TECHNICAL REPORT

EN 1177:2018
IMPACT ATTENUATING PLAYGROUND SURFACING – DETERMINATION OF CRITICAL FALL HEIGHT

HARDWOOD PLAY CHIP

CLIENT	M&B Surfaces Ltd
CLIENT ADDRESS	The Manor Suite Lulworth House 51 High Street Cheadle Staffordshire ST10 1AR
CLIENT CONTACT	Matt Burrows (Director)

REPORT NUMBER	LSUK.21-0009-A1	
REPORT STATUS	Final	
REVISION NUMBER & DATE	1.0	15/01/2021
REPORTED BY		David Rigby Technical Director
APPROVED BY		Professor David James Managing Director

SUMMARY OF REPORT / FINDINGS	In accordance with EN 1177:2018 test specimen(s) of impact attenuating material were struck by an instrumented headform in a defined series of impacts from different drop heights. The signals emitted by an accelerometer in the headform during each impact were processed to yield a severity from the measured impact energy, defined as head injury criterion (HIC) and peak acceleration (*g*max). The HIC and *g*max of each impact was plotted and the critical fall height was determined as the lowest drop height producing a HIC value of 1,000 or a *g*max value of 200. The test specimen(s) submitted met the requirements of EN 1177:2018 when tested under laboratory conditions on the 27/11/2020.

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SCOPE OF TESTING / PROJECT	EN 1177:2018 specifies a method for determining the impact attenuation of playground surfacing. It defines a “Critical Fall Height" for surfacing, which represents the upper limit of its effectiveness in reducing injury when using playground equipment conforming to EN 1176. It 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. Surfaces fulfilling the test requirements of EN 1177:2018 are considered to be in compliance with the requirements for impact attenuation in EN 1176-1. Injuries arise during the use of playground equipment for a variety of reasons and the great majority are minor. Even the presence of protection features like impact attenuating surfacing is known to affect the behaviour of children, as well as carers and play providers, which in turn can affect the risk. The majority of more serious injuries are attributable to falls and there are many factors that influence injury mechanisms during a fall that are independent of the surfacing, e.g. body orientation, awkwardness of fall, bone density, etc. The most severe injuries are likely to be injuries to the head. Recent research has indicated that arm and leg injuries are more frequent and could be influenced by the duration of the acceleration pulse. The committee responsible for EN 1177 maintains a constant review of research in this area for possible use in a future revision of the standard. The committee recognizes that there is a relationship between the risk of arm and leg injuries and surface type but takes the view that such injuries are not usually in the most severe category. At present the available injury data can be taken into account by limitation of the maximum (peak) acceleration. Consequently, the committee has chosen to make its priority the reduction of the likelihood of serious head injuries caused by a fall from playground equipment, because even though such injuries are relatively uncommon, they can have the most severe consequences. The severity of injury resulting from an impact to the head can be quantified in terms of Head Injury Criterion (HIC) and the level of HIC = 1,000 together with the upper limit of the peak acceleration of *g*max = 200g have been chosen as the upper limits for surfacing when assessed in accordance with EN 1177. Limiting the HIC value at a maximum of 1,000 is equivalent to a 3% chance of a critical head injury (MAIS 5), an 18% probability of a severe head injury (MAIS 4), a 55% probability of a serious head injury (MAIS 3), a 89% probability of a moderate head injury (MAIS 2), and a 99.5% chance of a minor head injury (MAIS 1), to an average male adult. Limiting *g*max to a maximum of 200g as well as limiting HIC to a maximum of 1,000 takes account of impacts of very short duration and follows the current research on arm injuries as a means of improvement to EN 1177. The Maximum Abbreviated Injury Scale (MAIS), was first developed by the Association for the Advancement of Automotive Medicine and is used extensively in the automotive industry as an indicator of the severity of head related injuries.

TEST PROCEDURE / STANDARDS	EN 1177:2018 – Impact attenuating playground surfacing – Determination of critical fall height EN 1176-1:2017 – Playground equipment and surfacing – Part 1: General safety requirements and test methods EN 933-1:2012 – Tests for geometrical properties of aggregates – Part 1: Determination of particle size distribution – Sieving method EN ISO/IEC 17025:2017 – General requirements for the competence of testing and calibration laboratories

PRODUCT (DETAILS / DESCRIPTION)	Impact attenuating material referred to as “Hardwood Play Chip” at depths of 100mm, 200mm and 300mm. The material has a size grading of 5mm – 30mm. This information was supplied by the client.

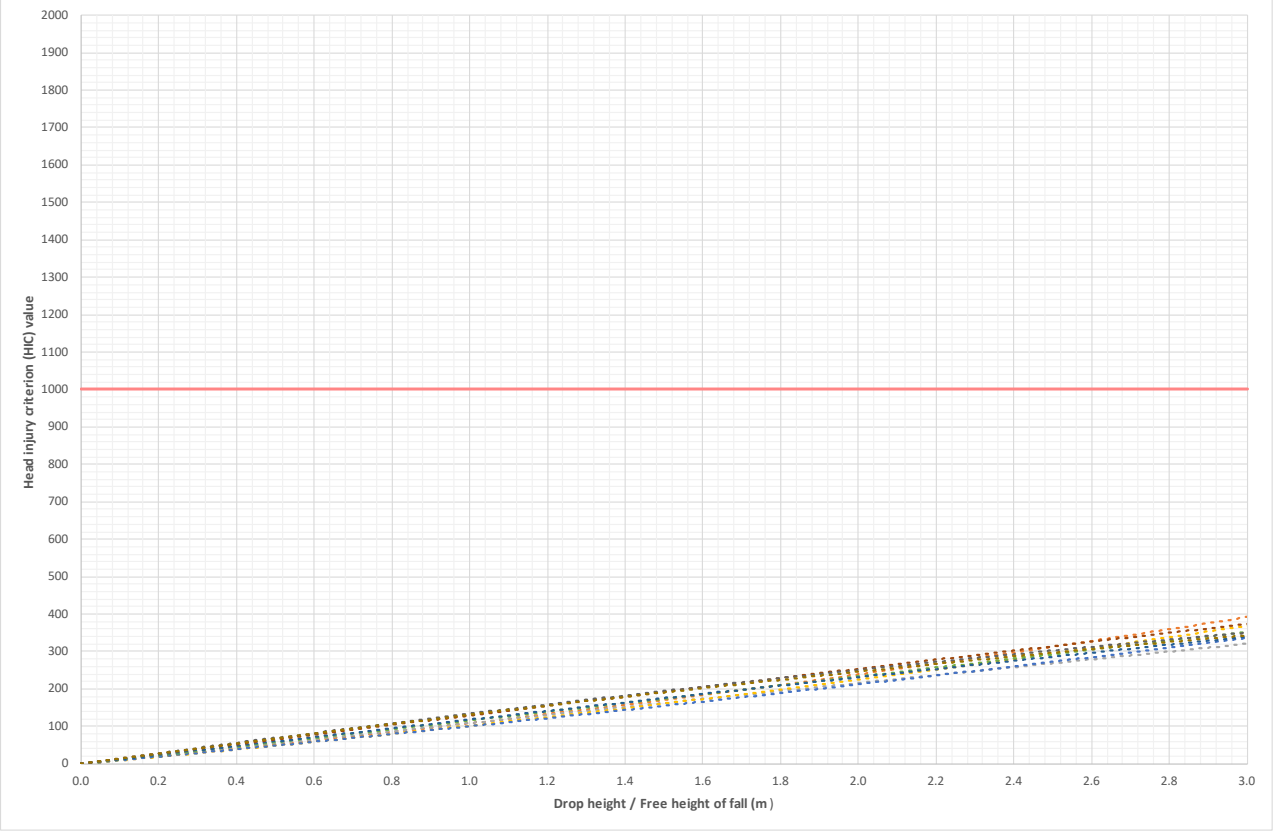
TEST CONDITIONS	The test specimen(s) were tested at 23 ± 2°C and 50 ± 10% relative humidity and conditioned for a minimum of 24 hours prior to testing commencement. The test specimen(s) had a surface temperature of 21.2°C at the commencement of testing. All tests were carried out loose laid on a flat, rigid concrete, or equivalent substrate of sufficient mass, density and thickness that its deformation during the test made no significant contribution to the test result. For testing of particulate material, a test frame without a base was used, with internal dimensions of 1m x 1m. For products intended to be laid over another layer, the entire system, surfacing with under layer(s) was tested. This is classed as a composite product.

TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES

Hardwood Play Chip at 100mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.50	170	188	170	168	151	178	193	218	191	Yes	
2.00	250	229	252	225	267	234	251	249	258	Yes	**>3.00**
2.50	297	202	234	229	281	277	318	263	277	Yes	
3.00	398	355	396	357	352	344	372	373	352	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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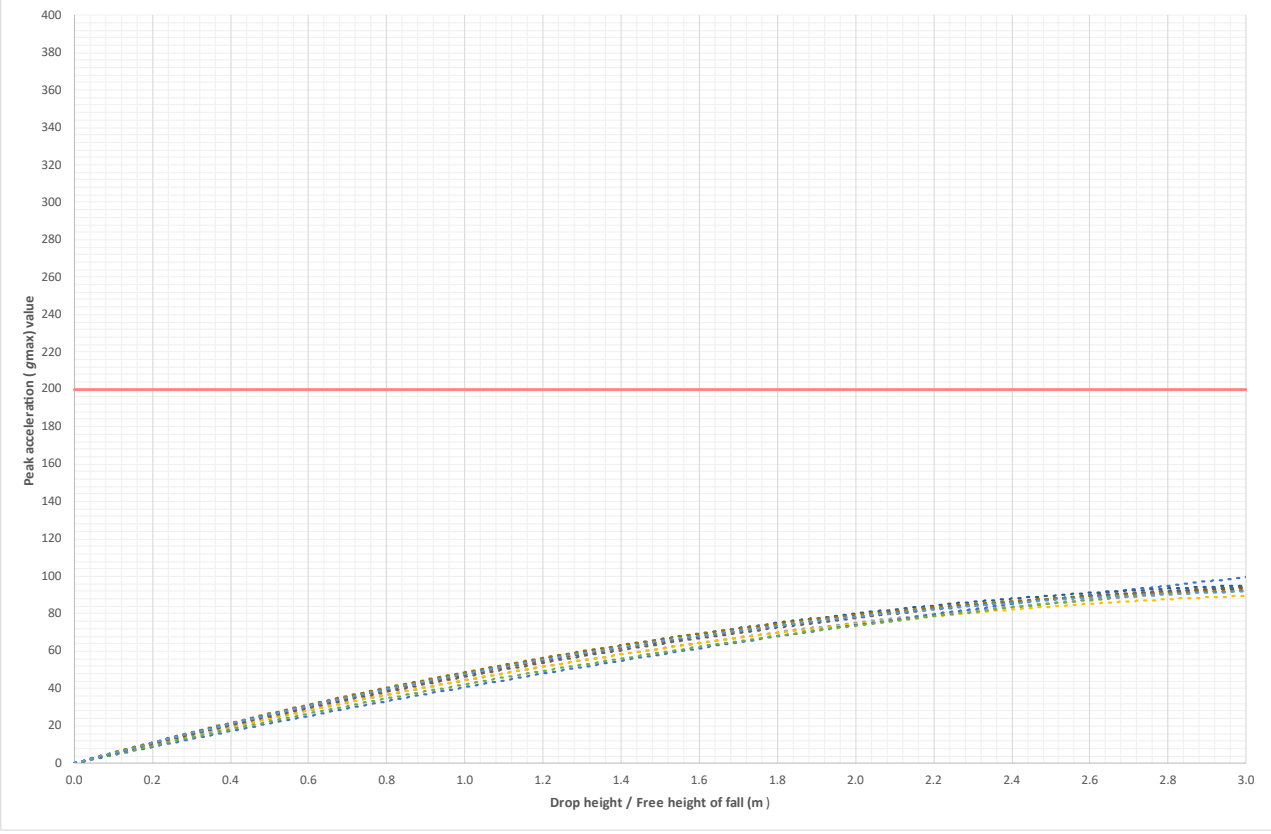
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

Hardwood Play Chip at 100mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.50	67	66	60	58	70	70	65	70	71	Yes	
2.00	72	71	75	78	79	76	77	78	76	Yes	**>3.00**
2.50	81	81	83	81	85	83	87	84	81	Yes	
3.00	96	92	102	96	98	97	95	95	96	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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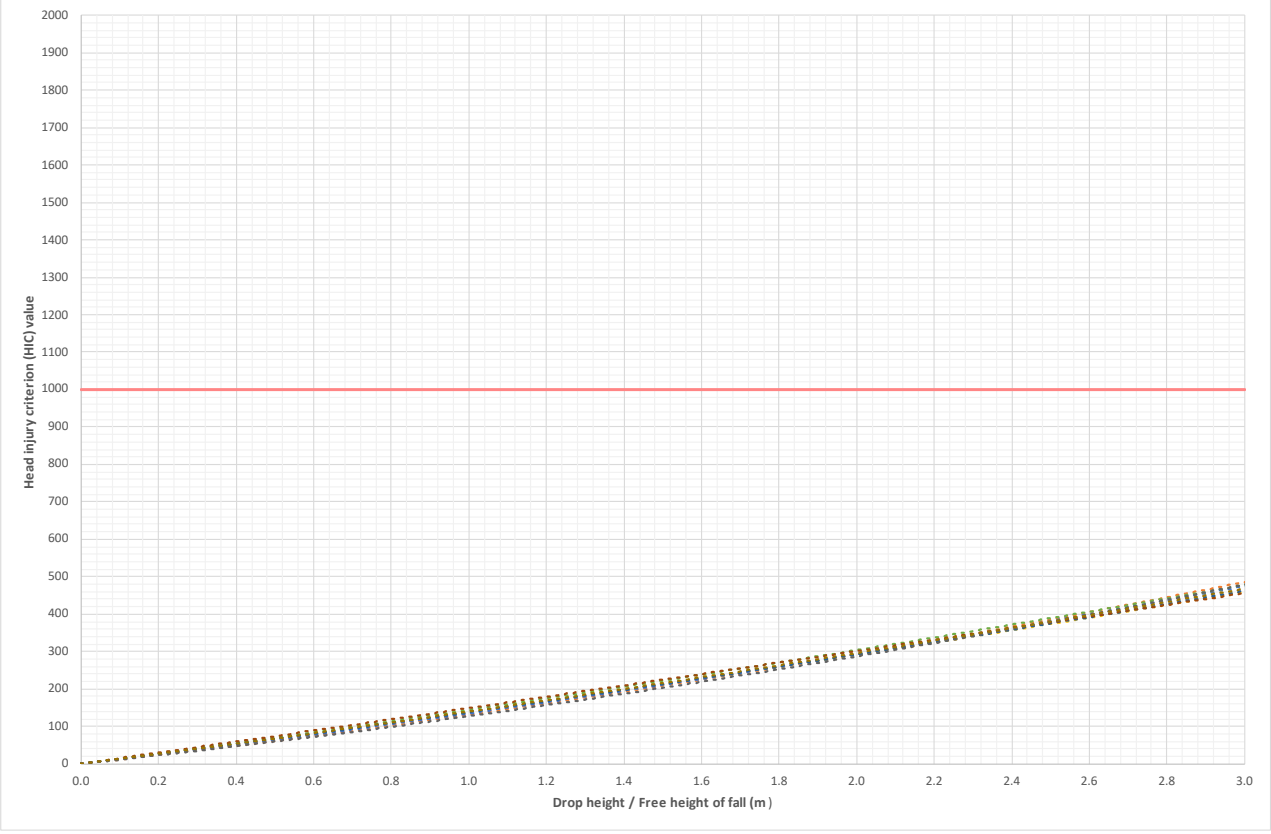
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES

Hardwood Play Chip at 200mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.80	254	260	256	280	275	270	286	264	269	Yes	
2.20	336	330	339	309	339	320	314	308	332	Yes	**>3.00**
2.60	404	386	374	389	395	380	392	400	381	Yes	
3.00	485	470	466	485	484	470	461	482	477	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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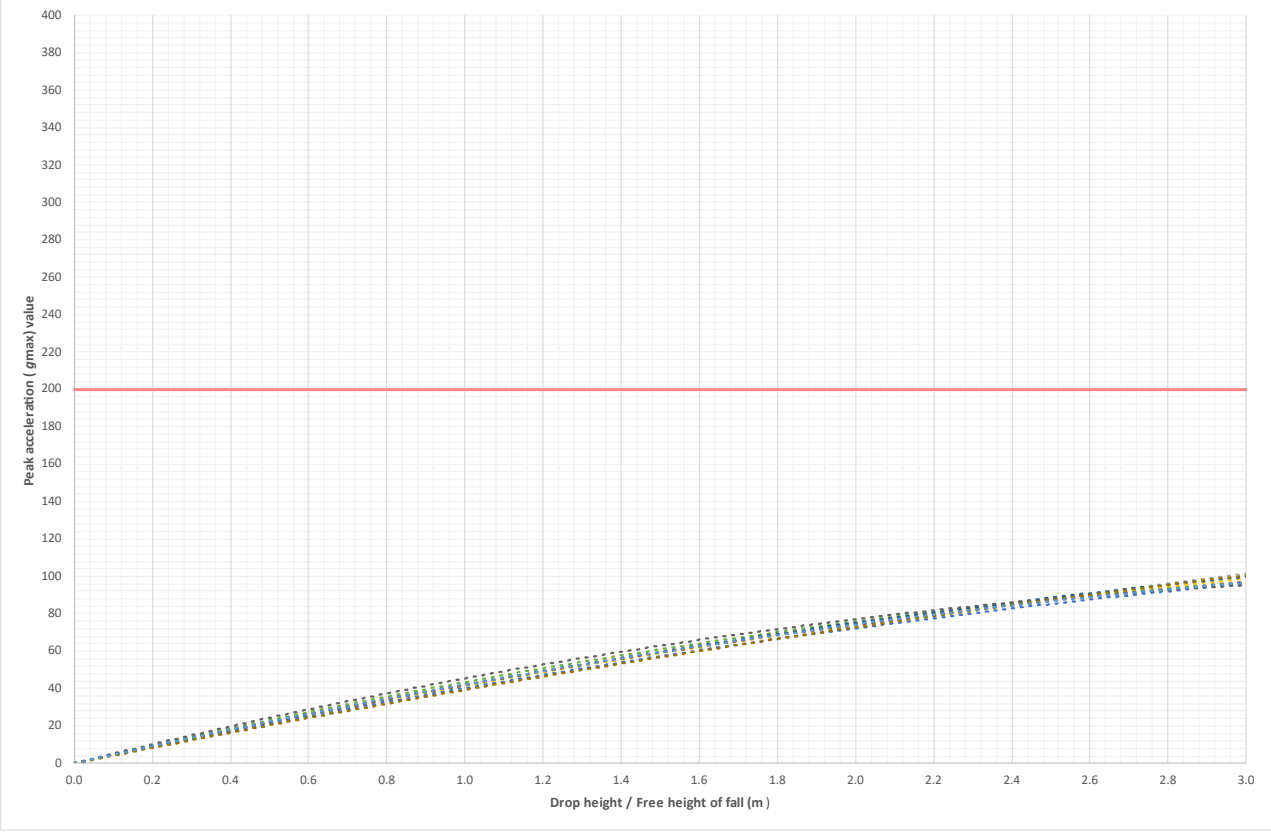
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

Hardwood Play Chip at 200mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.80	64	66	65	72	70	69	74	67	68	Yes	
2.20	82	83	80	78	80	79	78	76	81	Yes	**>3.00**
2.60	92	90	87	91	91	89	92	94	88	Yes	
3.00	100	98	96	97	100	97	95	99	97	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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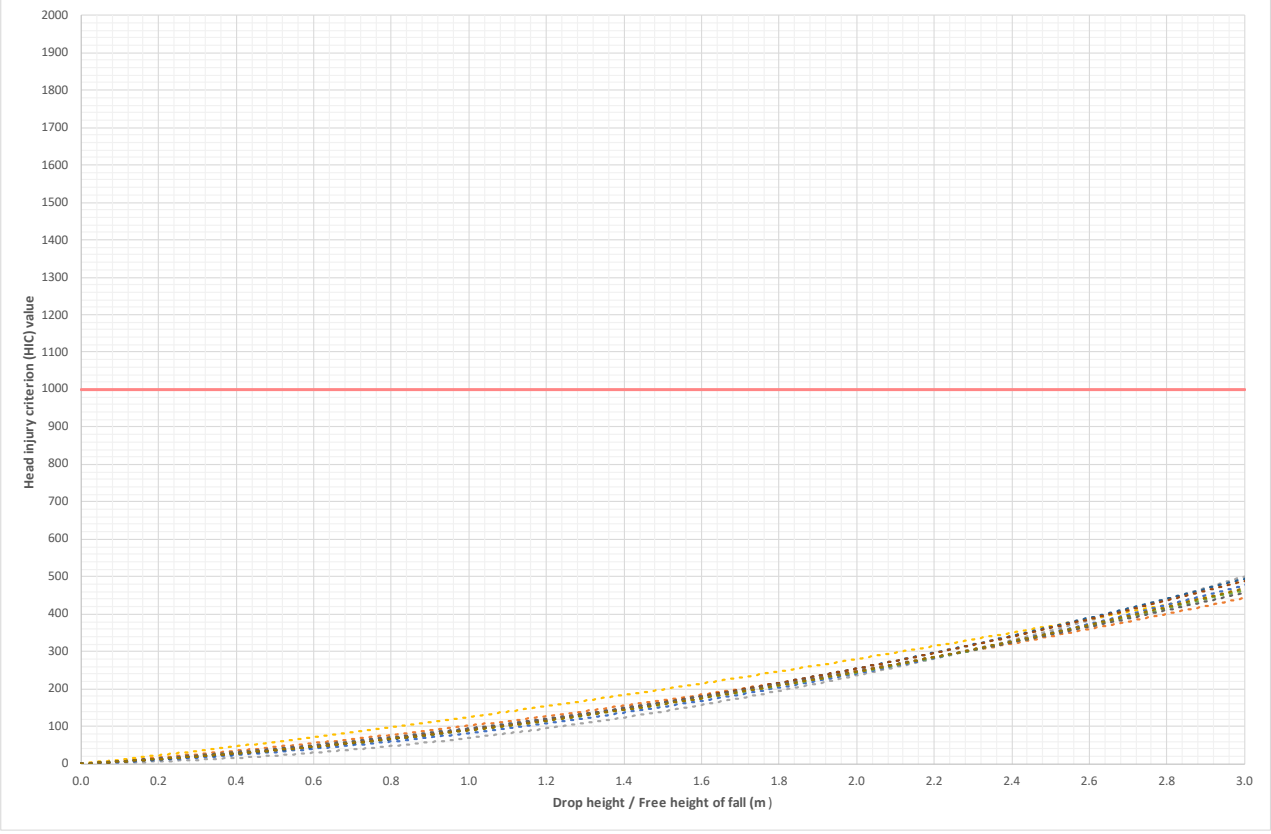
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES

Hardwood Play Chip at 300mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.80	231	205	257	214	231	212	236	225	209	Yes	
2.20	273	272	309	272	269	295	283	271	286	Yes	**>3.00**
2.60	349	378	376	370	347	401	368	364	371	Yes	
3.00	452	506	472	482	481	489	502	462	469	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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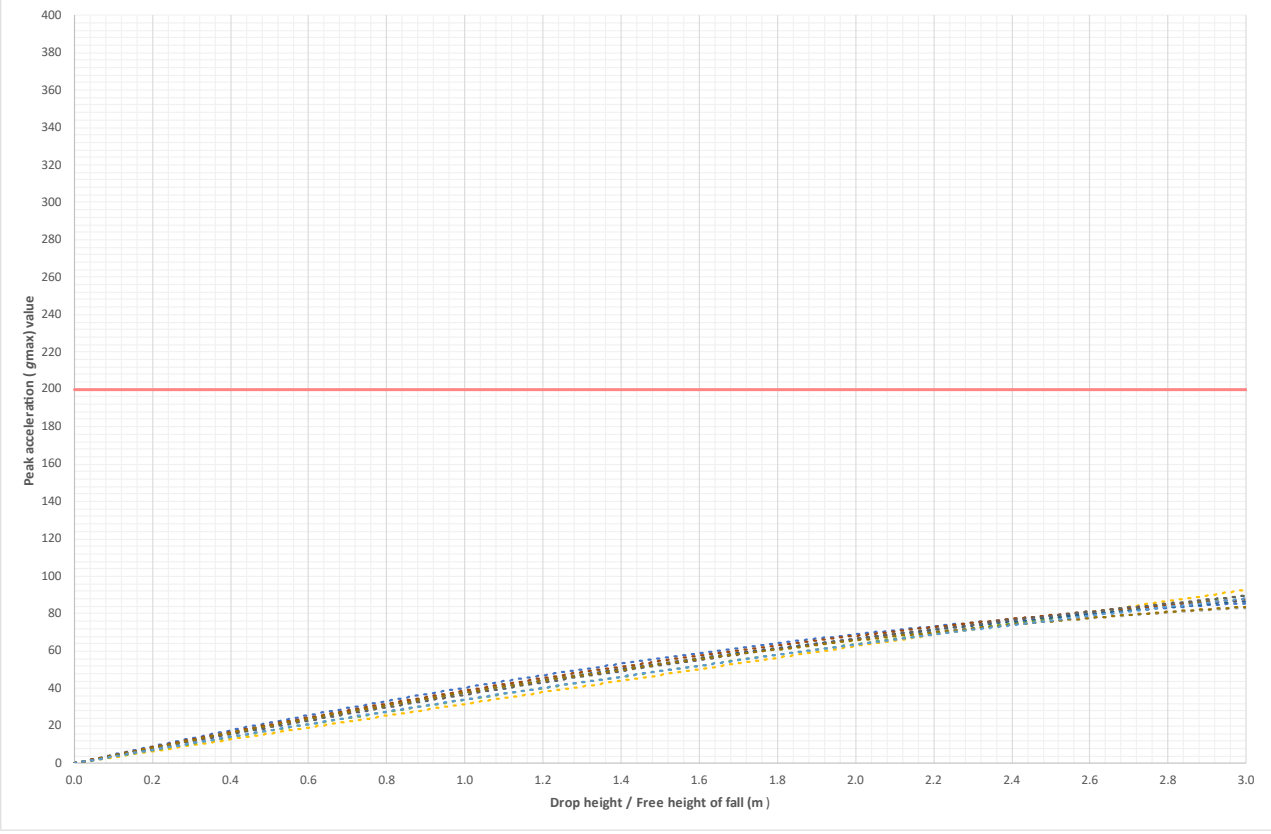
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

Hardwood Play Chip at 300mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	
0.00	0	0	0	0	0	0	0	0	0		
1.80	63	56	67	59	64	63	65	64	58	Yes	
2.20	69	70	72	67	69	72	70	68	70	Yes	**>3.00**
2.60	77	80	77	82	79	83	76	75	77	Yes	
3.00	84	93	88	89	88	87	93	86	89	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e. (t2 – t1) ≥ 3 ms.



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DISCUSSION	The test specimen(s) submitted were found to have critical fall height values of: **Hardwood Play Chip at 100mm >3.00m** **Hardwood Play Chip at 200mm >3.00m** **Hardwood Play Chip at 300mm >3.00m** The maximum Free Height of Fall (FHF) on playground equipment conforming with EN 1176-1 is 3m (see EN 1176-1:2017, 4.2.8.1).

CONCLUSIONS	The test specimen(s) submitted met the requirements of EN 1177:2018 when tested under laboratory conditions. All measurements were conducted with an uncertainty of ± 7%. This uncertainty is based on the findings of a round robin test conducted by CEN in 2011. The results relate only to the test specimen(s) received and tested.

APPENDIX A

Diagram showing all test positions	Example of time / acceleration curve

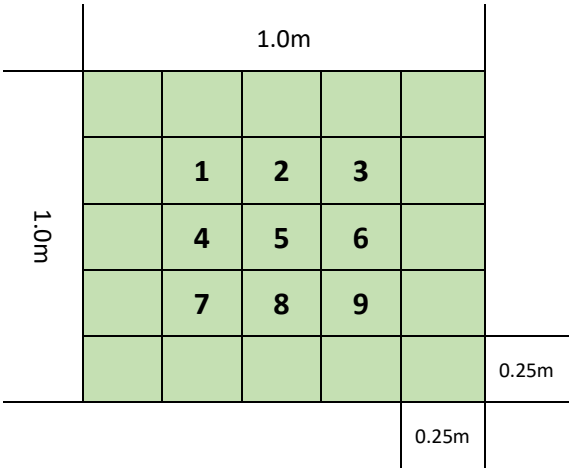
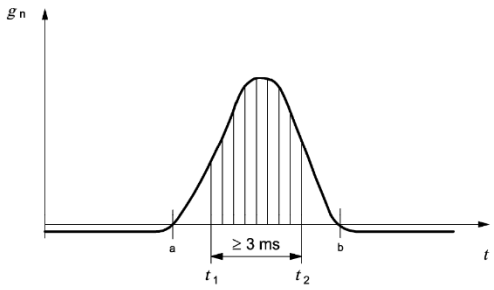


Diagram not to scale

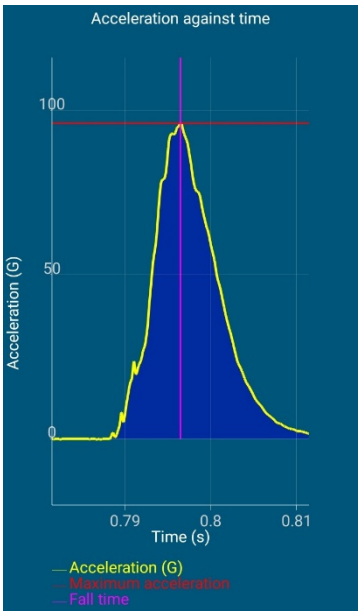


Key
g_n acceleration
t time
a t_{start}
b t_{end}

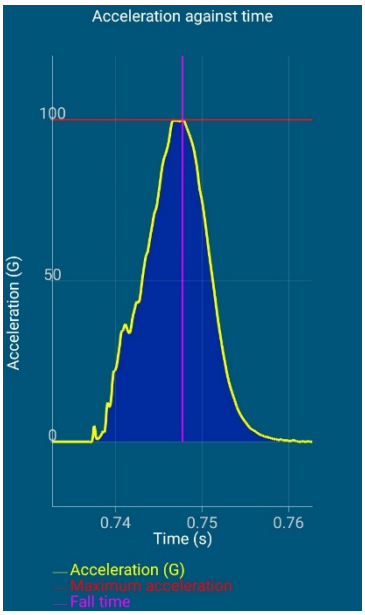
Product photograph – Hardwood Play Chip

APPENDIX B

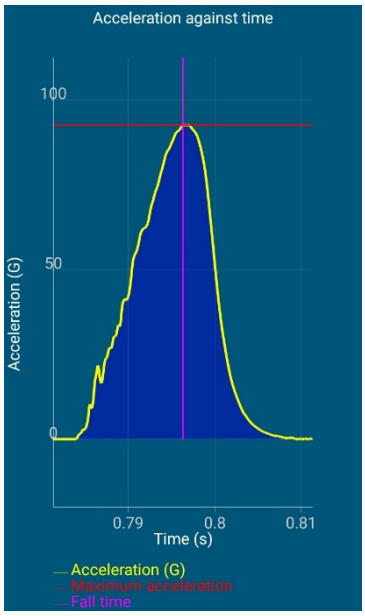
Time / acceleration curve – Hardwood Play Chip at 100mm



Time / acceleration curve – Hardwood Play Chip at 200mm



Time / acceleration curve – Hardwood Play Chip at 300mm



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