



Playground surfacing—Specifications, requirements and test method



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 - Australian Institute of Landscape Architects
 - Early Childhood Australia
 - Education and Early Childhood Services Registration and Standards Board
 - Engineers Australia
 - Kidsafe
 - Institute of Public Works Engineering Australasia
 - National Association of Testing Authorities, Australia
 - NSW Fair Trading
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-

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Australian Standard[®]

**Playground surfacing—Specifications,
requirements and test method**

Originated as AS/NZS 4422:1996.
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PREFACE

This Standard was prepared by the Standards Australia Committee CS-005, Playground Equipment, to supersede AS/NZS 4422:1996.

The objective of this Standard is to provide a test method to measure compliance with thresholds that if exceeded are more likely to lead to death associated with brain injury resulting from a fall or impact onto surfaces. The thresholds contained within this Standard only relate to acute brain injuries.

This Standard will apply from the date of publication.

The term 'informative' has been used in this Standard to define the application of the appendices to which it applies. An informative appendix is only for information and guidance.

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FOREWORD

Designers, operators, installers, and maintainers of playgrounds need to take reasonable care to identify and address foreseeable hazards in the play facilities that they are responsible. The most common cause of serious playground injury is a fall from a height onto the playground surface. Therefore, appropriately impact-attenuated playground surfaces are a key safety strategy and injury prevention intervention. This Standard sets out the methods for testing the impact-attenuation performance of playground surfaces. Such testing is required in the development of prototype surfacing products, at the commissioning of newly installed surfaces, and during the periodic field-testing of the impact attenuating surface to confirm continuing minimum acceptable performance.

The performance requirements contained within this Standard are minimum threshold values that designers, installers and operators are strongly encouraged to exceed. The better the impact-attenuating properties of a surface, the lower the frequency and severity of injuries, particularly brain injuries. Long-bone fractures involving the growth plate can also lead to permanent disability, but unfortunately impact attenuation of playground surfaces is not a particularly effective countermeasure for these. Playground surfaces that pass the minimum threshold values that also have an inherent bounce property are known to increase the likelihood of long-bone fractures. Playground surfaces that bring the child to rest over a short period of time or over a short distance (penetration) are also associated with a higher likelihood of injury associated with falls.

The test described in this Standard uses an instrumented hemispherical missile. The performance of an impact-attenuating surfacing system is specified in terms of its critical fall height (h_c), that is, the maximum fall height at which the impact test scores do not exceed any of three limits established by this Standard. Currently, these limits are peak acceleration during impact (g_{max}) less than 200g; a head injury criterion (HIC) value less than 1000; and a HIC duration greater than 3 ms.

The committee considered the use of other injury predicting indicators, including the maximum jerk (j_{max}), bounce, penetration, and energy. The members concluded that specifying any of these would create an additional reporting requirement that would pose an unnecessary financial burden on the playground industry. The committee considered increasing the HIC duration from 3 ms to 5 ms. The committee agreed to retain the 3 ms HIC duration pass/fail performance criteria and monitor and review if other jurisdictions or evidence supported increasing the HIC duration.

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% probability of a critical brain injury (equivalent to an Abbreviated Injury Score (AIS) of 5), an 18% probability of severe brain injury (AIS 4), a 55% probability of serious brain injury (AIS 3), a 89% probability of moderate brain injury (AIS 2), and a 99.5% chance of minor brain injury (AIS 1), to an average male adult. In setting the impact limits the CS-005 committee did not take into consideration recent research into the long-term effects of traumatic brain injury (TBI) associated with non-concussive impacts. It is the committee's intention to consider research in this area in any future revision of this Standard.

The committee is aware that impact-attenuating playground surfaces may, depending on the type of product, introduce inadvertent risks to children. For example, some products can become too hot for barefoot play in un-shaded areas on days of extreme high temperature. Other products, particularly those that are recycled, may contain hazardous sharps. In selecting an appropriately impact-attenuating surface for a particular site, playground designers, installers and operators are cautioned against selecting excessively dusty, sharp, ingestible, contaminated, or otherwise hazardous materials.

Children discover and learn about the world in which they live through play, which is essential for children's healthy growth and development. A child's perception of successful negotiation of risky situations is important for confidence building and competent risk assessment which leads to children learning how to manage their own safety. The minimum threshold impact-attenuation performance values of playground surfaces do not detract from this perception. Playground surfacing should prevent permanent injury and death while contributing positively to a child's ability to learn autonomous risk assessment skills.

STANDARDS AUSTRALIA

Australian Standard

Playground surfacing—Specifications, requirements and test method

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE AND OBJECTIVE

This Standard specifies test methods by which the performance of impact-attenuating surfaces can be determined in the laboratory and on-site, such as in playgrounds, sports surfaces and other sites.

The objective of this Standard is to provide a test method to measure compliance with thresholds that if exceeded are more likely to lead to death associated with brain injury resulting from a fall or impact onto surfaces. The thresholds contained within this Standard only relate to traumatic brain injuries.

1.2 APPLICATION

This Standard is intended to be used in conjunction with the AS 4685 series.

This Standard is also intended to be used as an impact-attenuating surface test method where no specific Standard exists.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

4685	Playground equipment and surfacing
4685.0	Part 0: Development, installation, inspection, maintenance and operation
4685.1	Part 1: General safety requirements and test methods (EN 1176-1:2008, MOD)

1141	Methods for sampling and testing aggregates
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1141.3.1	Method 3.1: Sampling—Aggregates
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AS ISO/IEC

17025	General requirements for the competence of testing and calibration laboratories
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ISO

6487	Road vehicles—Measurement techniques in impact tests—Instrumentation
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1.4 DEFINITIONS

For the purpose of this Standard, the following definitions apply.

1.4.1 Competent person

A person who has, through a combination of training, education and experience, acquired knowledge and skills enabling that person to correctly perform a specified task.

1.4.2 Critical fall height (h_c)

The maximum free height of fall for which a surface will provide an acceptable level of impact attenuation.

1.4.3 Drop height

The distance between the test position on the surfacing and the lowest point of the free falling missile prior to release.

1.4.4 Drop test (laboratory testing)

A minimum series of four impact measurements carried out from increasing fall heights, such that at least one measurement gives an HIC value above 1000, or a g_{\max} value above 200.

1.4.5 Free height of fall (h_f)

The greatest vertical distance from the clearly intended body support to the impact area below.

1.4.6 g_{\max}

The multiple of the acceleration (g) into gravity at the earth's surface at sea level that represents maximum acceleration experienced during impact.

1.4.7 Head injury criteria (HIC)

A measure of impact severity that considers the duration over which the most critical section of the deceleration pulse persists as well as the peak level of that deceleration.

1.4.8 HIC duration

The time interval over which the HIC is calculated, i.e. ($t_1 - t_2$).

NOTE: The $t_1 - t_2$ are two intermediate values of t between t_{start} and t_{end} attaining the maximum HIC value.

1.4.9 Impact-attenuating surfacing (IAS)

A surface, whereby the kinetic energy of an impact is dissipated by localized elastic hysteresis, deformation or displacement such that the maximum acceleration and HIC is reduced and the HIC duration is increased.

1.4.10 Impact attenuation

Property whereby the kinetic energy of an impact is dissipated by localized elastic hysteresis, deformation or displacement.

1.4.11 Impact measurement

The HIC value from the recorded acceleration of the missile falling from one fall height onto one test position.

1.4.12 Loose-fill surface

Surfacing material supplied for the purpose of impact attenuation in playgrounds, consisting of unbound, granular, chipped or fibrous elements such as sand, wood-fibre, bark mulch, wood chips or other materials. These may be organic or inorganic.

1.4.13 Measured fall height (h_m)

The height from which a single drop is conducted (being the h_f with a minimum additional 10% allowance) to determine the HIC, g_{\max} and HIC duration of the surface under test at a particular location. At the measured fall height the HIC and the g_{\max} will be less than or equal to 1000, less than or equal to 200g, and greater than 3 ms respectively, for a satisfactory result.

1.4.14 Test position

A position on the material to be tested, located perpendicularly below the centre of the missile.

1.4.15 Unitary surface

An impact-attenuating surface consisting of one or more material components (such as shredded rubber bound together with urethane) formed into a sheet, tile or other continuous surface where the underlying protective properties of the impact surfacing changes little with consecutive and/or repeated use.

SECTION 2 SAFETY REQUIREMENTS

2.1 TESTING PRINCIPLE

Test specimens or installed areas of the impact-attenuating material under test are struck by an instrumented missile in a defined series of impacts from different drop heights. The signal emitted by an accelerometer in the missile during each impact is processed to yield a severity from the measured impact energy, defined as HIC.

NOTE: See Appendix B, Figure B1.

The HIC of each impact is plotted and h_c shall be determined as the lowest drop height producing a HIC value of 1000.

2.2 TEST APPARATUS

2.2.1 Test rig

2.2.1.1 General

The test rig shall comprise—

- (a) a missile with accelerometer (see Clause 2.2.1.2); and
- (b) if using a triaxial (free-fall) accelerometer, a release system (see Clause 2.2.1.3) and length measuring equipment (see Clause 2.2.1.5); or
- (c) if using a uniaxial (guided) accelerometer, a guidance system (see Clause 2.2.1.4) and velocity measuring equipment (see Clause 2.2.1.6).

2.2.1.2 Missile and accelerometer

The missile shall consist of either—

- (a) a hemispherical ended aluminium alloy missile; or
- (b) a spherical shaped missile.

It shall have a diameter of 160 mm \pm 5 mm, a mass of 4.6 kg \pm 0.05 kg, with a maximum deviation from the hemispheric surface of 0.5 mm, incorporating an accelerometer as follows:

- (i) Triaxial accelerometer for free falling missile, mounted in the centre of gravity of the missile.
- (ii) Uniaxial accelerometer for guided missile, aligned to measure in the vertical axis \pm 5° and located directly above the centre of mass.

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

2.2.1.3 Release system

In the case of free-fall impact tests, the release system shall not create a rotation moment or any other forces on the missile, when released.

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

2.2.1.4 Guidance system

In the case of a uniaxial accelerometer, a guidance system shall be required to guide the missile, including a means to measure the velocity of the missile immediately prior to impact.

2.2.1.5 *Length measuring equipment*

In the case of free-fall impact tests, means shall be provided so that when conducting an impact test, the drop height can be measured directly prior to release of the missile.

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 missile (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%.

2.2.1.6 *Velocity measuring equipment*

In the case of guided impact tests, means shall be provided so that the theoretical drop height can be calculated by measuring the velocity of the missile immediately prior to the impact.

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

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

2.2.2 **Impact measuring equipment**

2.2.2.1 *General*

Impact measuring equipment shall consist of an accelerometer measurement system (see Clause 2.2.2.2), a recording device (see Clause 2.2.2.3) and a HIC calculation program (see Clause 2.2.2.4).

2.2.2.2 *Accelerometer measurement system*

The accelerometer measurement system shall be capable of measuring all frequencies in the range 0.3 Hz to 1000 Hz and having a sufficient response at all frequencies to keep amplitude errors below 5%, in accordance with ISO 6487 Channel Class 1000. It shall be capable of measuring, recording and displaying the acceleration and time duration of each complete impact.

2.2.2.3 *Recording device*

The recording device shall be capable of capturing and recording the acceleration time signals produced during an impact at a minimum sampling rate of 20 kHz.

Signal conditioning and filtering shall be compatible with the accelerometer and the data channel specified. This process shall conform to ISO 6487.

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

2.2.2.4 *Program for calculating the HIC value*

The apparatus shall include a program for calculating the HIC, HIC duration, g_{\max} , time and date for the recorded acceleration time history of each impact in accordance with Clause 2.4.7.7.

2.3 **ACCURACY OF TESTS**

2.3.1 **Calibration measuring device**

Apparatus shall be equipped with calibrated measuring devices.

Laboratory measurement equipment including the signal processing equipment and the measuring of drop height shall be validated at a minimum every six months.

On-site measurement equipment shall be validated before and after each set of measurements using a reference tile. If the validation value is greater than 10% the unit shall be re-calibrated.

Testing in accordance with this Standard shall be undertaken by a laboratory that fulfils the requirements of AS ISO/IEC 17025.

NOTES:

- 1 A laboratory may demonstrate that it fulfils the requirements of AS ISO/IEC 17025 through accreditation as a signatory member of the International Laboratory Accreditation Cooperation (ILAC), Mutual Recognition Arrangement (MRA) with a relevant scope of accreditation to cover the tests being performed.
- 2 In Australia, the signatory member of the ILAC MRA is the National Association of Testing Authorities, Australia (NATA).

2.3.2 Calibration criteria

Apparatus shall be calibrated based on the following criteria:

- (a) 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 a minimum every two years. Accelerometers shall have an uncertainty no greater than 5% at the 95% confidence level.
- (b) Velocity measurement systems shall be calibrated for the whole velocity range (up to 3 m drop height).
- (c) 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 $\pm 1\%$.
- (d) Reactions from the release system on the missile shall be tested by a minimum series of three consecutive drop tests on a defined reference surface with constant properties. The HIC values obtained shall not differ more than $\pm 5\%$.

NOTES:

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

2.4 LABORATORY TESTING

2.4.1 General

A competent person shall undertake laboratory surface impact testing.

NOTE: Testing laboratories making a statement of compliance with this Standard within documentation or test reports are advised to ensure that these statements are capable of being verified.

2.4.2 Test location

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

Impact attenuating surfacing systems that rely upon their sub-base (such as fine crushed rock) for performance shall be tested on a concrete substrate.

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

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

2.4.3 Temperature

Testing shall be carried out at a temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

2.4.4 Effects of moisture

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

NOTES:

- 1 The moisture content can significantly influence the impact attenuation of some loose particulate material.
- 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 AS ISO/IEC 17025. The h_c of such products can only be determined individually by an on-site test, on a mature, fully established installation.

2.4.5 Time/acceleration trace

Each impact shall display the time/acceleration trace and be examined for any anomalies before being processed and evaluated.

NOTES:

- 1 If high frequency components appear in the signal obtained from a drop test using the missile 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 missile is loose, in particular the accelerometer.
- 2 If high frequency components appear as a consequence of vibrations of the drop test missile, filtration of signals with a standardized filter will be necessary. Measure both with and without the filter and compare the HIC values.

2.4.6 Material type

2.4.6.1 *Loose-fill (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.

2.4.6.2 *Tiles (manufactured prior to installation)*

For testing tiles, a minimum four tiles with a minimum total dimension of $1\text{ m} \times 1\text{ m}$ shall be installed on a flat, rigid substrate according to the manufacturer's instructions, including all connecting and site fixing elements used for installation in the playground.

2.4.6.3 *Unitary surfaces intended to be manufactured on-site*

For testing surfacing intended to be manufactured on-site a minimum one test specimen shall be prepared without seams or joints with a minimum total dimension of $1.0\text{ m} \times 1.0\text{ m}$ and placed on a rigid substrate in accordance with the manufacturer's instructions.

2.4.6.4 *Unitary surfaces consisting of multiple layers*

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

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

2.4.7 Procedure

2.4.7.1 General

The test positions for each material tested shall be selected on the basis of trying to establish the 'worst case' h_c for that material. A minimum two drop heights of each drop test shall give a HIC value above 1000, or a g_{\max} value above 200g or a $t_1 - t_2$ above 3 ms.

2.4.7.2 Testing procedure for unitary surfacing products

For tiles, slabs or other unitary surfacing products, a minimum nine drop tests (minimum four drop heights) shall be conducted, each at a different test position on the test specimens.

Artificial grass that does not contain loose-fill material, such as sand, shall be tested in accordance with Clause 2.4.7.2.

In the case of tiles, which have joints in the surface, a drop test (minimum four drop heights) shall be conducted 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.
- (d) At any other point of inhomogeneity or discontinuity, to obtain the lowest value for h_c anywhere on the assembly.

Ensure that each drop test is completed within 15 min.

Record each HIC value.

2.4.7.3 Testing procedure for loose-fill (particulate) materials

For loose particulate materials, a minimum three drop tests shall be conducted as described below.

Artificial grass that contains loose-fill material such as sand shall be tested in accordance with Clause 2.4.7.3.

Prior to testing, particulate material shall be placed within the test frame above a flat level concrete substrate, uniformly distributed within the frame, and compacted to a depth of 200 mm with a 20 kg roller (50 times forward and backwards to simulate the compacted surface). The drop test procedure shall then be as follows:

- (a) Locate the first test position, which shall be not less than 250 mm from the frame, and conduct three consecutive impacts with the missile from the same drop height in the same test position without redistribution of the material. After three consecutive drops move to the next position.
- (b) Record each result.
NOTE: This procedure allows for possible effects of compaction of the material and is likely to give progressively higher values.
- (c) Redistribute the material in the frame and re-level it to the same test thickness.
- (d) Drop the missile from the second (incrementally higher) drop height, three times without re-distribution, as before.
- (e) 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.
- (f) 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 mix evenly with additional material of the same general characteristics (same batch, same moisture content, and same particle size distribution) 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, the particle size distribution shall be determined by carrying out a sieve test in accordance with AS 1141.3.1. Use five of the following sieve sizes which shall be consecutive:

- (i) 106 μm .
- (ii) 125 μm .
- (iii) 150 μm .
- (iv) 180 μm .
- (v) 212 μm .
- (vi) 250 μm .
- (vii) 300 μm .
- (viii) 355 μm .
- (ix) 425 μm .
- (x) 0.5 mm.
- (xi) 0.60 mm.
- (xii) 0.71 mm.
- (xiii) 0.85 mm.
- (xiv) 1.00 mm.
- (xv) 1.18 mm.
- (xvi) 1.40 mm.
- (xvii) 1.70 mm.
- (xviii) 2.00 mm.
- (xix) 2.36 mm.
- (xx) 2.80 mm.
- (xxi) 3.35 mm.
- (xxii) 4.00 mm.
- (xxiii) 6.00 mm.

2.4.7.4 *Selection of data for determination of h_c*

The lowest drop height equivalent to a HIC of 1000 shall be selected from any of the drop tests conducted in accordance with Clauses 2.4.7.1 and 2.4.7.2, using impact measurements with a minimum of two values giving HIC values below and a minimum of two values giving HIC values above 1000. Two of the drop heights shall be within 500 mm below the h_c , and two within 500 mm above the h_c .

If the sample does not meet any failure threshold criteria below 3.0 m then the h_c can be reported as ≥ 3.0 m. Extrapolation shall not be used to report h_c .

NOTE: This does not apply for materials giving HIC values lower than 1000 at the maximum test height.

2.4.7.5 Calculation of h_c

The h_c shall be the lowest height equivalent to a $g_{\max} \leq 200g$, a $HIC \leq 1000$, and a HIC duration of $(t_2 - t_1) \geq 3$ ms, whichever height is the lowest in accordance with Clauses 2.4.7.6–2.4.7.8.

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.

2.4.7.6 Calculation of g_{\max}

The g_{\max} shall be the maximum acceleration of the 4.6 kg hemispherical missile measured during the impact, expressed in g units where 1g equals the acceleration due to gravity.

The g_{\max} value for each impact shall be plotted against the corresponding drop height. A least squares best-fit exponential curve is drawn through the plotted points.

NOTE: From Appendix B, Figure B1 determine the height at which $g_{\max} \leq 200g$.

2.4.7.7 Calculation of HIC

Calculate the HIC value for each time/acceleration curve using the following equation:

$$HIC = \left[\left(\frac{\int_{t_1}^{t_2} a \times dt}{t_2 - t_1} \right)^{2.5} \times (t_2 - t_1) \right] \max.$$

for all time intervals (t_1, t_2) with a minimum sampling rate of 20 kHz between t_{start} and t_{end} where

- t_{start} = the time, at the start of an impact event, when the acceleration of the missile exceeds 2g
- t_{end} = the time, at the end of an impact event, when the acceleration of the missile falls below 2g
- a = the acceleration experienced by the missile 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)

The HIC value for each impact shall be plotted against the corresponding drop height. A least squares best-fit exponential curve is drawn through the plotted points. The HIC shall be no more than 1000, i.e. $HIC \leq 1000$.

2.4.7.8 Calculation of HIC duration

The HIC duration is the time interval over which the HIC integral is evaluated and shall be no less than 3 ms, i.e. $(t_2 - t_1) \geq 3$ ms.

2.5 ON-SITE TESTING

2.5.1 General

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.

Testing procedures will vary depending on whether the surface is unitary or loose particulate material.

A competent person shall undertake on-site surface impact testing.

NOTE: Persons making a statement of compliance with this Standard with documentation or test reports are advised to ensure that these statements are capable of being verified.

2.5.2 Test location

2.5.2.1 General

The location of the areas to be tested shall depend on the foreseeable fall potential. A distinction should be made between the respective impact areas of various play elements in the playground in relation to their h_f .

2.5.2.2 Criterion for selection of the points to be tested

Drop heights shall be based on h_m of each play element, or of the highest h_m in the playground in the case of a loose-fill surface.

For surfaces containing movable equipment, either h_c of the surface shall be determined or the entire surface shall meet the requirements for the h_m of the highest piece of equipment.

Ensure that the distance between any two test positions shall not be less than 250 mm and that no position is closer than 250 mm from the edge of the impact attenuating surface.

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.

Falling areas shall not be tested if they are inclined at more than 10° to the horizontal.

2.5.3 Operating conditions

The temperature of the surfacing, measured at the test position on the day of the test, shall be between 0°C and $+65^\circ\text{C}$.

Surfaces that are likely to be affected by residual humidity (e.g. sand) shall be visually checked before testing. If the surface is saturated with water the test shall not be performed.

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

2.5.4 Procedures

2.5.4.1 Testing procedure for unitary surfaces

A minimum of one test shall be carried out per 10 m^2 of impact area. One drop shall be performed for each test location based on the h_m of the respective item and in accordance with the location and number of test points required for individual types of equipment as detailed in Table 2.1.

TABLE 2.1
MINIMUM TESTING LOCATIONS ADJACENT TO EQUIPMENT

Equipment type	Minimum number of test points
Swing—Types 1 and 2	1 front and back of each seat
Swing—Type 3	4 around the single point seat
Swing—Type 4	1 at back of each seat and 1 in the centre
Slide—Open	1 at starting section + 1 at run-out section + 1 each side
Slide—Tunnel	1 at entrance + 1 at exit
Cableway	1 per 5 linear metres along cable + 1 at terminus
Carousel—All types	4 equally spaced around the unit
Seesaw—Type 1	1 adjacent each end
Seesaw—Types 2 and 3	2 equally spaced around the unit
Rocking equipment—Type 4	1 adjacent each end
Seesaw—Type 5	4 equally spaced around the unit
Seesaw—Type 6	1 per seat
Overhead items	1 per linear metre
Spatial networks	1 per anchor point (located equidistant between each anchor point) + 1 adjacent to each support pole
Other items	1 at the base of the exit

NOTE: For equipment types see relevant Parts of AS 4685.

2.5.4.2 *Testing procedure for loose-fill (particulate) material surfaces*

A minimum of one testing point shall be used per playground surface where loose particulate materials are used. This shall be the point of lowest infill material depth and shall be tested at the highest h_m in the playground.

The material infill depth shall be measured at various locations across the playground surface to ensure consistency of surface depth.

Once the point of lowest infill material depth has been determined, three consecutive drops shall be undertaken from the h_m without redistribution of the material.

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

2.5.4.3 *Testing points that fail to meet the required impact-attenuating criteria*

If at the h_m the HIC exceeds 1000, the g_{max} exceeds 200g, or the HIC duration is less than 3 ms, the result shall not be satisfactory. The surface should be re-tested at a lower height as described in Clauses 2.5.4.1 and 2.5.4.2 until the HIC is less than 1000, and the g_{max} is less than 200g, and the HIC duration is greater than or equal to 3 ms. Record this height as the h_c of the surface.

2.5.5 Expression of the results

The results of the on-site verification of h_m shall be given in raw figures to the first decimal place and expressed in metres.

When tested at the h_m , if the HIC is less than or equal to 1000, the g_{max} is less than or equal to 200g, and the HIC duration is greater than or equal to 3 ms, the result is declared satisfactory.

If, when tested at the h_m , the HIC exceeds 1000, the g_{max} exceeds 200g or the HIC duration is less than 3 ms, the result is not satisfactory. After re-testing at lower heights, the actual h_c of the surface shall be determined.

2.6 TEST REPORT

2.6.1 Tests carried out in a laboratory

The laboratory test report shall be undertaken by a laboratory that fulfils the requirements of AS ISO/IEC 17025 and shall include the following:

- (a) The number and date of this Standard, i.e. AS 4422.
- (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 AS 1141.3.1 (for sand or gravel), density, mass/unit area and any other properties likely to influence the h_c of the material.
- (c) For particulate materials, a photograph of the material tested, with an indication of the scale.
- (d) A statement that reads 'This material shall also conform to the requirements of AS 4685.0'.
- (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, HIC duration and g_{\max} value for each.
- (i) The h_c and its uncertainty for the surfacing tested, expressed in metres, rounded to one decimal place, e.g. 2.6 ± 0.2 m. For laboratory testing of loose-fill, all testing shall be conducted on a prepared sample of $200 \text{ mm} \pm 10 \text{ mm}$ thick. The report shall state the h_c and uncertainty at the 95% confidence level.

NOTE: The report should state that the minimum installed thickness should be 300 mm.

- (j) The curve of HIC vs. drop height from which h_c of the surfacing was determined.
- (k) Either the time/acceleration curve of one impact with HIC equal to or greater than 1000 or, for maximum HIC values below 1000, the highest value measured or for a minimum HIC duration less than 3 ms. This shall show HIC, g_{\max} , $t_2 - t_1$ values.

The HIC validation shall be determined using the following equation:

$$\text{HIC} = (t_2 - t_1) \times (0.87 \times g_{\max}) \times 2.5 (\pm 10\%)$$

- (l) The date type and serial number of the test equipment, date of last calibration.
- (m) Name, signature and qualification of the testing person or entity.
- (n) The IAS shall have product labelling that uniquely identifies the product and its critical fall height. It shall also include a statement that this information is to be passed onto the customer.

NOTE: Testing laboratories making a statement of compliance with this Standard with documentation or test reports are advised to ensure that these statements are capable of being verified.

2.6.2 Tests carried out on-site

The on-site verification report shall contain at a minimum the following information:

- (a) A statement on the cover of the report advising that—
 - (i) the tests were performed on-site;
 - (ii) description of the weather conditions (dry-bulb temperature and precipitation) prevailing on the day of the test; and
 - (iii) the results shall not be considered comparable to those of a laboratory test.
- (b) The number and date of this Standard, i.e. AS 4422.
- (c) Verification that the on-site testing was conducted in accordance with this Standard.
- (d) The test location, i.e. playground address.
- (e) The date that the testing was conducted.
- (f) A description of the product tested.
- (g) The condition of the impact-attenuating surface at the time of the test, including its temperature and any other factor(s) that may affect the results.
- (h) A statement declaring the results of the testing to be satisfactory or not satisfactory.
- (i) Name, signature and qualification of the testing person or entity.

The on-site verification report may also contain the following:

- (i) The identification and localization of each point tested, using descriptions, drawings or photographs.
- (ii) The h_f and h_m for the points tested.
- (iii) The results of each test, specifying h_m used and the corresponding HIC, HIC duration and g_{max} .
- (iv) The thickness in millimetres of the surfacing measured at each point tested.

APPENDIX A
TEST RIG FOR DETERMINATION OF CRITICAL FALL HEIGHT (h_c)
(Informative)

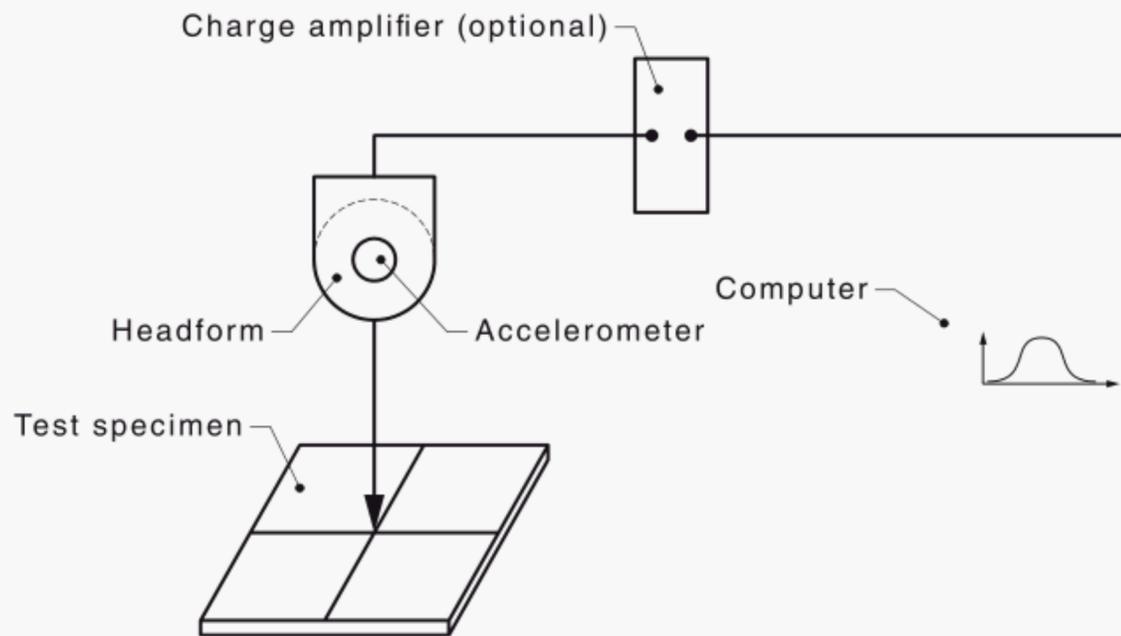


FIGURE A1 TYPICAL TEST RIG FOR DETERMINATION OF CRITICAL FALL HEIGHT (h_c)

APPENDIX B

TYPICAL EXAMPLES OF TRACE OF ACCELERATION AGAINST TIME AND CURVE OF HIC VALUES AGAINST DROP HEIGHT

(Informative)

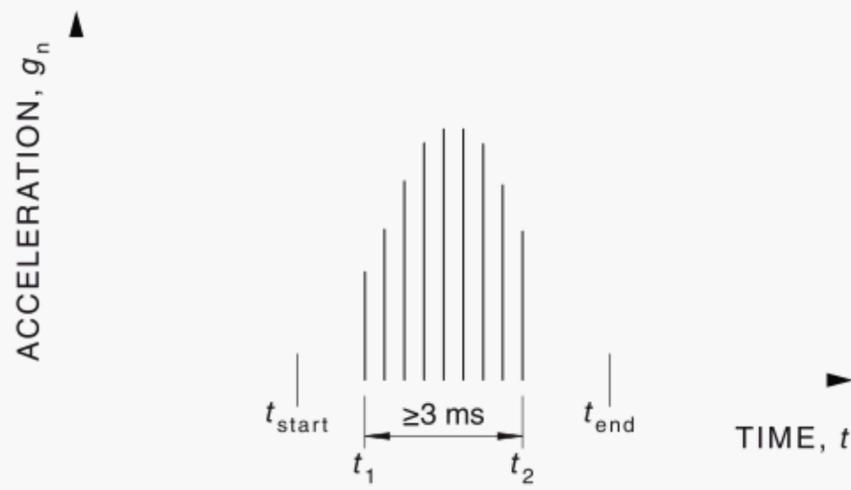
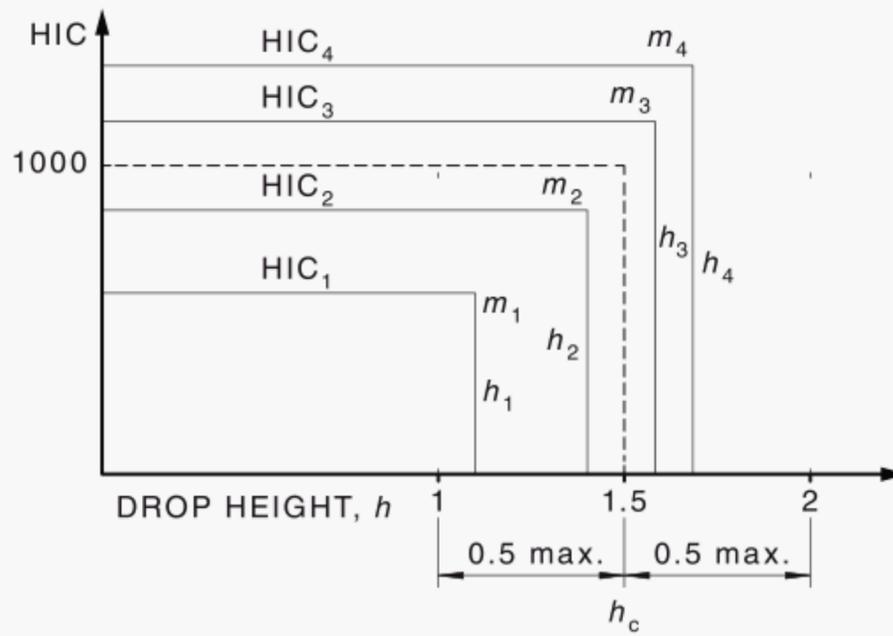


FIGURE B1 TYPICAL TRACE OF ACCELERATION AGAINST TIME



LEGEND:
m Impact measurements
h_c Critical fall height

DIMENSIONS IN METRES

FIGURE B2 TYPICAL CURVE OF HIC VALUES AGAINST DROP HEIGHT

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