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PROPOSAL FOR A NEW DRAFT REGULATION: UNIFORM PROVISIONS CONCERNING THE APPROVAL OF TYRES WITH REGARD TO ROLLING SOUND EMISSIONS

Transmitted by the secretariat

Note: The text reproduced below was prepared by the secretariat and contains the test method for tyre/road sound levels and the specifications for the test site which were agreed by GRB. It is based on the prescriptions contained in appendix 1 and 2 to document TRANS/WP.29/GRB/R.141/Rev.1, as amended during the thirtieth session of GRB (TRANS/WP.29/GRB/28, para. 19 and annex 3).

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Note: This document is distributed to the Experts on Noise only.

Annex 3

TEST METHOD FOR TYRE-ROAD SOUND LEVELS

COAST-BY METHOD

0. Introduction

The presented method contains specifications on measuring instruments, measurement conditions and the measurement method, in order to obtain the noise level of a set of tyres mounted on a test vehicle rolling at high speed on a specified road surface. The maximum sound pressure level is to be recorded, when the test vehicle is coasting, by remote-field microphones; the final result for a reference speed is obtained from a linear regression analysis. Such test results cannot be related to tyre noise measured during acceleration under power or deceleration during braking.

1. Measuring instruments

1.1. Acoustic measurements

The sound level meter or the equivalent measuring system, including the windscreen recommended by the manufacturer shall at least meet the requirements of Type 1 instruments in accordance with IEC 60651, second edition.

The measurements shall be made using the frequency weighting A, and the time weighting F.

When using a system that includes a periodic monitoring of the A-weighted sound level, a reading should be made at a time interval not greater than 30 ms.

1.1.1. Calibration

At the beginning and at the end of every measurement session, the entire measurement system shall be checked by means of a sound calibrator that fulfils the requirements for sound calibrators of at least precision Class 1 according to IEC 942:1988. Without any further adjustment the difference between the readings of two consecutive checks shall be less than or equal to 0.5 dB. If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

1.1.2. Compliance with requirements

The compliance of the sound calibration device with the requirements of IEC 60942:1988 shall be verified once a year and the compliance of the instrumentation system with the requirements of IEC 60651:1979/A1:1993, second edition shall be verified at least every two years, by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

1.1.3. Positioning of the microphone

The microphone (or microphones) must be located at a distance of 7.5 m ± 0.05 m from track reference line CC′ (figure 1) and 1.2 m ± 0.02 m above the ground. Its axis of maximum sensitivity must be horizontal and perpendicular to the path of the vehicle (line CC′).

1.2. Speed measurements

The vehicle speed shall be measured with instruments with an accuracy of ± 1 km/h or better when the front end of the vehicle has reached line PP′ (figure 1).

1.3. Temperature measurements

Measurements of air as well as test surface temperature are mandatory. The temperature measuring devices shall be accurate within ± 1°C.

1.3.1. Air temperature

The temperature sensor is to be positioned in an unobstructed location close to the microphone in such a way that it is exposed to the airflow and protected from direct solar radiation. The latter may be achieved by any shading screen or similar device. The sensor should be positioned at a height of 1.2 m ± 0.1 m above the test surface level, to minimize the influence of the test surface thermal radiation at low airflows.

1.3.2. Test surface temperature

The temperature sensor is to be positioned in a location where the temperature measured is representative of the temperature in the wheel tracks, without interfering with the sound measurement.

If an instrument with a contact temperature sensor is used, heat-conductive paste shall be applied between the surface and the sensor to ensure adequate thermal contact.

If a radiation thermometer (pyrometer) is used, the height should be chosen to ensure that a measuring spot with a diameter of ≥ 0.1 m is covered.

1.4. Wind measurement

The device must be capable of measuring the wind speed with a tolerance of ± 1 m/s. The wind shall be measured at microphone height. The wind direction with reference to the driving direction shall be recorded.

2. Conditions of measurement

2.1. Test site

The test site must consist of a central section surrounded by a substantially flat test area. The measuring section must be level; the test surface must be dry and clean for all measurements. The test surface shall not be artificially cooled during or prior the testing.

The test track must be such that the conditions of a free sound field between the sound source and the microphone are attained to within 1 dB(A). These conditions shall be deemed to be met if there are no large sound reflecting objects such as fences, rocks, bridges or building within 50 m of the centre of the measuring section. The surface of the test track and the dimensions of the test site shall be in accordance with appendix 2 of this annex.

A central part of at least 10 m radius shall be free of powdery snow, tall grass, loose soil, cinders or the like. There must be no obstacle which could affect the sound field within the vicinity of the microphone and no persons shall stand between the microphone and the sound source. The operator carrying out the measurements and any observers attending the measurements must position themselves so as not to affect the readings of the measuring instruments.

2.2. Meteorological conditions

Measurements shall not be made under poor atmospheric conditions. It must be ensured that the results are not affected by gusts of wind. Testing shall not be performed if the wind speed at the microphone height exceeds 5 m/s.

Measurements shall not be made if the air temperature is below 5 °C or above 40 °C or the test surface temperature is below 5°C or above 50 °C.

2.3. Ambient noise

The background sound level (including any wind noise) shall be at least 10 dB(A) less than the measured tyre-road sound emission. A suitable windscreen may be fitted to the microphone provided that account is taken of its effect on the sensitivity and directional characteristics of the microphone.

Any measurement affected by a sound peak which appears to be unrelated to the characteristics of the general sound level of tyres, shall be ignored.

2.4. Test vehicle requirements

2.4.1. General

The test vehicle shall be a motor vehicle and be fitted with four single tyres on just two axles.

2.4.2. Vehicle load

The vehicle must be loaded such as to comply with the test tyre loads as specified in paragraph 2.5.2. below.

2.4.3. Wheelbase

The wheelbase between the two axles fitted with the test tyres shall for Class C1 be less than 3.50 m and for Class C2 and Class C3 tyres be less than 5 m.

2.4.4. Measures to minimize vehicle influence on sound level measurements

To ensure that tyre noise is not significantly affected by the test vehicle design the following requirements and recommendations are given.

Requirements:

(a) Spray suppression flaps or other extra device to suppress spray shall not be fitted.

(b) Addition or retention of elements in the immediate vicinity of the rims and tyres, which may screen the emitted sound, is not permitted.

(c) Wheel alignment (toe in, camber and caster) shall be in full accordance with the vehicle manufacturer's recommendations.

(d) Additional sound absorbing material may not be mounted in the wheel housings or under the underbody.

(e) Suspension shall be in such a condition that it does not result in an abnormal reduction in ground clearance when the vehicle is loaded in accordance with the testing requirement. If available, body level regulation systems shall be adjusted to give a ground clearance during testing which is normal for unladen condition.

Recommendations to avoid parasitic sound:

(a) Removal or modification of components on the vehicle that may contribute to the background sound of the vehicle is recommended. Any removals or modifications shall be recorded in the test report.

(b) During testing it should be ascertained that brakes are not poorly released, causing brake noise.

(c) It should be ascertained that electric cooling fans are not operating.

(d) Windows and sliding roof of the vehicle shall be closed during testing.

2.5. Tyres

2.5.1. General

Four identical tyres shall be fitted on the test vehicle. Tyres with special fitting requirements shall be tested in accordance with these requirements (e.g. rotation direction). The tyres shall have full tread depth prior to run-in.

Tyres are to be tested on rims permitted by the tyre manufacturer.

2.5.2. Tyre loads

The test load Q_t for each tyre on the test vehicle shall be 50 % to 90 % of the reference load Q_r, but the average test load $Q_{t,avr}$ of all tyres shall be 75 % ± 5 % of the reference load Q_r.

For all tyres the reference load Q_r corresponds to the maximum mass associated with the load capacity index of the tyre. In the case where the load capacity index is constituted by two numbers divided by slash (/), reference shall be made to the first number.

2.5.3. Tyre inflation pressure

Each tyre fitted on the test vehicle shall have a test pressure P_t not higher than the reference pressure P_r and within the interval:

$$P_r \, (Q_t/Q_r)^{1.25} \leq P_t \leq 1.1 \, P_r \, (Q_t/Q_r)^{1.25}$$

where P_r is the pressure corresponding to the pressure index marked on the sidewall.

For Class C1 the reference pressure is Pr = 250 kPa for “standard” tyres and 290 kPa for “reinforced” tyres.

The minimum test pressure shall be P_t = 150 kPa.

2.5.4. Preparations prior to testing

The tyres should be "run-in" prior to testing to remove compound nodules or other tyre pattern characteristics resulting from the moulding process. This will normally require the equivalent of about 100 km of normal use on the road.

The tyres fitted to the test vehicle shall rotate in the same direction as when they were run-in.

Prior to testing tyres shall be warmed up by running under test conditions.

3. Method of testing

3.1. General conditions

For all measurements the vehicle must be driven in a straight line over the measuring section (AA’ to BB’) in such a way that the median longitudinal plane of the vehicle is as close as possible to the line CC’.

When the front end of the test vehicle has reached the line AA’, the vehicle’s driver must have put the gear selector on neutral position and switched off the engine. If abnormal noise (e.g. ventilator, self-ignition) is emitted by the test vehicle during the measurement, the test must be repeated.

3.2. Nature and number of measurements

The maximum sound level expressed in A-weighted decibels (dB(A)) shall be measured as the vehicle is coasting between lines AA’ and BB’ (figure 1 - front end of the vehicle on line AA’, rear end of the vehicle on line BB’). This value will constitute the result of the measurement.

At least four measurements shall be made on each side of the test vehicle at test speeds lower than the reference speed specified in paragraph 4.2. and at least four measurements at test speeds higher

than the reference speed. The speeds shall be approximately equally spaced over the speed range specified in paragraph 3.3.

3.3. Test speeds

The test vehicle speeds shall be within the range:

(i) from 70 km/h to 90 km/h for Class C1 and Class C2 tyres;

(ii) from 60 km/h to 80 km/h for Class C3 tyres.

4. Interpretation of results

The measurement shall be invalid if an abnormal discrepancy between the maximum value and the other values is recorded.

4.1. Determination of test result

Reference speed V_{ref} used to determine the final result will be:

(i) 80 km/h for Class C1 and Class C2 tyres,

(ii) 70 km/h for Class C3 tyres.

4.2. Regression analysis of noise measurements

The (not temperature corrected) tyre-road noise level L_R in dB(A) is determined by a regression analysis according to:

where:

$$L_R = \overline{L} - a \cdot \overline{\nu}$$

$\overline{L}$ is the mean value of the noise levels L_i, measured in dB(A):

$$\overline{L} = \frac{1}{n} \sum_{i=1}^{n} L_i,$$

n is the measurement number ($n \geq 16$),

$\overline{\nu}$ is the mean value of logarithms of speeds ν_i:

$$\overline{\nu} = \frac{1}{n} \sum_{i=1}^{n} \nu_i \quad \text{with } \nu_i = \lg(V_i / V_{ref}),$$

a is the slope of the regression line in dB(A):

$$a = \frac{\sum_{i=1}^{n} (v_i - \bar{v})(L_i - \bar{L})}{\sum_{i=1}^{n} (v_i - \bar{v})^2}$$

4.3. Temperature correction

For Class C2 tyres, the final result shall be normalized to a test surface reference temperature h_{ref} by applying a temperature correction, according to the following:

$$L_R(h_{ref}) = L_R(h) + K(h_{ref} - h)$$

where h = the measured test surface temperature,
h_{ref} = 20 °C,

For Class C1 tyres, the coefficient K is -0.03 dB(A)/°C when $h > h_{ref}$ and -0.06 dB(A)/ °C when $h < h_{ref}$.
For Class C2 tyres, the coefficient K is -0.02 dB(A)/°C

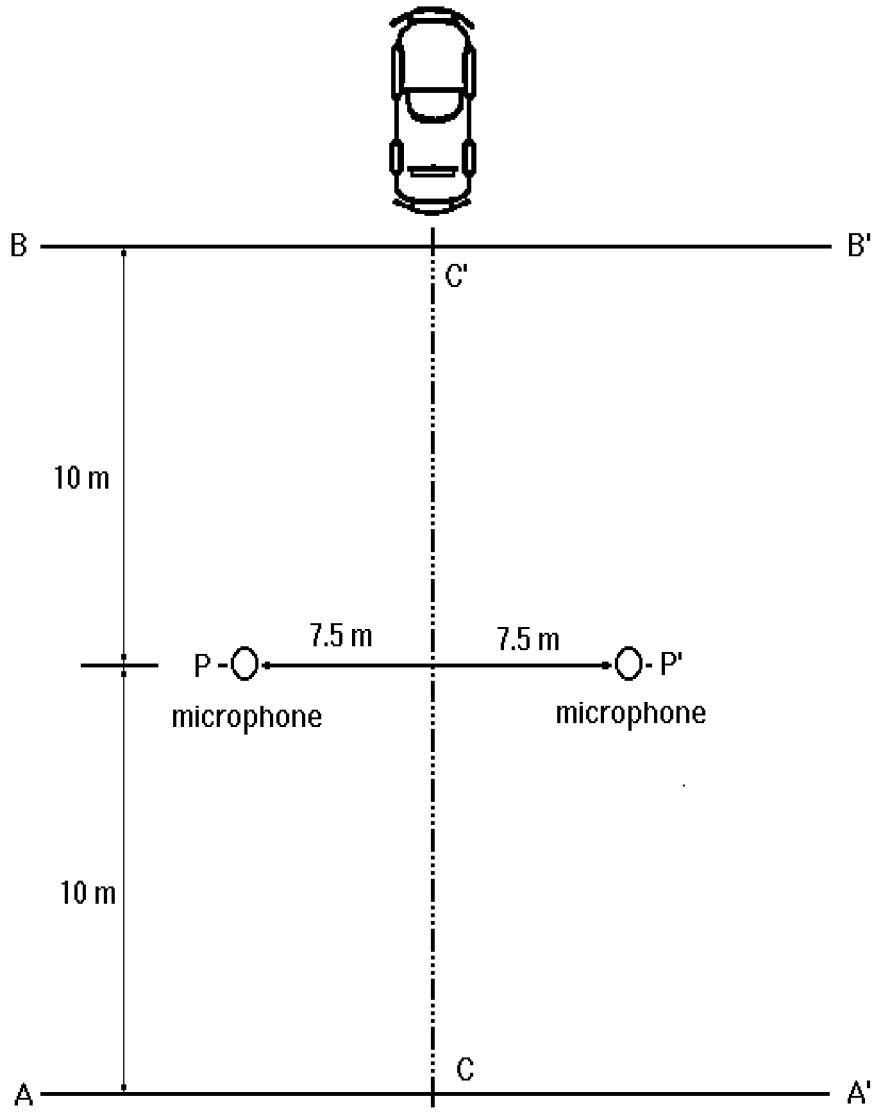
If the measured test surface temperature does not change more than 5 °C within all measurements necessary for the determination of the sound level of one set of tyres, the temperature correction may be made only on the final reported tyre-road sound level as indicated above, utilizing the arithmetic mean value of the measured temperatures. Otherwise each measured sound level L_i shall be corrected, utilizing the temperature at the time of the sound recording.

There will be no temperature correction for Class C3 tyres.

[4.4. In order to take account of any measuring instrument inaccuracies, the results according to paragraph 4.3. shall be reduced by 1 dB(A).]

[4.5. The final result, the temperature corrected tyre-road noise level $L_R(h_{ref})$ in dB(A), shall be rounded [down] to the nearest [lower] whole value.]

Figure 1: Microphone Positions for the Measurement



Annex 3 - Appendix

TEST REPORT

The test report shall include the following information:

(a) meteorological conditions inclusive air and test surface temperature,

(b) date and method of check of compliance of the test surface with ISO 10844:1994,

(c) test rim width,

(d) tyre data: manufacturer, brand name, trade name, size, load index, reference pressure,

(e) test vehicle description and wheelbase,

(f) tyre test load Q_t in N and in per cent of the reference load Q_r for each test tyre,
average test load $Q_{t,avr}$ in N and in per cent of the reference load Q_r,

(g) cold inflation pressure in kPa for each test tyre,

(h) test speeds when the vehicle passed line PP’,

(i) maximum A-weighted sound levels for each coast-by and each microphone,

(j) the test result L_R: A-weighted sound level in decibel at reference speed, corrected for temperature (if applicable), expressed to one decimal place.

(k) regression line slope.

Annex 4

SPECIFICATIONS FOR THE TEST SITE

1. Introduction

This appendix describes the specifications relating to the physical characteristics and the laying of the test track. These specifications based on a special standard 1/ describe the required physical characteristics as well as the test methods for these characteristics.

2. Required characteristics of the surface

A surface is considered to conform to this standard provided that the texture and voids content or sound absorption coefficient have been measured and found to fulfil all the requirements of paragraphs 2.1. to 2.4. below and provided that the design requirements (para.3.2.) have been met.

2.1. Residual voids content

The residual voids content (*VC*) of the test track paving mixture shall not exceed 8%. For the measurement procedure, see paragraph 4.1.

2.2. Sound absorption coefficient

If the surface fails to comply with the residual voids content requirement, the surface is acceptable only if its sound absorption coefficient " $\leq$ 0.10. For the measurement procedure, see paragraph 4.2. The requirement of paragraphs 2.1. and 2.2. is met also if only sound absorption has been measured and found to be " $\leq$ 0.10.

Note: The most relevant characteristic is the sound absorption, although the residual voids content is more familiar among road constructors. However, sound absorption needs to be measured only if the surface fails to comply with the voids requirement. This is motivated because the latter is connected with relatively large uncertainties in terms of both measurements and relevance and some surfaces therefore erroneously may be rejected when based only on the voids measurement.

2.3. Texture depth

The texture depth (TD) measured according to the volumetric method (see paragraph 4.3. below) shall be:

$$TD \geq 0.4 \text{ mm}$$

1/ ISO 10844:1994 If a different test surface is defined, in the future, the reference standard will be amended accordingly.

2.4. Homogeneity of the surface

Every practical effort shall be taken to ensure that the surface is made to be as homogeneous as possible within the test area. 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 others, the texture may be different and unevenness causing bumps may also occur.

2.5. Period of testing

In order to check whether the surface continues to conform to the texture and voids content or sound absorption requirements stipulated in this standard, periodic testing of the surface shall be done at the following intervals:

(a) For residual voids content *(VC)* or sound absorption *(")*:

when the surface is new;

if the surface meets the requirements when new, no further periodical testing is required. If it does not meet the requirement when it is new, it may do later because surfaces tend to become clogged and compacted with time.

(b) For texture depth (TD):

when the surface is new;

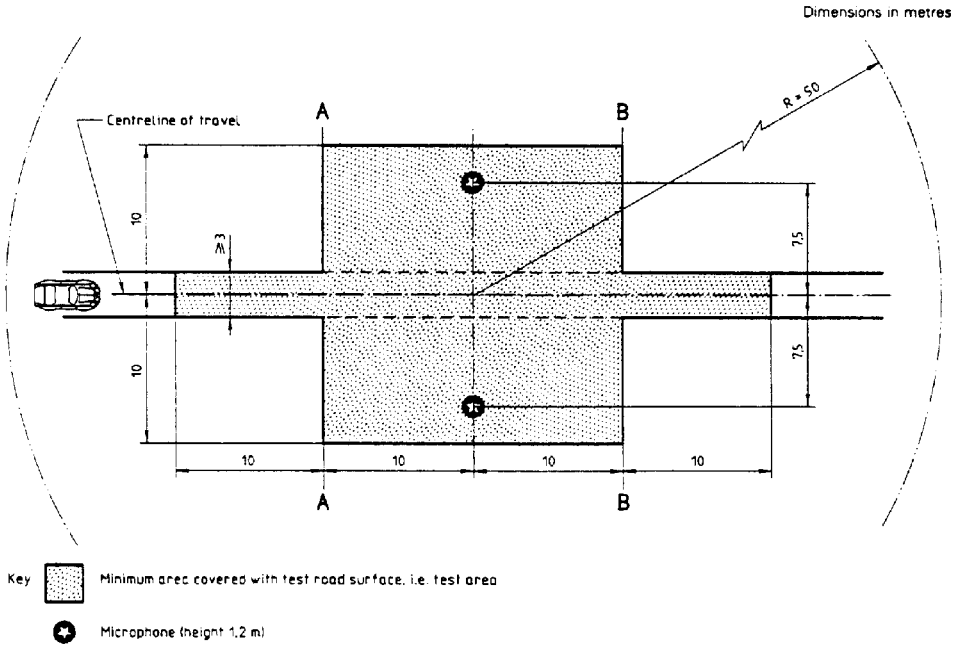
when the noise testing starts (NB: not before four weeks after laying);

then every twelve months.

3. Test surface design

3.1. 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. This will require that the width of the track is at least 3 m and the length of the track extends beyond lines AA and BB 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. According to annex *9, appendix 1*, paragraph 3.*2.*, measurements have to be made on each side of the vehicle. This can be made 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 latter method is used, then there are no surface requirements on that side of the track where there is no microphone.



NOTE — There shall be no large acoustically reflective objects within this radius.

Figure 1: Minimum requirements for test surface area
The shaded part is called "Test Area".

3.2. Design and preparation of the surface

3.2.1. Basic design requirements

The test surface shall meet four design requirements:

3.2.1.1. It shall be a dense asphaltic concrete.

3.2.1.2. The maximum chipping size shall be 8 mm (tolerances allow from 6.3 mm to 10 mm).

3.2.1.3. The thickness of the wearing course shall be ≥ 30 mm.

3.2.1.4. The binder shall be a straight penetration grade bitumen without modification.

3.2.2. Design guidelines

As a guide to the surface constructor, an aggregate grading curve which will give desired characteristics is shown in Figure 2. In addition, Table 1 gives some guidelines in order to obtain the desired texture and durability. The grading curve fits the following formula:

$$P\ (\%\ passing) = 100 \cdot (d/d_{max})1/2$$

where:

d = square mesh sieve size, in mm
d_{max} = 8 mm for the mean curve
= 10 mm for the lower tolerance curve
= 6.3 mm for the upper tolerance curve

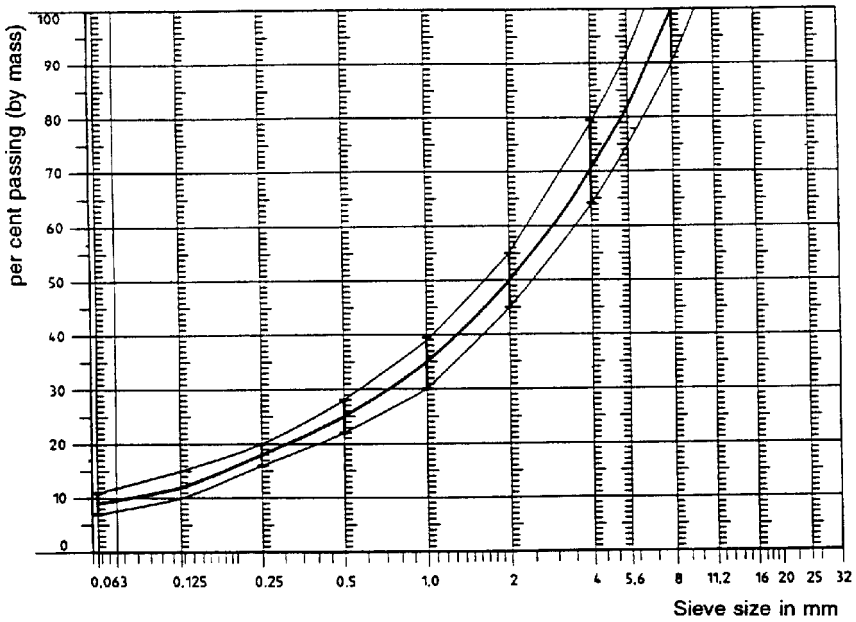


Figure 2: Grading curve of the aggregate in the asphaltic mix with tolerances.

In addition to the above, the following recommendations are given:

(a) The sand fraction (0.063 mm < square mesh sieve size < 2 mm) shall include no more than 55% natural sand and at least 45% crushed sand.

(b) The base and sub-base shall ensure a good stability and evenness, according to best road construction practice.

(c) The chippings shall be crushed (100% crushed faces) and of a material with a high resistance to crushing.

(d) The chippings used in the mix shall be washed.

(e) No extra chippings shall be added onto the surface.

(f) The binder hardness expressed as PEN value shall be 40-60, 60-80 or even 80-100 depending on the climatic conditions of the country. The rule is that as hard a binder as possible shall be used, provided this is consistent with common practice.

(g) The temperature of the mix before rolling shall be chosen so as to achieve by subsequent rolling the required voids content. In order to increase the probability of satisfying the specifications of paragraphs 2.1. to 2.4. above, the compactness shall be studied not only by an appropriate choice of mixing temperature, but also by an appropriate number of passings and by the choice of compacting vehicle.

Table 1: Design guidelines

	Target values		Tolerances
	By total mass of mix	By mass of the aggregate	
Mass of stones, square mesh sieve (SM) > 2 mm	47.6 %	50.5 %	± 5
Mass of sand 0.063 < SM < 2 mm	38.0 %	40.2 %	± 5
Mass of filler SM < 0.063 mm	8.8 %	9.3 %	± 2
Mass of binder (bitumen)	5.8 %	N.A.	± 0.5
Max. chipping size	8 mm		6.3 - 10
Binder hardness	(see para. 3.2.2. (f))		
Polished stone value (PSV)	> 50		
Compactness, relative to Marshall compactness	98 %		

4. Test method

4.1. Measurement of the residual voids content

For the purpose of this measurement, cores have to be taken from the track in at least four different positions which are equally distributed in the test area between lines AA and BB (see figure 1). In order to avoid inhomogeneity and unevenness in the wheel tracks, cores should not be taken in wheel tracks themselves, but close to them. Two cores (minimum) should be taken close to the wheel tracks and one core (minimum) should be taken approximately midway between the wheel tracks and each microphone location.

If there is a suspicion that the condition of homogeneity is not met (see paragraph 2.4.), cores shall be taken from more locations within the test area.

The residual voids content has to be determined for each core, then the average value from all cores shall be calculated and compared with the requirement of paragraph 2.1. In addition, no single core shall have a voids value which is higher than 10%.

The test surface constructor is reminded of the problem which may arise when the test area is heated by pipes or electrical wires and cores must be taken from this area. Such installations must be carefully planned with respect to future core drilling locations. It is recommended to leave a few locations of size approximately 200 mm x 300 mm where there are no wires/pipes or where the latter are located deep enough in order not to be damaged by cores taken from the surface layer.

4.2. Sound absorption coefficient

The sound absorption coefficient (normal incidence) shall be measured by the impedance tube method using the procedure specified in ISO 10534-1: "Acoustics - Determination of sound absorption coefficient and impedance by a tube method." 2/

Regarding test specimens, the same requirements shall be followed as regarding the residual voids content (see paragraph 4.1.). The sound absorption shall be measured in the range between 400 *Hz* and 800 Hz and in the range between 800 *Hz* and 1,600 *Hz* (at least at the centre frequencies of third octave bands) and the maximum values shall be identified for both of these frequency ranges. Then these values, for all test cores, shall be averaged to constitute the final result.

2/ To be published.

4.3. Volumetric macrotexture measurement

For the purpose of this standard, texture depth measurements shall be made on at least 10 positions evenly spaced along the wheel tracks of the test strip and the average value taken to compare with the specified minimum texture depth. See *Standard* ISO 10844:1994 for description of the procedure.

5. Stability in time and maintenance

5.1. Age influence

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

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

The stability over time is determined mainly by the polishing and compaction by vehicles driving on the surface. It shall be periodically checked as stated in paragraph 2.5.

5.2. Maintenance of the surface

Loose debris or dust which could significantly reduce the effective texture depth must 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.

5.3. 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 in figure 1) where vehicles are driving, provided the test area outside the strip met the requirement of residual voids content or sound absorption when it was measured.

6. Documentation of the test surface and of tests performed on it

6.1. Documentation of the test surface

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

6.1.1. The location of the test track.

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

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

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

6.1.5. Date when the surface was laid and contractor.

6.1.6. All or at least the latest test result, including:

6.1.6.1. the residual voids content of each core;

6.1.6.2. the locations in the test area from where the cores for voids measurements have been taken;

6.1.6.3. 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;

6.1.6.4. the locations in the test area from where the cores for absorption measurement have been taken;

6.1.6.5. texture depth, including the number of tests and standard deviation;

6.1.6.6. the institution responsible for tests according to paragraphs 6.1.6.1. and 6.1.6.2. and the type of equipment used;

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

6.2. 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 standard were fulfilled or not. Reference shall be given to a document according to paragraph 6.1. describing the results which verify this.

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