Surfacing Materials for Indoor Play Areas
Impact Attenuation Test Report

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George F. Sushinsky
Directorate for Laboratory Sciences

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Executive Summary

Staff from the U. S. Consumer Product Safety Commission (CPSC) conducted drop (impact) tests of materials that might be considered for use as protective surfacing for indoor play areas. The materials included carpeting, carpet padding, exercise and gymnastic pads, and various types of surfacing mats. The tests were based on procedures in ASTM 1292-04 - Impact Attenuation of Surfacing Materials within the Use Zone of Playground Equipment. Maximum deceleration (g-max) and Head Injury Criterion (HIC) values were determined for each material. The Critical Height of the materials was determined from these values.

The test data show a general trend of increasing critical height with increasing sample thickness. The samples with critical heights greater than 0.30 m (12 in) basically fall into two categories, pads and mats as defined in the report. In general, the mat materials had better impact attenuation performance than the pad materials. This advantage also extended to the lower unit cost of the mat materials compared to the pad materials for a given critical height performance.

There are choices for indoor surfacing that can provide impact protection to mitigate the potential for serious head injury in an indoor environment. The CPSC Laboratory tests of several products and materials show that some of the choices are better than others. Mat samples offered the best choice of material in terms of the level of critical height per unit thickness and cost. For the types tested, carpeting (with padding) did not perform well enough to be considered as a suitable protective surfacing material.

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Purpose and Background

The purpose of this U.S. Consumer Product Safety Commission (CPSC) work is to develop information on the range of available surfacing for use under indoor play equipment at daycare centers, preschools, etc. Staff plans to use the information to develop consumer information and/or participate in voluntary standards activities related to playground surfacing as appropriate.

CPSC staff receives occasional inquiries about surfacing for indoor play areas. These inquiries are often prompted by state and local requirements for play areas (outdoors and indoors) in child care facilities to meet the recommendations in the CPSC *Handbook for Public Playground Safety*[1] (Handbook). The relevant ASTM voluntary standard (ASTM F2373-05 Consumer Safety Performance Specification for Public Use Play Equipment for Children 6 Months to 24 Months[2]) exempts supervised settings from protective surfacing requirements for equipment heights up to 18 inches (460 mm). Despite this exemption, the standard, recognizes that hard surfaces are unsuitable for use under and around playground equipment. The voluntary standard sites examples of hard surfaces as asphalt, concrete, terrazzo, and "other materials with similar characteristics." ASTM F2373-05 also references ASTM F1292-04 – Impact Attenuation of Surfacing Materials within the Use Zone of Playground Equipment[3], in discussing the surfacing characteristics needed for unsupervised settings or for equipment greater than 18-inches (0.46-m) high in supervised settings. This voluntary standard "specifies impact attenuation requirements for playground surfaces and surfacing materials and provides a means of determining impact attenuation performance using a test method that simulates the impact of a child's head with the surface. The test method quantifies impact in terms of g-max and Head Injury Criterion (HIC) scores. G-max is the measure of the maximum acceleration (shock) produced by an impact. The Head Injury Criterion or HIC score is an empirical measure of impact severity based on published research describing the relationship between the magnitude and duration of impact accelerations and the risk of head trauma."[3]

This report builds on earlier work by the National Program for Playground Safety (NPPS). NPPS had 24 products from suppliers of child-care and exercise/tumbling/gymnastic equipment tested to the requirements of ASTM F1292. The subsequent report[4] noted that "Nearly 60 percent of the materials tested had a critical height of 0.3048 meters (one foot) or less. … carpet and safety floor tiles provided virtually no fall protection. …." In their study, NPPS staff reported that "Only landing mats at least 10.16 centimeters (four inches) thick consistently registered critical heights above 0.9 meters (3 feet)."

Test Program

In the current CPSC staff study, a number of different materials were selected for evaluation of their impact attenuation properties. Some of these included materials similar to those evaluated in the NPPS study. The CPSC staff study followed the basic outline of the test procedures in ASTM F1292, similar to those followed in the NPPS study, by looking at the g-max and Head Injury Criteria (HIC). For the CPSC staff work, data measurements were taken at drop heights as low as two inches (50 mm) and at intervals from 2 to 12 inches (50 to 300 mm) based on the performance of the product in preceding impact tests.

Samples

Materials were loosely classified as mats, pads, carpets, and carpet padding. Mats were generally unitary (homogenous) materials. Most of the tested mats had a thickness less than 1 in (25 mm). Four mats exceeded this dimension and had thicknesses ranging from 1.1 to 1.8 in (28 to 46 mm). Mats generally were uniform throughout their thickness but several also had a laminated or adhesively bonded surface coating to improve wear characteristics. (See edge photographs of mats M-3 to M-6, and M-13 and M-14.) Most of the mats also were generally of a discrete size with interlocking edges. The term "pad" was used for products with thicknesses greater than 1 in (25 mm). All of the tested pads had an outer covering typical of an exercise or gymnastics pad. Carpet samples consisted of commercial quality, residential, or indoor/outdoor carpeting. Carpet padding was either a woven fiber felt or bonded foam. The carpet and carpet padding materials were tested as separate materials and in combinations appropriate to the use of the materials. A complete list of the materials, dimensions, available forms, and limited construction details is in Table 1 of Appendix I. (Tables are grouped together at the end of this report in Appendix 1 – Tables.) Materials used in the samples are listed where known. Photographs of the samples are in Appendix II.

Test Equipment

CPSC staff conducted the tests with one of the monorail impact towers at the CPSC Laboratory (LS). This tower has a capability of testing with drop heights up to 12 ft (3.7 m) but it was modified by placing a 18 in by 18 in by 36.4 in (460 mm by 460 mm by 920 mm) reinforced concrete column on the steel base of the tower to facilitate testing. A 1-in (25-mm) thick steel plate was grouted in place and secured with expansion anchors and bolts onto the top of the concrete column. Photograph 1 shows the test tower base.

The electronics and software packages used in the testing are commercially available system packages that are routinely used in the impact testing of protective headgear. The software is capable of reporting the g-max and HIC of an impact test on surfacing materials. In addition to the data processing hardware, the measurement system includes a uniaxial accelerometer mounted in the center of a ball arm connection between the impact missile and the impact support assembly. The accelerometer is capable of measuring impacts up to 1000 g.

Photograph 1 – Test tower, concrete base, F1292 hemispherical impactor, and electronics.

The test missiles consisted of a "spherical impactor" and the hemispherical impactor described in section 8.2.1 of ASTM F1292-04. The spherical impactor is a 5.75-in (146-mm) diameter aluminum sphere mounted on the ball-arm connector of the impact drop assembly. The combined mass of the spherical impactor, accelerometer, and supporting assembly is 11.0 ± 0.22 lbm (5.0 ± 0.1 kg). The hemispherical impactor surface is 6.3 ± 0.1 in (160 ± 2 mm) in diameter. The combined mass of the hemispherical impactor, accelerometer, and supporting assembly is 10.1 ± 0.05 lbm (4.6 ± 0.02 kg).

In addition to the test materials, the missiles were also used to impact a modular elastomer programmer (MEP). The MEP is 6 in (150 mm) in diameter and 1 in (25 mm) thick. The MEP has a durometer of 60 ± 2 Shore A and is used to verify the impact system operation for helmet testing.

Test Procedure

1. System Verification

CPSC staff conducted several initial system verifications to assure proper operation of the impact measurement system by following established LS procedures used in headgear testing. These procedures, outlined in 16 CFR 1203.17(b)(1) *Instrument System Check*[5], involve dropping the spherical impactor onto the MEP. Coincident with this system check, LS staff also conducted a series of impacts on the MEP using the F1292-04 missile. The data from these comparison drops were consistent on a day to day basis. Subsequently, LS staff used the F1292-04 missile impacts of the MEP as a measure that the impact test system was operating properly. Photograph 1 shows the F1292-04 hemispherical missile and MEP as used in the testing.

2. Sample Tests

All samples were tested at room temperature (between 18°C and 24°C [64°F to 74°F]). The relative humidity ranged from 20 to 35 percent. Mat, carpet, and carpet pad samples had sample sizes as dictated by the available size of the material. These were typically 18 in by 18 in (460 mm by 460 mm) or smaller. Larger mats were cut to produce sample sizes of 18 in by 18 in (460 mm by 460 mm). LS staff tested pad samples as received by supporting the parts of the pads that overlapped the 18 in by 18 in (460 mm by 460 mm) steel impact surface on the concrete column as demonstrated in Photograph 2. Double-sided, adhesive, carpet tape was used to attach each of the samples to the steel plate.

LS staff conducted initial impacts on a sample from drop heights intended to be below the impact attenuation performance criteria established in ASTM F1292-04. Those criteria require the average g-max to be 200 g's or less and the average calculated HIC to be 1000 or less for the last two of a series of three impacts. For thin materials, the initial drop height started at 2 in (50 mm) and increased in 2-in (50-mm) increments until the impact parameters exceeded one or both of the performance criteria. The initial series of impacts were conducted at the same location on the sample.

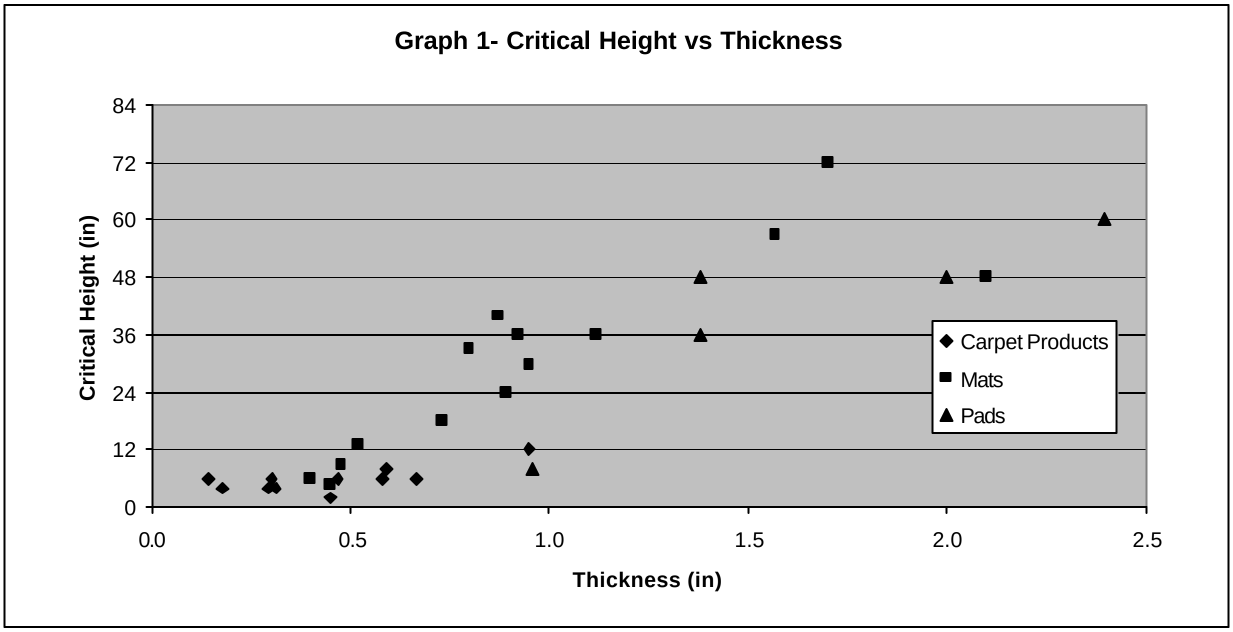
Once the initial impacts produced a performance failure (based on g-max or HIC), LS staff then impacted a new section of the sample from the drop height that produced the prior failure. This provided some insight into the damage that occurred to the sample from prior impacts and gave a measure of the critical height of the material. LS staff generally tested the thicker pad samples in even increments of 12 in (0.30 m) until failure and then retested the sample at a new location from the failure drop height. In most tests, the reported drop heights are measured drop heights. In some tests at the measured drop height, if the g-max or HIC values were near the failure performance criteria, LS staff retested the sample from a slightly higher drop height. For these retests, the drop height was increased about five percent above the prior drop height. This increase in drop height resulted in an increase in impact velocity. The increased impact velocity was then used to calculate a theoretical drop height[a] which was then used to estimate the critical height of the sample.

The nominal time interval between impacts in a set of three impacts from a given drop height was one minute. ASTM F1292-04 allows a time interval between impacts of 1.5 ± 0.5 minutes.

[a] The theoretical drop height of the impact missile is the drop height that, under standard conditions, results in an impact velocity equal to the missiles's measured impact velocity. The standard conditions assume that friction and air resistance do not affect the acceleration of the missile and that the acceleration due to gravity is equal to the standard value of *g* at sea level. In a free-fall impact test, the actual drop height approximates the theoretical drop height. In a guided impact test, the theoretical drop height will be less than the actual drop height, due to the effects of friction in the guidance mechanism. (from ASTM F1292-04, terminology 3.2.19)

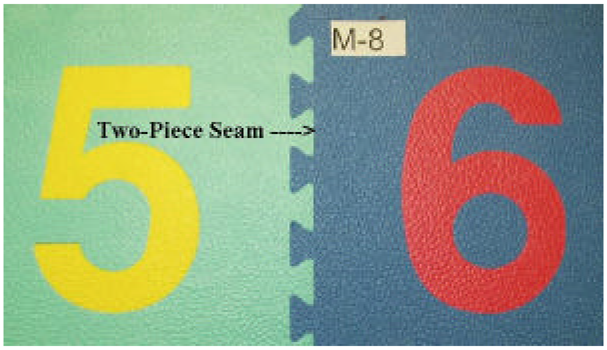
Test Results

Tabulated test results are presented in Table 2. Graph 1[b] shows the relationship between critical height and the thickness of the sample. There is a general trend that shows increasing critical height with increasing sample thickness. For samples with critical heights greater than 0.30 m (12 in), there appear to be two separate sets of data. One consists of Pads 1, 5, 6, 7, and 8 (? symbol). The second set contains the mat materials (¦ symbol). The relationship between critical height and sample thickness is the general trend, but as is seen for samples with a thickness near 1 in (25 mm), the critical heights range from 8 to 40 in (0.20 to 1.0 m).

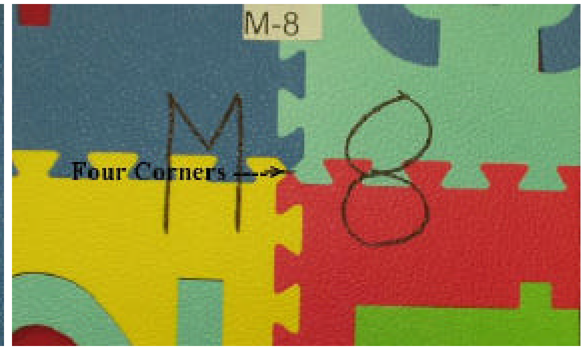


The data shown in Graph 1 is for impacts onto a "solid" core of the sample. Mats that came in discrete sizes (not sheet goods) had edges that interlocked to allow larger surfaces to be covered. These products were also tested at the seam between two mats and at the corner where four mats met. (See Photographs 2 and 3 for examples of these locations.) In general, impacts on the seam or corner of a sample showed significantly reduced impact attenuation (higher g-max values) for the same drop height than impacts onto the solid core of the sample. See Graph 2. Similarly, folding pads displayed reduced impact attenuation when tested at the seams with either the sewn or open side of the fold absorbing the impact. (See Photographs 4 and 5 for examples of sewn and open seams.) This is shown in Graph 3.

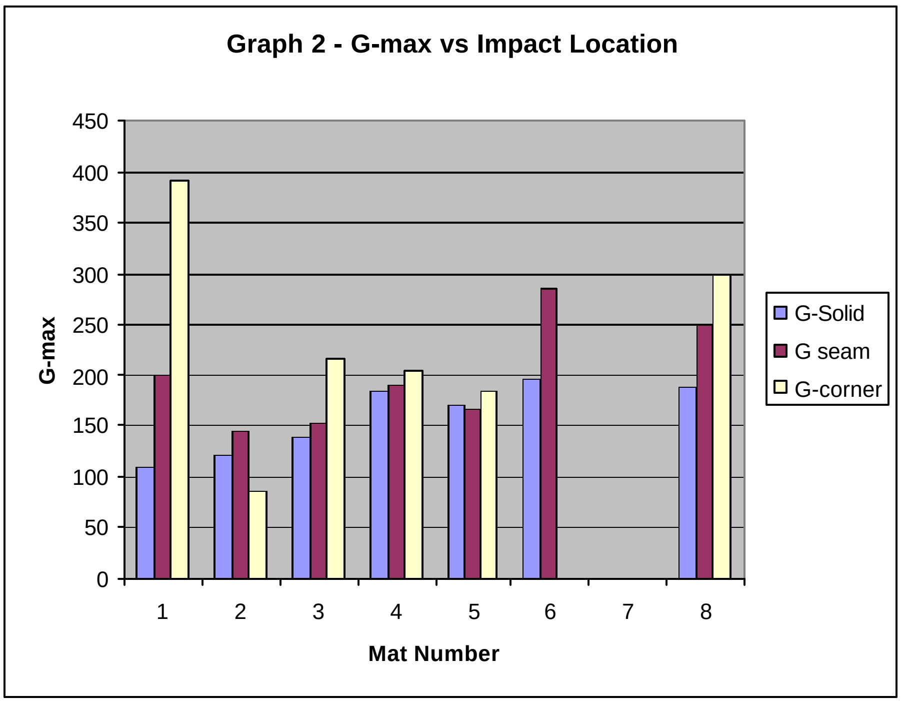
[b] Supporting tables for the Graphs are in Appendix 1



Photograph 2 - 2-Seam Sample – Typical

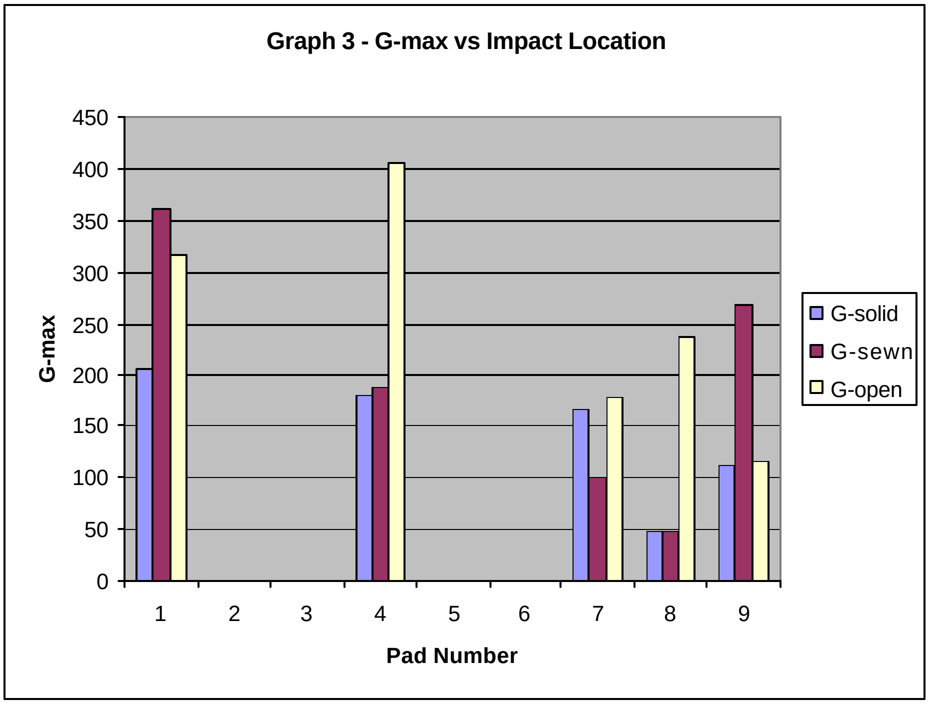


Photograph 3 - 4-Corner Sample – Typical



Photograph 4 – Sewn seam – Typical

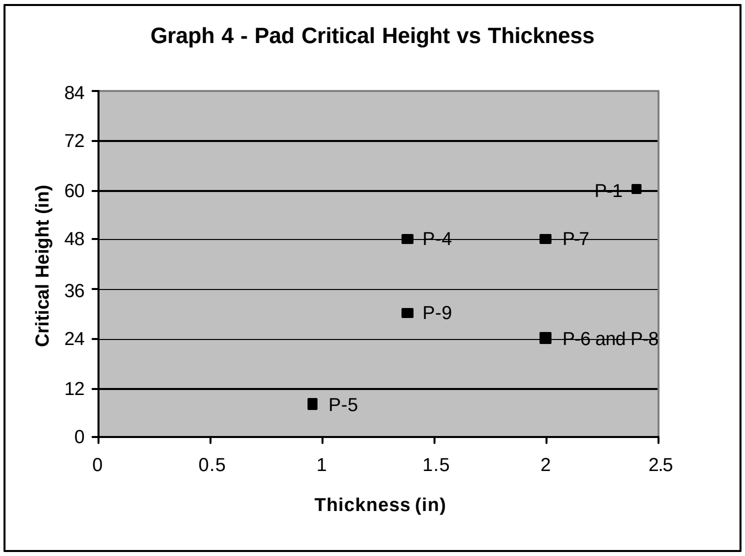
Photograph 5 – Open seam – Typical



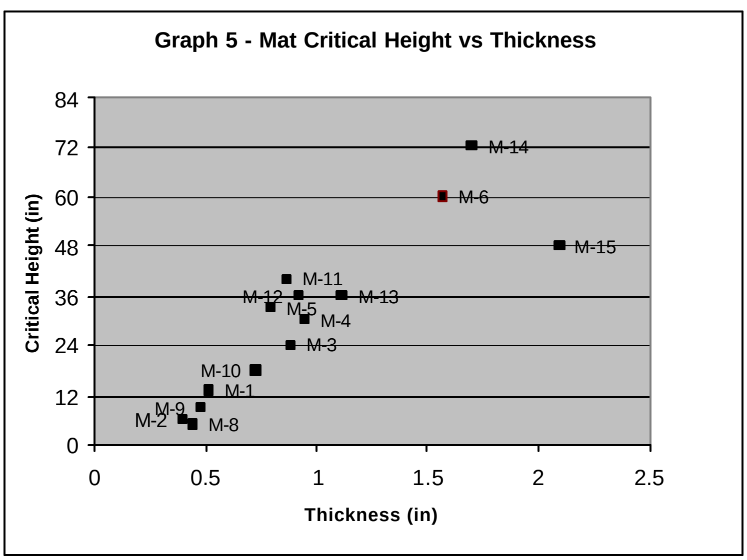
Discussion

The data provided in this report agrees in substance with that previously developed in the NPPS study. The areas of agreement include the large number of the sample materials that have critical heights less than 12 in (300 mm) and the general trend for thicker samples to have higher critical heights. The materials tested in this program show better impact attenuation properties than those seen in the NPPS study which reported critical heights above 36 in (910 mm) for materials at least 4 in (100 mm) thick. In the CPSC staff tests, several materials had critical heights at 36 in (910 mm) or greater for thicknesses as small as 0.87 in (22 mm). See Graph 1 for the overall trends.

The pads appear to offer lower impact attenuation (on a per thickness basis) than the mats as shown in Table 3. Within the pad "family" the impact attenuation of a pad is not always related to its thickness. (See Graph 4.) Pads 5, 6, and 8 are different pads from the same retailer and contain polyurethane foam covered in a reinforced vinyl. Pads 4, 7, and 9 are also from this retailer. Pads 4 and 9 have cores of polyethylene foam. Pad 4's core is described as "firm" in the product literature. Pad 1 which has the best impact attenuation of any of the pad samples has a two-layer core. Forty-five percent of the thickness is soft polyurethane foam and the second layer is crosslink polyethylene foam. Pad 7 uses bonded urethane foam for its core material. This material is much denser than the two materials used in the other pad cores.



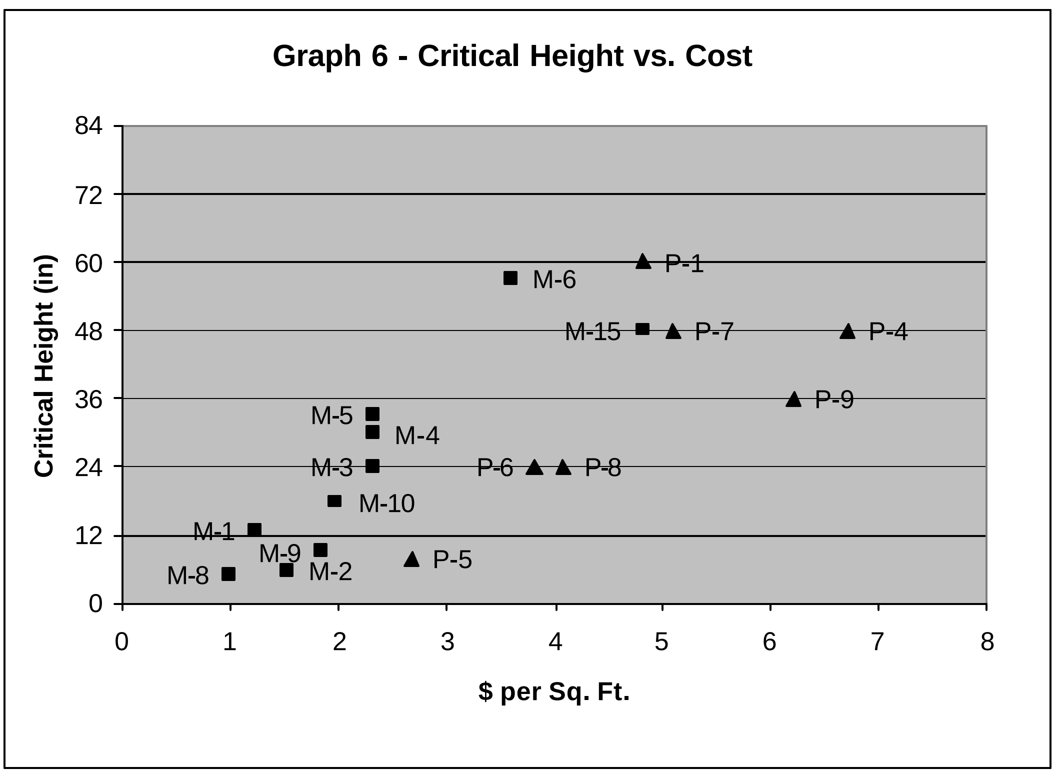
The mat samples show a linear relationship between critical height and thickness, with the exception of mat 15. The materials used in the mats range from flat rubber flooring (Mats 9 and 10) to multi-layer carpet and foam products specifically marketed for indoor play room surfacing (Mats 13 and 14). Mats 1 consists of polyethylene with a calcium carbonate filler. Mats 2 through 8 are made from poly(ethylene-co-vinyl acetate). Mats 2 through 6 (from the same retail source) differ in either firmness (as identified in the product literature) or thickness. Mats 3, 4, and 5 have the same nominal thickness. As described qualitatively by the manufacturer, Mat 3 is “soft”, Mat 4 is “firm”, and Mat 5 is “extra firm”. From Graph 5, impact attenuation improves with firmness, but thickness dominates the trend in impact attenuation. Mats 11 and 12 are the top surface layers of an outdoor surfacing system made from polyvinyl chloride (PVC) material. These mats have “waffle-patterned” bottoms under relatively thin surface layers. Finally, Mat 15 is made from a dense, closed cell PVC material.



Graph 6 shows a near linear relationship between critical height and cost (on a per square foot basis) for the mat samples. The pad sample data trend is less clear but in general the pads cost more than mats on a per square foot basis. From this graph, it can be interpreted that a cost of about $3 per square foot of mat material will provide an indoor surface with a critical height of 36 in (910 mm). Lower height play equipment or the "ideal" selection of material thickness and hardness may reduce the price of the mat surface by 30 percent or more without greatly affecting the shock absorbing quality of the surfacing. Installation costs would add to the total cost of the surface.

Carpets and carpet pads do not appear to offer enough impact resistance to merit CPSC staff consideration as a suitable protective surface. The better impact-absorbing carpeting, C-5 and C-7 achieve this distinction because of the depth of the carpet pile.

One other factor, material deformation, was noted during the tests that may also relate to the suitability of the product/material for use as an impact-absorbing surface. Many of the materials showed permanent deformation at the impact site as a result of the tests – especially for impacts from drop heights near the critical height of the product. In a qualitative evaluation of permanent deformation of the samples, samples with the most noticeable impact damage were the carpet and pad samples, and Mat 1. Mats 2, 3, 4, 9, 10, 11, and 12 exhibited no noticeable deformation damage. The other samples had varying amounts of permanent deformation several weeks after testing. Materials with the most deformation are probably a poor choice for placement under play equipment and in high traffic areas.



Conclusions

There are choices for indoor surfacing that can provide impact protection to mitigate the potential for serious head injury in an indoor environment. The CPSC laboratory tests of several products and materials show that some of the choices are better than others. Mat samples offered the best choice of material in terms of the level of critical height per unit thickness and cost. For the types tested, carpeting (with padding) did not perform well enough to be considered as a suitable protective surfacing material.

References

1. *Handbook for Public Playground Safety*, CPSC Pub. No. 325, 1997
2. ASTM F2373 – *Consumer Safety Performance Specification for Public Use Play Equipment for Children 6 Months to 24 Months*, ASTM International, 2005
3. ASTM F1292 – *Impact Attenuation of Surfacing Materials within the Use Zone of Playground Equipment*, ASTM International, 2004
4. Mack M., Sacks J., Hudson S., Thompson D., *The Impact Attenuation Performance of Materials used under Indoor Playground Equipment at Child Care Centers*, Injury Control and Safety Promotion, Vol. 8, No.1, 2001
5. 16 CFR 1203, *Safety standard for bicycle helmets*, U.S. Government printing Office

Acknowledgements

The help of John Worthington in test machine preparation and operation and Dean Galarowicz in sample preparation is appreciated. Shing-Bong Chen provided identification of the materials in the mat samples. The advice and counsel of Richard McCallion was invaluable in the operation of the test equipment.

APPENDIX 1 – Tables

Table 1 – Sample Description

Table 2 – Impact Attenuation Results – Critical Height

Table 3 – Impact Attenuation Results – increasing sample thickness

Table 4 – Impact Location Data Comparison

Table 1 – Sample Description

Sample Designation	Product	Sample Form	Sample Thickness (in)	Cost ($ per sq. ft)	Other (simple description – see photographs in Appendix II)
Carpet					
C-1	Carpet	Sheet	0.29	unk	Carpet sample swatch
C-2	Carpet	Sheet	0.28	unk	Carpet sample swatch
C-3	Carpet	Sheet	0.25	unk	Carpet sample swatch
C-4	Carpet	Sheet	0.18		Indoor/outdoor
C-5	Carpet	Sheet	0.58		Plush
C-6	Carpet tile	18” by 18” tile	0.35	unk	Carpet tile with rubberized backing
C-7	Carpet	Sheet	0.67	unk	Plush
Carpet Padding					
CP-1	Carpet Pad	Sheet	0.22	unk	22 oz – for use with C-1, C-2, C-3
CP-2	Carpet Pad	Sheet	0.31	unk	32 oz – for use with C-1, C-2, C-3
CP-3	Carpet Pad	Sheet	0.45	unk	Bonded foam
Carpet and Carpet Pad Combinations					
C2P2	-	sheet	0.59	unk	Carpet 2 and Carpet pad 2 combination
C3P1	-	sheet	0.47	unk	Carpet 3 and Carpet pad 1 combination
C5P3	-	sheet	1.03	unk	Carpet 5 and Carpet pad 3 combination
Pads – fabric coated					
P-1	Pad 1	48” by 72”	2.4	4.82	3-pc folding tumbling pad
P-4	Pad 4	48” by 72”	1.38	6.72	3-pc folding tumbling pad
P-5	Pad 5	24” by 72”	0.96	2.69	3-pc folding exercise pad
P-6	Pad 6	24” by 72”	2.0	3.81	3-pc folding exercise pad
P-7	Pad 7	48” by 72”	2.0	5.09	3-pc folding foam pad
P-8	Pad 8	48” by 72”	2.0	4.07	3-pc folding tumbling pad
P-9	Pad 9	48 “ by 96”	1.38	6.22	4-pc folding martial arts pad

Table 1 – Sample Description (continued)

Sample Designation	Product	Sample Form	Sample Thickness (in)	Cost ($ per sq. ft)	Other (simple description – see photographs in Appendix II)
Mats					
M-1	Mat 1	24” by 24”	0.52	1.25	Interlocking squares
M-2	Mat 2	20” by 20”	0.40	1.53	Interlocking squares – standard
M-3	Mat 3	40” by 40”	0.89	2.34	Interlocking squares – soft
M-4	Mat 4	40” by 40”	0.95	2.34	Interlocking squares – firm
M-5	Mat 5	40” by 40”	0.80	2.34	Interlocking squares – extra firm
M-6	Mat 6	40” by 40”	1.57	3.60	Interlocking squares – firm
M-7	Mat 7	12” by 12”	0.45	1.00	Interlocking squares
M-8	Mat 8	12” by 12”	0.45	1.00	Interlocking squares
M-9	Mat 9	sheet	0.48	1.86	rubber sheet flooring
M-10	Mat 10	sheet	0.73	1.98	rubber sheet flooring
M-11	Mat 11	20” by 20”	0.87	unk	solid top surface from outdoor playground surfacing system
M-12	Mat 12	20” by 20”	0.92	unk	perforated top surface from outdoor playground surfacing system
M-13	Mat 13	sheet	1.12	unk	Indoor surfacing system
M-14	Mat 14	sheet	1.70	unk	Indoor surfacing system
M-15	Mat 15	27” by 72”	2.1	4.81	pool float

Table 2 – Impact Attenuation Results – Critical Height

Sample Designation	Product	Critical Height	Thickness (in)
Carpet			
C-1	Carpet	4 in	0.29
C-2	Carpet	NT	0.28
C-3	Carpet	NT	0.25
C-4	Carpet	2 in	0.18
C-5	Carpet	6 in	0.58
C-6	Carpet tile	4 in	0.31
C-7	Carpet	6 in	0.67
Carpet Padding			
CP-1	Carpet Pad	2 in	0.22
CP-2	Carpet Pad	4 in	0.31
CP-3	Carpet Pad	2 in	0.45
Carpet and Carpet Pad Combinations			
C2P2	C2P2	8 in	0.59
C3P1	C3P1	6 in	0.47
C5P3	C5P3	12 in	1.03
Pads			
P-1	Pad 1	60 in	2.4
P-4	Pad 4	48 in	1.38
P-5	Pad 5	8 in	0.96
P-6	Pad 6	24 in	2.0
P-7	Pad 7	48 in	2.0
P-8	Pad 8	24 in	2.0
P-9	Pad 9	36 in	1.38

Table 2 – Impact Attenuation Results – Critical Height (continued)

Sample Designation	Product	Critical Height	Thickness (in)
Mats			
M-1	Mat	13 in	0.52
M-2	Mat	6 in	0.40
M-3	Mat 3	24 in	0.89
M-4	Mat 4	30 in	0.95
M-5	Mat 5	33 in	0.80
M-6	Mat 6	60 in	1.57
M-7	Mat 7	NT	0.45
M-8	Mat 8	5 in	0.45
M-9	Mat 9	9 in	0.48
M-10	Mat 10	18 in	0.73
M-11	Mat 11	40 in	0.87
M-12	Mat 12	36 in	0.92
M-13 (P-2)	Pad 2	36 in	1.12
M-14 (P-3)	Pad 3	72 in	1.70
M-15 (P10)	Pad 10	48 in	2.1

Table 3 – Impact Attenuation Results – increasing sample thickness

Sample Designation	Product	Critical Height	Sample Thickness (in)
C-4	Carpet	2 in	0.18
CP-1	Carpet Pad	2 in	0.22
C-3	Carpet	NT	0.25
C-2	Carpet	NT	0.28
C-1	Carpet	4 in	0.29
CP-2	Carpet Pad	4 in	0.31
C-6	Carpet tile	4 in	0.35
M-2	Mat	6 in	0.40
M-8	Mat 8	5 in	0.45
CP-3	Carpet Pad	6 in	0.45
C3P1	C3 and CP1	8 in	0.47
M-9	Mat 9	9 in	0.48
M-1	Mat 1	13 in	0.52
C-5	Carpet	6 in	0.58
C2P2	C2 and CP2	8 in	0.59
C-7	Carpet	6 in	0.67
M-10	Mat 10	18 in	0.73
M-5	Mat 5	33 in	0.80
M-11	Mat 11	40 in	0.87
M-3	Mat 3	24 in	0.89
M-12	Mat 12	36 in	0.92
M-4	Mat 4	30 in	0.95
P-5	Pad 5	8 in	0.96
C5P3	C5 and CP3	12 in	1.03
M-13	Pad 2	36 in	1.12
P-9	Pad 9	36 in	1.38
P-4	Pad 4	48 in	1.38
M-6	Mat 6	57in	1.57
M-14	Pad 3	72 in	1.70
P-8	Pad 8	24 in	2.0
P-6	Pad 6	24 in	2.0
P-7	Pad 7	48 in	2.0
M-15	Pad 10	48 in	2.1
P-1	Pad 1	60 in	2.4

Table 4 – Impact Location Data Comparison

Mat Sample	Drop Height	g-max			HIC		
	in						
		Solid	2-Seam	4 Corners	Solid	2-Seam	4 Corners
M-1	12	110	200	392	165	295	763
M-2	6	122	144	87	108	126	79
M-3	24	139	152	217	346	374	510
M-4	33	183	190	206	574	588	638
M-5	33	171	166	184	620	600	656
M-6	60	196	285	-	912	1252	-
M-8	7	188	250	300	186	268	344
Pad Sample	**Drop Height**	**g-max**			**HIC**		
	in						
		solid	sewn seam	open seam	solid	sewn seam	open seam
P-1	74	207	362	316	995	1702	1210
P-4	48	179	187	406	734	638	1493
P-4	60	451	482	-	1770	2222	-
P-7	48	166	101	177	547	316	574
P-7	60	236	158	-	972	614	-
P-8	24	49	49	237	57	54	410
P-8	36	256	260	-	462	522	-
P-9	36	112	268	115	384	674	372

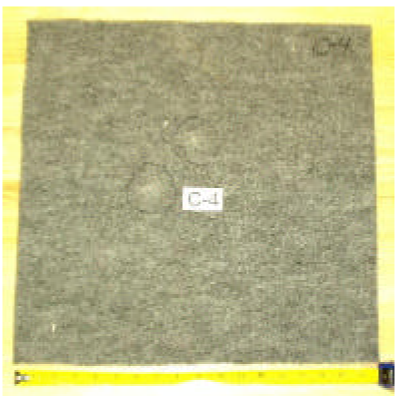
APPENDIX II – Photographs of Samples

A. Carpets

C-1

C-2

C-3



C-4

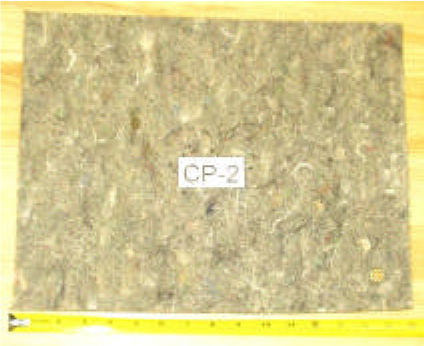
C-5

C-6

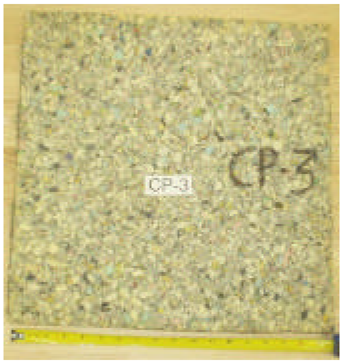
C-7

B. Carpet Pads

CP-1

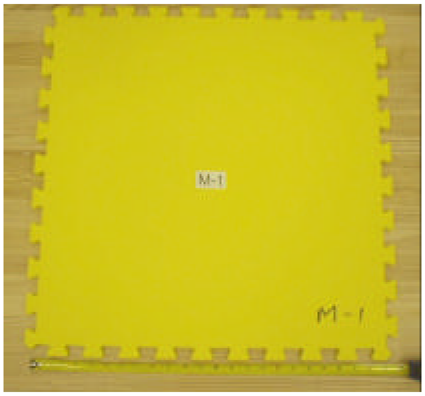


CP-2



CP-3

C. Mats



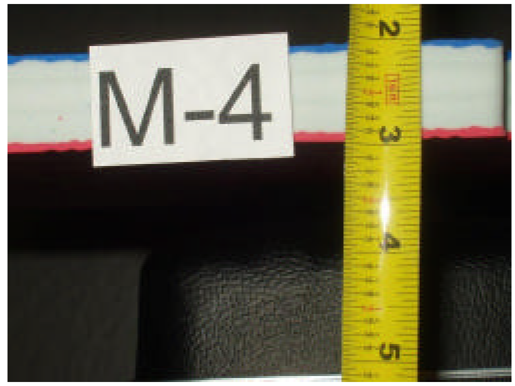
M-1

M-2

M-3

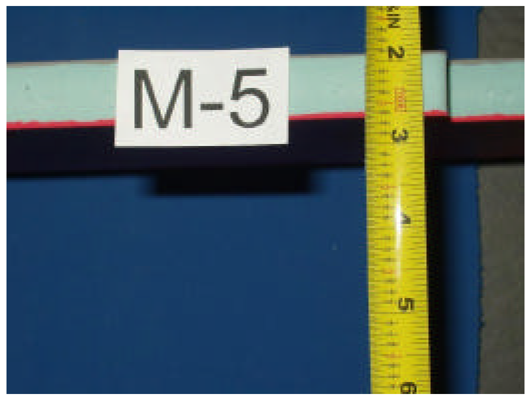
M-3 (edge)

M-4



M-4 (edge)

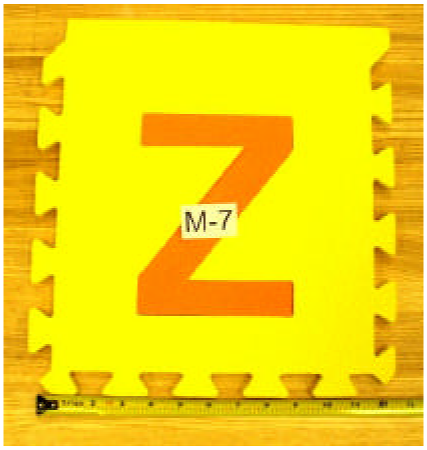
M-5



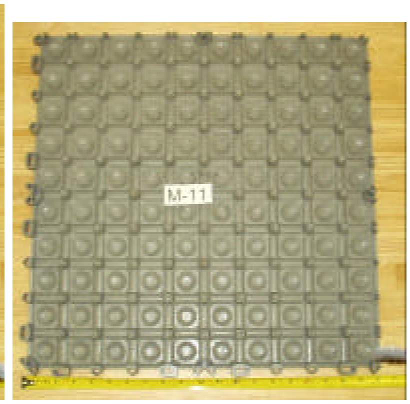
M-5 (edge)

M-6

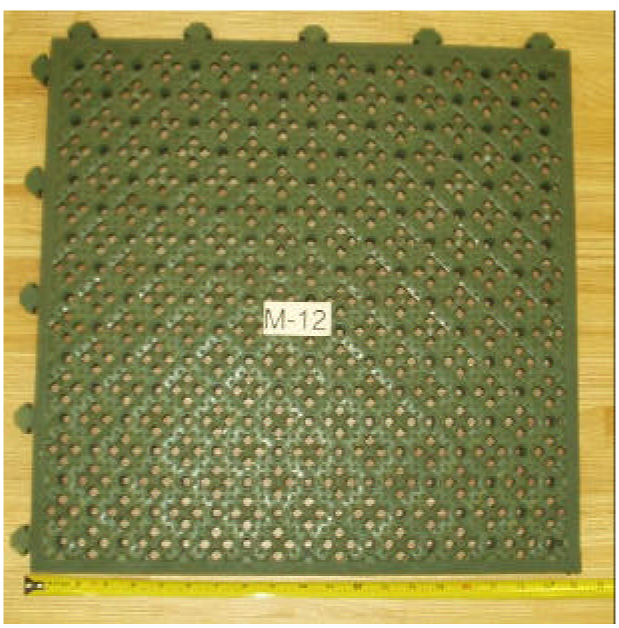
M-6 (edge)

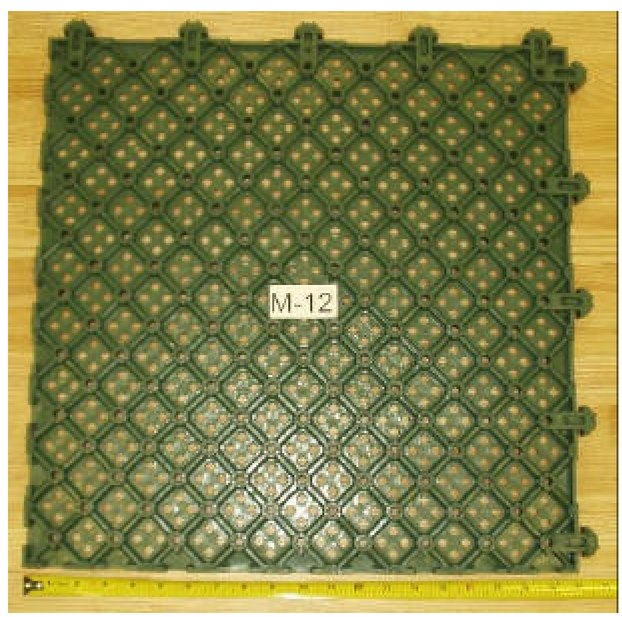


M-7 **M-8** **M-9**



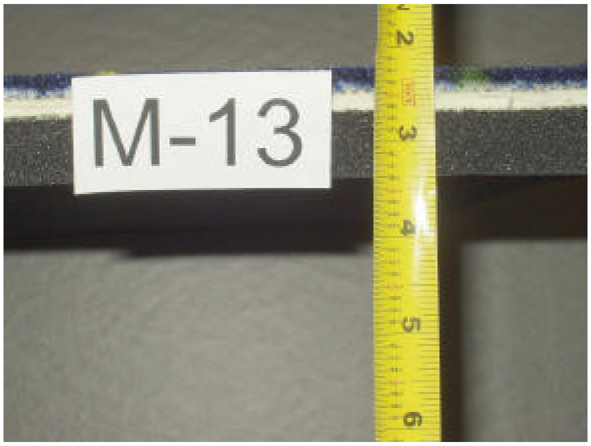
M-10 **M-11 (top)** **M-11 (bottom)**



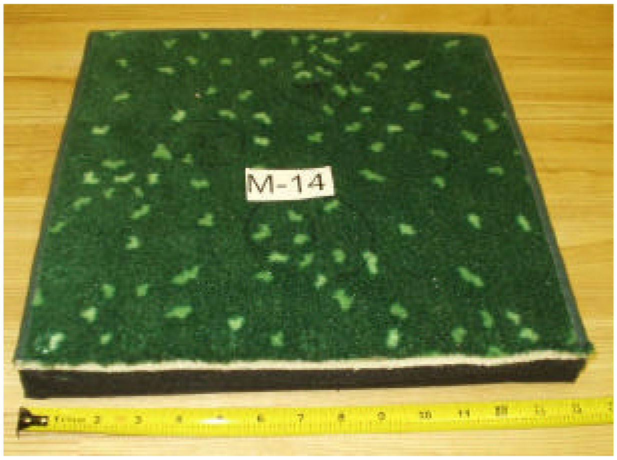


M-12 (top) **M-12 (bottom)**

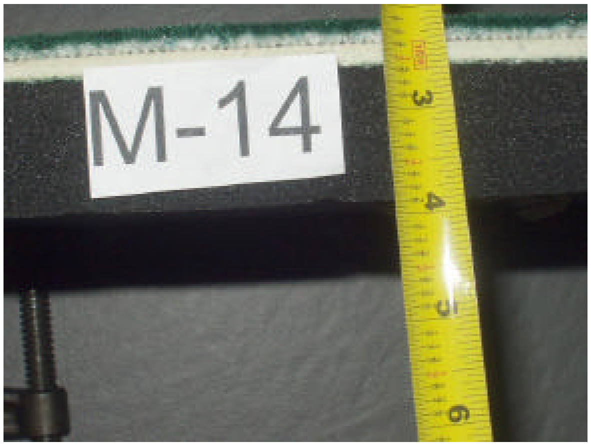
M-13



M-13 (edge)



M-14



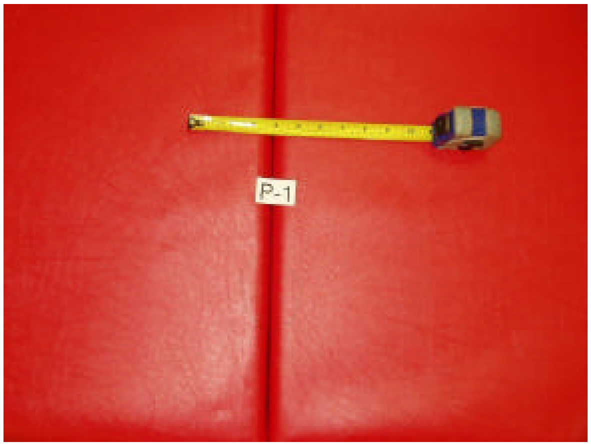
M-14 (edge)

M-15

D. Pads

P-1

P-1 (sewn seam)



P-1 (open seam)

P-4

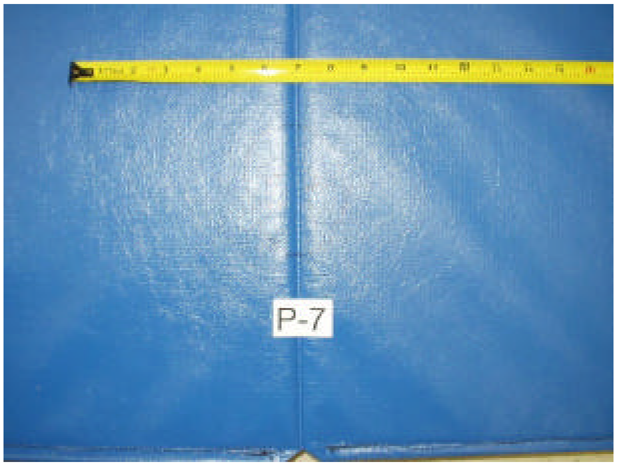
P-4 (sewn seam)

P-4 (open seam)

P-5

P-6

P-7

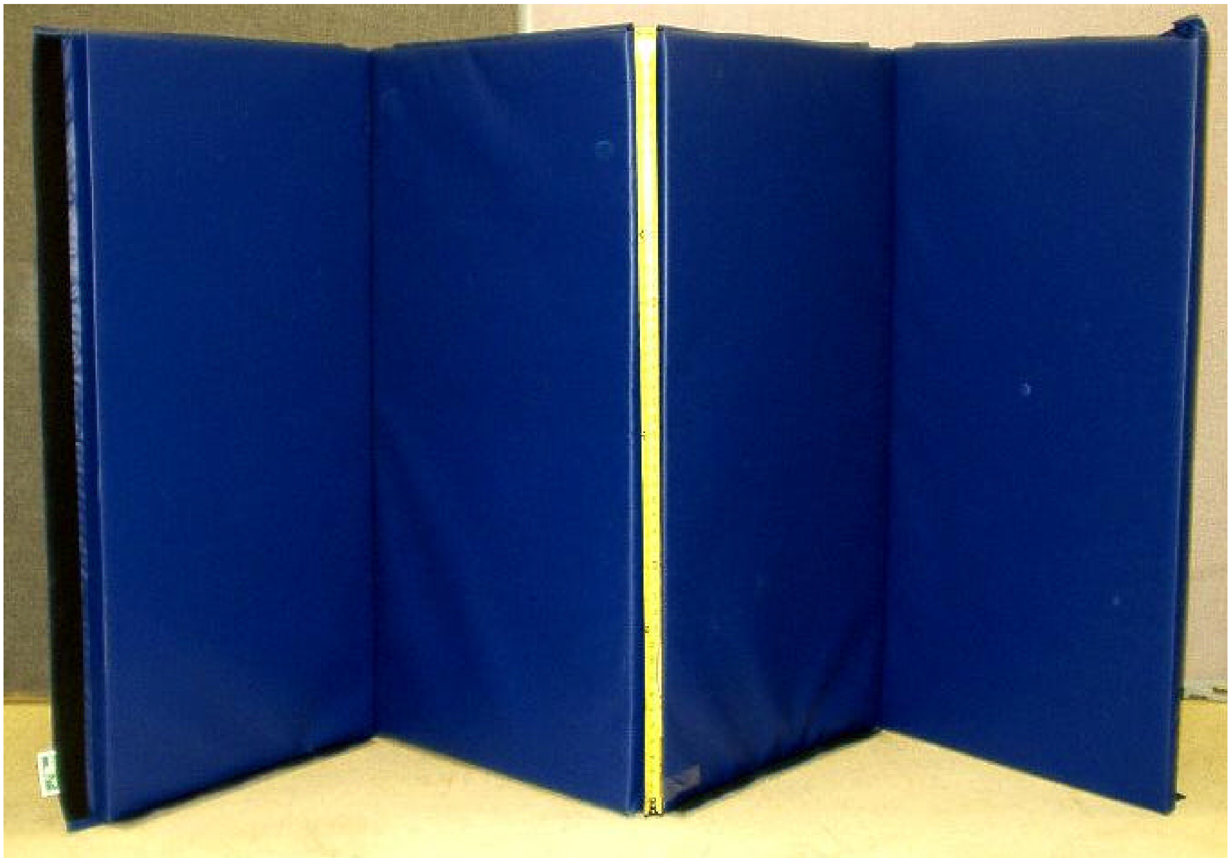


P-7 (sewn seam)

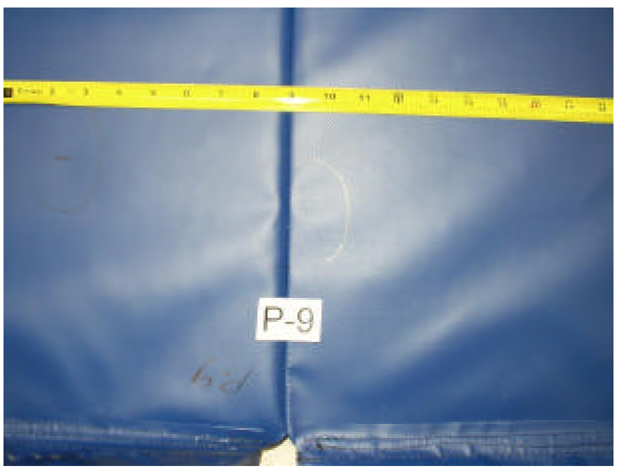
P-7 (open seam)

P-8

P-8 (sewn seam) **P-8 (open seam)**



P-9



P-9 (sewn seam)

P-9 (open seam)

ACKNOWLEDGEMENT

This report was originally authored by George Sushinsky, who retired from CPSC before the report was finalized. Rick McCallion of the Directorate for Laboratory Sciences is the current contact for issues related to playground surfacing.