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BSI Standards Publication

Road and airfield surface characteristics

Part 14: Procedure for determining the skid resistance of a pavement surface using a device with longitudinal controlled slip (LFCN): ViaFriction (Road Analyser and Recorder of ViaTech AS)

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National foreword

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Road and airfield surface characteristics - Part 14: Procedure for determining the skid resistance of a pavement surface using a device with longitudinal controlled slip (LFCN): ViaFriction (Road Analyser and Recorder of ViaTech AS)

Caractéristiques de surface des routes et aéroports - Partie 14: Mode opératoire de détermination de l'adhérence d'un revêtement de chaussée à l'aide d'un dispositif à frottement longitudinal contrôlé (CFLRDK): le ROAR (Analyseur de Route et Enregistreur du Norsemeter)

Oberflächeneigenschaften von Straßen und Flugplätzen - Teil 14: Verfahren zur Bestimmung der Griffigkeit von Fahrbahndecken durch Verwendung eines Geräts mit geregeltem Schlupf in Längsrichtung (LFCN): Das ViaFriction-Messgerät (Road Analyser and Recorder of ViaTech AS)

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Contents

Page

European foreword

This document (CEN/TS 15901-14:2016) has been prepared by Technical Committee CEN/TC 227 “Road materials”, the secretariat of which is held by DIN.

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1 Scope

This Technical Specification describes a method for determining the wet road skid resistance of a surface by measurement of the longitudinal friction coefficient LFCN. The described method is also used to determine the skid resistance on a surface covered by ice or snow.

The method provides friction coefficient measurements of the pavement by using an electrically braked test wheel.

ViaFriction can operate in the following modes:

— Fixed slip: The slip ratio is fixed. The slip ratio can be set to a value from 1 % to 75 %.

— Fixed slip speed: The slip speed is fixed. The slip speed has to be lower than the vehicle speed.

— Variable slip: The test wheel is braked from 0 % to 75 % slip ratio recording F 30, F 60 and the slip ratio/friction curve.

The test tyre is dragged over a pre-wetted pavement under controlled speed conditions while the test tyre is parallel to the direction of motion and perpendicular to the pavement. Skid resistance measurement on winter roads do not require pre-wetted pavement.

To determine the macrotexture of the pavement surface a laser system can be added. This system is placed in front of the towing vehicle in order to measure the macrotexture (mean profile depth — MPD) on dry pavements and on the same path as the skid resistance measurement is done. The standard for this measurement and the device is described in EN ISO 13473-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 13473-1, *Characterization of pavement texture by use of surface profiles — Part 1: Determination of Mean Profile Depth (ISO 13473-1)*

ISO 13473-2, *Characterization of pavement texture by use of surface profiles — Part 2: Terminology and basic requirements related to pavement texture profile analysis*

ASTM 1551, *Standard Specification for Special Purpose, Smooth–Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
wet road skid resistance
property of a trafficked surface that limits relative movement between the surface and the part of a vehicle tyre in contact with the surface, when lubricated with a film of water

Note 1 to entry: Factors that contribute to skid resistance are tyre pressure, contact area, tread pattern and rubber composition: the alignment, texture, surface contamination and characteristics of the road surface, vehicle speed and weather conditions.

Note 2 to entry: The skid resistance of a surface in Europe varies seasonally. Generally, wet skid resistance is higher in winter as a result of the effects of wet detritus and the effects of frost and wear by tyres on microtexture and macrotexture. Wet skid resistance is lower in summer as a result of dry polishing by tyres in the presence of fine detritus.

Note 3 to entry: The change in skid resistance of a surface in service is affected by the volume of traffic and the composition of the traffic, i.e. cars, buses, commercial vehicles of different sizes, as the tyres of these vehicles polish and/or wear the surfacing material in different ways. The geometry of the road will affect the change in skid resistance. Generally, tyres polish less on straight roads than on bends.

Note 4 to entry: Where the surface contains aggregate with a coating of binders, e.g. bitumen, resin or Portland cement, the skid resistance can change as the coating is worn away by tyres.

3.2
dry road skid resistance
property of a trafficked surface that limits relative movement between the surface and the part of a vehicle tyre in contact with the surface. The contact is not lubricated with a film of water

3.3
skid resistance
characterisation of the friction of a road surface when measured in accordance with a standardised method

3.4
friction coefficient
μ
ratio between the horizontal force in the direction of the motion that can be activated between the test wheel and the wet pavement and the vertical wheel load accomplished under controlled slipping conditions

Note 1 to entry: The controlled slipping condition is achieved by an electrical brake system. If the vehicle is in motion, the test wheel slides or slips in the forward direction.

3.5
friction
resistance to relative motion between two bodies in contact, the frictional force being the force, acting tangentially in the contact area, which is measured by a friction-measuring device

3.6
slip ratio
slip speed divided by the vehicle speed

3.7
fixed slip speed
this is a fixed slip where the slip speed is configurable and independent of the vehicle speed. The vehicle speed has always to be higher than the configured fixed slip speed

3.8
F 30
friction value at 30 km/h slip speed

3.9
F 60
friction value at 60 km/h slip speed

3.10
LFCN
longitudinal friction coefficient measured with the ViaFriction

3.11
macrotexture
deviation of a pavement from a true planar pavement with characteristic dimensions along the pavement 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 centre wavelengths

Note 1 to entry: Peak to peak amplitudes normally vary in the range 0,1 mm to 20 mm.

Note 2 to entry: Macrotexture is a major factor influencing skid resistance at high speeds but it also has an effect at low speeds.

3.12
Mean Profile Depth
MPD
descriptor of macrotexture, obtained from a texture profile measurement as defined in EN ISO 13473-1 and ISO 13473-2

3.13
calibration
periodic adjustment of the offset, the gain and the linearity of the output of a measurement method so that all the calibrated devices of a particular type deliver the same value within a known and accepted range of uncertainty, when measuring under identical conditions within given boundaries or parameters

3.14
retaliation friction devices
type of friction device fitted to vehicles

Note 1 to entry: When the vehicle brakes are used with full force for a short period, the speed change or deceleration is used to calculate the friction.

Note 2 to entry: This type of friction device is used on winter road surfaces covered with ice or snow.

3.15
braking force coefficient
ratio between the longitudinal frictional force and the load on the test wheel

Note 1 to entry: The test wheel mass which is without dimension.

3.16
vehicle speed
speed at which the device traverses the test surface

3.17
slip speed
relative speed between the test wheel and the pavement in the contact area

3.18
wheel path
part of the pavement where the majority of the vehicle wheel passes are concentrated

Note 1 to entry: The wheel path is not a fixed location on a pavement surface. On a worn pavement, the wheel path can usually be identified easily visually. On a new laid surface, the position of the wheel path needs to be estimated by experienced operators.

Note 2 to entry: For special circumstances such as acceptance tests, a particular path can be defined, for example (700 ± 150) mm from the edge of the running lane of a road.

3.19
theoretical water film thickness
thickness of a water film between a test wheel and a test pavement, assuming the pavement has zero texture depth

3.20
winter road
road surface having a temperature below +5 °C

Note 1 to entry: The road surface may be covered by snow and ice. The wet road skid resistance cannot be measured due to the risk of depositing ice on the road.

3.21
summer road
road surface having a temperature of 5 °C or more where wet road skid resistance can be measured

4 Recommended uses

The ViaFriction is used in the following fields of application:

— road network monitoring (Pavement Management measuring wet road skid resistance on summer roads and measuring dry road skid resistance on winter roads);

— approval of new surfacing;

— measurements after traffic accidents;

— investigation of surface skid resistance;

— comparative measurements among different devices;

— testing of tyres.

5 Safety

Safety measures shall be in place to maintain safe working practice in accordance with current regulations, and to ensure the safety of other users of the area being measured, including measures to control traffic as necessary.

The wetting of pavements can have an effect on other road users and every effort should be made to ensure that they do not have to make any sudden changes in speed or direction.

When measuring skid resistance on roads under traffic the device may operate at speeds different to normal road speeds and as a result can create a hazard for other road users. So the specified test speed for tests in accordance with this document should be taken into account.

Tests that involve water deposition should not be carried out if there is a risk of water freezing on the pavement.

6 Essential characteristics

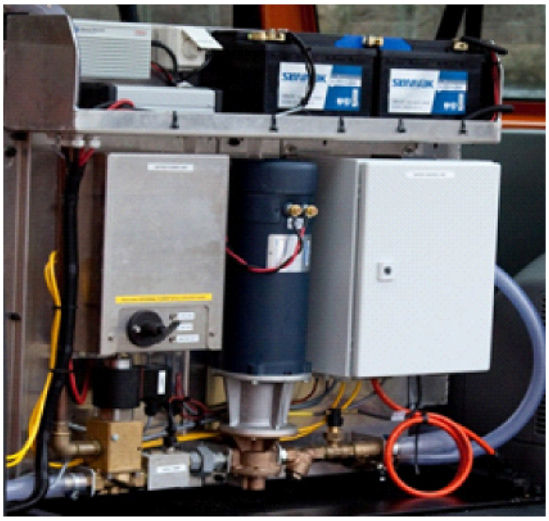
6.1 Principle of measurements

The following principles are used in order to perform continuous measurement of longitudinal friction coefficient. The measurement can be performed on either a wetted surface or a surface covered with snow or ice.

— Fixed slip: the tangential speed of the test wheel is fixed at given percentage of the vehicle speed. The percentage can be set to any value from 1 % to 75 %.

— Fixed slip speed the relative speed between the test wheel and the pavement surface is kept constant: this means a lower slip ratio at higher test speeds. The pulling vehicle will have a higher speed than the pre-set travel speed.

— Variable slip: The test wheel is frequently braked from 0 % slip ratio to 75 % slip ratio.



a) Watering system

b) Skid resistance device

Figure 1 — The ViaFriction system

6.2 Description of ViaFriction

The device is either fixed to a trailer with water tank and watering system, or fitted to a van with water tank and watering system in the trunk. A typical device is illustrated in Figures 1 a) and 1 b).

ViaFriction maintains a test wheel slip ratio using a controlled electrical brake system. The test wheel speed and the vehicle speed are measured in order to brake the test wheel to a correct slip ratio. The brake power needed to maintain a correct slip ratio is measured. The relation between brake power and wheel torque is established by the calibration process, chapter 10. The static vertical load, measured dynamic vertical force, brake power and speed are used to calculate the friction coefficient. The pre-wetting watering system enables the operator to set the theoretical water film thickness from 0 mm to 1 mm at a maximum speed of 120 km/h. Skid resistance measurements on roads require 0,5 mm water film thickness. Skid resistance measurements on airports require 1,0 mm water film thickness.

7 Key characteristics

7.1 General

The minimum requirements to ensure a good repeatability and reproducibility of the devices results are listed below.

7.2 Test speed

The test speed for the road version of ViaFriction is in between 20 km/h and 95 km/h. The speed is measured and the output is directly displayed to the driver and simultaneously recorded.

7.3 Braking system

The slip ratio is realized with an electrical system. Within the operational range, the average slip ratio percentage is kept within ± 1 % of the pre-set percentage, given the equal conditions.

7.4 Static wheel load

The apparatus is designed to provide an equal static load to the test wheel.

NOTE The various ViaFriction applications (trailer, car mount, truck mount) will have different static load.

7.5 Test wheel arrangement

The test wheel is mounted to run freely around bends without being subjected to lateral forces. The test wheel arrangement comprises of swing arm with suspension for maintaining an even tyre pressure also on uneven roads. Two separate speed sensor systems contain a standard encoder attached to the measuring and trailer wheel.

7.6 Test wheel

The test wheel used for measuring wet road skid resistance is using a tyre in accordance with ASTM 1551, mounted on a special rim and balance.

Tyre properties are as specified in ASTM 1551, Table 2, physical properties of tread components.

Tyre pressure: (207 ± 2) kPa.

The test wheel used for measuring dry road skid resistance is using the following tyre:

Trelleborg Unitester 520, 4.00 – 8, 6PR, tyre pressure (200 ± 2) kPa.

Store the tyres for the test wheel according to the storage specification stated in ASTM 1551. The standard states tyre storage below 29 °C, in subdued light and away from ozone-generating equipment. The maximum storage time is 1 year.

Before using a new test wheel for friction measurements, carry out a “braking in cycle” to condition the tread surface and remove all traces of mould lubricants and other impurities that might affect the frictional characteristics of the test wheel. The “braking in” cycle shall be done under measuring conditions, on a test length of at least 2 km.

Before using a new test wheel, the test wheel shall be approved using the following procedure:

— Measure a distance of at least 1 000 meters using an already approved test wheel. Perform a total of 4 repetitions.

— Measure the same distance using the new test wheel. Perform a total of 4 repetitions.

— Compare the result from each of the measurements using the new test wheel with the average of the measurements using the approved test wheel. The new test wheel is approved if the measured average friction for each measurement differs not more than ± 0,03 from the average measurement using the approved test wheel. Repeat the measurements using the new test wheel if necessary.

7.7 Minimum sampling interval

The minimum sampling interval for the brake friction force is 25 mm.

7.8 Pavement wetting system, water film thickness

The pavement wetting system consists of a watering nozzle and a water pump. The section length to be measured with one water tank filling depends by the volume of the water tank(s). Water consumption measuring roads is 35 l/km.

The vehicle speed is measured and the water flow is computer controlled in order to keep a constant water thickness independent of vehicle speed. For a level of 0,5 mm thickness in 50 km/h, this will give a flow of 29 l/min (35 [l/km] * 50 [km/h] * 1/60 [h/min]). The thickness is set by the operator. The water is applied to the pavement in front of the test wheel. The flow of water for pavement wetting is controlled to a constant theoretical water film thickness of 0,5 mm for roads and 1,0 mm for airports.

NOTE The water film thickness is called “theoretical” because it means the thickness on a perfectly dense, smooth and horizontal pavement. The real water film thickness depends on the pavement on which it is applied. For example on porous pavements the water depth is depending on the real porosity of the pavement. The theoretical water requirement for a 0,5 mm thick, 70 mm wide and 1 km long strip is 35 litres.

The nozzle shape and its position ensure that the water is delivered just in front of the test wheel over the full width of the contact patch. The water used for testing shall be reasonably clean, free of suspended solids, oil and salt and have no added chemicals such as wetting agents or detergents.

7.9 General requirements for measurements

The skid resistance measurements shall not be performed when it is raining or when water is sprayed from the pavement by the traffic.

7.10 Parameters recorded

An electronic recorder shall be provided, able to measure and display the following parameters:

— skid resistance at an interval of approximately 50 mm;

The skid resistance is calculated using the formula:

$$LFCN = H/V$$

where

H is the measured horizontal force;

V is the static vertical force;

LFCN is the skid resistance average over a test section of 5 m;

— travelled distance;

— test speed;

— pavement surface temperature;

— air temperature.

8 Test procedure

8.1 Standard test conditions

Table 1 — Standard test conditions

Air temperature	> 5 °C, < 50 °C
Pavement temperature	> 5 °C (testing season: April till November)
	< 50 °C
Pavement status	no pollution
Test wheel	ASTM 1551 tyre
Method	fixed slip, using 18 % slip ratio
Static wheel load	Specific to ViaFriction unit.
Vehicle speed	60 km/h for routine measurements and 60 km/h and 80 km/h for control of new pavements
Theoretical water film thickness	0,5 mm
Length for the mean value	minimum 5 m

The standard conditions are the Norwegian standard conditions. The slip ratio, water film thickness and the vehicle speed may differ from the standard conditions due to national requirements. If the ViaFriction is harmonized with other devices, the ViaFriction slip ratio and test speed should be set to values used by the other devices.

8.2 Prior to testing

Prior to testing, perform the following checks:

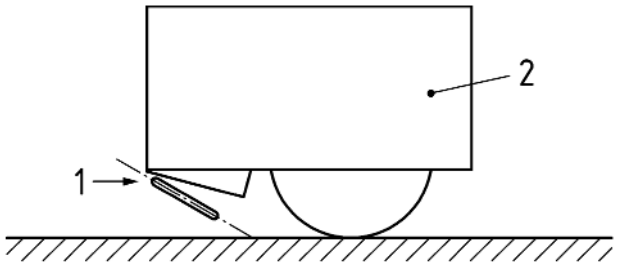
— Check tyre pressure and wear. The tyres have wear indicators telling if the tyre is worn out.

— Check test wheel for presence of flat spots, damage, or other irregularities that can affect test results.

— Check that the test wheel is approved using the procedure in 7.6. Additional run-in prior to each test is not required.

— Check the Via Friction unit for damages that may affect the measurements.

— Check if the nozzle position is correct. The nozzle shall point towards the middle of the test wheel path, and the angle shall be 30° ± 5°.



Key

1 ViaFriction

2 measure angle of nozzle with respect to ground

Figure 2 — Nozzle position

8.3 Testing

Adjust the vehicle speed to that specified and start recording friction.

Continue with the test maintaining the specified test speed.

Usually the path taken by the test wheels should follow the wheel path induced by the traffic. During the test the operator should monitor speed, test line and recorded values. The operator can also insert codes to indicate a deviation from the test line or other conditions that could affect the validity of the measurements.

The beginning and the end of the section shall be marked with kilometric points or with well-defined locations near the road.

On completion of the test length, after the final reference point, stop the recorder and raise the test wheel.

Skid resistance measurements shall only be taken on pavements that are free of obvious contamination.

9 Data recording

During the test the parameters defined in 7.10 of this specification are recorded continuously and simultaneously for successive subsections along the road.

The average skid resistance (*LFCN*) for the test length is stored in the database.

10 Calibration

The calibration of braking force involves specialized equipment and shall be performed by personnel trained by the manufacturer of the equipment.

1) When major parts (brake, bearings) have been replaced inside the ViaFriction unit, or every 2 years, the braking force measurement has to be calibrated.

    a) The braking force is calibrated using a machine that rotates the test wheel in speed up to 1100 rpm and 200 Nm applied torque, while measuring the applied torque on the test wheel.

    b) The machine is used to measure at least 5 torque levels at 4 different speeds.

2) When major repair has been done, or every year the flow calibration of the water system shall be checked.

    a) The water flow is checked by simulating various vehicle speeds and checking the actual flow of water.

3) At least once per year, the repeatability of the measurements shall be checked the following way:

    a) The check shall be performed on two different road surfaces with a length of 500 m and a difference in friction level of at least 0,3.

    b) Four consecutive measurements shall be performed on each road surface.

    c) The accuracy of the measured friction level shall comply with the values stated in chapter 11.

4) The distance calibration and the test wheel speed sensor shall be checked or recalibrated on the most frequent of the following:

    a) Once per year.

    b) At every change of the test wheel tyre.

    c) When the friction device has performed 200 km measurement since last distance calibration.

11 Accuracy

For determining the accuracy of the friction measurements the repeatability is used (see Table 2).

Table 2 — Precision of measurement

For 90 % of the runs the difference of mean between the two runs (10 m-values)	$\Delta\mu \leq 0{,}04$
For more than 90 % of the runs the standard deviation of the offset between the two runs (10 m-values)	$\Delta\sigma \leq 0{,}01$

12 Test report

The test report shall contain the following information in each measuring file:

— name of the organization;

— names of ViaFriction driver and operator;

— date of test;

— filename (with name of the test section);

— test length description;

— specification of the lane;

— start location (chainage or marker on road);

— end location (chainage or marker on road);

— friction value *LFCN* (10 m-value);

— test speed;

— static load;

— temperature of the air and pavement;

— comments.

Bibliography

[1] ISO 13473-3, *Characterization of pavement texture by use of surface profiles — Part 3: Specification and classification of profilometers*

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