DRAFT FOR DEVELOPMENT

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15901-7:2009

Road and airfield surface characteristics

Part 7: Procedure for determining the skid resistance of a pavement surface using a device with longitudinal fixed slip ratio (LFCG): the GripTester®

ICS 93.080.20

BSI
British Standards

National foreword

This Draft for Development is the UK implementation of CEN/TS 15901-7:2009.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than 3 years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of Update Standards.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee B/510/5, Surface characteristics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Road and airfield surface characteristics - Part 7: Procedure for determining the skid resistance of a pavement surface using a device with longitudinal fixed slip ratio (LFCG): the GripTester(r)

Caractéristiques de surface des routes et aéroports - Partie 7 : Mode opératoire de détermination de l'adhérence d'un revêtement de chaussée à l'aide d'un dispositif à coefficient de frottement longitudinal fixe (CFLG): le GripTester

Oberflächeneigenschaften von Straßen und Flugplätzen - Teil 7: Verfahren zur Bestimmung der Griffigkeit von Fahrbahndecken durch Verwendung eines Geräts mit festem Schlupfverhältnis in Längsrichtung (LFCG): der GripTester

This Technical Specification (CEN/TS) was approved by CEN on 27 June 2009 for provisional application.

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Foreword

This document (CEN/TS 15901-7:2009) has been prepared by Technical Committee CEN/TC 227 “Road materials”, the secretariat of which is held by DIN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This Technical Specification describes a method for determining the skid resistance of a surface by measurement of the longitudinal friction coefficient LFCG.

The method provides a measure of the wet skid resistance properties of a bound surface by measurement of the longitudinal friction coefficient using a continuous reading small braked wheel fixed-slip device.

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.

Test speeds can vary from 5 km/h to 130 km/h depending on the application. The measured values can be affected by the test speed.

The method has been developed for use on paved areas such as roads and airport runways and may also be used indoors.

This Technical Specification covers the operation of the GripTester.

The GripTester® is a device developed by Findlay Irvine Ltd in the United Kingdom that uses the braked-wheel fixed-slip principle with a small test wheel to make measurements of skid resistance continuously on airfields, roads and other surfaces. The fixed slip ratio is 15 %.

A machine conforming to the general characteristics of the GripTester and the specific provisions of this Technical Specification may also be used for the tests.

The skid resistance of a pavement is determined by friction measurements and measurements of pavement texture. Where measurement of pavement texture is required the standard for this measurement and the device is described in EN ISO 13473-1.

2 Normative references

The following referenced documents are indispensable for the application 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 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 4662, *Rubber – Determination of rebound resilience of vulcanizates*

3 Recommended uses

The method is applicable to the following types of pavements, for example:

— road surfacings;

— road markings;

— airport runways;

— flight decks;

— footways;

— pedestrian precincts;

— test panels of surfaces intended for any of the above.

The device may be used for the following fields of application:

— monitoring of networks (pavement management);

— approval of new surfacing;

— measurements for project-level compliance;

— investigation of surface skid resistance;

— comparative measurements among different devices;

— research measurements.

4 Terms and definitions

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

4.1
friction
resistance to relative motion between two bodies in contact

NOTE The frictional force is the force which acts tangentially in the contact area.

4.2
skid resistance
characterisation of the friction of a road surface when measured in accordance with a standardised method

4.3
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 Factors that contribute to skid resistance include the tyre pressure, contact area, tread pattern, and rubber composition; the alignment, texture, surface contamination, and characteristics of the road surface; the vehicle speed; and the weather conditions.

The skid resistance of a road 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.

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 away 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.

Where the surface contains aggregate with a coating of binder, e.g. bitumen, resin or Portland cement, the skid resistance will change as the coating is worn away by tyres.

4.4
pedestrian slip resistance
property of the trafficked surface to maintain the adhesion of a pedestrian shoe sole

4.5
bound surface
top layer or surface course of a road with the aggregates secured permanently in place

NOTE Aggregates are commonly secured in place by bitumen or Portland cement.

4.6
operating speed
speed at which the device traverses the test surface

4.7
contact area
overall area of the road surface instantaneously in contact with a tyre

NOTE This term describes the overall area generally covered by the tyre. Due to the effects of surface texture or any tyre tread pattern, not all of the tyre or road surface in the contact area can be in contact at any instant.

4.8
slip speed
relative speed between the test tyre and the travelled surface in the contact area

4.9
slip ratio
slip speed divided by the operating speed

NOTE For devices meeting the requirements of this Technical Specification the slip ratio is fixed by the geared braking system of the test wheel.

4.10
fixed slip
condition in which a braking system forces the test wheel to roll at a fixed reduction of its operating speed

4.11
braked wheel friction tester
apparatus that can be moved over the test surface at a known, steady speed and that includes a test wheel, a system for braking the test wheel and instrumentation for measuring the resulting friction between the test tyre and test surface

4.12
vertical force
load
force applied by the wheel assembly on the contact area

NOTE Some devices use an assumed load based on the static load.

4.13
horizontal force
drag
force acting tangentially on the test wheel in line with the direction of travel

4.14
GripTester
device developed by “Findlay Irvine Ltd in the United Kingdom” in the form of a trailer which can be towed by a vehicle that contains the recording and control computer and a water supply, which is not manufactured under license

4.15
instantaneous LFC
drag divided by the vertical load

4.16
longitudinal friction coefficient
LFC
ratio between horizontal force (drag) and vertical load (load) for a braked wheel in controlled conditions, which is normally a decimal number quoted to two significant figures

NOTE LFC varies depending on the slip ratio of the device and the operational speed.

4.17
LFCG
LFCG measured by a small braked wheel fixed slip device meeting the requirements of this Technical Specification

NOTE 1 It is the mean of a number of instantaneous friction readings over a defined length.

NOTE 2 The range of the LFCG is 0,00 to 1,20.

4.18
sampling length
distance over which responses of the sensors are sampled to determine a single measurement of the recorded variables

NOTE 1 The sampling length depends upon the detailed operation of device and its recording system; a number of samples may be combined to determine a measurement for a subsection.

NOTE 2 This should not be confused with horizontal resolution which is the shortest distance over which a change in the measured parameter can be detected.

4.19
subsection
defined length of surface for which one set of the measured variables is reported by the device

NOTE Different devices may use different subsections depending on the context of the measurements, such as 1 m, 5 m, 10 m or 20 m.

4.20
test section
length of road between defined points (e.g. location references, specific features, or measured distances) comprising a number of subsections over which a continuous sequence of measurements is made

4.21
water delivery system
system for depositing a given amount of water in front of the test tyre so that it then passes between the tyre and the surface being measured

4.22
water flow rate
rate at which water is deposited on the surface to be measured in front of the test tyre

NOTE Water flow rate is expressed in litres per second (l/s).

4.23
theoretical water film thickness
theoretical thickness of a water film deposited on the surface in front of the measuring tyre, assuming the surface has zero texture depth

4.24
wheelpath
part of the pavement surface where the majority of vehicle wheel passes are concentrated

NOTE The wheelpath is not a fixed location on a pavement surface. On a worn pavement, the wheelpath is usually easily identified visually. On a newly laid surface, the position of the wheelpath needs to be estimated by experienced operators.

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

4.25
nearside wheelpath
wheelpath that is closest to the edge of the road in the normal direction of travel

NOTE For countries that normally drive on the right, this is the right-hand side, and, for countries that normally drive on the left, this is the left-hand side.

4.26
routine testing
measurement of the skid resistance of a surface in standardized test conditions, which normally include a defined water flow rate

4.27
airfield operational testing
measurement of the skid resistance of a surface on an airfield in response to an operational need and in whatever conditions exist at the time of the test, which can include contamination by ice, snow, slush or water

NOTE These tests do not include water deposition.

4.28
push mode
mode in which the device is pushed by a pedestrian

4.29
tow mode
mode in which the device is towed by a vehicle

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.

NOTE The wetting of surfaces can have an effect on other users of the site 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 trafficked roads the device may operate at speeds different to normal road speeds and as a result can create a hazard to other road users. The test speed specified when calling for tests in accordance with this Technical Specification should take this into account.

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

When carrying out a friction survey at an airport, ensure that all activities are under the control of the airport operators.

6 Essential characteristics

6.1 Principle of measurements

Devices complying with this Technical Specification operate on the principle that the measuring wheel is to give a fixed slip ratio of 15 % between it and the speed of travel along the wetted pavement surface. The wheel slips as it is towed along the wetted pavement surface at a constant speed and the slipping force is measured. A typical device is illustrated in Figure 1.

6.2 Description of GripTester®

The device is a trailer having two drive wheels and a single small test wheel similar to a "go-kart" wheel. It is capable of being manually pushed or being towed behind a vehicle at speeds between 5 km/h and 100 km/h. The test wheel is mounted on a stub axle and is mechanically braked by a fixed gear and chain system with a ratio of 27:32 in relation to the drive wheels so that there is a slip ratio of just over 15 %. The static load on the test wheel is (250 ± 30) N when towed or (260 ± 30) N when used in push mode. During operation, the stub axle becomes elastically deformed by the horizontal drag and vertical load forces acting on the test tyre.

The drive wheel tyres have a patterned tread and carry just over three quarters of the weight of the instrument. The test wheel tyre has a smooth tread. The two drive wheels are mounted on the main axle, which also carries a toothed wheel. A proximity sensor is mounted adjacent to this toothed wheel in such a way that signals from this sensor can be transmitted to a signal processing unit (SPU) for calculation of distance. Two strain gauge bridges on the stub axle continuously measure the horizontal drag and vertical load forces, transmitting these signals to the SPU, which calculates instantaneous LFG. These readings are sent to a data capture device where the LFCG, distance, and speed are computed and stored.

When used for routine testing of a pavement in wet condition, water is deposited in front of the test tyre from a water tank fitted with a control valve. A water nozzle is mounted directly in front of the test wheel delivering a controlled amount of water to the road surface under investigation. In towing mode, water flow rate is further controlled by a pump and may be monitored with a flow meter.

When the device is used in towing mode, the towing vehicle shall comply with the following technical requirements:

— tow bracket (central and/or right and/or left);

— sufficient space for the water tank;

— electricity supply for the water supply system, data acquisition computer and guidance system.

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 equipment

The test equipment shall include the following features:

— trailer containing a test and drive wheel assembly;

— water supply and flow control mechanism;

— electronic recorder and measurement control system;

— a fixed slip ratio: (15 ± 1) %.

7.3 Drive tyre

The drive tyres shall be 254 mm(10 inch)-diameter, treaded tyre; both drive tyres shall be identical.

NOTE A Dunlop 10 × 3,60-5, tread KT3-W, tread compound K8-CIK has been found suitable to ensure the drive tyre does not slip on the surface. Other sources of tyres may be used provided that the same value of LFCG is achieved.

7.4 Test tyre

The test tyre shall be tubed, pneumatic, natural rubber, 254 mm(10 inch)-diameter with a smooth surface.

The tyre resilience shall be in the range at (46 ± 3) as measured by the Lupke test in accordance with ISO 4662 at 20 °C. The Shore hardness (IRHD) of the rubber shall be (58 ± 2), in accordance with ISO 48.

The tyre is conditioned in accordance with ASTM E1844-96.

NOTE 1 An ASTM E1844-96 tyre has been found to be suitable. Other sources of tyres may be used provided that the same value of LFCG is achieved.

Inflate the tyre to a pressure of (138 ± 3) kPa when measured at 20 °C.

NOTE 2 The tyre pressure should be equivalent to that at the specified temperature. In practice, other pressure values will apply at other temperatures.

Discard the test tyre when it loses 6 mm in diameter (3,0 mm tyre wear), or if otherwise damaged.

Date stamp all tyres and mark each one indelibly with a unique reference number. Mark the tyre with an indicator that will enable wear of 3 mm to be identified. Do not use a tyre which has worn beyond the minimum diameter. Do not use a tyre that is more than two years old. Tyres should be stored in a cool dry environment away from direct sunlight, in such a way that they are not damaged or distorted.

NOTE 3 This can be achieved by storing vertically.

7.5 Pavement wetting system, water film thickness

The theoretical water film thickness for the LFCG test shall be 0,25 mm minimum at the test speed for wet testing of roads. For other applications a different thickness may be required and shall be reported.

NOTE The water film thickness is called "theoretical" because it means the thickness on a perfectly dense, smooth and horizontal pavement. The actual water film thickness depends on the pavement on which it is applied. For example on porous pavements the water depth is depending on the porosity of the pavement.

The flow rate of the water shall be capable of being adjusted to achieve this value at various test speeds.

The wetted area shall cover the full width of the tyre 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.

7.6 Measurement control system and recorder

The control system shall enable the operator to control the water supply. An electronic recorder shall be provided, able to measure, as a minimum, the horizontal drag, vertical load, speed and distance travelled.

The data recorder system shall be able to measure and record data in accordance with the requirements of Clause 10 of this specification.

7.7 Parameters recorded

For each test section the following are measured and recorded:

— the average LFCG for each subsection;

In order to determine the LFCG the equipment shall measure the average horizontal drag force, H, and the average vertical load, V, for a maximum sampling length of 400 mm in tow mode or 40 mm in push mode.

— the LFCG for a defined test length is calculated using the formula LFCG = H/V. The resulting LFCG values shall be aggregated to calculate the average for the subsection;

— the average test speed for each subsection;

Speed shall be recorded to an accuracy of ± 1 km/h and recorded in kilometres per hour (km/h) to the nearest 1 km/h.

— the length of the subsection.

The subsection length shall be defined before testing is carried out. Typically 1 m, 5 m, 10 m or 20 m may be used.

NOTE The temperature of the water in the tank and/or surface temperature may be measured. These temperatures may be used to adjust the measured LFCG.

8 Test Procedure

8.1 Standard test conditions

The standard test conditions of the method are (see Table 1):

Table 1 — Standard test conditions

Air temperature	> 4 °C
Pavement temperature	> 5 °C < 50 °C
Pavement status	no pollution
Test wheel	smooth ASTM-tyre small diameter
Method	constant slip ratio, 15 %
Static wheel load	(250 ± 20) N
Operating speed	5 km/h to 130 km/h
Theoretical water film thickness	0,25 mm minimum
Length for the mean value	optional
Wheelpath	Normally nearside wheelpath or as required

8.2 Prior to testing

Prior to testing the device shall be checked for the following:

— the general function of the appliance is tested — for example the free running of rotating parts;

— tyre pressure and wear of all tyres;

— smooth operation of the suspension;

— wheels and wheel rims for damage and the tyre tread for foreign bodies;

— water supply and flow;

— battery condition.

8.3 Routine testing

8.3.1 General

Wherever possible, the surface to be measured should be free from standing water, frost, grease, debris or other contamination. The water delivery system shall be set up to provide the required water flow rate.

The temperature of water applied shall be not less than 5 °C and not greater than 35 °C.

NOTE The tank of water should be protected from the sun.

During the test the operator shall monitor speed, test line and recorded values. The operator should indicate a deviation from the test line or other conditions that could affect the validity of the readings.

8.3.2 Tow mode

Prior to the first test, check that the measuring system has reached the appropriate stable state. This shall be done by switching on the device for at least 5 min and towing the device over at least 500 m with the water delivery system in operation.

With the water delivery system in operation, tow the device smoothly and at a standard speed, operating the data capture device in accordance with the manufacturer's instructions.

8.3.3 Push mode

Prior to the first test, check that the measuring system has reached the appropriate stable state. This shall be done by switching on the device for at least 5 min and pushing the device over at least 20 m with the water delivery system in operation.

With the water delivery system in operation, push the device smoothly and at the standard speed of (5 ± 2) km/h, operating the data capture device in accordance with the manufacturer's instructions.

NOTE 1 The test speed will be defined by the user of the data depending upon his specific requirements. The test speed is not necessarily the same as the speed used for the purposes of analysing the results for which the values may need to be adjusted.

NOTE 2 Usually the path taken by the test wheel should follow the nearside wheelpath or the path taken by normal vehicular flow (in particular the path taken by heavy goods vehicles).

8.4 Airfield operational testing

8.4.1 Towing mode

Prior to the first test check that the measuring system has reached the appropriate stable state. This shall be done by switching on the device for at least 5 min and towing the device over at least 500 m.

Adjust the towing vehicle speed to the speed specified for the test length and start the recorder.

Continue with the test, maintaining the specified test speed and entering reference codes at the appropriate locations.

8.4.2 Push mode

Prior to the first test, ensure that the measuring system has reached the appropriate stable state. This shall be done by switching on the device for at least 5 min and pushing the device over at least 20 m.

Push the device smoothly and at the standard speed of (5 ± 2) km/h, operating the data capture device in accordance with the manufacturer's instructions.

9 Data Recording

During a test, the recorder shall be able to display and make a continuous record of the required parameters defined in 7.7 of this specification for successive subsections along the road.

The recorder shall be able to record automatic or manual input reference points.

The operator shall be able to insert codes to indicate a deviation from the intended test line.

10 Calibration

10.1 General

The calibration of the machine shall be carried out at the frequency given in Table 2.

Table 2 — Frequency of calibration

Operation	Frequency
Load zero/drag zero (quick check)	on day of test
Horizontal and vertical load (full calibration)	monthly
Distance	monthly
Water flow rate	3 monthly
Full manufacturer's service and calibration	annually
Correlation exercise with other devices where described in national requirements	annually

10.2 Load zero/drag zero quick check

The display values of the measured forces on the unstressed test wheel are tested in horizontal and vertical direction.

10.3 Vertical load and horizontal force (full calibration)

10.3.1 Check/adjust the vertical load zero

Check that the device records zero load when no load is applied.

10.3.2 Check/adjust the vertical load gain

Apply a vertical load of 200 N perpendicular to the test wheel axle and adjust the gain of the load cell to the required target.

10.3.3 Check/adjust the horizontal force zero

Remove the chain tension and check that the recorded horizontal force is zero.

10.3.4 Check/adjust the horizontal force gain

Apply a horizontal force of 150 N perpendicular to the test wheel axle and adjust the gain of the load cell to the required target.

10.4 Distance

Carry out a distance calibration as described below or if the drive tyres are changed, or if a malfunction is suspected.

Ensure tyre pressures are correct according to the manufacturer's instructions.

Select a straight, level stretch of road of known length at least 400 m.

Start the recorder. Tow the device along the length and record the distance at the start and end of the test section. The result shall be within ± 1,0 % of the known length.

10.5 Water Flow rate

Pump the water into a calibrated receptacle of at least ten litres capacity and measure the time to fill.

10.6 Full manufacturer's service and calibration

The device shall have an annual independent calibration of the measuring devices.

A comparative test is done with a reference device and a certificate of compliance provided.

10.7 Correlation exercise with other devices

Where required by national regulations, devices should be checked one against each other on different surfaces.

11 Precision

The repeatability r is the maximum difference expected between two measurements made by the same machine, with the same tyre, using the same crew on the same section of road in a short space of time, with a probability of 95 %.

The reproducibility R is the maximum difference expected between two measurements made by different machines with different tyres using different crews on the same section of road in a short space of time, with a probability of 95 %.

Trials on different surfaces in April 2004 in UK showed that for routine testing at 50 km/h the repeatability of the LFCG measured using a GripTester was $r = 0{,}03$ and its reproducibility was $R = 0{,}07$.

Trials on different surfaces in May 2005 in France showed that for routine testing at 30 km/h the repeatability of the LFCG measured using a GripTester was $r = 0{,}03$ and its reproducibility was $R = 0{,}08$.

Trials on different surfaces in September 2004 in Germany showed that for routine testing at 80 km/h the repeatability of the LFCG measured using a GripTester was $r = 0{,}03$ and its reproducibility was $R = 0{,}06$.

12 Test report

A report shall be produced including the following information:

a) name of the organization carrying out the test;

b) names of driver and operator;

c) machine reference;

d) date of test;

e) weather conditions;

f) test section description; direction/lane/start and finish points;

g) start time;

h) target speed;

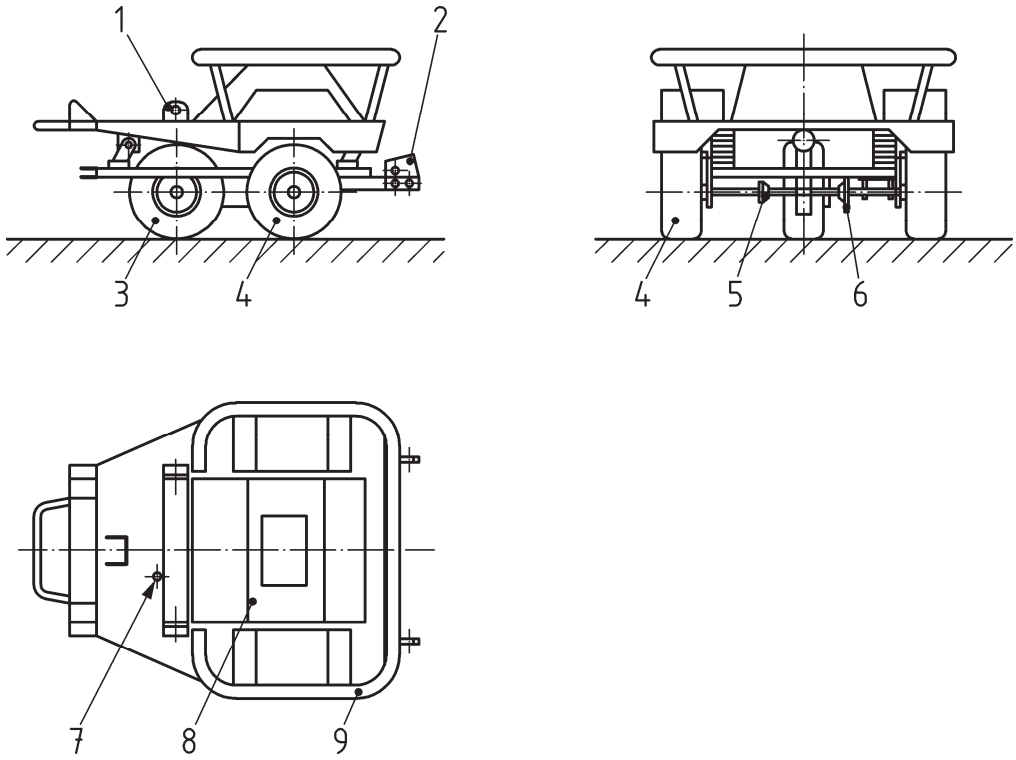
i) test tyre reference and serial number;

j) distance tested;

k) average LFCG for each sub-section;

l) comments.

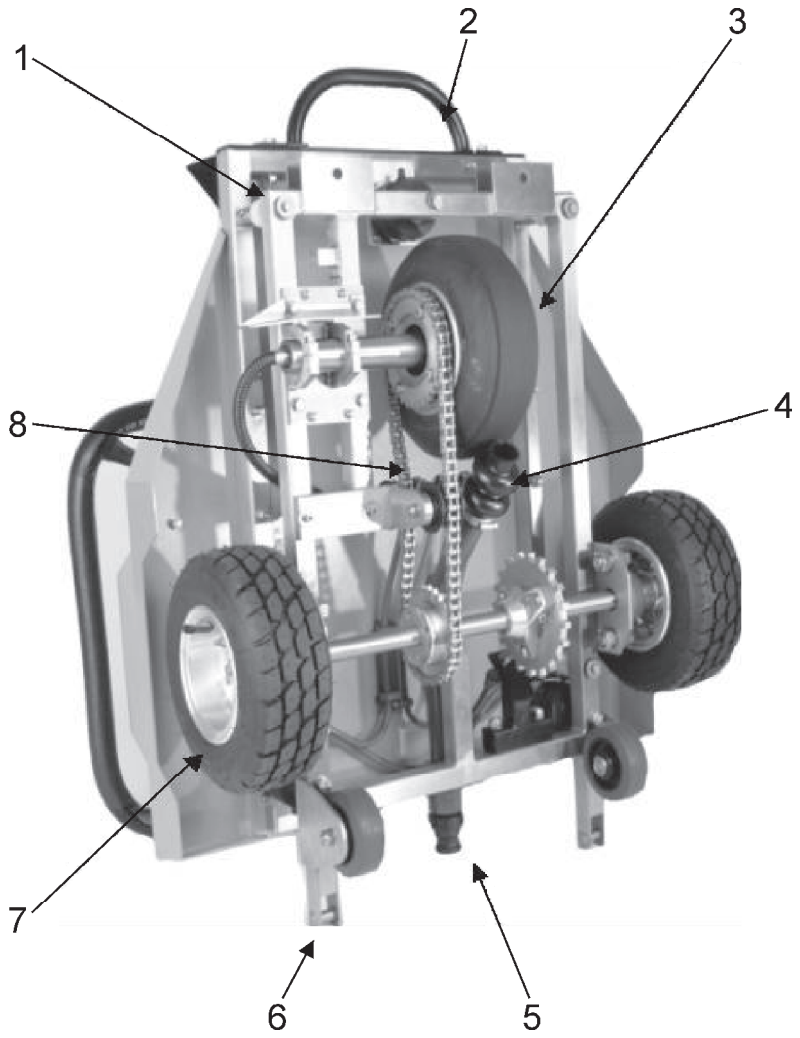
Recorded data shall be kept in an appropriate medium for subsequent processing.



Key

1 pushing trunnion
2 towing bracket
3 test wheel
4 drive wheels
5 sprocket
6 toothed wheel
7 calibration hole
8 SPU weather cover
9 guard rail

Figure 1 — Diagrammatic layout of a typical device



Key

1 chassis
2 lifting handle
3 measuring wheel
4 water supply
5 water connection
6 towing bracket
7 drive wheel
8 transmission chain

Figure 2

Bibliography

[1] ASTM E1844-96, *Standard Specification for A Size 10 x 4-5 Smooth-Tread Friction Test Tire*

[2] EN ISO 13473-1, *Characterization of pavement texture by use of surface profiles – Part 1: Determination of Mean Profile Depth (ISO 13473-1:1997)*

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