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Characterization of pavement texture by use of surface profiles —

Part 6: Verification of the performance of laser profilometers used for pavement texture measurements

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

Partie 6: Vérification de la performance des profilomètres lasers utilisés pour les mesurages de la texture d'un revêtement

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation 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.

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

A list of all parts in the ISO 13473 series can be found on the ISO website.

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.

Introduction

Pavement texture data are often used in research and surveys of pavement surface properties, such as tyre/road noise, rolling resistance, skid resistance, as well as splash and spray. Measurements of pavement texture are used in several other ISO standards; mostly to characterize test or reference surfaces.

For the measurement of pavement surface texture, laser profilometers are most frequently used. In recent years, it has appeared that, despite the use of standard methods (such as those in other parts of ISO 13473), there can be differences between results measured by various equipment, exceeding normal uncertainty estimations. One of the reasons for this can be that the equipment does not fully meet the intentions of the standards; for example ISO 13473-3[3].

To deal with this problem, this document specifies how one can verify that a particular device meets the intended characteristics of laser profilometer systems used for pavement texture measurements.

WARNING — Emitted laser beams could be hazardous for the eye and all tests done according to this standard shall be done with the appropriate safety precautions for the specific sensor.

Characterization of pavement texture by use of surface profiles —

Part 6: Verification of the performance of laser profilometers used for pavement texture measurements

1 Scope

This document describes methods for checking laser profilometer performance with respect to the capability of such equipment in measuring pavement texture.

The objective of this document is to make available an internationally accepted procedure by which performance of various laser-based equipment for pavement texture measurements can be evaluated. The document includes guidelines and recommendations intended to assist users of laser profilometers in verification of their equipment. This document is not intended as the basis for qualifying or approving laser profilometers. The procedure aims at providing tools for verifying that such systems perform satisfactory in all respects important for the correct measurements of texture, as well as to detect when and in what way the performance is unsatisfactory. This document also provides some general information about the limitations and trade-offs of laser profilometer systems.

Modern profilometers in use for measurements on pavements are almost entirely of the contactless type (such as laser point or line triangulation) designed for two- or three-dimensional measurements, and this document is intended for evaluating the performance of this type of profilometers. However, some other contactless types of profilometer can use applicable parts of ISO 13473.

This document has been prepared as a result of a need identified to correct for unacceptable differences in results measured by various equipment, even if the operators of these claim that they meet the applicable part of ISO 13473. It is not intended for other applications than pavement texture measurement. To be able to exclude errors influenced by programming mistakes or wrong interpretation of ISO 13473-1 a reference program code, digital profiles and calculated reference MPD-values can be reached via Annex A. This document is a complement to other parts of ISO 13473 in which some specifications are given but methods to check them are not included.

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 13473-1, *Characterization of pavement texture by use of surface profiles — Part 1: Determination of mean profile depth*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13473-1 and the following apply.

ISO and IEC maintain terminological 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
laser profilometer
equipment for contactless pavement texture measurement using a laser spot or line projected on the surface captured by a device that accurately digitizes and records texture profiles when the system is moved over the pavement surface

3.2
background noise
variation of the signal when the measurement system is at rest

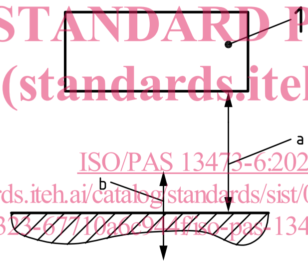
Note 1 to entry: Such noise often is of the type that is called white noise.

3.3
measurement range
range of values of vertical distance covered by the sensor,

Note 1 to entry: See Figure 1.

3.4
standoff
distance between middle of the *measurement range* (3.3) and pavement

Note 1 to entry: See Figure 1.



Key

1 sensor

a Standoff.

b Measurement range.

Figure 1 — Illustration of the terms measurement range and standoff

4 Symbols and abbreviated terms

A list of symbols and abbreviations used in this document is given in Table 1.

Table 1 — The meaning of symbols and abbreviations

Symbol or term	Reference document	Meaning
DAC	EN 13108-1	Dense Asphalt Concrete (pavement)
MPD	ISO 13473-1	Mean Profile Depth
MSD	ISO 13473-1	Mean Segment Depth
PA	EN 13108-7	Porous Asphalt (pavement)
RMS	ISO 13473-1	Root Mean Square
SMA	EN 13108-5	Stone Mastic Asphalt (pavement)

5 Methodology and its use

The important technical characteristics of laser profilometers used for measurements of pavement texture are identified, and for each one a procedure is proposed that intends to check that particular performance of the device and, where appropriate, compare it with limits for acceptable performance.

When a device or system has been checked according to this document, it is possible to refer to this document and claim to what extent the device meets the given requirements.

6 Identification and evaluation of design and performance parameters

This clause identifies design and performance parameters that are of interest in the subject of pavement texture measurements by laser profilometers. Some of the parameters are subject to evaluation in this document, while others are left to the manufacturers' own specifications.

The following fundamental design parameters are not intended to be evaluated according to this specification, but it should be checked that they are all listed in a specification by the manufacturer. The items considered include:

— operating temperature range;

— standoff;

— triangulation angles;

— laser light wavelength;

— sampling frequency;

— existence of antialiasing filter;

— horizontal resolution in longitudinal direction (usually determined by the setting of an encoder);

— horizontal resolution in transversal direction (in 3D equipment, usually determined by the number of points sampled across the laser line);

— vertical resolution;

— vertical measurement range.

The results are important for the user and are provided as information; no judgement of conformity to requirements is made for these parameters.

The following parameters are intended to be evaluated according to this specification:

a) laser power;

b) laser spot size;

c) calibration (scale) factor;

d) linearity;

e) background noise;

f) horizontal position measurement accuracy;

g) sensitivity to abrupt change in surface reflectivity;

h) spike content of measured signal;

i) effect of ambient light;

j) dropout rate;

k) validation of dropout detection system;

l) synchronization between invalid parts of the profile and dropout indications.

7 Test methods and instruments

7.1 General conditions

The following subclauses suggest test methods to be used, while Clause 9 suggests the frequency of testing.

If the equipment can operate at different modes optimized for certain pavements (such as on bright or dark surfaces), the tests described below should be performed in the modes which are relevant for the intended pavements.

When performing the following tests, where relevant, the laser system shall be mounted at an angle typical of its normal operation.

All tests described in this clause can be done with both spot and line lasers. Regarding line lasers, all tests should be done at the part of the line that is used to measure the texture properties.

7.2 Laser power

7.2.1 Test method

The power of a spot laser should be measured and integrated over the entire laser spot. The spot should be measured in a position located at standoff. The physical design of receivers (laser power sensors) for laser power meters are not adapted for measuring the power of a laser line at standoff. Instead, it is recommended to use a receiver with a large area and measure the power of a line laser as close as possible to emitted laser source.

Follow the recommendations from the supplier to decide a limit of approval for the laser power.

It is recommended to apply ISO 13694[6] for this purpose.

NOTE 1 In order to monitor the progress of laser deterioration with time, measure this power when the sensor is new and then periodically monitor how the laser diode deteriorates. The period depends on the type of laser and the use of the laser, but if the laser is in operation frequently or during long periods over a year, a suitable period would be a test every year. If the measured laser power is less than half of the initially measured laser power this is an indication why the performance in the other tests can be insufficient.

NOTE 2 Loss of laser power might, for example, have the effect of increasing background noise and the rate of drop-outs.

NOTE 3 When measuring the laser power, search for the maximum power by moving the receiver of the laser power meter and register the value.

7.2.2 Instruments

There are commonly used instruments to measure laser power, which integrate over the entire area, including the appropriate laser wavelength, and give the total time-averaged power. It is up to the user to find such an instrument.

NOTE Use the same type of instrument to follow the deterioration of the laser power since different instruments tend to give different results.

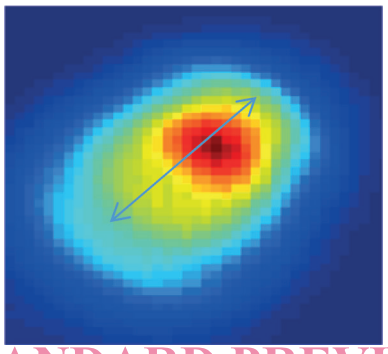
7.3 Laser spot size

7.3.1 Test method

Check the vertical measurement range of the sensor, according to the manufacturer's specifications. Measure laser spot size at standoff and near the two ends of the range (at 10 % and 90 % of the vertical range).

For spot lasers:

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 %) of the maximum intensity within the spot. The laser spot size is the maximum diameter of the spot within this contour line; see Figure 2.



NOTE The maximum laser spot size is the diameter indicated by a straight line in the figure.

Figure 2 — Example of enlarged laser spot, where light intensity is indicated by colour (dark red is the highest and dark blue is the weakest)

For line lasers:

A line laser's effective line width is taken as that contained within a distance limited by where the intensity of the line width is 1/e (approximately 37 %) of the maximum intensity.

Regarding the required maximum laser spot size, refer to the appropriate standard; for example ISO 13473-1 for MPD and ISO 13473-5[5] for megatexture measurements, and also to ISO 13473-3[3] for various classes of profilometers.

It is recommended to consider the method in ISO 11146-1[2] for this purpose.

NOTE For 3D equipment using a continuous line, the size of the line is determined in the direction perpendicular to the line.

7.3.2 Instruments

Use a laser beam analyser or any other system designated for the purpose of measuring laser spot sizes.

NOTE It is possible to make this kind of measurement by using a razorblade to shade off part of the illuminated spot and moving this in the laser spot plane by a micrometer screw. See Reference [10] for hints and instructions.

7.4 Accuracy of the calibration (scale) factor

7.4.1 General

Each sensor is normally delivered with a "scale factor"; i.e. how to convert the output values of the sensor to a displacement in millimetres. Alternatively, the output is presented directly as a displacement or position in millimetres. The accuracy of this should be checked.