BRITISH STANDARD

BS EN
1177:2008

Impact attenuating playground surfacing — Determination of critical fall height

ICS 97.200.40

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 1177:2008. It supersedes BS EN 1177:1998, which will be withdrawn on 31 May 2009.

The UK committee considers it essential that BS EN 1177 should be used in conjunction with BS 7188 so that other properties of abrasive wear, resistance to indentation and ease of ignition are still measured.

The UK participation in its preparation was entrusted to Technical Committee SW/65, Children's playground equipment.

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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English Version

Impact attenuating playground surfacing - Determination of critical fall height

Sols d'aires de jeux absorbant l'impact - Détermination de la hauteur de chute critique

Stoßdämpfende Spielplatzböden - Bestimmung der kritischen Fallhöhe

This European Standard was approved by CEN on 25 April 2008.

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Foreword

This document (EN 1177:2008) has been prepared by Technical Committee CEN/TC 136 “Sports, playground and other recreational facilities and equipment”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2008, and conflicting national standards shall be withdrawn at the latest by May 2009.

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 implement this European Standard: 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.

This document supersedes EN 1177:1997.

European standards for playground equipment and surfacing comprise this European Standard and EN 1176, which consists of a number of parts as follows:

EN 1176-1, *Playground equipment and surfacing — Part 1: General safety requirements and test methods*

EN 1176-2, *Playground equipment and surfacing — Part 2: Additional specific safety requirements and test methods for swings*

EN 1176-3, *Playground equipment and surfacing — Part 3: Additional specific safety requirements and test methods for slides*

EN 1176-4, *Playground equipment and surfacing — Part 4: Additional specific safety requirements and test methods for cableways*

EN 1176-5, *Playground equipment and surfacing — Part 5: Additional specific safety requirements and test methods for carousels*

EN 1176-6, *Playground equipment and surfacing — Part 6: Additional specific safety requirements and test methods for rocking equipment*

EN 1176-7, *Playground equipment and surfacing — Part 7: Guidance on installation, inspection, maintenance and operation*

EN 1176-10, *Playground equipment and surfacing — Part 10: Additional specific safety requirements and test methods for fully enclosed play equipment*

EN 1176-11, *Playground equipment and surfacing — Part 11: Additional specific safety requirements and test methods for spatial network*

For inflatable play equipment see

EN 14960, *Inflatable play equipment — Safety requirements and test methods*

The principal changes from the previous edition of this European Standard are that all safety requirements have been removed and are now included in EN 1176-1 so that this standard is now only a method for assessing impact attenuation. As a result of round robin testing, additional criteria for carrying out the test procedure and additional requirements for the test equipment have been introduced.

Introduction

This European Standard is based on the safety principles given in EN 1176-1 for playground equipment and provides a method for the assessment of impact attenuation of surfaces intended for use in the impact area as defined in EN 1176-1.

Injuries caused by falls from playground equipment occur for a variety of reasons but the most severe injuries are likely to be injuries to the head. The committee responsible for this European Standard recognizes that there are many factors that influence injury mechanisms independent of the surfacing, e.g. body orientation, awkwardness of fall, bone density, etc. Recent research has indicated that permanent disabilities and long bone injuries could be influenced by the duration of the acceleration pulse. The committee responsible for this European Standard intends to consider recent research in this area in a future revision of this standard.

Consequently, priority has been given to developing a criterion for surfacing materials intended to assess their ability to reduce the likelihood of head injuries.

On the basis of statistical analysis of available data the Head Injury Criterion (HIC) at a tolerance level of 1 000 has been used as the upper limit for the brain injury severity unlikely to have disabling or fatal consequences. By choosing measurement of HIC as the criterion of safety, the method considers only the kinetic energy of the head when it impacts the surface of the impact area. This is considered to be the best model available to predict the likelihood of head injury from falls. Surfaces fulfilling the test requirements of this standard are considered to be in compliance with the requirements for impact attenuation in EN 1176-1.

NOTE The HIC value of 1 000 is merely one data point on a risk severity curve where a HIC of 1 000 is equivalent to a 3 % chance of a critical injury (MAIS[1)] 5), a 18 % probability of a severe (MAIS 4) head injury, a 55 % probability of a serious (MAIS 3) head injury, a 89 % probability of a moderate injury (MAIS 2), and a 99,5 % chance of a minor head injury (MAIS 1), to an average male adult.

There are a variety of materials available providing impact attenuation, including rubber tiles, mats, slabs, continuous synthetic surfacing, either prefabricated or formed 'in-situ', loose particulate material, such as gravel, sand, wood chips, bark, etc. The method in this European Standard can be used to assess any of these surfaces.

1) Maximum Abbreviated Injury Scale, first developed by the Association for the Advancement of Automotive Medicine and used extensively in the automotive industry as an indicator of the severity of head-related injuries.

1 Scope

This European Standard specifies a method for determining the impact attenuation of playground surfacing. It defines a “Critical Fall Height" (see 3.2) for surfacing, which represents the upper limit of its effectiveness in reducing head injury when using playground equipment conforming to EN 1176. The test methods described in the European Standard are applicable for tests carried out in a laboratory and for tests on site.

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.

EN 933-1, *Tests for geometrical properties of aggregates – Part 1: Determination of particle size distribution – Sieving method*

EN 1176-1:2008, *Playground equipment and surfacing — Part 1: General safety requirements and test methods*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

ISO 6487:2002*, Road vehicles – Measurement techniques in impact tests – Instrumentation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1176-1:2008 and the following apply.

3.1
impact attenuation
property of a surface, which dissipates the kinetic energy of an impact by localized deformation or displacement such that the acceleration is reduced

3.2
critical fall height
maximum free height of fall, for which a surface will provide an acceptable level of impact attenuation, determined as described in 4.4

3.3
head injury criterion (HIC) value
criterion for head injuries caused from falls as calculated in accordance with 4.6.1

3.4
test position
position on the material to be tested located vertically below the centre of the headform

3.5
drop height
distance between the test position on the surfacing and the lowest point of the free falling headform prior to release

NOTE In the case of a guided headform this value is calculated from measurement of velocity at impact (see 4.2.6).

3.6
impact measurement
HIC value from the recorded acceleration of the headform falling from one fall height onto one test position

3.7
drop test
series of impact measurements determined from at least four increasing drop heights

3.8
loose particulate material
material which absorbs the energy of an impact usually through its displacement

4 Test method

4.1 Principle

Test specimens or installed areas of the impact attenuating material under test are struck by an instrumented headform in a defined series of impacts from different drop heights. The signal emitted by an accelerometer (see Figure B.1) in the headform during each impact is processed to yield a severity from the measured impact energy, defined as head injury criterion (HIC).

The HIC of each impact is plotted and the critical fall height is determined as the lowest drop height producing a HIC value of 1 000 (see Figure B.2).

4.2 Apparatus

4.2.1 Test rig, comprising a headform with accelerometer (4.2.2), optionally with a charge amplifier (4.2.3) and, if using a uniaxial accelerometer, a guidance system (4.2.4) and impact measuring equipment (4.2.8), as shown in Figure A.1.

4.2.2 Headform, consisting of either

a) an aluminium alloy ball; or

b) a hemispherical ended aluminium alloy missile.

It shall have a diameter of 160 mm $\pm$ 5 mm, a mass of 4,6 kg ± 0,05 kg, with a maximum deviation from the hemispheric surface of 0,5 mm, incorporating an accelerometer as follows:

c) triaxial accelerometer for free falling headforms, mounted in the centre of gravity of the headform; or

d) uniaxial accelerometer for guided headforms, aligned to measure in the vertical axis $\pm$ 5° and located directly above the centre of mass.

The impacting part of the headform between the lower boundary and accelerometer shall be homogeneous and free from voids.

4.2.3 Charge amplifier (optional)

4.2.4 Guidance system, to guide the headform when using a uniaxial accelerometer, including a means to measure the velocity of the headform immediately prior to impact.

4.2.5 Length measuring equipment, such that for the free-fall impact test, the drop height can be measured directly prior to release of the headform.

NOTE Calculating the drop height from the measured time between release and contact of the missile with the surface may be not sufficient because of possible time differences between the start of time measurement and the effective release of the headform (e.g. caused by permanent magnetism in a magnetic release system).

In all cases, the drop height shall be measured with an uncertainty of not greater than 1 %.

4.2.6 Velocity measuring equipment, such that for the guided impact test, the theoretical drop height can be calculated by measuring the velocity of the headform immediately prior to the impact**.**

In all cases, the velocity shall be measured with an uncertainty of not more than ± 1 %.

NOTE To allow for frictional losses, the velocity of the headform immediately prior to impact is recorded in order to calculate the equivalent drop height as if the headform had been in free fall.

4.2.7 Release system, such that for the free-fall impact test, it does not create a rotation moment or any other forces on the headform, when released.

NOTE A rotation moment or other forces on the headform would cause additional accelerations after impact in the triax, leading to an uncontrollable error of the resultant for the vertical measurement.

4.2.8 Impact measuring equipment, consisting of an accelerometer measurement system (4.2.9), a recording device (4.2.10) and a HIC calculation program (4.2.11).

4.2.9 Accelerometer measurement system, capable of measuring all frequencies in the range 0,3 Hz to 1 000 Hz and having a sufficient response at all frequencies to keep amplitude errors below 5 %, in accordance with ISO 6487. It shall be capable of measuring, recording and displaying the acceleration and time duration of each complete impact.

NOTE For a sufficient response at low frequencies, the - 3 dB lower limiting frequency should be less than or equal to 0,3 Hz to reduce the error by overshooting the baseline after the impact and underestimating the g-max. and HIC score, particularly for longer pulse durations (see frequency response diagram in ISO 6487:2002, Figure 1). An accelerometer with a time constant of 2 s or greater and appropriate signal conditioning will generally meet this requirement.

4.2.10 Recording device, capable of capturing and recording the acceleration time signals produced during an impact with a minimum sampling rate of 10 kHz. Signal conditioning and filtering shall be compatible with the accelerometer and the data channel specified and shall conform to ISO 6487.

NOTE According to ISO 6487 the analogue anti-aliasing filters should have an attenuation of at least 30 dB at half the sampling rate.

4.2.11 Program for calculating the HIC value for the recorded acceleration time history of each impact, in accordance with 4.6.

4.3 Accuracy of tests

4.3.1 Apparatus shall be equipped with calibrated measuring devices. The impact measuring system, including the signal processing equipment and the measuring of drop height, shall be validated at least annually by a competent laboratory in accordance with EN ISO/IEC 17025.

NOTE For on-site testing, it is recommended that the frequency of equipment validation be increased.

4.3.2 Accelerometers shall be calibrated for the whole frequency range. Recalibration shall be carried out at time intervals recommended by the manufacturer of the accelerometer or at least every two years. Accelerometers shall have an uncertainty not greater than 5 %.

4.3.3 Velocity measurement systems shall be calibrated for the whole velocity range (up to 3 m drop height).

4.3.4 The computer algorithm used for the calculation shall be checked by imposing a half-sine curve and the result, when compared with an independent mathematical calculation of this curve, shall not deviate by more than ± 1 %.

4.3.5 Reactions from the release system on the headform shall be tested by a series of at least three consecutive drop tests on a defined reference surface with constant properties. The HIC values obtained shall not differ more than ± 5 %.

NOTE 1 These tests are for checking any deviations or anomalies in the components and neither replace calibration nor the validation for compliance of the apparatus with this European Standard.

NOTE 2 Experience has shown that comparative testing on defined surfaces might not be sufficient and that an external calibration of the measuring device is required.

4.4 Conditions for testing

4.4.1 Testing in the laboratory

4.4.1.1 Testing shall be carried out at a temperature of 23 °C ± 5 °C.

4.4.1.2 Testing shall be carried out on a flat, rigid concrete, or equivalent substrate of sufficient mass, density and thickness that its deformation during the test makes no significant contribution to the test result.

4.4.1.3 For testing particulate material, a test frame without a base shall be used, having internal dimensions not less than 1 m × 1 m, and capable of containing the material to the depth specified by the supplier.

NOTE 1 The dimensions given usually reduce the influence of containment on particulate materials.

Particulate materials shall be placed in the test frame above the flat rigid substrate and uniformly distributed within the frame, without compaction, to a depth specified by the supplier.

NOTE 2 The depth can be determined by laying a 1 m × 1 m × 10 mm sheet of plywood on the material and measuring the thickness of the layer below the plywood.

4.4.1.4 For testing tiles, at least four tiles with a minimum total dimension of 1 m x 1 m shall be installed on a flat, rigid substrate (4.4.1.2) according to the manufacturer's instructions, including all connecting and site fixing elements used for installation in the playground.

4.4.1.5 For testing surfacing intended to be manufactured on site, either of the following shall be prepared without seams or joints:

a) at least one test specimen with a minimum total dimension of 1 m × 1 m, placed on a rigid substrate (4.4.1.2) in accordance with the manufacturer's instructions; or

b) at least nine separate specimens, each not less than 500 mm × 500 mm, laid in turn on a flat rigid substrate (4.4.1.2) in accordance with the manufacturer's instructions.

4.4.1.6 For products intended to be laid over another layer, the entire system, surfacing with under layer, shall be tested on the flat rigid substrate (4.4.1.2) and reported as a composite product.

NOTE Substrates other than the flat, rigid substrate (4.4.1.2) are likely to contribute to the impact attenuation of the material being tested.

4.4.1.7 If it is suspected that the impact attenuation of the material could be influenced by moisture (e.g. sand), the moisture content at the time of testing shall be measured and reported together with the test method used.

NOTE 1 The impact attenuation of some loose particulate material can be significantly influenced by its moisture content.

NOTE 2 Products intended to be installed in combination with a natural substrate (e.g. lawn, grass, natural turf, sand) cannot be meaningfully tested in the laboratory and cannot be subject to a test report according to EN ISO/IEC 17025. The critical fall height of such products can only be determined individually by an on-site test, on a mature, fully established installation.

4.4.2 Testing on site

4.4.2.1 Testing on site shall be carried out and reported generally as described for laboratory testing, except that other relevant climatic conditions shall be identified (temperature, moisture, etc.), measured and reported when carrying out the test.

4.4.2.2 Testing on site cannot be used for product certification and an individual test report conforming to 4.7.2 shall be issued prefaced by the statement in 4.7.3.

NOTE As the performance of some materials is greatly affected by temperature, moisture and other factors, the test will only determine a critical fall height in the actual situation at the time of the test.

4.5 Procedure

4.5.1 Time/acceleration trace

Display the time/acceleration trace for each impact and examine it for any anomalies before being processed and evaluated.

If high frequency components appear in the signal obtained from a drop test using the headform described in this test method, it is very likely that some mechanical fault is present in the apparatus. Check to ensure that no component of the headform is loose, in particular the accelerometer.

If high frequency components appear as a consequence of vibrations of the drop test headform, filtration of signals with a standardized filter will be necessary. Measure both with and without the filter and compare the HIC values.

4.5.2 Selection and definition of the test position

4.5.2.1 For each selected drop height, carry out the impact measurement in all relevant test positions of the test pieces or test material, as far as is practical, to determine the test position of the critical fall height.

4.5.2.2 Ensure that the distance between any two test positions is not less than 250 mm and that no position is closer than 250 mm from the edge of the test specimen, assembly or test frame.

NOTE These distances are to avoid influences on the test position from previous tests and from the edges at the perimeter of the test specimen.

4.5.2.3 For all tests, ensure that the location of each test position where the critical fall height is measured is referenced to the test specimens or material and is related to the structure and/or geometry of the surfacing. Indicate this in the test report.

4.5.2.4 When site tests are carried out, ensure that the location of each test position where the critical fall height is measured is also referenced to the playground equipment. Indicate this in the test report.

4.5.2.5 For loose particulate materials and natural surfacing, locate the test position for each drop height at a new (untested) ground position.

NOTE Loose particulate materials and natural surfacing include topsoil and sand.

4.5.2.6 Do not test falling areas if they are inclined at more than 10° to the horizontal.

4.5.2.7 If different types of ground and/or surfacing are used in the impact area, test each type of area separately.

4.5.3 Procedures for specific types of product

4.5.3.1 Fabricated surfacing products

4.5.3.1.1 Testing in the laboratory

For tiles, slabs or other fabricated surfacing products, conduct at least nine drop tests, each at a different test position on the test specimens (see 4.4.1.4 and 4.4.1.5).

For tiles, conduct a drop test (minimum four drop heights) in the following positions:

a) in the centre of the tiles;

b) in the centre of a joint between two adjoining tiles;

c) at the junction where the greatest number of tiles meet; and

d) at any other point of inhomogeneity or discontinuity, to obtain the lowest value for the critical fall height anywhere on the assembly.

Ensure that each drop test is completed within 15 min.

Record each HIC value.

4.5.3.1.2 Testing on site

Use the procedure described in 4.5.3.1.1, except that all drop heights shall be at the relevant maximum free height of fall of the equipment for that position.

4.5.3.2 Loose particulate materials and natural surfaces

4.5.3.2.1 General

For loose particulate materials, conduct at least three drop tests as described in 4.5.3.2.2 or 4.5.3.2.3, as appropriate.

4.5.3.2.2 Testing in the laboratory

Locate the first test position, which shall be not less than 250 mm from the frame, and conduct three consecutive impacts with the headform from the same drop height in the same test position without redistribution of the material (see 4.4.1.3).

Record each result.

NOTE This procedure allows for possible effects of compaction of the material and is likely to give progressively higher values.

Redistribute the material in the frame and re-level it to the same test thickness.

Drop the headform from the second (incrementally higher) drop height, three times without re-distribution, as before.

Re-distribute the material in the frame and re-level it to the same test thickness. Repeat the procedure until all necessary drop heights (minimum of four) have been tested.

Record each HIC value.

To measure HIC values for the same product, installed at a different layer thickness, remove all the material from the frame and replace it with fresh material before testing at a new thickness.

For materials that are likely to be significantly influenced by their moisture content (e.g. sand), measure the moisture content at the time of testing and record the method used and the result.

When testing sand or gravel, determine the particle size distribution by carrying out a sieve test in accordance with EN 933-1.

4.5.3.2.3 Testing on site

For testing on site, carry out the procedure as described in 4.5.3.2.2 for each drop height (minimum of four), using a separate position for each drop height, ensuring that the material is present at the same layer depth at each test position. From each drop height, drop the headform three times on the same test position without redistribution and record the highest value for HIC from the three drops. Carry out the test at the next drop height on a different part of the surface, at least 250 mm away.

Record each HIC value.

When testing on site, a variety of test positions shall be selected to ensure the worst case situation is included (e.g. access position). When testing sand or gravel on site, it is not necessary to determine the particle size distribution.

4.5.4 Selection of data for determination of critical fall height

Select the lowest drop height equivalent to a HIC of 1 000 from any of the drop tests conducted in accordance with 4.5.3, using impact measurements with at least two values giving HIC values below and at least two giving HIC values above 1 000 (see Figure B.2). Two of the drop heights shall be within 500 mm below the critical fall height, and two within 500 mm above the critical fall height.

This does not apply for materials giving HIC values lower than 1 000 at the maximum test height.

4.6 Calculation of results

4.6.1 Calculate the head injury criterion (HIC) value for each time/ acceleration curve from the formula

$$HIC = \left[\left(\frac{\int_{t_1}^{t_2} a \times dt}{t_2 - t_1} \right)^{2,5} \times (t_2 - t_1) \right] \quad \text{max.}$$

for all time intervals (t_1 ,t_2) with a minimum sampling rate of 8 000 Hz between t_{start} and t_{end}

where

t_{start} is the time, at the start of an impact event, when the acceleration of the headform equals or exceeds zero;

t_{end} is the time, at the end of an impact event, when the acceleration of the headform first equals or falls below zero

a is the acceleration experienced by the headform and expressed in g (acceleration due to gravity);

t_1, t_2 are any two intermediate values of t between t_{start} and t_{end}, t being the time expressed in milliseconds [ms].

This procedure is only valid for impact events with a HIC duration of more than 3 ms, i.e. $(t_2 - t_1) \geq 3$ ms.

4.6.2 To calculate the critical fall height, produce one curve from all selected heights (4.5.4), in which the HIC values are plotted against the corresponding drop heights obtained. Interpolate the curve to obtain the drop height equivalent to a HIC of 1 000.

If any single drop test gives an anomalous result, repeat this test on a new test position and investigate further by adding further drop tests for the part of the curve in question.

NOTE An example of a correct curve is illustrated in Figure B.2.

4.6.3 Determine the critical fall height as the lowest drop height producing HIC of 1 000 obtained from any of the drop tests.

4.7 Test report

4.7.1 General

Test reports shall be issued only for clearly defined surfacing materials and sub-structures, when tested in accordance with 4.4 and 4.5.

4.7.2 Tests carried out in the laboratory

The test report for laboratory testing shall be prepared in accordance with EN ISO/IEC 17025 and shall include the following:

a) the number and date of this European Standard, i.e. EN 1177:2008;

b) a full description of the product tested, including its thickness or layer depth (for particulate materials), the result of a sieve test in accordance with EN 933-1 (for sand or gravel), density, mass/unit area and any other properties likely to influence the critical fall height of the material;

c) for particulate materials, a photograph of the material tested, with an indication of the scale;

d) a statement that 'This material shall also conform to the requirements of EN 1176-1, in particular, Clauses 4 and 6';

e) the method of fixing used to retain the samples or the internal dimension of the test container used and the layer thickness for loose particulate material;

f) a diagram showing all the test positions;

g) the condition of the surfacing at the time of the test, including the temperature, expressed in degrees Celsius, and the moisture content (e.g. for sand), if relevant, including the method used;

h) the results from each drop test, giving all drop heights used and the corresponding HIC value for each;

i) the critical fall height for the surfacing tested, expressed in metres, rounded down to one decimal place; (e.g. 1,59 m is reported as 1,5 m)

j) the curve of HIC vs. drop height from which the critical fall height of the surfacing was determined; and

k) either the time/acceleration curve of one impact with HIC equal to or greater than 1 000 or, for maximum HIC values below 1 000, the highest value measured.

4.7.3 Tests carried out on site

The report for tests carried out on site shall include the following statement as a preface to the report:

'This test was carried out on site with the particular climatic and site conditions occurring on the day of test. The results shall therefore not be treated as reproducible to the same standard that can be achieved in a laboratory test.'

The report shall include the following:

a) the number and date of this European Standard, i.e. EN 1177:2008;

b) the location of the site (e.g. postal address) and, if relevant, the substrate on which the surfacing was tested;

c) a description of the product tested and a reference, if applicable, for its identification;

d) for particulate materials, a photograph of the material tested, with an indication of the scale;

e) the layer thickness for loose particulate material;

f) identification and location of each test position;

g) the condition of the surfacing at the time of the test, including the temperature and humidity, the age of the product (if known) and any other factors that may be considered to have influenced the result, e.g. the moisture content (in the case of particulate materials);

h) the results from each drop test, giving all drop heights used and the corresponding HIC value for each;

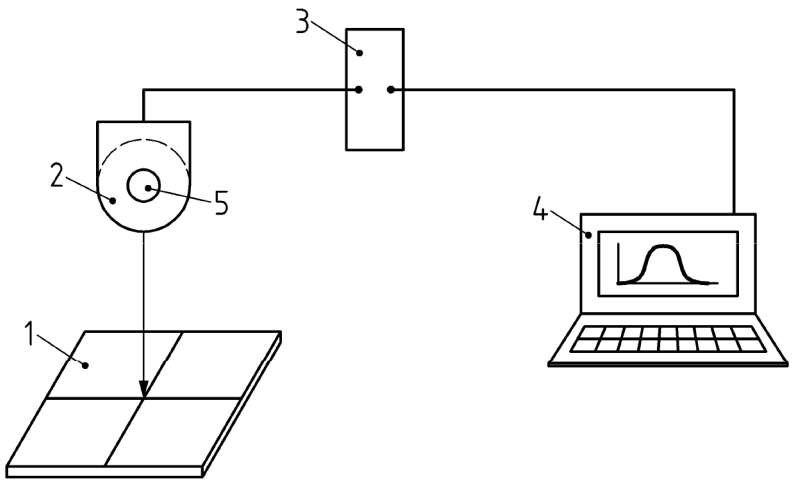
i) the critical fall height for the surfacing tested, expressed in metres, rounded down to one decimal place (e.g. 1,59 m is reported at 1,5 m);

j) the curve of HIC vs. drop height from which the critical fall height of the surfacing was determined for each test location; and

k) either the time/acceleration curve of one impact with HIC equal to or greater than 1 000 or, for maximum HIC values below 1 000, the highest value measured.

Annex A
(informative)

Test rig for determination of critical fall height



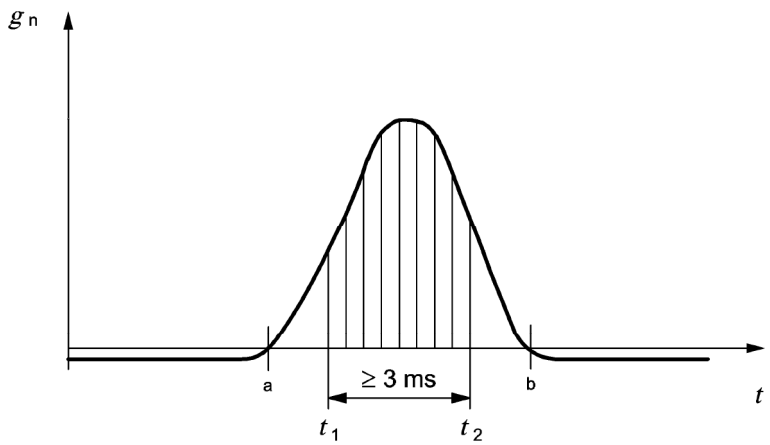
Key

1 test specimen
2 headform
3 charge amplifier (optional)
4 computer
5 accelerometer

Figure A.1 — Test rig for determination of critical fall height

Annex B
(informative)

Typical examples of trace of acceleration against time and curve of HIC values against drop height



Key

g_n acceleration

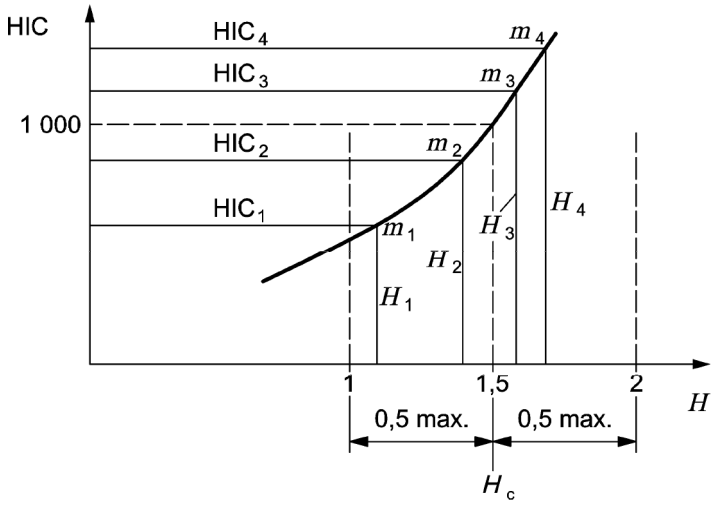
t time

a t_{start}

b t_{end}

Figure B.1 — Typical trace of acceleration against time

Dimensions in metres



Key

m impact measurements

H drop height

H_c critical fall height

Figure B.2 — Typical curve of HIC values against drop height

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