Characterization of pavement texture by use of surface profiles —

Part 3: Specification and classification of profilometers

ICS 17.140.30; 93.080.20

British Standards

National foreword

This British Standard reproduces verbatim ISO 13473-3:2002 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee EH/1, Acoustics, to Subcommittee EH/1/2, Transport noise, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Characterization of pavement texture by use of surface profiles —

Part 3: **Specification and classification of profilometers**

Caractérisation de la texture d'un revêtement de chaussée à partir de relevés de profils de la surface —

Partie 3: Spécification et classification des appareils de mesure de profil

Reference number
ISO 13473-3:2002(E)

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Annex

Foreword

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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.

Attention is drawn to the possibility that some of the elements of this part of ISO 13473 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13473-3 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 13473 consists of the following parts, under the general title *Characterization of pavement texture by use of surface profiles*:

— *Part 1: Determination of Mean Profile Depth*

— *Part 2: Terminology and basic requirements related to pavement texture profile analysis*

— *Part 3: Specification and classification of profilometers*

Annex A of this part of ISO 13473 is for information only.

Introduction

Profilometers have been used in research on surface characteristics of pavements on roads and airfields since the 60's and have recently also been applied to general pavement surveys. Although most of the designs have been based on laser sensor technology, the principles of operation, measurement and analyses have been and are very different. This part of ISO 13473 is an attempt to facilitate the comparison of different profilometers and to specify requirements needed when they are applied to pavement engineering.

Characterization of pavement texture by use of surface profiles —

Part 3:
Specification and classification of profilometers

1 Scope

This part of ISO 13473 specifies requirements for profilometers used in pavement engineering in order to give meaningful and accurate measurement of pavement micro-, macro- and megatexture characteristics of paved road and airfield surfaces. It also includes schemes for the classification of such profilometers with respect to their use and overall accuracy. The profilometers may be of any operational type.

The scope of this part of ISO 13473 does not include profile analysis of machined surfaces. Also excluded from the scope is the profile analysis of road unevenness.

NOTE 1 Profile analysis of machined surfaces is dealt with in other standards, for example ISO 3274, ISO 4287, ISO 4288, ISO 5436-1, ISO 5436-2 and ISO 12085.

NOTE 2 Profile analysis of road unevenness is dealt with in ISO 8608.

NOTE 3 Throughout this part of ISO 13473, the use of the term “pavement” means “paved road or airfield surface”.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 13473. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this part of ISO 13473 are encouraged to investigate the possibility of applying the most recent edition of the normative document 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 13473-2:2002, *Characterization of pavement texture by use of surface profiles — Part 2: Terminology and basic requirements related to pavement texture profile analysis*

3 Terms and definitions

For the purposes of this part of ISO 13473, the terms and definitions given in ISO 13473-2 apply.

4 General classes of profilometers for texture measurement

4.1 Mobility

The classes of profilometers with respect to mobility are as follows (see also Table 1).

a) **Mobile, high speed**: Profilometers of this class are mounted on a vehicle and used at a driving speed of 60 km/h or more. Such profilometers do not normally disturb other traffic.

b) **Mobile, low speed**: Profilometers of this class are mounted on a vehicle and used at a driving speed of less than 60 km/h. Although such profilometers are truly mobile, on high-speed roads they are often a nuisance to other traffic.

c) **Stationary, fast**: Profilometers of this class are placed on the pavement each time a measurement is carried out, but are able to move fast enough in order not to require that the pavement section be closed for a short time. An example is a profilometer mounted on a trailer or other vehicle which must be stopped during measurement but which, after some seconds, can move on to the next measuring location. Another example is a profilometer operating at walking speed.

d) **Stationary, slow**: Profilometers of this class are placed on the pavement each time a measurement is carried out, but operate so slowly that the pavement section must be closed to other traffic.

Table 1 — Classes of profilometers with respect to mobility

	Fast	Slow
Mobile	operating speed: $\geqslant$ 60 km/h	operating speed: $<$ 60 km/h
Stationary	time on lane per single measurement: $<$ 1 min	time on lane per single measurement: $\geqslant$ 1 min

4.2 Texture wavelength range

The classes of profilometers with respect to wavelength range classes are given in Table 2. The wavelengths are expressed as one-third-octave-band centre wavelengths and the performance shall pertain to the entire band in question.

Table 2 — Classes according to texture wavelength range

Values in millimetres

	Wavelength range class					
	A	B	C	D	E	F
Texture wavelength range covered	0,05 to 0,16	0,20 to 0,50	0,63 to 2,0	2,5 to 50	63 to 200	250 to 500
One-third-octave bands covered (centre wavelengths)	0,05; 0,063; 0,08; 0,10; 0,125; 0,16	0,20; 0,25; 0,315; 0,40; 0,50	0,63; 0,80; 1,0; 1,25; 1,6; 2,0	2,5; 3,15; 4; 5; 6,3; 8; 10; 12,5; 16; 20; 25; 31,5; 40; 50	63; 80; 100; 125; 160; 200	250; 315; 400; 500

NOTE If, for example, a profilometer covers the range 0,3 mm to 100 mm, the range specification is written as wavelength range class CD; if it covers the range 0,2 mm to 500 mm, it is a wavelength range class BF profilometer.

4.3 Pavement contact

Profilometers may be of two types depending on whether or not the sensor contacts the pavement.

a) **Contact devices**: The sensor makes contact with the measured surface.

b) **Contactless devices**: The sensor makes no contact with the measured surface.

4.4 Principle of operation

Profilometers may be based on different principles of operation, mainly pertaining to the type of sensor. The following list may not be complete, but it indicates the preferred terms for the most common principles in current use.

a) **Laser profilometer**: A device utilizing an electro-optical sensor in which a laser beam is reflected against the pavement, the spot of which is projected via optical lenses on a position-sensitive semiconductor transducer. The sensor is moved along the surface to be measured, resulting in an electrical output signal proportional to the height (elevation) of the laser spot on the surface as a function of distance.

b) **Light-sectioning profilometer**: A device utilizing either a narrow or an extended beam of light, creating on the pavement a thin line or an intensively illuminated band with sharp light edges. The light may be flashed with a very short exposure time or may shine continuously. A video camera monitors this light line or light edge from an angle in relation to the light beam. In the x-y output of the camera sensor, the profile is distinguishable as the transition between the light edges and the background. This device must not be moved during the time when the profile is sampled, because the profile trace will then be blurred.

c) **Stylus profilometer**: A device using a stylus (needle) which touches the pavement and which is mechanically connected to a displacement transducer. The latter may be of many different principles, but linear potentiometers or linear variable differential transformers (LVDT) are the most common. The sensor is moved or stepped along the surface to be measured, resulting in an electrical output signal proportional to the height (elevation) of the contact spot on the surface as a function of distance.

d) **Ultrasonic profilometer**: A device utilizing an electro-acoustical sensor in which a beam of ultrasonic sound is transmitted to the pavement and reflected from it. A microphone picks up the reflected sound, and the time between the transmitted and received ultrasound is calculated and transformed into a corresponding distance. The sensor is moved along the surface to be measured, resulting in an electrical output signal proportional to the height (elevation) of the ultrasound-exposed spot on the surface as a function of distance.

5 Types of measurements

Examples of the most common types of measurements and analyses that are made with profilometers are the following.

a) **General recording of profile curves**: This can be made for simple illustration purposes or for qualitative assessment of the texture.

b) **Measurement of mean profile depth (MPD)**: A method for the measurement of MPD is described in ISO 13473-1. The MPD is used to assess the skid resistance speed gradient characteristics (see reference [1] in the Bibliography).

c) **Measurement of profile amplitude distributions**: See ISO 13473-2 for definitions.

d) **Other amplitude-related measurements from profile curves**: Some profilometers provide r.m.s. values as an output. It is also possible to present skewness and kurtosis. See ISO 13473-2 for definitions.

e) **Texture spectrum measurement**: Profile curves are often analysed in terms of their spectral content; this is most often expressed as octave or one-third-octave band texture spectra. See ISO 13473-2 for definitions.

This part of ISO 13473 does not specify how measurements with profilometers shall be used or applied in special cases. However, the above list gives some guidelines for further study. In particular, ISO 13473-2 specifies and harmonizes terms and measures useful in pavement engineering.

6 Specific performance requirements

6.1 General

A profilometer system which produces an electrical signal that is proportional to the distance between a sensor reference plane and the surface spot in question shall be used. The sensor may be a mechanical, acoustical or electro-optical type of sensor or a video camera. The final output shall be linearly related to the texture profile and linearity may be obtained either in hardware or software.

The profilometer system shall also provide means of moving the sensor along or across the surface at an elevation (vertically) which is essentially constant over at least one full wavelength. However, this requirement is not applicable when the profile is produced by a technique such as light sectioning, where the profile and its reference line or plane are recorded instantaneously.

6.2 Vertical measuring range

The capability of the system to measure vertical displacement (profile and the vertical motion of the sensor as well) shall meet the minimum requirements given in Table 3.

If the system has a range-tracking capability, i.e. the sensor carrier is displaced by a servo-mechanism to approximately follow the longer wavelengths of the profile, the requirements of the sensor of mobile systems may be relaxed to be the same as for stationary devices.

Table 3 — Minimum vertical measuring range

Values in millimetres

	Wavelength range class			
	A	B	C	D, E and F
Texture wavelength range covered	0,05 to 0,16	0,20 to 0,50	0,63 to 2,0	2,5 to 500
Mobile, high speed	N.A.	N.A.	50	60
Mobile, low speed	N.A.	40	50	60
Stationary, fast	N.A.	20	20	20
Stationary, slow	10	10	10	20
The indication N.A. (not applicable) means that there are no devices that reasonably will meet such requirements at the time of publication of this part of ISO 13473.				

NOTE The requirements given in Table 3 are a compromise that attempts to satisfy conflicting requirements for vertical resolution and the risk of out-of-range measurements. They are expected to satisfy most texture measuring needs on pavements normally used on streets, roads and airfields. A single and unusually large irregularity may nevertheless drive the sensor out-of-range, which may be acceptable if it does not occur too often (see 6.13). However, in cases where there is abnormally high unevenness or megatexture, wider ranges may be needed.

6.3 Horizontal evaluation length

The horizontal evaluation length shall meet the minimum requirements given in Table 4. Over the “evaluation length” the profile shall be continuously measured (dropouts accepted according to 6.13).

Table 4 — Minimum “uninterrupted” horizontal evaluation length

Values in millimetres

	Wavelength range class					
	A	B	C	D	E	F
Texture wavelength range covered	0,05 to 0,16	0,20 to 0,50	0,63 to 2,0	2,5 to 50	63 to 200	250 to 500
Mobile, high speed	N.A.	N.A.	20	200	1 000	2 000
Mobile, low speed	N.A.	5	20	200	1 000	2 000
Stationary, fast	N.A.	5	20	200	500	1 000
Stationary, slow	5	5	20	200	500	1 000
Note that in order to get the appropriate statistical representativity, several such evaluation lengths may be required. The indication N.A. (not applicable) means that there are no devices that reasonably will meet such requirements at the time of publishing of this part of ISO 13473.						

Furthermore, over a distance up to the maximum wavelength, the level of the profilometer reference plane or line shall not change significantly. This effect shall be included in the requirements for background noise. For example, if a road vehicle carries the sensor, the vehicle shall not change its vertical position over this distance.

NOTE 1 The requirements given in Table 4 are a compromise between practicability and accuracy.

NOTE 2 One way to avoid the problem of vertical vehicle motion is to employ a so-called “Accelerometer-established inertial profiling reference” which is achieved by mounting an accelerometer system to the vehicle body and integrating the acceleration twice to obtain vehicle body displacement (see reference [2]).

NOTE 3 At the time of publication of this part of ISO 13473, work is underway to develop a Technical Specification describing procedures for spectral analysis in more detail. In this work it is considered to increase the evaluation length requirement for class F for mobile devices from 2 m to 3 m.

6.4 Vertical resolution

Profilometer sensors in systems measuring and presenting only profile curves, and those presenting only overall values like MPD and ETD (as in ISO 13473-1), shall have a vertical resolution of 0,05 mm or better. If, however, detailed parts of profiles are to be analysed, by zooming or similar techniques, the vertical resolution shall meet the minimum requirements of Table 5.

Table 5 — Minimum vertical resolution

Values in millimetres

	Wavelength range class					
	A	B	C	D	E	F
Texture wavelength range covered	0,05 to 0,16	0,20 to 0,50	0,63 to 2,0	2,5 to 50	63 to 200	250 to 500
Minimum vertical resolution	0,001	0,003	0,01	0,03	0,04	0,05
NOTE For profilometer systems which rely on a digitized profile, the resolution is often (but not necessarily) equal to the quantity represented by the least significant bit (LSB).						

For profilometers used for texture spectrum analysis, vertical resolution shall meet the minimum requirements of Table 5.

6.5 Nonlinearity

Vertical nonlinearity after the final signal processing shall be no greater than 2 % of the range for wavelength range classes D, E and F, and 5 % for classes B and C. The performance for Class A is yet to be determined.

6.6 Horizontal resolution

The horizontal resolution, Δx, shall meet the requirements of Table 6 over the entire vertical measuring range. Horizontal resolution is determined in practice by the following characteristics according to type of device.

a) In the case of a contactless device, utilizing a laser or other electro-optical principle or a sensor based on sound transmission, the spot of the radiation shall be such that its average diameter on the road surface shall be no greater than Δx. In this case, the effective spot is taken as that contained within an area limited by a contour line where the intensity of the spot is 1/e (approximately 37 %)[1)] of the maximum intensity within the spot.

b) In the case where a light-sectioning device is used, the projected light band or line shall be sufficiently sharp to give a light/dark transition within Δx. In this case, the effective line width is taken as that where the intensity of the line has reduced from 100 % to 1/e (approximately 37 %) of the maximum intensity within the line.

c) In the case where a contact device is used (e.g. utilizing a stylus sensor), the tip of the contacting part shall be such that the tip, at its widest dimension, has a diameter of no more than Δx, up to Δx in height from the tip.

NOTE 1 Ideally, the horizontal resolution would be measured as the ability to reproduce small objects or changes horizontally. However, it is not yet possible to specify such a method which is technically and practically acceptable. In the interim, the above procedures can be used to estimate the resolution. For contactless devices, spot size or line width are reasonable indicators of horizontal resolution, but spatial properties of the detector are equally important. With the designs and products available at the time of production of this part of ISO 13473, the spot size and line width are the major determining factors for horizontal resolution, and thus can be used as specified above.

NOTE 2 The shape of the stylus tip can influence the response at extremely short wavelengths. The distribution of intensity within a laser spot of the laser profilometers in use when this part of ISO 13473 was produced is approximately Gaussian. In order to resemble such a spot, the stylus tip should be rounded.

1) "e" is the base of the natural system of logarithms (2,718 281 8...).

Table 6 — Minimum values applying to horizontal resolution, Δx, and sampling interval

Values in millimetres

	Wavelength range class					
	A	B	C	D	E	F
Texture wavelength range covered	0,05 to 0,16	0,20 to 0,50	0,63 to 2,0	2,5 to 50	63 to 200	250 to 500
Min. horizontal resolution, Δx, and sampling interval	0,02	0,05	0,2	1	20	50

6.7 Sampling interval

The sampling interval shall not exceed the values specified in Table 6.

If the profile is used for spectrum analysis, the sampling interval shall not exceed the resolution in order to avoid potential problems with spatial aliasing. For other purposes, the sampling interval may be longer than the resolution, provided it still meets the requirements of Table 6.

If the profile is used for spectrum analysis, sampling interval fluctuation shall not be greater than $\pm$ 10 % when using octave or one-third-octave bands, and not greater than $\pm$ 3 % when using one-twelfth-octave bands.

For most profilometer systems, the sampling interval is determined by a constant temporal frequency. In such cases, it is important to observe that the requirements on sampling interval above imply corresponding requirements for maintaining a constant measuring speed; see 6.9. Alternatively, the sampling interval may be determined by a distance-sensing device, in which case the measuring speed has no direct relation to the sampling interval.

6.8 Potential destruction of measured pavement

For contact devices, the contact forces on the surface shall not be so high as to cause penetration or destruction of the surface texture. Such destruction is usually detectable as a clearly visible track left where contact was made.

6.9 Measuring speed

The speed with which the profile is traced shall be such that the requirements for sampling and bandwidth are met. For example, in cases where the sampling interval is based on a constant time frequency, this means that the measuring speed shall be kept sufficiently constant in order to meet the requirements for the sampling interval fluctuation according to 6.7. This applies to stationary as well as mobile profilometers. However, it shall be noted that the speed could influence the frequency scale for any spectral analysis. The relationship is:

$$f = v\lambda^{-1} \quad (1)$$

where

f is the (time) frequency on the spectrum analyser scale (Hz);

v is the profilometer speed (m/s);

λ is the texture wavelength (m).

In order to avoid any such speed influence, it is recommended to synchronize the sampling rate with the measuring speed.

In some devices the speed can influence the background noise, since the latter may be higher at higher frequencies. In addition, depending on how sampling takes place and whether there is lowpass filtering, the speed can influence the upper and lower wavelength limits.

6.10 Alignment of sensor and local slope limitation

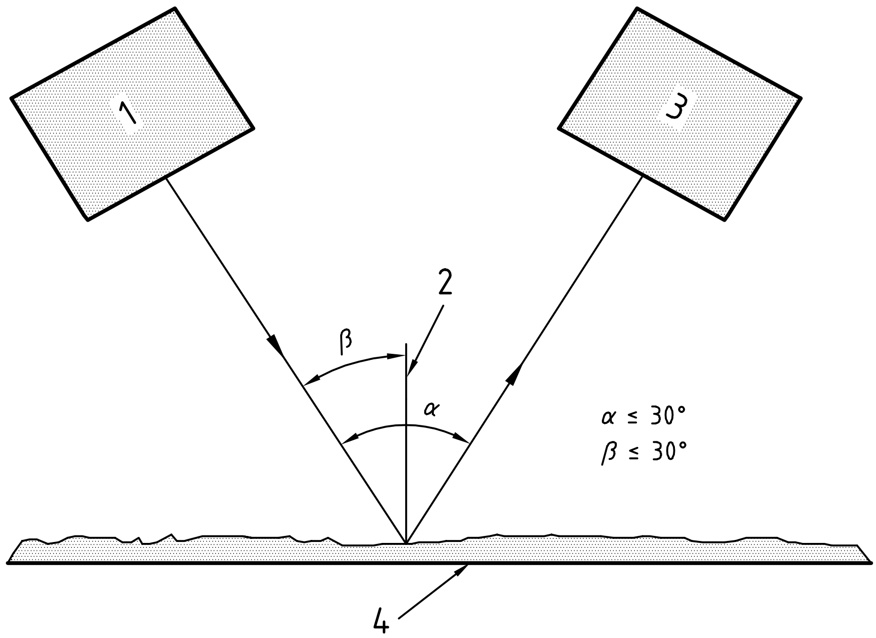
The sensor shall be able to follow a profile with a local slope angle (as defined in 3.6.15 of ISO 13473-2:2002) of 40° or more. This can be achieved if the following requirements are met.

a) **For contact devices** (stylus profilometers): The axis longitudinally through the stylus shall be at an angle of no more than 30° to the surface normal.

b) **For contactless devices**: The angle α between the optical or acoustical axis of the radiation towards the surface and the optical or acoustical axis of the detector (reflected radiation) shall be no more than 30° (see Figure 1).

c) **For contactless devices**: The same requirement as in b) applies to the angle β, which is the angle between the surface normal and the optical or acoustical axis of the radiation towards the surface (see Figure 1). Larger angles will cause very deep textures to be under-estimated.

NOTE The alignment of the optical plane of some devices is transverse to the direction of measurement, while others have a longitudinal alignment. Due to this, one may obtain different results for different alignments on isotropic surfaces. The alignment should be adapted to the particular device and application.



Key

1 Radiation-emitting device
2 Surface normal
3 Radiation-receiving device
4 Road surface

Figure 1 — Requirements regarding alignment of contactless sensors

6.11 Texture wavelength range of sensor and recording system

The frequency response of the entire measuring and data-collection system shall be within ± 1 dB over the specified texture wavelength range given in Table 2.

NOTE The response could be checked by using machined surfaces as inputs to simulate textures with known profiles. For mobile devices, such surfaces (discs or drums) could be rotated underneath the sensing device, which is then stationary.

6.12 Indication of invalid readings

In electro-optical systems, invalid readings can occur due to the special photometric properties of the surface or shadowing of the light in deep troughs of the profile. In addition, laser diodes will deteriorate with use, which will eventually result in excessive invalid readings. For this reason, it is recommended that there be a means of periodically monitoring the laser intensity, for example as part of the calibration process.

If the signal from the profilometer can become significantly lower or higher than the true profile due to readings being invalid, the equipment shall identify all such potentially invalid readings in a special “invalid” signal output which can be used to correct for such readings.

The invalid signal shall meet the same minimum bandwidth and sampling requirements as the profile signal (see 6.7 and 6.11).

The profilometer system shall have means of ensuring that invalid readings do not significantly influence the measured results. For example, when the signal becomes invalid, it may be held at the previous correct level, or a linear interpolation may be made between the previous and subsequent correct levels. The linear interpolation procedure is preferred.

6.13 Dropout rate

Measurements on a particular pavement are considered valid only if the dropout rate for the evaluation length in question is not more than 5 % if linear interpolation between invalid values is not used, or 10 % if linear interpolation is used.

6.14 Background noise

Background noise shall not exceed the values specified in Table 7 when the averaging time is equal to the normal averaging time of a profile measurement. The table applies to static background noise (see ISO 13473-2). If it is possible to test for dynamic background noise (e.g. by using an ideal, extremely smooth-textured surface with “normal” reflectivity variations), the requirement shall apply also to such noise.

Table 7 — Maximum background noise expressed as a corresponding texture profile (r.m.s. values) and texture profile level rel. to 10^{-6} m

		Wavelength range class					
		A	B	C	D	E	F
Texture wavelength range covered [a]		0,05 mm to 0,16 mm	0,20 mm to 0,50 mm	0,63 mm to 2,0 mm	2,5 mm to 50 mm	63 mm to 200 mm	250 mm to 500 mm
One-third-octave bands covered (centre wavelengths in mm) [a]		0,05; 0,063; 0,08; 0,10; 0,125; 0,16	0,20; 0,25; 0,315; 0,40; 0,50	0,63; 0,80; 1,0; 1,25; 1,6; 2,0	2,5; 3,15; 4; 5; 6,3; 8; 10; 12,5; 16; 20; 25; 31,5; 40; 50	63; 80; 100; 125; 160; 200	250; 315; 400; 500
Maximum background noise expressed as r.m.s. values and profile levels	Overall profile measurement only	0,002 mm 6 dB	0,006 mm 16 dB	0,02 mm 26 dB	0,05 mm 34 dB	0,07 mm 37 dB	0,10 mm 40 dB
	Detailed profile study (zooming, etc.) and spectral analysis	0,001 mm 0 dB	0,003 mm 10 dB	0,01 mm 20 dB	0,03 mm 30 dB	0,04 mm 32 dB	0,05 mm 34 dB

[a] The values are the overall values within the wavelength range in question.

6.15 Sensitivity to vibrations

It shall be ensured that the sensor is stable in its vertical position at least during the measurement of a full baseline length and for all operating speeds, or that it has some means of compensation for vertical movements. This requires that vibrations (e.g. those occurring at the natural suspension frequency of the sensor and/or its carrier) shall have negligible influence, i.e. they shall not violate the background noise requirements of 6.14.

For a mobile device, for which vibrations may be a problem, a suitable test is to run the test vehicle (carrying the device) on a smooth and even surface so that the tyres roll over an object having a height of 20 mm to 25 mm, a width of 200 mm and a length of 100 mm to 150 mm, placed on the surface. Rolling over the object will excite vibrations in the vehicle. The difference in the recorded profile with and without the object is an indication of the influence of vibrations.

6.16 Stand-off distance

The stand-off distance for contactless devices shall be sufficient to protect the sensor from accidentally touching the pavement.

6.17 Sensitivity to ambient light

The output profile signal shall not change by more than 0,1 mm when changing from dark ambient light to ambient light typical of sunny weather, and *vice versa*.

6.18 Sensitivity to surface optical properties

The output profile signal shall not change by more than 0,1 mm when moving the sensor from very dark to very bright materials and *vice versa*. It is recommended that the sensor be moved over a smooth surface having transitions from white to black to white; note the result. See further the notes in 6.19.

NOTE Experience has shown that application of a layer of paint to the surface can improve the performance. The paint must, however, be thin enough in order not to change the texture being measured.

6.19 Problems with low reflectivity or sensitivity to dampness/wetness of surface

It shall be reported whether or not the output profile is sensitive to the degree of moisture on the pavement, and what type or quantity of wetness or dampness that is acceptable, if any.

NOTE 1 The problem is two-fold:

— for contactless devices the diffuse reflectivity may be so low that drop-out rates become too high;

— the sensor radiation may sometimes not hit the actual texture spot but some water level above that spot.

NOTE 2 Newly laid surfaces, at least if bituminous, generally have a glossy and extremely dark appearance. Profilometers relying on optical beams usually have problems with such surfaces because too little light is diffused in the direction towards the receiving element. Dropout rates become high and there may be transients at extreme transitions between dark and bright surfaces. The same applies to surfaces that are dark due to moisture.

7 Calibration

Calibration shall be made by means of a special calibration surface, having a known profile. The accuracy of the calibration surface, in relation to its theoretical profile, shall be at least 0,05 mm vertically.

The calibration procedure shall be designed so as to obtain a maximum error of the texture amplitude value of 5 % (of the calibration surface amplitude), corresponding to 0,4 dB if a logarithmic scale is used, or 0,1 mm, whichever is the lower.

Calibration procedures are not specified in this part of ISO 13473. Annex A gives examples of various calibration surfaces and other suggestions.

The type of calibration used shall be reported.

NOTE One suitable calibration surface is a surface machined to obtain a triangular profile with a peak-to-peak value of 5 mm to 20 mm and a texture wavelength of 10 mm to 50 mm. This gives an indication of not only amplitude but also of nonlinearity and the texture wavelength scale.

8 Reporting of specifications

Any document presenting a profilometer and referring to this part of ISO 13473 shall include information on whether or not the requirements of this part of ISO 13473 are met. Items that are not met shall be specified and deviations reported. It is also mandatory to report the following (as described in clause 4):

a) mobility class;

b) texture wavelength range;

c) surface contact or not;

d) principle of the operation.

Furthermore, unless there is a reference given to some publicly available document containing this information already, it is recommended that the relevant data for the profilometer be reported in full. The performance regarding the following items is then recommended to be specified:

e) vertical measuring range;

f) horizontal evaluation length;

g) vertical resolution;

h) nonlinearity;

i) horizontal resolution;

j) sampling interval;

k) potential destruction of measured pavement;

l) measuring speed;

m) alignment of sensor and local slope limitation;

n) bandwidth of sensor and recording system;

o) dropout rate;

p) background noise;

q) stand-off distance;

r) sensitivity to vibrations;

s) sensitivity to ambient light;

t) sensitivity to surface optical properties;

u) sensitivity to dampness/wetness of surface;

v) type of calibration.

NOTE A compilation of specifications of most of the profilometers in use in 1994 is included in reference [1], although the reporting of data there does not meet this recommendation.

Annex A
(informative)

Calibration surfaces

Calibration surfaces given in Table A.1 have been found to be practical.

Table A.1 — Useful calibration surfaces

Type of profile	Suitable for following type of profilometers	Amplitude calibration	Wavelength calibration
Triangular (e.g. 10 mm peak-bottom and 20 mm wavelength)	Rotating at edge of a disc: All mobile lasers Straight profile: Mobile light-sectioning and all stationary devices	r.m.s. value of triangle wave (for spectrum: r.m.s. of fundamental)	Fundamental and harmonics
Rectangular (e.g. 10 mm peak-bottom, each level ⩾ 10 mm long)	Rotating at edge of a disc: All mobile lasers Straight profile: Mobile light-sectioning and all stationary devices	On flat top and bottom parts	Only if the profile can be correctly measured (difficult on vertical slopes)
Staircase (e.g. 10 mm long steps, each 1 mm high)	Rotating at edge of a disc: All mobile lasers Straight profile: Mobile light-sectioning and all stationary devices	On flat parts Linearity can be checked	Not recommended when using this profile

Calibration surfaces according to Table A.1 can be machined by a qualified workshop to a high degree of mechanical accuracy. For optical profilometers, it is recommended that the surfaces be blasted and/or painted with a matt finish to obtain a diffuse appearance, spreading the reflected light uniformly. The relative error in the machining and mechanical measurement can be reduced to negligible values if dimensions of the size suggested in Table A.1 are used. Smaller profiles will have higher relative errors. If possible, the calibration should be made with a speed between the surface and profilometer that is the same as normally used during measurement (dynamic calibration). For the rotating calibration surfaces, this may be obtained with a rotation speed giving the appropriate profile movement underneath the sensor which is then stationary.

Note that for a triangular wave it is not recommended to calibrate on the extreme peaks and valleys of the profile since they might be poorly reproduced by the profilometer. It is better to use the r.m.s. value that is much less influenced by poor reproduction of the peak and valleys of the profile. A sinusoidal profile may also be very suitable in this application, although it is usually more expensive to produce.

Calibration may be made easily if the calibration profile is mounted on a dynamometer roll, over which the sensor is placed, and the dynamometer is run at a rotational speed giving a circumferential speed equal to the normal profilometer operating speed.

Some procedures use slope suppression (see ISO 13473-1). When this is applied to a calibration surface with relatively long texture wavelength, the slope can be influenced somewhat by the beginning and end points of the profile. Ways to avoid this problem are

— to adapt the measurement procedure for calibration surfaces so that the slope is negligible and do not apply the slope suppression or

— to use a fundamental texture wavelength (period) no longer than 20 mm for the calibration profile, and include a sample sufficiently long to cover at least 20 periods; or use a sample length such that the beginning and ending profile segments are symmetrical. This is especially important if slope suppression is necessary.

In both the above cases, it is recommended to base the calibration on the r.m.s. value of the calibration profile rather than on peak values. Apart from peak values being more sensitive to the slope than r.m.s. values, they are also more sensitive to the imperfect high-frequency response of profilometers.

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