ANNEX 3
Proposals for Revision of EN 1177

1. **Decisions taken in the meeting of Round Robin participants+ TC/136/SC1/WG1 in green letters**
2. **Further results of investigations by yellow underlayer**

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Impact attenuating playground surfacing — Test methods for determination of the critical fall height

Stoßdämpfende Spielplatzböden — Prüfverfahren für die Bestimmung der kritischen Fallhöhe
Revêtements de surface d'aires de jeux absorbant l'impact — Méthodes d'essai pour la determination de la hauteur de chute critique

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Need to be adapted acc. changes in the text !

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Foreword

This document (prEN 1177:2006) has been prepared by Technical Committee CEN/TC 136 “Sports, playground and other recreational equipment”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1177:1997.
This standard 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 runways

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

EN 1177 Impact attenuating playground surfacing — Test methods

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Introduction

This standard is based on the safety principles laid down in the European Standard EN 1176-1 for playground equipment and provides test methods for the impact attenuation of surfaces intended for use in the impact area.
Injuries caused by falls from playground equipment occur from a variety of reasons but it is considered that the most severe injuries are likely to be injuries to the head.
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 and 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 1000 is merely one data point on a risk severity curve where a HIC of 1000 is equivalent to a 3% chance of a critical injury (MAIS 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. It is for this reason that a HIC value of 1000 should be considered as an absoluted maximum threshold."

There is 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 test method in this standard can be used to assess any of these surfaces.

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1 Scope

This standard specifies a method of test by which the impact attenuation of playground surfacing can be determined. It defines a “Critical Fall Height" (see 3.5) for surfacing, that 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 standard are applicable for tests carried out in a laboratory and for tests on site.

NOTE Laboratory test reports are able to provide definite reproducible surface conditions. As this is very difficult to achieve when testing is carried out on site, in this case the report shall describe the ambient conditions during the test and any other factors that could influence the performance. It is recommended that single site tests are not used to form the basis of product certification.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1176-1:2006, *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 1302, *Technical drawings — Method of indicating surface texture*~~

3 Terms and definitions

For the purposes of this standard, the definitions given in EN 1176-1 apply together with the following:

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. It is determined ~~according to the lowest test result~~ in accordance with the test procedure laid down in 4.4.

~~lowest test result obtained in accordance with 4.4~~

~~NOTE The critical fall height represents the upper limit for the free height of fall (see EN 1176-1), for which the surfacing provides an acceptable level of impact attenuation.~~

3.3
head injury criterion (HIC) value
criterion for head injuries caused from falls as calculated in accordance with the formula given in 4.5.1

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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 4.2.4).

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

3.7
drop test
series of impact measurements ~~carried out from at~~ 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 absorbing materials 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 calculated (see Figure B.2).

4.2 Apparatus

4.2.1 Test rig, comprising headform with accelerometer (see 4.2.2) with charge amplifier (see 4.2.3) (optional), if using a uniaxial accelerometer a guidance system (see 4.2.4) and impact measuring equipment (see 4.2.5) as shown in Figure A.1.

4.2.2 Headform, consisting of either

1. an aluminium alloy ball; or

2. a hemispherical ended aluminium alloy missile;

of diameter 160 mm ± 5 mm, mass 4,6 kg ± 0,05 kg, with a max. deviation from the hemispheric surface of 0.5mm ~~surface roughness of less than class N11 in accordance with ISO 1302~~, incorporating an accelerometer as follows:

3. triaxial accelerometer for free falling headform, mounted in the centre of gravity of the headform; or

4. uniaxial accelerometer for guided headforms, aligned to measure in the vertical axis ± ~~1°~~;5° and located directly above the centre of mass

and being such that the impacting part of the headform between the lower boundary and accelerometer is homogeneous and free from voids.

4.2.3 Charge amplifier (optional)

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

4.2.5 Drop height measurement~~, to repeatably measuring the drop height after each impact:~~

4.2.5.1 For free- fall impact test, the drop height shall be measured directly, prior to release of the headform, using an adequate length measuring equipment.

Note: Calculating the drop height from the measured time between release and contact of the missile with the surface may be not sufficient for reasons of possible time differences between start of time measurement and effective release of the headform (e.g. caused by remanent magnetism in a magnetic release system).
The drop height shall be measured with an uncertainty of not greater than 1%.

4.2.5.2 For guided impact test the theoretical drop height must be calculated by measuring the velocity of the headform immediately prior to the impact

The velocity shall be measured with an uncertainty of not more than +- 1%.
NOTE In order 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.

4.2.6 Release system

For free-fall impact test, the release system shall 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.

4.2.7 Impact measuring equipment , consisting of the accelerometer measurement system, the recording device and the HIC- calculation program.: ~~2 Hz to 1000 Hz. It shall be capable of measuring, recording and displaying the acceleration and time duration of each complete impact and calculating the HIC value using the equation given in 4.5.1~~

4.**2.7.1 The accelerometer measurement system** shall measure all frequencies in the range of max. 0,3 Hz to min. 1000 Hz and shall have a sufficient response at all frequencies keeping 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 shall be less than, but max. 0,3 Hz to reduce the error by overshooting the baseline after the impact and underestimating the g-max.and HIC- score, in particular for longer pulse durations (see frequency response diagram in ISO 6487 Fig 1). An accelerometer with a time constant of 2s or greater and appropriate signal conditioning will generally meet this requirement.

4.2.7.2 The recording device shall be capable to capture and record 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 specification and shall be in compliance with ISO 6487.
Note: According ISO 6487 the analog anti-aliasing filters should have an attenuation of at least 30 dB at half the sampling rate.
4.2.7.3 The calculation of the HIC value shall be carried out for each recorded acceleration time history of each impact according chapter 4.5.

(additional tests by C.S.T and Prof.Eager. for consideration of influence, see also Fig 1.3 ASTM. Test at both 0.1 and 1.0Hz.)→ has been done

4.2.8 Accuracy and tests

Apparatus shall be equipped with calibrated measuring devices.(4.2.8) ~~All components of~~ the impact measuring ~~equipment~~ system (4.2.5) including the signal processing equipment shall be ~~calibrated~~ ~~and~~ validated by relevant accredited bodies, in accordance with the principles laid down in ISO/IEC 17025 for periodical calibration.

NOTE: Annual calibration of the measuring system is recommended as a minimum. It is also recommended for on site tests that this frequency be increased.

4.2.8.1 Accelerometers shall be calibrated for the whole frequency range by laboratories accredited for acceleration measurement. Recalibration shall be carried out at time intervals recommended by the manufacturer of the accelerometer, at least every two years.
The accelerometers shall have an uncertainty of not greater than 5%.
4.2.8.2 Velocity measurement systems shall be calibrated by laboratories accredited for the whole velocity range (up to 3m drop height).
4.2.8.3 The computer algorithm used for the calculation shall be checked by imposing a half-sin curve and the result compared with an independent mathematical calculation of this curve shall not deviate more than +/- 1%..
4.2.8.4 Reactions from the release system on the headform shall be tested by a series of min. 3 consecutive drop tests on a defined reference surface with constant properties. The HIC values received shall not differ more than +-5%.
NOTE: These tests are for checking any deviations or anomalities in the components and do neither replace calibration nor the validation for compliance of the apparatus with the standard, carried out by the accredited laboratory.
NOTE Experience has shown that comparative testing on defined surfaces cannot be considered to be sufficient and that an external calibration of the measuring ~~and calculating~~ device is required.

4.2.7→ 4.3.1

4.2.8→ 4.3.1

4.2.9→ 4.2.8 new

~~The drop height shall be measured with an uncertainty of not greater than 1%.~~
~~The acceleration shall have an uncertainty not greater than 5%.(response from Kent, Mark)→ see new clause 4.2.6.1~~

4.3 Conditions for testing

4.3.1 Testing in laboratory

4.3.1.1 Testing shall take place at 23°C ± 5 °C.

4.3.1.2 (4.2.8.) **Flat rigid concrete ~~substrate~~ or equivalent substrate,** ~~for laboratory testing~~, of sufficient mass and thickness that its deformation during the test makes no significant contribution to the test result

4.3.1.3 (4.2.7) ~~For laboratory testing,~~ A test frame without a base, of internal dimensions not less than 1 m × 1 m, capable of containing particulate material to the depth specified by the supplier.

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

Particulate materials shall be placed in the test frame ~~(see 4.2.6~~ 4.3.1.3)above the flat rigid substrate (~~4.2.7~~) and uniformly distributed within the frame, without compaction, to a depth specified by the supplier.

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

4.3.1.4 For tiles, at least four, but min. 1x1m, shall be installed according to the manufacturers instructions ~~the manner given by the manufacturer~~, including all connecting and site fixing elements ~~normally~~ used for installation in the playground on the flat rigid substrate (~~4.2.7~~ 4.3.1.2)

4.3.1.5 For surfacing intended for manufacture on site without seams or joints there shall be prepared either:

a) at least one test specimen of at least 1 m × 1 m, placed on a rigid substrate (~~4.2.7~~ 4.3.1.2) according to the manufacturer's instructions; or

b) at least 9 separate specimens, each not less than 500 mm × 500 mm, laid in turn on a flat rigid substrate (~~4.2.7~~ 4.3.1.2) according to the manufacturer's instructions.

4.3.1.6 Substrate below test specimens

Other substrate than the flat rigid substrate (~~4.2.7~~ 4.3.1.2) is likely to contribute to the impact attenuation of the tested material. In case of products intended to be laid over some other layer, the entire system, surfacing with underlayer, shall be tested on the flat rigid substrate (~~4.2.7~~ 4.3.1.2) and reported as a composite product.

4.3.1.7 (4.3.1.2) 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 and the test method used shall be recorded

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

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NOTE: 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 ISO/IC 17025. The critical fall height of such products can only be determined individually by an on site test, on a mature, fully established installation.

4.3.2 Testing on site

4.3.2.1 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 at the time of the test.

4.3.2.2 ~~For any testing on site~~ Playground site testing cannot be used for product certification and ~~a test report to ISO/IEC 17025 is not possible.~~ an individual test report meeting the requirements in 4.6 shall be issued prefaced by the statement in 4.7.

NOTE Since 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.

4.4 Procedure of testing

4.4.1 Time/acceleration trace

Display the time/acceleration trace for each impact and examine 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. Carry out checks 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. Carry out measurement both with and without the filter and compare the HIC values.

4.4.2 Selection and definition of the test position

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

4.4.2.2 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 This distance is to avoid influences on the test position from the free edges of the material.

4.4.2.3 Ensure that the test position where the critical fall height is found is related to the structure or geometry of the test pieces or material, or related to characteristic places on the playground when tests on site are carried out and indicate this position in the test report

4.4.2.4 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.

4.4.2.5 Do not test inclined falling areas if they are inclined at greater than 10° to the horizontal

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

4.4.3 Specific procedures

4.4.3.1 PreFabricated surfacing products

For tiles, slabs or other prefabricated surfacing products, conduct at least nine drop tests, each at a different test position on the test specimens (see 4.3.1.4).
For tiles, conduct a drop test (minimum 4 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) any other point of inhomogeneity or discontinuity, to obtain the lowest value for critical fall height anywhere on the assembly.

Ensure that each drop test is completed within 15 min.

Record each HIC value.

4.4.3.2 Loose particulate materials and natural surfaces

For loose particulate materials conduct at least three drop tests,……, in the following manner:

4.4.3.2.1 Testing in 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.
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 4) have been tested.
Record each HIC value.
To measure HIC of 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 (eg sand), measure the moisture content at the time of testing and report the method of test and the result.

4.4.3.2.2 Testing on site

For on site testing carry out the procedure as described in 4.4.3.2.1 for each drop height (minimum 4), 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.

NOTE When testing on site a variety of test positions should be selected to ensure the worst case situation is included (e.g. access position).

4.4.4 Selection of data for determination of critical fall height

For determination of the critical fall height select the lowest drop heights equivalent to HIC = 1 000 from any of the drop tests conducted in accordance with 4.4.3, 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 of the critical fall height, one above and one below~~. 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

~~NOTE~~ This does not apply for materials giving HIC values lower than 1 000 for the maximum free height of fall to be confirmed.

4.5 Calculation of results

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

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

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} 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 any two intermediate values of t between t_{start} and t_{end} (t is the time in seconds).

NOTE This procedure is only valid for impact events with a ~~total~~ HIC duration of more than 3 ms, i.e.: ~~(t_{end} – t_{start})~~*(t2 – t1)* ≥ 3 ms. Proposal Australia: >=6ms

4.5.2 For the calculation of the critical fall height, produce one curve from all selected heights (4.4.4), in which the HIC values are plotted against the corresponding drop heights obtained. Interpolate the curve to obtain the drop height equivalent to HIC = 1 000.

If any single drop test gives an anomalous result, this drop test shall be repeated on a new test position and investigated further.

Anomalies in the curve shall be investigated by adding further drop tests for the part of the curve in question.

NOTE Example for a correct curve see Figure B.2.

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

4.6 Laboratory Test Report

Test reports shall be issued only for clearly defined surfacing materials and sub-structures, when tested according 4.2. ~~and~~ 4.3 and 4.4
The test report for laboratory testing shall be prepared in accordance with EN ISO/IEC 17025 and shall in addition include the following:

a) the number and date of this European Standard; EN 1177:2007

b) a full description of the product tested, including its thickness or layer depth (for particulate materials),sieve test in accordance with EN 933-1 (for sand or gravel) density, weight/unit area and any other properties likely to influence the Critical Fall Height of the material.

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

d) a statement that 'This material also needs to meet the requirements of ~~suitability for use within a playground as required by~~ EN 1176-1:2007, 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 in degrees Celsius and the moisture content (eg sand) if relevant (including the test 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 at 1,5 m)

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

k) the time/acceleration curve of one impact with HIC >=1000 (In the case of maximum HIC values below 1000, the highest measured.)

4.7 Report about verification on site

~~A test report according EN ISO/IEC 17025 is not possible~~.
The report for on site testing shall be as the laboratory report and additionally 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.'

a) the number and date of this European Standard; EN 1177:2007

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

c) a description of the product tested

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

e) ~~a statement that 'This material also needs to meet the requirements of suitability for use within a playground as required by EN 1176-1:2006, in particular, clauses 4 and 6;~~

f) ~~the method of fixing used to retain the samples or~~ the layer thickness for loose particulate material;

g) identification and localisation of each test position

h) 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 a influenced the result, e.g. the moisture content (in the case of particulate materials). ~~sieve test in accordance with EN 933-1(for sand or gravel)~~

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

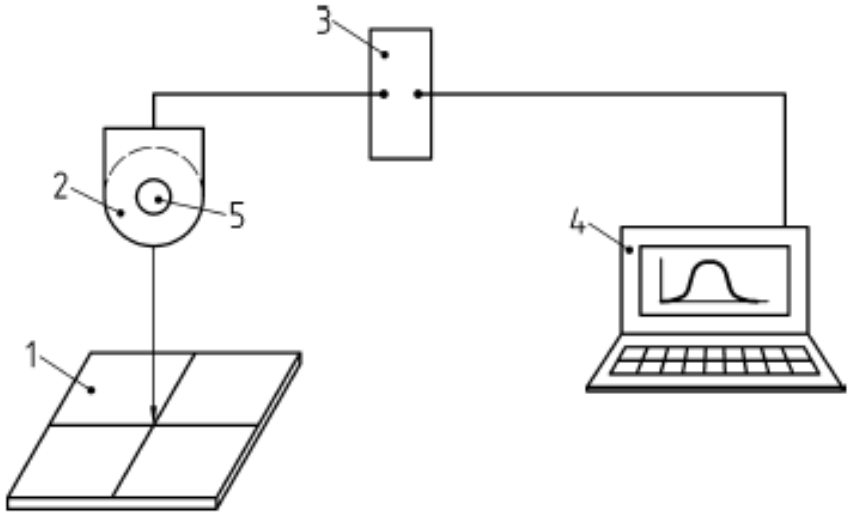
j) the critical fall height for the surfacing tested, expressed in metres, rounded down to one decimal place (e.g. 1,59 m is reported at 1,5 m)

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

l) the time/acceleration curve of one impact with HIC >=1000 for each test location (In the case of maximum HIC values below 1000, the highest measured.)

Annex A
(informative)

Test rig for the 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 the determination of critical fall height

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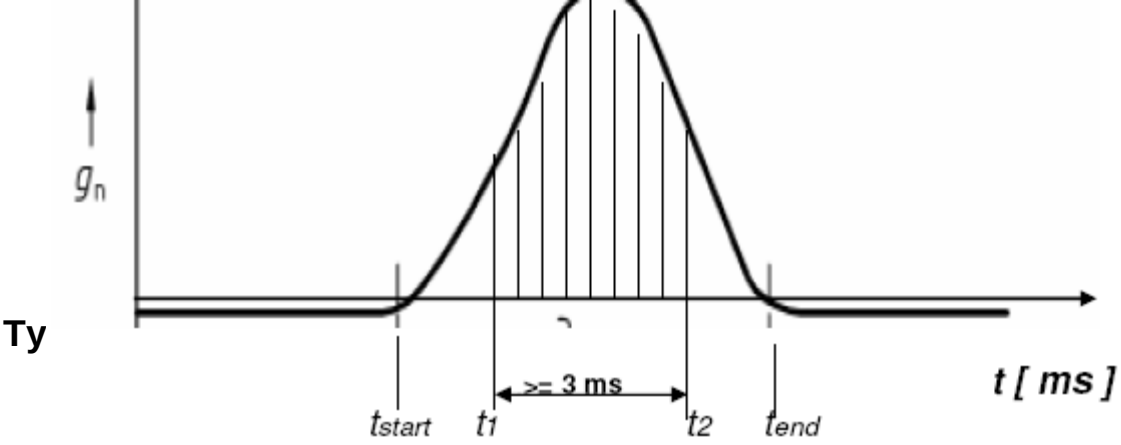

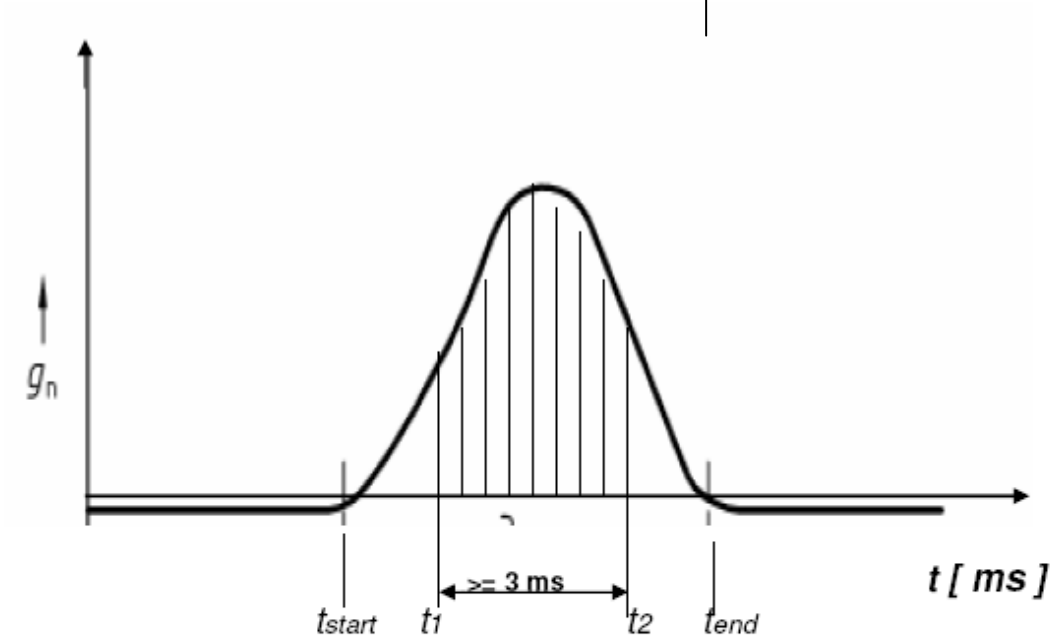

Key

g_n acceleration
t time

Figure B.1 — Typical trace of acceleration against time

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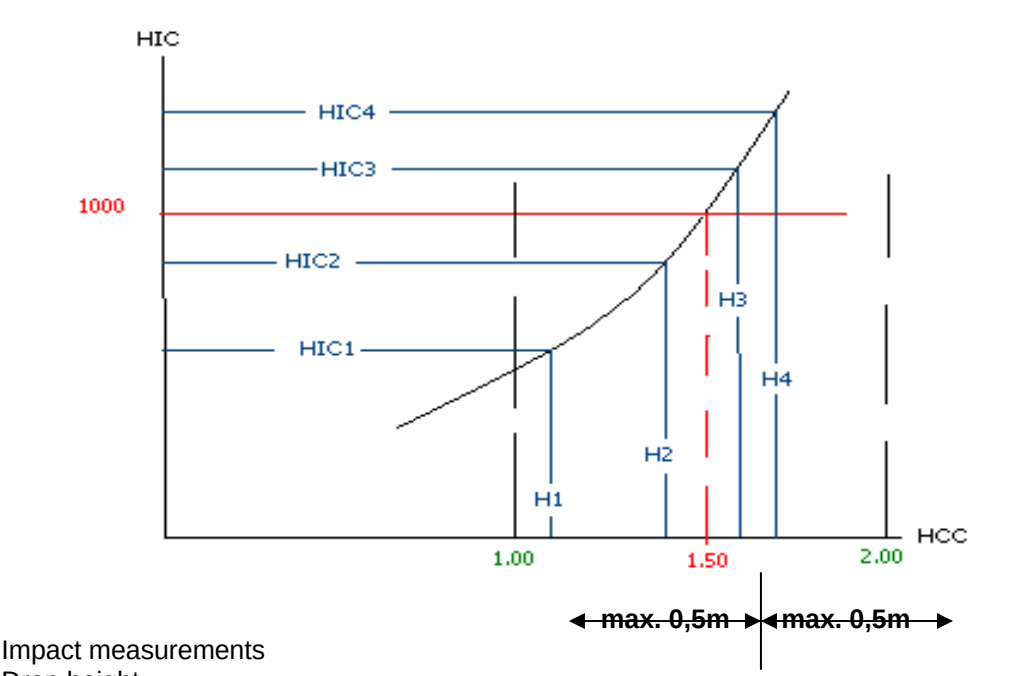

Key

m	Impact measurements
H	Drop height
H_c	Critical fall height

Figure B.1 — Typical curve of HIC values against drop height

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