noise were reduced exposing the tyre/road contribution. This document includes a revised specification of the surface which reduces the variability in performance and describes a second type of surface that is more representative of the effect on tyre/road noise of surfaces on roads used for high and medium speed traffic.

In addition, it is important that if the test is to provide a high degree of reproducibility between different test sites, the surface design should not only minimise the inter-site variation of tyre/road noise, but should also ensure that the propagation of noise is unaffected by the surface used. This latter consideration precludes the use of road surfaces which have open textures and which have the property of absorbing noise from the power unit and other related sources.

Acoustics — Specification of test tracks for the purpose of measuring noise emitted by road vehicles and their tyres

1 Scope

This International Standard specifies the essential properties of two test surfaces, Surfaces A and B respectively, which minimise inter-site variation in vehicle and tyre noise measurements.

In particular, both the surface designs given in this International Standard will

- produce consistent levels of tyre/road noise under a wide range of operating conditions including those appropriate to vehicle noise testing; for the first surface

- provide negligible absorption of noise from the vehicle's power unit and related sources;

- be consistent with general road-building practice.

Surface A is essentially consistent with the specifications of the previous standard, ISO10844:1994 and results in low levels of tyre/road noise under most testing conditions.

Surface B is a coarser surface and has an influence on tyre/road noise generation that is representative of that on many roads designed to carry high- and medium-speed traffic.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 362:1998, *Acoustics - Measurement of noise emitted by accelerating road vehicles - Engineering method.*

ISO 7188:1985, *Acoustics - Measurement of noise emitted by passenger cars under conditions representative of urban driving.*

ISO 10534-2:1998, *Acoustics - Determination of sound absorption coefficient and impedance in impedance tubes - Part 2: Transfer-function method*

ISO 13472-3 Acoustics -- Measurement of sound absorption properties of road surfaces in situ -- Part 3: Spot method for low absorption surfaces

ISO 13473-1:1997, *Characterisation of pavement texture profiles utilising surface profiles – Part 1: Determination of Mean Profile Depth*

ISO 13473-2:200x, *Characterisation of pavement texture profiles utilising surface profiles – Part 2: Terminology related to pavement texture profile analysis*

ISO 13473-3:200x, *Characterisation of pavement texture profiles utilising surface profiles – Part 3: Specifications and classification of profilometers*

ISO 13325:200x, Tyres – Coast-by methods for measurement of tyre/road sound emission.

EN13108-5:200x Bituminous mixtures – Material Specification –Part 5 – Stone Mastic Asphalt

3 Terms and Definitions

3.1
Sound absorption coefficient
Sound waves impinging on the road surface will be partly reflected and partly absorbed. The sound absorption coefficient a denotes that fraction of the impinging sound intensity which is absorbed in the road surface material:

$$\alpha = \frac{\text{unreflected sound intensity}}{\text{total incident sound intensity}}$$

The sound absorption coefficient is, in general, dependent on frequency and on angle of incidence. For the purposes of this International Standard, a frequency range of 400 Hz to 1600 Hz and normal incidence is assumed.

3.2
Macrotexture
deviation of a pavement surface from a true planar surface with the characteristic dimensions along the surface of 0,5 mm to 50 mm, corresponding to texture wavelengths with one-third-octave bands including the range 0,63 mm to 50 mm of centre wavelengths

NOTE 1 Peak-to-peak amplitudes may normally vary in the range 0,1 mm to 20 mm. This type of texture is the texture which has wavelengths of the same order of size as tyre tread elements in the tyre/road interface. Surfaces are normally designed with a sufficient macrotexture to obtain a suitable water drainage in the tyre/road interface. The macrotexture is obtained by suitable proportioning of the aggregate and mortar of the mix or by surface finishing techniques.

3.3
megatexture
deviation of a pavement surface from a true planar surface with the characteristic dimensions along the surface of 50 mm to 500 mm, corresponding to texture wavelengths with one-third-octave bands including the range 63 mm to 500 mm of centre wavelengths

NOTE Peak-to-peak amplitudes normally vary in the range 0,1 mm to 50 mm. This type of texture is the texture which has wavelengths in the same order of size as a tyre/road interface and is often created by potholes or 'waviness'. It is usually an unwanted characteristic resulting from defects in the surface. Surface roughness with longer wavelengths than megatexture is referred to as unevenness.

3.4
Gradient and Crossfall
Gradient is the percentage change in elevation measured along the longitudinal axis of the test site. The crossfall is the lateral gradient of the test surface. Both parameters are measured in percent.

3.5
Uneveness
deviation of a pavement surface from a true planar surface with the characteristic dimensions along the surface of 0,5 m to 50 m, corresponding to wavelengths with one-third-octave bands including the range 0,63 m to 50 m of centre wavelengths

NOTE 1 Pavement characteristics at longer wavelengths than 0,5 m are considered to be above that of texture and are referred to here as unevenness. For airfield applications, even longer wavelengths than 50 m would be considered.

NOTE 2 Longitudinal unevenness is a type of surface roughness which, through vibrations, affects ride comfort in and road holding of vehicles. Transverse unevenness, due to for example rutting, affects safety through lateral instability and water accumulation.

3.6
Mean Profile Depth, MPD
the average value of the height difference between the profile and a horizontal line through the highest peak (the peak level) over a 100 mm long baseline as shown in Figure 1

NOTE 1 Profile depth is normally expressed in millimetres(mm).

NOTE 2 Whereas texture depth and mean texture depth both refer to a three-dimensional case, the term profile depth refers to a two-dimensional case, i.e. when studying a profile.

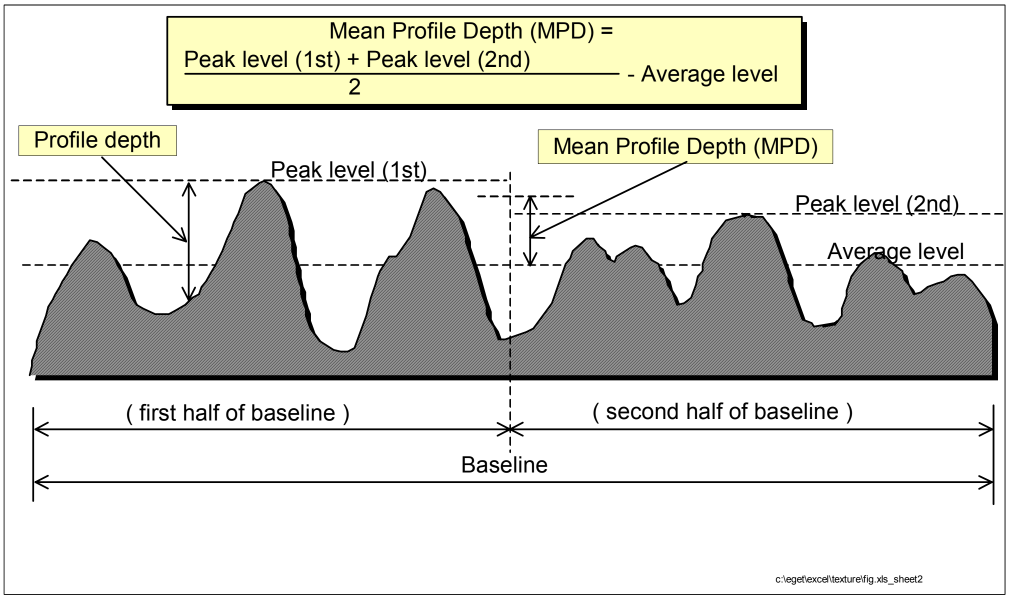

Figure 1 — Illustration of average level, peak level and Mean Profile Depth (MPD)

3.7
texture profile level
$L_{tx,\lambda}$ or $L_{TX,\lambda}$
logarithmic transformation of an amplitude representation of a profile curve $Z(x)$, the latter expressed as a root mean square value, in accordance with the following formula:

$$L_{tx,\lambda} \text{ or } L_{TX,\lambda} = 20 \lg a_\lambda / a_{ref} \text{ dB} \qquad (6)$$

where

$L_{tx,\lambda}$ = texture profile level (dB re 10^{-6} m)

a_λ = root mean square value (m)

a_{ref} = reference root mean square value = 10^{-6} (m)

λ = subscript indicating a value obtained with a one-third-octave band filter having centre wavelength λ (see 4.4)

and where $L_{TX,\lambda}$ (TX written as capitals) is equivalent to the above but for octave band filters (see 4.4).

NOTE 1 Texture profile level is normally expressed in decibels relative to a reference level of 10^{-6} metres (dB re 10^{-6} m).

NOTE 2 Texture amplitudes expressed as root mean square values, whether filtered or not, may have a range of several magnitudes; typically 10^{-5} m to 10^{-2} m. Spectral characterization of signals is used frequently in studies of acoustics, vibrations, and electrotechnical engineering. In all those fields it is most common to use logarithmic amplitude scales. The same approach is preferred in this standard.

NOTE 3 Texture profile levels in practical pavement engineering typically range between 20 dB and 80 dB with these definitions.

4 Basic test surface design

4.1 Area

When designing the test track layout, it is important to ensure that, as a minimum requirement, the area traversed by the vehicles running through the test strip is covered with the specified test material with suitable margins for safe and practical driving. Therefore the width of the track shall be at least 3 m and the length of the track shall extend beyond lines AA and BB (see figure 1) by at least 10 m at either end. Figure 1 shows a plan of a suitable test site and indicates the minimum area which shall be machine laid and machine compacted with the specified test surface material.

ISO 362 and ISO 7188 require measurements to be carried out on both sides of the vehicle. This can be done either by measuring with two microphone locations (one on each side of the track) and driving in one direction, or measuring with a microphone only on one side of the track but driving the vehicle in two directions. If the former method is used, the requirements of figure 1 shall be observed. If the latter method is used, then there are no surface requirements outside of the wheeltrack on that side of the track where there is no microphone.

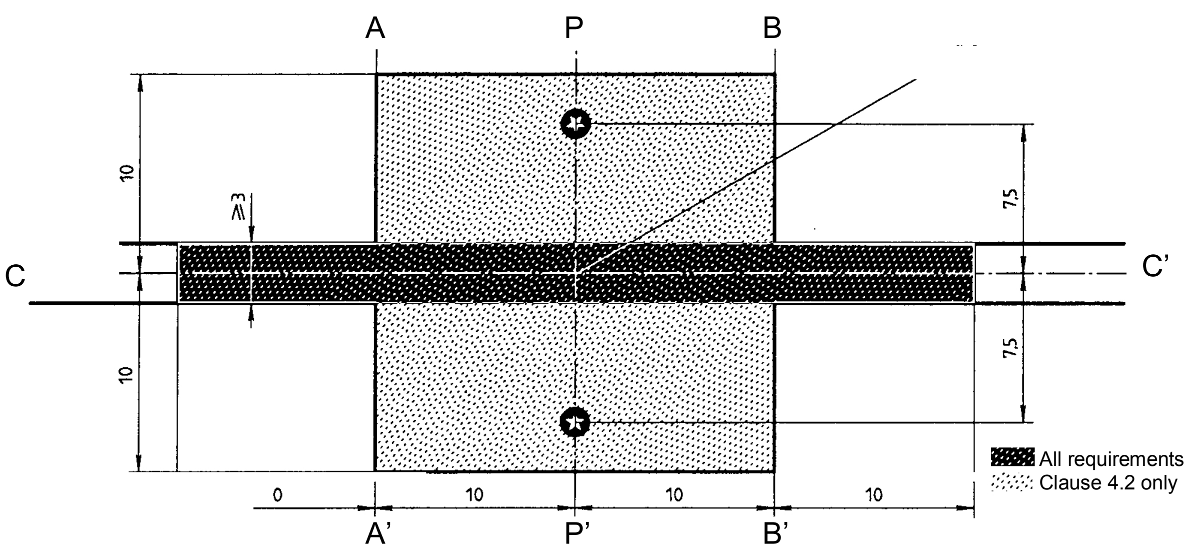

Figure 1 – Minimum requirements for test surface area

4.2 Design requirements for the surfaces

The material laid in the wheeltrack area of each test surface shall be a dense asphaltic concrete with a wearing course of a single layer ≥ 30 mm thick. The nominal maximum chipping size for Surface A shall be 8 mm and for

Surface B, 14 mm. The surface in the wheeltrack area shall be compacted sufficiently such that the acoustical aborption and texture characteriscts meet the requirements of Clause 6.1

The material laid in aprons of the test surface shall be sufficiently dense to reduce absorption coeffient to the require,emts of 6.1 although texture characteristics are not specified for this area. The material in each apron may treated with an appropriate sealing compund to reduce absorpton to the required levels.

The test area shall be essentially flat and level and gradient, measured along line CC' and crossfall measured along line PP' within the tolerances of Clause 6.2.

5 Test methods

5.1 Sound absorption coefficient

The sound absorption coefficient (normal incidence) shall be measured by the impedance tube method using the procedure specified in ISO 13472-3. Measure the sound absorption in the range between 400 Hz and 800 Hz and in the range between 800 Hz and 1600 Hz (at least at the centre frequencies of the third-octave bands) and identify the maximum and average values for both of these frequency ranges. Then average these values, for all test cores, to constitute the final result.

If the highest value is obtained at 800 Hz, this value shall be retained for one of the frequency bands only.

5.2 Texture profile measurement

Measurements of texture profile shall be made in each wheeltrack with a laser profilometer as described in ISO 13473-3 :200x. The Profile measurements shall cover a total distance of not less than 50%, ie 10 m, evenly distributed in each wheel track between lines AA' and BB'.

5.3 Surface uneveness, gradient and crossfall

Measurements shall be made with an appropriate system along lines CC' and PP'

6 Required characteristics of the surfaces

A surface is considered to conform to the requirements of this International Standard if it meets the requirements shown in Table 1.

		Surface type	
		A	**B**
Sound Absorption Coeff	Max 400-800Hz	<0.1	<0.1
	Mean 400-800Hz	<0.1	<0.1
	Max 800-1600Hz	<0.1	<0.1
	Mean 400-800Hz	<0.1	<0.1
Mean Profile Depth, mm		>0.25	>1.0
Texture Profile level, dB	$L_{TX,63}$	[40 +/- 3]	[52 +/- 3]
	$L_{TX,4}$	[43 +/- 3]	[45 +/- 3]
Gradient, %		<2%	<2%
Crossfall, %		<2%	<2%

6.1 Homogeneity of the surface

The surface shall be made as homogeneous as possible within the test area.

NOTE This includes the texture and voids content, but it should also be observed that if the rolling process results in more effective rolling at some places than at others, the texture may be different and unevenness causing bumps may also occur.

6.2 Period of testing

In order to confirm that the surface continues to conform to the texture and sound absorption requirements stipulated in this International Standard, periodic testing of the surface(s) shall be carried out at the following intervals.

a) For sound absorption:

- when the surface is new;
- if the surface meets the requirement when new, no further periodic testing is required; if it does not meet the requirement when it is new, it may do so later because surfaces tend to become clogged and compacted with time.
- if the surface has been cleaned and/or retextured

b) For gradient and crossfall

- when the surface is new;

c) For texture characteristics (including uneveness)

- when the surface is new;

- when the noise testing starts (NB: not before 4 weeks after laying); and
- then every 12 months.

7 Stability with time and maintenance

7.1 Influence of age

In common with many other surfaces, it is expected that the tyre/road noise levels measured on the test surface may increase slightly during the first 6 to 12 months after construction.

The surface will achieve its required characteristics not earlier than 4 weeks after construction. The influence of age on the noise from trucks is generally less than that from cars.

The stability over time occurs mainly from polishing and compaction by vehicles driving on the surface. It shall be periodically checked as specified in 4.5.

7.2 Maintenance of the surface

It is essential that loose debris or dust which could significantly reduce the effective texture depth be removed from the surface. In countries with winter climates, salt is sometimes used for de-icing. Salt may alter the surface temporarily or even permanently in such a way as to increase noise and is therefore not recommended.

7.3 Repaving the test area

If it is necessary to repave the test track, it is usually unnecessary to repave more than the test strip (of 3 m width, see figure 1) where vehicles are driving, provided the test area outside the strip met the requirement for sound absorption when it was measured.

8 Documentation of the surface and of tests performed on it

8.1 Documentation of the test surface

The following data shall be given in a document describing the test surface.

a) The location of the test track.

b) Type of binder, binder hardness, type of aggregate, maximum theoretical density of the concrete (ρ_R), thickness of the wearing course and grading curve determined from cores from the test track.

c) Method of compaction (e.g. type of roller, roller mass, number of passes).

d) Temperature of the mix, temperature of the ambient air and wind speed during laying of the surface.

e) Date when the surface was laid and name of contractor.

f) All or at least the latest test result, including

1) the residual voids content of each core;

2) the locations in the test area where the cores for voids measurement have been taken;

3) the sound absorption coefficient of each core (if measured); specify the results both for each core and each frequency range as well as the overall average;

4) the locations in the test area where the cores for absorption measurement have been taken;

5) texture depth, including the number of tests and standard deviation;

6) the institution responsible for tests 1) and 3) and the type of equipment used;

7) date of the test(s) and date when the cores were taken from the test track.

8.2 Documentation of vehicle noise tests conducted on the surface

In the document describing the vehicle noise test(s) it shall be stated whether all the requirements of this International Standard were fulfilled or not. Reference shall be given to a document according to 8.1 describing the test results, which verify this.

Annex A
(informative)

General considerations

A.1 Road surface factors affecting noise generation

For non-porous surfaces, tyre/road noise is controlled by the texture characteristics of the road surface. In general, reducing the overall texture from a high level will tend to reduce tyre/road noise, although for smooth road surfaces tyre noise can be high, partly due to the excitation of tyre tread pattern resonances. Accordingly, to minimize tyre/road noise, the surface should have just sufficient texture to avoid these resonances.

For porous surfaces, the sound absorption of the road affects both the rolling noise sources on the vehicle and the noise generated by the power unit. Consequently, in order to minimize the influence of the road surface on the propagation of power unit noise, the surface should be of a reflective material, thereby minimizing the degree of acoustic absorption in the surface.

The mechanical impedance of the road surface can change both as a result of ageing of the binder and other materials and as a result of changes of the temperature of the surface layer. In general, the noise level will tend to increase as the stiffness of the surface layer increases. Consequently, it is important to consider carefully the choice of binder and binder viscosity to minimize variations in the stiffness characteristics due to temperature and ageing effects.

A.2 Tyre influence on vehicle noise emission

It is beyond the scope of this International Standard to consider the specification of the vehicles' tyres, but clearly the construction and design of the tyres can influence the overall noise level emitted by a vehicle during a noise test. However, for current generation tyres, provided the dimensions are similar, the range of vehicle noise caused by differences in tyre design is generally smaller than that produced by differences in the road surface design.

A.3 Road surface safety

The surface specified in this International Standard has been designed to be broadly equivalent to road surfaces which provide adequate skidding performance at low to moderate vehicle speeds under both wet and dry conditions, and it is, therefore, considered to be similar to road surfaces located in many urban streets where vehicle speeds are not allowed to exceed, say, 60 km/h. However, it is not representative of road surfaces designed for higher speed applications, such as motorways, as the surface is relatively smooth at the texture wavelengths which affect wet skidding performance at higher vehicle speeds.

It follows that the skidding performance and hence safety of the standard surface is entirely adequate for vehicle tests carried out under the relatively low vehicle speed ranges required as part of the ISO vehicle noise test procedures.

A.4 Sound absorption

Experiments have shown that the sound absorption of a road surface, as caused by air voids in the surface layer, may influence vehicle noise during vehicle operation in accordance with ISO 362 and ISO 7188 more than other road surface characteristics. In addition, surfaces with significant porosity have been found to be result in variable acoustic performance under different meteorological conditions, partcially following any raindfall even after the surface is superficially dry. It follows that sound absorption in this International Standard has to be low enough to be negligible and limits are given to ensure this.

The porosity of a test surface influences the measured vehicle noise level to a large degree. This is due to two effects:

- the tyre/road noise generation is reduced since the air pressure gradients in the tyre tread are reduced when there is an air drainage; and

- porosity in the surface reduces the sound energy reflected from the surface and also influences the sound propagation.

The second effect also affects vehicle noise other than tyre/road noise. It has been noted that the second effect has the greater effect on the overall noise at the driving conditions used in ISO 362 and IS07188.

In order to limit the effect of porosity, maximum limits of sound absorption have been established. This should be measured using the procedure of ISO 13472-3 .

A.5 Comments regarding surface texture

The design is governed by the desire to enable testing of noise from both light and heavy vehicles with minimum influence and variability due to tyre/road noise. It is important not to have too smooth a texture for cars, since then the tyre noise may be influenced by tyre resonances and by the type of tyre, and to have a rougher texture for trucks and buses. For heavy vehicle tyres, it has been shown that both the absolute noise levels and the differences between tyres are less if the surface texture is relatively rough. See, for example, ref. [15].

Therefore, if the planned testing is mainly of cars, a mean texture depth (MTD) value located towards the lower end of the permitted range may be desirable and if the testing is mainly concerned with heavy vehicles, the value of MTD would better be chosen as high as attainable in practice. However, the extent to which the texture depth can be predetermined and controlled during construction is limited, as the higher priority is to ensure, by adequate compaction of the surface, that the void volume is reduced below the target level given in the specification in order to ensure that the finished surface does not have significant acoustical absorption properties.

A.6 Road surface characteristics other than texture and absorption

As mentioned already in C.1, studies of the influence of tyre/road noise of road surface characteristics have shown that apart from texture and absorption the following characteristics may be of importance:

- friction, and

- stiffness (mechanical impedance).

To measure and to specify limits for these characteristics would complicate this International Standard very much. However, by the use of this test surface the problems are handled as follows.

a) The texture of the surface as well as the PSV value of the aggregate are chosen such that they should give a relatively high friction. The variability in friction which can be expected when the requirements here are fulfilled is expected to be small enough to have a negligible noise influence.

b) As mentioned in C.1, the stiffness of the surface is affected principally by the temperature of the surface and the age of the binder. The influence of age of the binder is noted in 7.1. The influence of temperature on stiffness is presently uncertain but is thought to be small.

In order to limit the influence of stiffness, the surface is said to be satisfactory for noise testing no earlier than 4 weeks after construction (see 7.1).

Bibliography