TECHNICAL REPORT

EN 1177:2018

IMPACT ATTENUATING PLAYGROUND SURFACING – DETERMINATION OF CRITICAL FALL HEIGHT

M&M RUBBER PLAYGROUND CHIPPINGS

CLIENT	M&M Rubber Play Surfacing Ltd
CLIENT ADDRESS	4 Market Place Cheadle Staffordshire ST10 1AH
CLIENT CONTACT	Matt Burrows

REPORT NUMBER	LSUK.18-0442	
REVISION NUMBER & DATE	1.0	25/05/2018
REPORTED BY		David Rigby Laboratory Manager
APPROVED BY		Dr Colin Young 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.

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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 head 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. On the basis of statistical analysis of available data the Head Injury Criterion (HIC) at a tolerance level of 1,000 and peak acceleration (*g*max) at a tolerance level of 200 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 EN 1177:2018 are considered to be in compliance with the requirements for impact attenuation in EN 1176-1. 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 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. 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 – Tests for geometrical properties of aggregates – Part 1: Determination of particle size distribution – Sieving method ISO 6487:2002 – Road vehicles – Measurement techniques in impact tests – Instrumentation EN ISO/IEC 17025 – General requirements for the competence of testing and calibration laboratories

PRODUCT (DETAILS / DESCRIPTION)	Rubber playground chippings at depths of 50mm, 100mm and 200mm.

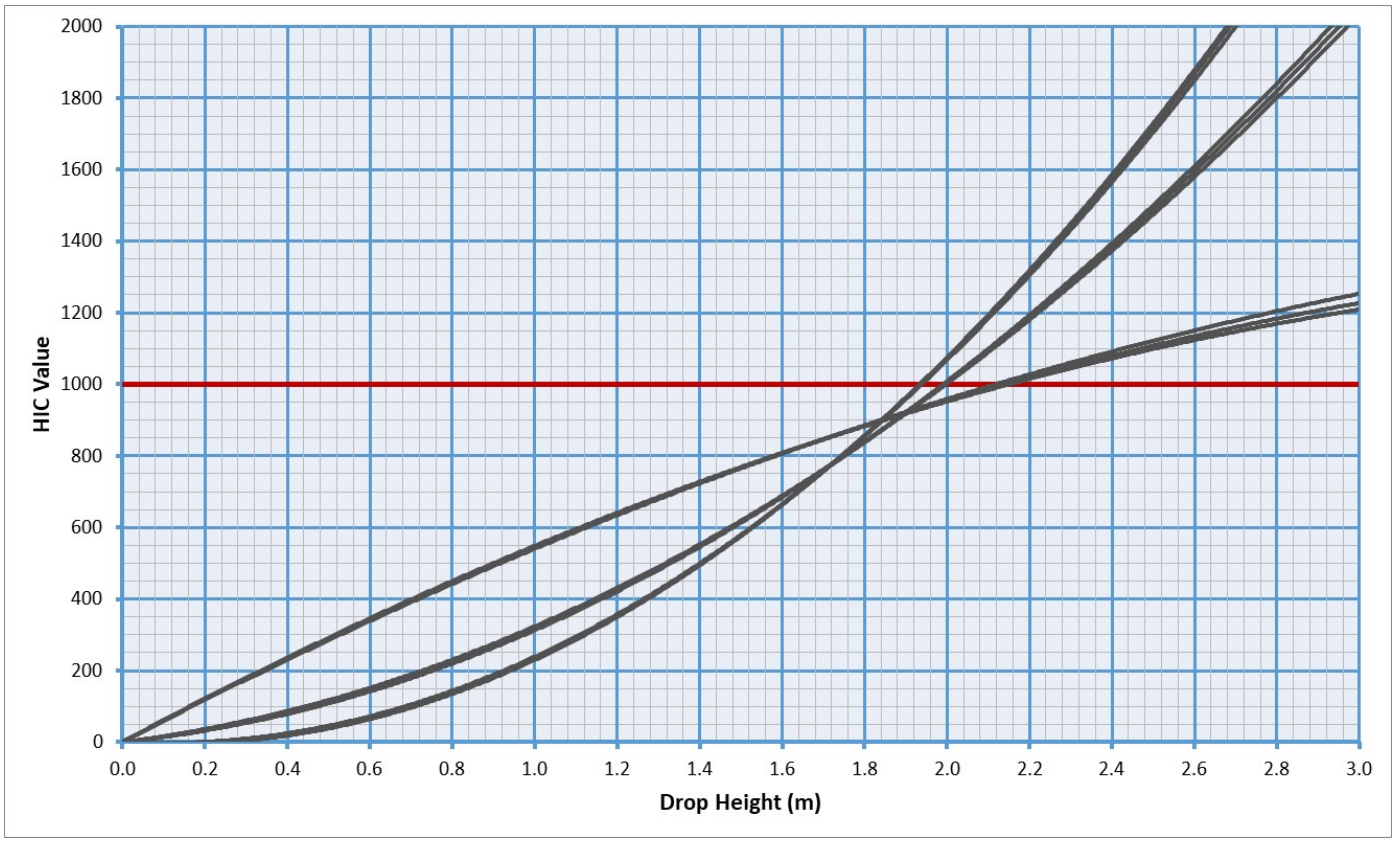
TEST CONDITIONS	The test specimen(s) were tested at 23 ± 2°C and 50 ± 4% relative humidity and conditioned for a minimum of 24 hours prior to testing commencement. The test specimen(s) had a surface temperature of 25.3°C. All tests were carried out loose laid on a flat, rigid concrete, or equivalent 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

M&M Rubber Playground Chippings at 50mm depth

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		
1.70	857	749	747	851	743	741	864	755	751	Yes	
1.90	887	987	873	896	993	879	881	980	864	Yes	**1.93**
2.10	1023	1165	1223	1016	1159	1214	1029	1174	1229	Yes	
2.30	1039	1451	1221	1032	1438	1211	1051	1458	1230	Yes	
CFH (m)	2.14	1.94	1.99	2.15	1.94	2.00	2.12	1.93	1.99	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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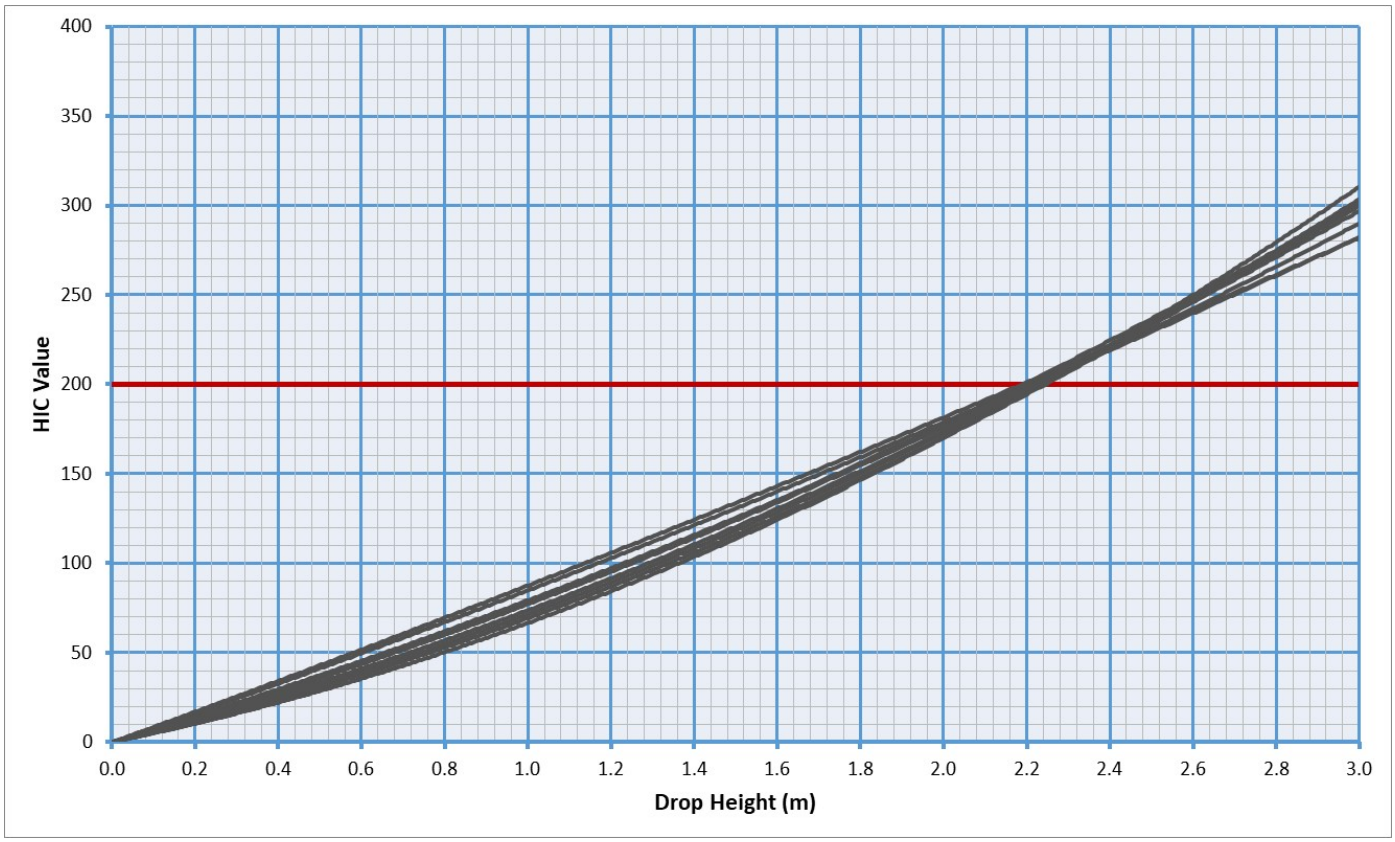
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

M&M Rubber Playground Chippings at 50mm depth

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		
1.90	158	171	160	152	168	154	163	178	166	Yes	
2.10	188	171	194	183	165	191	193	179	196	Yes	**2.19**
2.30	215	209	222	223	216	229	206	204	217	Yes	
2.50	229	238	220	223	236	217	235	245	226	Yes	
CFH (m)	2.23	2.23	2.21	2.24	2.24	2.22	2.21	2.19	2.19	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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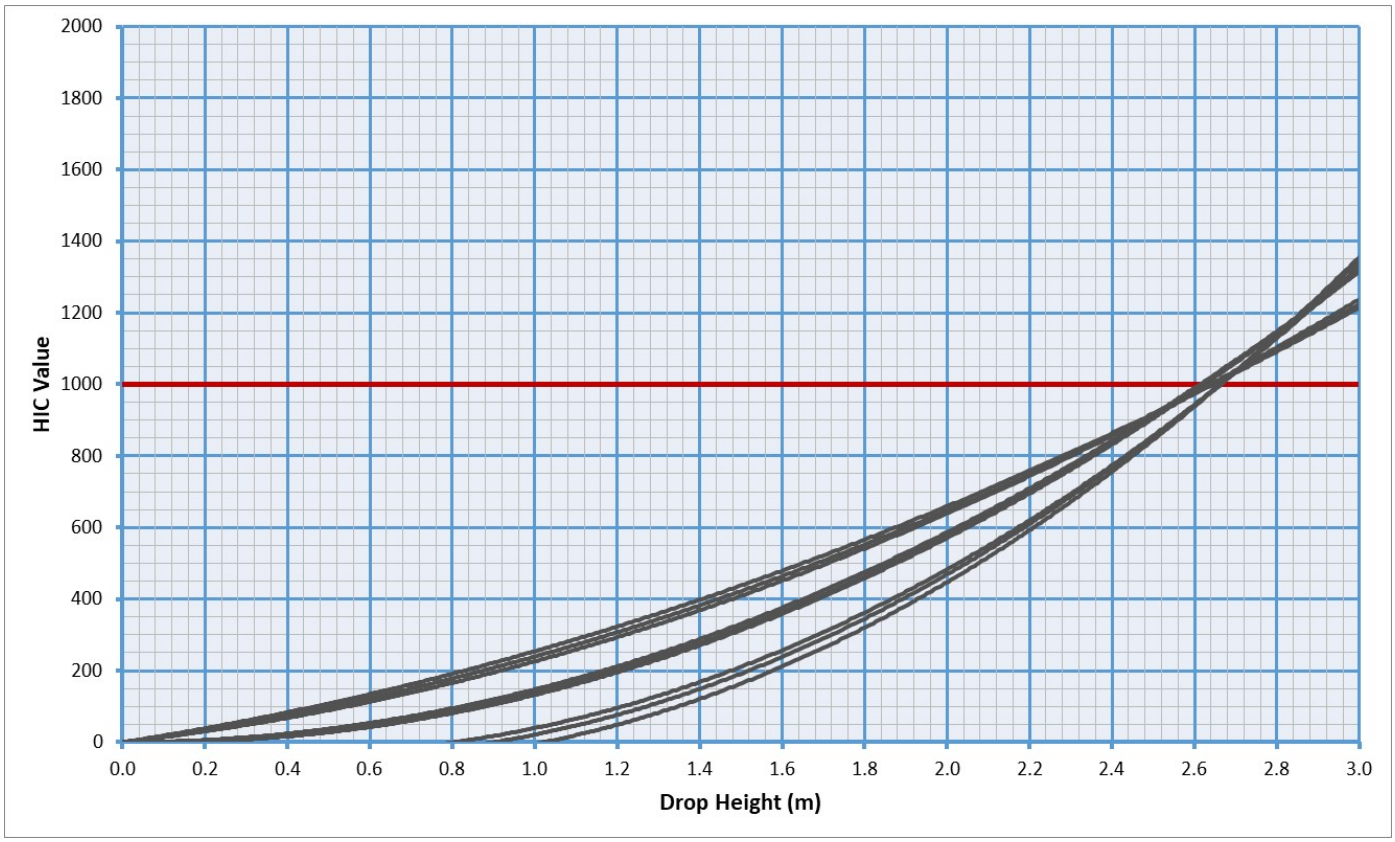
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES

M&M Rubber Playground Chippings at 100mm depth

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		
2.30	782	647	824	789	653	829	771	638	814	Yes	
2.50	912	910	895	923	918	904	907	889	902	Yes	**2.61**
2.70	1028	1035	1019	1020	1029	1012	1036	1042	1027	Yes	
2.90	1254	1223	1175	1259	1214	1170	1243	1229	1182	Yes	
CFH (m)	2.62	2.66	2.64	2.61	2.66	2.64	2.62	2.66	2.64	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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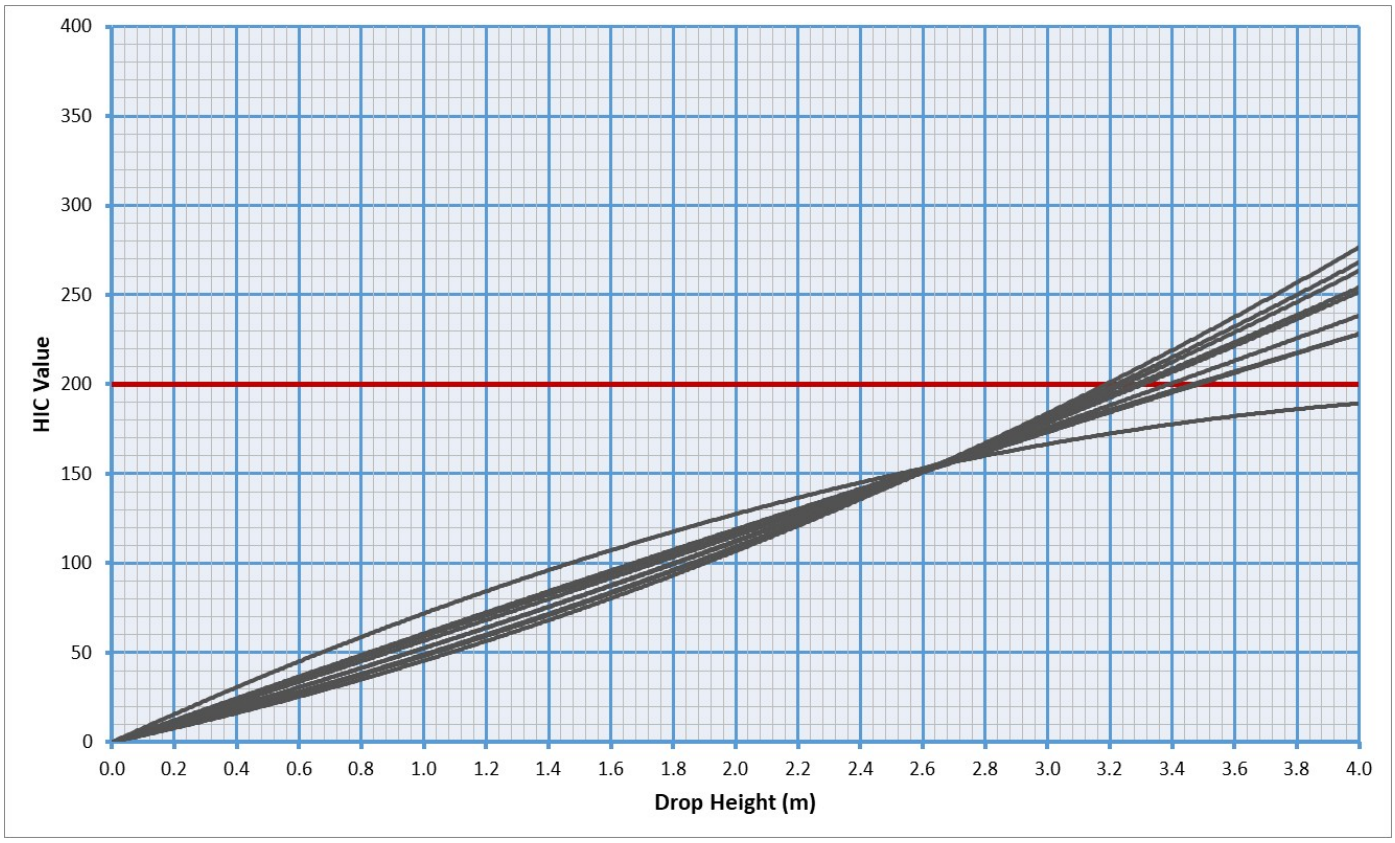
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

M&M Rubber Playground Chippings at 100mm depth

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		
2.50	148	148	146	142	145	144	152	149	150	Yes	
2.70	161	153	157	168	157	162	156	149	152	Yes	**>3.00**
2.90	159	178	172	153	171	165	153	173	166	Yes	
3.00	182	178	185	189	183	191	175	172	181	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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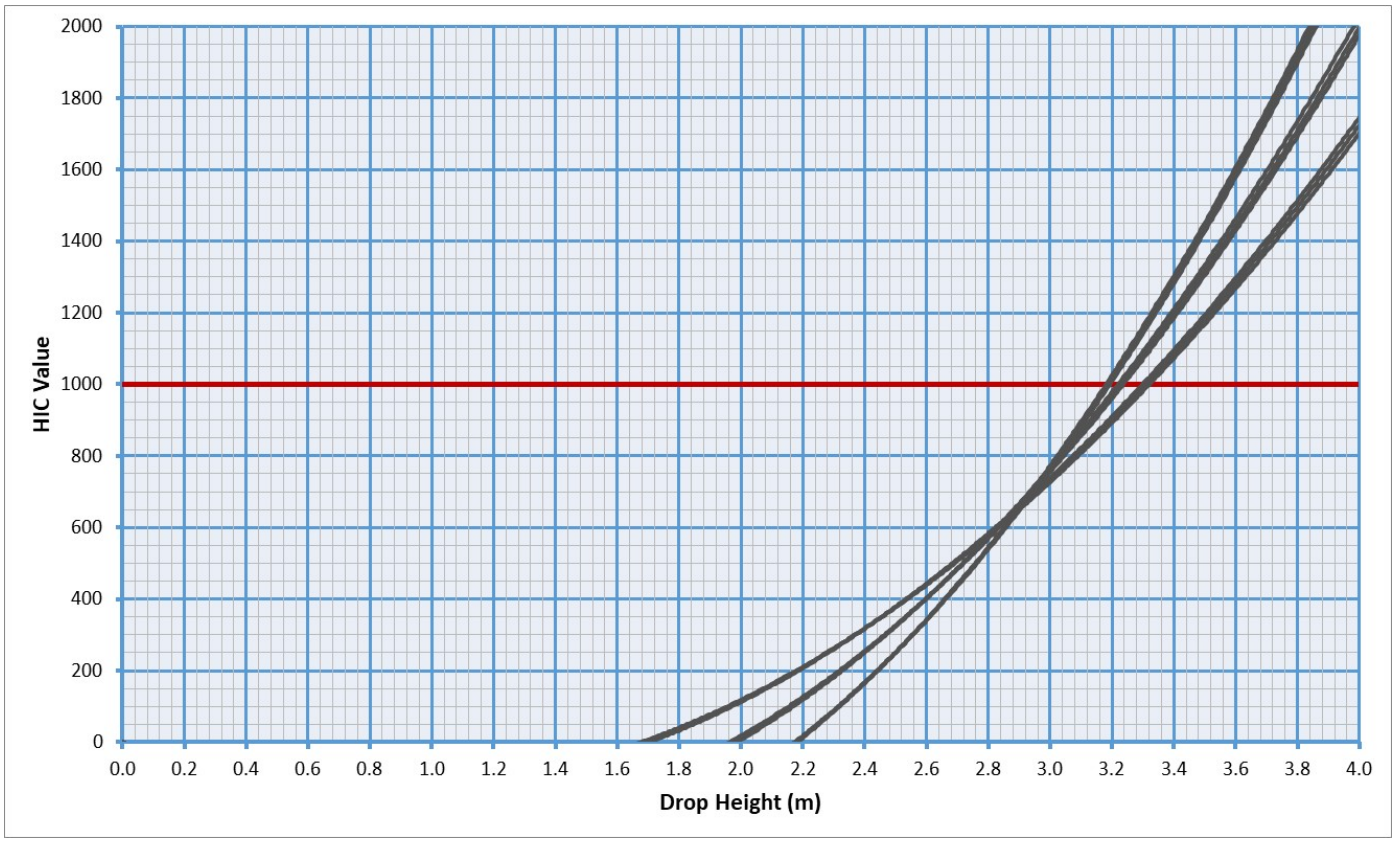
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES

M&M Rubber Playground Chippings at 200mm depth

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		
2.70	510	462	419	519	468	424	503	456	412	Yes	
2.80	559	582	571	553	576	568	564	587	576	Yes	**>3.00**
2.90	692	707	654	699	714	659	683	701	648	Yes	
3.00	716	729	758	724	736	764	710	723	751	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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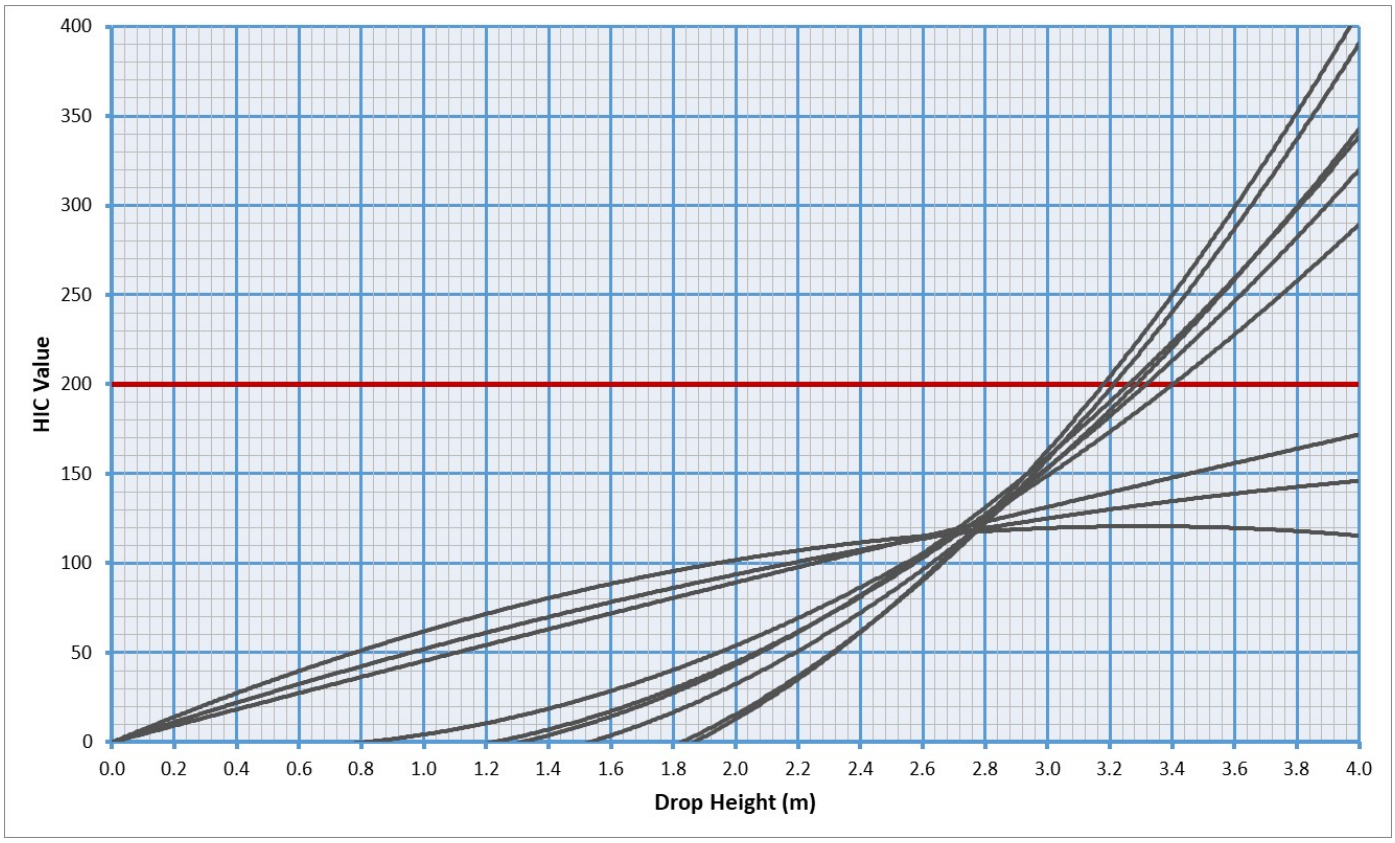
TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES

M&M Rubber Playground Chippings at 200mm depth

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		
2.70	98	117	124	99	112	120	103	126	132	Yes	
2.80	125	129	111	131	138	116	122	125	104	Yes	**>3.00**
2.90	158	131	119	153	126	113	164	135	128	Yes	
3.00	146	159	130	141	153	124	151	168	137	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: M&M Rubber Playground Chippings at 50mm depth 1.93m M&M Rubber Playground Chippings at 100mm depth 2.61m M&M Rubber Playground Chippings at 200mm depth >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.

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APPENDIX

Diagram showing all test positions	Example of time / acceleration curve

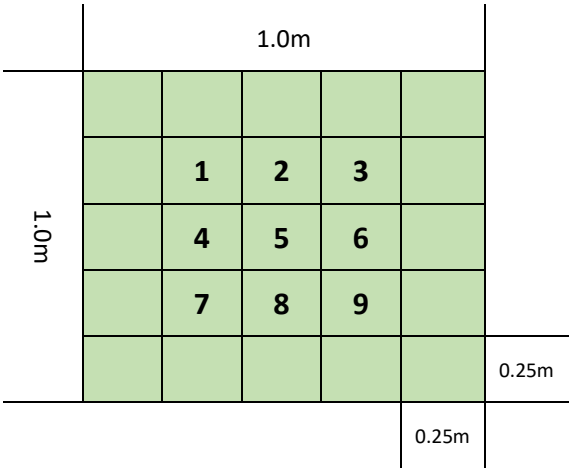
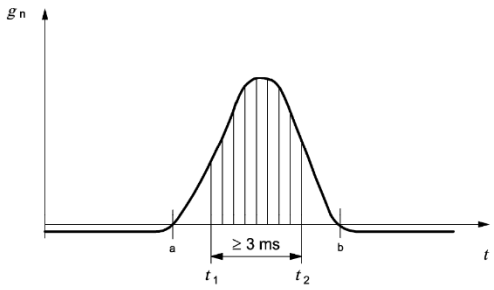


Diagram not to scale



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

Rubber chippings – Photograph 1	Rubber chippings – Photograph 2