

NRPA, St. Louis 2016 Edition - Surfacing

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SPECIAL POINTS OF INTEREST

- Every sport and recreation activity is concerned with the prevention of concussions and other serious injuries. It is time to listen to the experts and focus on injury prevention for TBI and other serious injuries in playgrounds... [Read more](#)
- Playground budgets constantly increase with surfacing taking a larger portions of the budget, particularly when rubber or turf surfaces are chosen. When these surfaces fail ADA or ASTM standards, the project fails and cost skyrocket... [Read more](#)
- Standards provide consistency and accuracy in measurements. Failure to follow standards brings only chaos and confusion for owner/operators, suppliers and inspectors... [Read more](#)
- Owner/operators often need to understand how their surfaces are performing for compliance to ASTM F1292. This could be during the formal testing or as a confirmation of the maintenance being performed to ensure compliance. Whether it is to determine the most adverse location in a playground surface as required by ASTM F1292 field test or to determine the frequency of the formal testing to ASTM F1292 the performance of a pre-test using the test device prescribed by the Standard becomes part of a playground surface maintenance and compliance program....[Read more](#)

Time to Prevent Concussions (TBI) in Playgrounds

CDC, Science and Medicine Chart New Course for Playgrounds

There are two very opposite views of injury prevention in playgrounds. We have those who have long recognized the devastating effects of head injuries in playgrounds^{1,2,3,4}, which includes a high enough frequency to be a public health concern^{5,6,7}, while others dismiss the issue as non-existent⁸, inconsequential⁹, statistically immaterial¹⁰, having no merit or not been thought through¹¹. It would appear that two recent studies provide critical information that concussions are occurring in playgrounds at increasing rates¹² and pediatric concussions are more complex and debilitating than previously reported¹³. These are the latest studies in a more than 45 year history of information related to injury prevention on playgrounds and it is time that prevention mechanisms are put into place to ensure that this devastation is significantly reduced.

The recent study by the CDC, outlines the problem of concussions as a result of falls in playgrounds is not going away, in fact it is increasing¹⁴. Where children present with multiple injuries such as fracture and concussion, the fracture is captured leaving the concussion¹⁵ as unaccounted for in the statistics resulting in a significant under reporting¹⁶. Almost released simultaneously is the study reporting that childhood concussions of the type documented by the CDC, take as long as two years to resolve¹⁷. The CDC also reported that the injuries actually are taking place in playgrounds and are the result of falls to the surfacing.

Remember, it is not so much the type of play struc-

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ture you fall from, but the height from which you fall in less than a second and the sudden stop on the surface that causes the “unreasonable injury”. So is this a problem? Why is it children and not the general population? For whom is it a problem? Why after more than 50 years has this problem not been addressed? What are the roadblocks to solving the problem? Does this need outside intervention?

Someone would have to have been living under a rock for the past 15 years to not be aware that concussions are devastating and if not treated and resolved, lead to life-long complications and in some cases suicides. We are a long way from what ASTM¹⁸ and CSA¹⁹ have long called for. The prevention of the life-threatening injuries. Alternatively the CEN²⁰ approach is to prevent accidents with a disabling or fatal consequence. The question to every parent, grandparent, caregiver and owner is what severity of injury you are prepared to accept being sustained by your child at the playground. A serious injury such as a fracture requiring surgery, concussion or other injuries requiring medical treatment are likely the limit. Standards still reside in the realm of anything, but hopefully not kill a child, while society, public health and governments are at the prevention of serious and debilitating injuries, which includes concussions.

The message of the various playground injury studies and particularly the CDC paper, is that over the last 50 years falls to the playground surface have by far been the major contributor to playground injuries and this has not changed. This is not, as the CDC has pointed out, for the lack of standards or the technology to test performance, but the resistance around the world to require and ensure confirmation in the field that the surfaces on which children are falling, complies to the performance of standards even if that just takes a child to the risk of being at the brink of death. The only playground standard in the world that requires field compliance is the CSA Z614²¹, which has required this since 1998. Failure to move forward runs the risk of regulators stepping in and making changes. Worse is the threat of law suits when an injury occurs. These outcomes are preventable.

Every playground standard in the world requires the installation of a surface that provides a $G_{max} < 200$ and/or $HIC < 1000$. These are the values for a 10% risk of skull fracture and severe head injuries that could cause death. A sad fact is that manufacturers do their level best to install surfaces that just meet

these requirements at the time of installation. This is evidenced by the publishing of “critical height” information for surfaces and recommending that this be equated with the minimal fall height of the play structures, without consideration of “reasonable foreseeable use”. Reliance on this “critical height” data without the confirmation of the installed surface performance with a field test, place children at even greater risk and gives owner/operators a false sense of security that they have met the requirements of the national standards.

If there is the ability and performance to test compliance in the field, why is it not done? The first argument is that the cost will be astronomical and playgrounds will never be built again and children will suffer play deprivation or play in locations more hazardous than the formal playground. Nothing could be further from the truth. Back in the late 1990s, the Ontario government mandated that all structures and surfacing in Child Care, be inspected and tested annually to the requirements of the CSA Z614 as a precondition of licensing. This has by no means diminished the quantity of playgrounds and has enhanced the quality and prevention of injuries. There is not a second argument. On second thought it could be that manufacturers concerned with failure and replacement cost just want to stick with their laboratory test certificates. Really there is not third argument.

Most standards require compliance in the field, the problem is the language makes it implicit and often does not make explicit. The easiest standard to look at is the CSA Z614 which requires in section 10.4.6 “*Periodic site testing of the installed protective surfacing shall be performed*”. In ASTM F1487 there are multiple references to surfacing requirements; 7.1.1 requires the accessible route to meet F1292; 9.1.1 requires a use zone with a surface that meets F1292; 11.2.2 requires the installation of a surface that meets F1292; 13.2.1 requires the owner/operator to maintain the surfacing to F1292, while 13.3 requires the owner to maintain detailed records of compliance. In Europe, EN1176-7 requires an annual inspection of the overall safety level of the playground, including surfacing.

The compliance of a surface is performed with a sophisticated scientific device that is defined in both

the ASTM F1292²² and En1177²³ Standards and cannot be determined visually or with a magic toe, egg or parcelled together device. The use of compliant devices ensures consistent data that owner/operators can know that they actually comply with their national standards. Some of the devices provide proprietary software that ensures tamperproof records that will stand the test of time and scrutiny should regulatory or legal oversight be necessary.

Protective surfacing is typically installed at or close the critical height (pass/fail) limit. Synthetic surfacing almost always fails the test either at the time of installation or shortly thereafter. It is for this reason that ASTM F2479, the Guide for Poured-In-Place in section 6.4 states; *“Consideration by the owner/operator to test the surfacing system in the field after installation and periodic testing thereafter will determine whether the surfacing system is in compliance with Specification F1292. The owner/operator is required to stipulate the drop height(s) for the test prior to purchase of the surface. The owner operator may stipulate a higher drop height for testing than the fall height stipulated in the applicable equipment standards.”* Further section 6.5 states; *“Field testing in accordance with the procedures set forth in Specification F1292 should take place following the total cure of the surface system to provide values that are reflective of the surface as intended. A strategy to ensure the testing of the surface takes place, is to build the cost of the testing into the total budget price of the surface from the contractor.”*

When the option for playground surfacing ranges from loose fill sand and gravel to loose fill woodchips and Engineered Wood Fiber to synthetic surfacing, cost is always a concern. Tiles, poured-in-place and synthetic turf are the highest capital cost systems and because of the investment alone should be tested at the time of installation and for the entire five year warranty period. There is also very little that can be done other than expensive replacement when the system fails. Generally loose fill can be maintained to remain in compliance. Testing can be taken as either a cost within the construction contract, protection of the investment or the ongoing maintenance of the playground. The CSA Z614^{25,26}, section 11.1.1 requires *“The cost of inspection and maintenance shall be considered and incorporated into the budget at the time of design, purchase of equipment and installation.”* This will ensure compliance and maintaining a budget that will be acceptable to all.

Beyond the standards we have the laws and regulations around the world that encompass playgrounds and could very easily be brought with full force to the playground. The United States has the DOJ (Department of Justice) 2010 ADA Standards for Accessible Design that requires compliance to ASTM F1292 in each and every playground. Additionally there is the Consumer Product Safety Commission (CPSC) Handbook on Public Playground Safety (Handbook), which not only stipulates F1292 as the surfacing test, but also states that the fall height of the playground shall be the fall height of the highest component in the playground and the critical height is to exceed this fall height. In some jurisdictions, such as California, the CPSC Handbook is set as the requirement of their Public Health and Safety Code.

The United States and Canada have Consumer Product Safety Acts that require prevention of serious injury that includes concussion, while Europe has a General Product Directive amongst others that require prevention exposure to serious risks and hazards. Given enough concern, any of these laws can trigger the intervention of regulators to make changes



Failed Products Lead to Failed Projects

Standards are Just a Beginning

Playground projects fail when the products within the playground fail, costing owners thousands of dollars they do not have and are then faced with the hard choices of finding the money for replacement or running the risk of having an injury and inevitable law suit or an ADA complaint. The usual culprit is failure to understand and use standards appropriately at the time of specification, installation, inspection and warranty compliance. Although all standards set minimum performance and generally protect manufacturers, some standards contain protection for owners like gold nuggets. The key is finding them.

In the United States the two most widely used Standards are ASTM and ISO. Most of us are familiar with those developed under the rules and procedures of ASTM International. Less familiar are the standards from the International Standards Organization (ISO). ISO has not written many standards specific to sport, athletics, play structures or play and recreation surfaces, but have established guides such as Guide 50 and the TR20183 Technical Report on Definitions and Injury Thresholds that connect to this type of work. Interestingly ASTM standards are viewed as “industry standards” and therefore some consider them tainted as being minimums as to what industry is prepared to do rather than being in the interest of the user of a product or surfacing system. This is not necessarily the fault of the manufacturers working in a competitive world, but rather the failure on the part of users, specifiers, risk managers and consumers to actively participate and advance their interests. ISO standards on the other hand are seen as being written by standards organizations with less vested interest in the outcomes and therefore might be more representative of consumer and user needs and injury prevention.

ASTM publishes standards on the consensus basis. An overview can be seen at <http://www.astm.org/ABOUT/overview.html>. On the face of it, there is a

gathering of experts and interested parties for a particular subject matter, but the truth might not be as simple. Generally each standards group is made up of a maximum of 50% manufacturers, with the rest being general interest, consumers, regulators, etc. Voting on new or changes to standards is by the whole group and advancement initially requires 50% plus 1. Changes or improvements to standards can also force significantly greater level of approval. First is the ballot voting process where as few as 10.1% of the voters voting negative on a ballot in a committee can cause a ballot to fail and kill or delay the change. The frustrating and problematic part of the ballot process is that a negative does not have to have technical merit. Statements such as this change is likely to hurt my business or I don't like it must be taken seriously and considered as valid. Since negatives are generally dealt with during a face to face meeting with limited time, an overabundance of negatives will take a meeting beyond the time deadline. Other negative voters take to writing multi paragraph statements with the problem that each paragraph requires meeting time. Effectively when time runs out, the ballot dies as well. Unfortunately this has become an overused tactic of those looking to stall or stop changes for the betterment of the injury protection of the user or quality and durability of a product for the owner and user. If the sponsor of a standard is willing to persevere, or accept changes that lessening the quality of the standard it just might see the light of day and then a standard or a change to an existing standard is published.

The democratic ASTM process has merit in gathering diverse knowledge and science, but what can go wrong within the ASTM open and democratic process? First, the bar of entry is very low, costing \$75 per year and no technical competency in the subject matter is required. Second, the manufacturers will have a vested financial interest in having a standard that does not increase cost or complicate manufacturing, delivery of products or increase their liability for negligence or warranties. Third, individuals or organizations that distribute, test or install products may qualify as non-redundant voting interest joining with the purpose of forming a voting block to advance an idea or more likely stop a change. The democratic process, although open and transparent, lends itself to the abuse of the filibuster as a block of 33% of the voters can usually defeat a change, particularly when negatives are dealt with at meetings that are often poorly attended. It is for this rea-

son that ASTM has the option of working within the entire committee and sub-committee to get the balance and view of the whole group rather than just the few who have the time or financial resources to travel to meetings. This last option is rare because of the time required and the need to write lengthy rationales.

ISO operates on the international level and works under the requirements of the World Trade Organization (WTO) and is on the basis of country to country interaction. Under ISO, similar to ASTM, there are topic committees for products and services. Normally once a standard is written it becomes the standard of use and adopted in all countries. The exception is that when there is a national standard that is more stringent, the national standard can stand. There are also cases where a sector is regulated or a standard is mandated by a government authority, such as compliance to ASTM F1292 on the accessible routes in the DOJ 2010 ADA Standards for Accessible Design.

ISO is likely to remain outside the domain of sport and recreation surfaces as many international sports bodies around the world either have their own standards and regulations or refer to national standards. It would take a concerted effort on behalf of a number of nations to change this.

So why talk about ISO if there are no specific performance based standards in play structures or play and sport surfacing? The presence in the world of the ISO documents mentioned above, Guide 50 and TR20183, lend the specifiers, owner/operators and users considerable options to invoke international language that provides better protection in some instances than do the performance based ASTM standards. Using a combination of the ISO and ASTM judiciously will be of tremendous help. The Technical Report from TC83 on Definitions and Injury Thresholds has as part of its scope the following;

There shall be the utmost safe construction, production and maintenance covering a reasonable foreseeable misuse / intended use evaluated by the manufacturer. Any areas of risk have to be defined and precautions taken. Nevertheless the use of the equipment or activities with this equipment on sports or

play grounds will create a residual risk related to the individual user. This has to be evaluated by a risk assessment and reduced to an acceptable or tolerable risk of performance. The result of this evaluation may deviate by age and social grouping.

This ISO document goes on to discuss hazards, injury severity and other factors involved in product and services and injury prevention. There is a clear responsibility on the part of the designer and manufacture to fully understand their products and any hazards that might be presented to users and states that hazards are not apparent during anticipated or designed use, but are with reasonable foreseeable misuse and these must be removed. This Technical Report will also act as guidance for standards writers in their deliberations and should result in more protective performance requirements. This document was written through international agreement with the goal to harmonize language and scopes while leaving certain national standards such as playgrounds in place rather than moved to the ISO level. This would allow for the unique cultural aspects and injury concerns with regard to children's play to remain within the national realm. This is good news for manufacturers and owner/operators as they remain in control of their own standards provided they understand the technical requirements and how to take best advantage for their needs.

Owner/operators need to understand that when they build a public use playground they have certain specific obligations beyond building a fun, challenging space whether using factory manufactured or natural elements. Although budgets have a lot to do with choices, compliance for the life of the playground to the ADA, the CPSC Handbook on Public Playground Safety, ASTM F1292, F1951 and F1487 and in some cases State Health and Safety Codes and more stringent Accessibility requirements do not consider a lack of budget. Sometimes it is like owners do not understand that playgrounds and protective surfacing are dynamic outdoor environments that by their natures will get worse rather than better over time. Installing to the bare minimums of the standards invites failure, injury and costly replacements or law suits.

For playground owners referencing standards can help; however many standards have major inadequacies in the way they protect the supplier, but still hold the owner

responsible. Examples of these are;

ASTM F1292 section 4.4.2 states “When an installed playground surface is tested in accordance with this section, if the impact test scores at any tested location in the use zone of a play structure do not meet the performance criterion, bring the surface into compliance with the requirements of this specification or the play structure shall not be permitted to be used until the playground surface complies.”

This places the owner on notice that when a failure occurs the total cost and burden of repair or replacement is on them unless they have written a long term performance based warranty into their contract.

ASTM F1292 section 4.4.1 states “When an installed playground surface is tested in accordance with the requirements of Sections 16 – 19 at the reference drop height, the surface performance parameters at every tested location in the use zone shall meet the performance criteria of this specification. The reference drop height shall be the greater of (1) the height specified by the owner/operator prior to purchase, (2) the critical fall height specified when the playground surface was installed, (3) the equipment fall height, or (4) the critical height of the surface at the time of installation.”

This states there are clear performance limits, but owners and their consultants can use this section to selected higher drop heights than the fall height. This can include consideration of where a child might fall and stipulate a height based on a physical measure or by description of a play component or feature such as the tops of guardrails or barriers. This also is what makes the requirement of the CPSC handbook to test from the highest play component in the playground compliant with ASTM F1292. This section works very well with what most purchasers know as the IPEMA certificate. An owner may specify a certain IPEMA certified surface and then perform the testing from that height. Failure to take advantage of this section only places the owner in jeopardy of premature failure.

ASTM F1292 section 4.4.3 states “The specifier is permitted to specify additional impact attenuation performance requirements, providing that such additional performance requirements are more stringent than the performance requirements of this specification.”

Since the standard requires that the performance of the surface shall never exceed 200g or 1000 HIC, it is foolish to allow the surface at the time of installation to just meet this requirement as a failure will be expensive, requiring repair or replacement. Interestingly it is the surfaces that cost the most that rarely can be repaired and will require replacement in whole or in part.

ASTM F1487 section 7.1.1 states “Accessible routes within a use zone shall conform to the performance requirements of Specifications F1292 and F1951.”

ASTM F1487 section 9.1.1 states “There shall be a use zone for each play structure which shall consist of obstacle-free surfacing that conforms to Specification F1292 appropriate for the fall height of the equipment.”

ASTM F1487 section 11.2.2 states “The owner/operator shall install protective surfacing within the use zone of each play structure in accordance with Specification F1292 appropriate for the fall height of each structure and Specification F1951 where applicable.”

ASTM F1487 section 13.2.1 “The owner/operator shall maintain the protective surfacing within the use zone of each play structure in accordance with Specification F1292 appropriate for the fall height of each structure and Specification F1951 where applicable.”

Most playground owners have adopted compliance with ASTM F1487 as a matter of normal practice. They have likely even sent staff once or multiple times to take the CPSI course. Unfortunately this training is not comprehensive on ASTM F1292 and is generally after the fact with most practitioners learning what has likely gone wrong after the playground is installed. Many owners require that their contractors are certified CPSIs, but again they rarely have any influence on the choice of surfacing or can change the decisions that have been made.

This begs the question, why are owner’s consultants and landscape architects not required to be certified CPSIs or to have taken a course related to the performance of surfacing. These professions are the gatekeepers for injury prevention and preservers of the public purse avoiding the need for a significant replacement or a loss in a law suit.

Success of a playground project is the work of many groups and professionals, but can only work with a collaborative effort or the acceptance of responsibility of all players. Remember standards set the drop dead minimum and that when any part of the playground project fails, the entire playground fails and the owner will suffer considerable cost.

Standards as a Measure of

Consistent Performance

The aim of Standards is not to open a door to endless wisdom, but to put a limit to endless errors **

Where would owners, designers, regulators, manufacturers, installers and anyone providing products or services anywhere in the world be without standards? Standards form the foundation, setting the bar, not always the highest bar, for performance of goods and services provided from around the world to domestic and worldwide markets. For the playground industry this means that play components and surfacing can be designed and/or manufactured in the United States, Canada, Europe or, China etc. and shipped and installed to any other country around the world and provided they meet a measureable standard, they will be accepted by the owner and opened to children for play. Picture the chaos if everyone used their own probes, gauges or measurements. Playgrounds would be in massive confusion and non-payments for noncompliance and the lawyers would have a field day.

There can be confusion for purchasers as manufacturers claim compliance to a standard, which is not necessarily ASTM F1487. This is the case with many of the new structures that are being installed in projects around the United States. The logical question is; then why so many standards; ASTM, CEN, CSA, etc. for play structures? Good question for play equipment standards, but the same cannot be said for protective surfacing standards. While play structure standards all set the injury threshold as prevention of fatality, serious or debilitating injury and for falls set fall heights for specific components, the protective surfacing standard establishes the test device, the test method and a pass/fail value.

Protective surfacing, there are two dominant standards, ASTM F1292 and En1177 and they rely on the single device, the 4.6kg (10.15lbs) hemispherical metal headform that has extensive technical requirements covering their design and building. For testing a surface the headform is dropped a minimum of three times from the same height to the

same location. The deceleration due to gravity (g) and calculating the Head Injury Criteria (HIC) for each drop are recorded and reported. The pass/fail is calculated and even here both standards provide similar requirements.

The pass/fail in ASTM F1292 is that from the drop height for the test, the average g of the last two of three drops shall not exceed 200g, while the average HIC value for the last two of three drops shall not exceed 1000. For the CEN En1177-08 the height at which the HIC exceeds 1000 following a series of 4 sets of three drops shall be higher than the fall height of the structure. The child should never find themselves at a height above where the pass/fail is exceeded. Both standards use the threshold of 1000 then identical with some exceptions which will be explained, particularly in the context meeting national standards. For those in Canada thinking that they are unique having the passing of the 200g and 1000 HIC threshold with a field test, must understand that the CSA Z614 requires that the procedure used to perform the field test is either ASTM F1292 or En1177. Since 1999 the Triax2000 has been compliant with both international standards as are the Triax2010 and wireless Triax2015.

Everyone testing to ASTM F1292 or EN1177 must be using the same device in the performance of the drop test with the only variations being in the actual procedure and therefore it is instructive that we understand which parts are the same and then the differences and if the differences have any consequence in the choice a playground owner might make in relation to the prevention of injury for their children.

The history of the impact measuring test devices is the same for the ASTM and CEN. Back in the 1950s and 60s the military and automotive industry performed experiments on animals with similarities to humans and human cadavers to determine the maximum deceleration in g that the human head could tolerate and not result in a fatality, but could still result in severe brain damage and dysfunction to the injured party. This was used to determine a threshold of 200g. A consequence of the early studies was that each impact had a duration in time and this time along with the maximum deceleration was a factor in the resulting head injury and death. This resulted in the development of the Wayne State Tolerance Curve and Gadd Severity Index in the 1960s. Later though a modification of SI in the early 1970 by Versace, the HIC was developed and adopted by the US Na-

tional Highway Transportation Safety Administration. In 1980, the US CPSC adopted the 200 g threshold, presumably using and AS/ISO C head-form, and this was later adopted into for first ASTM F1292 in 1991, the HIC was added in the 1993 revision. A detailed explanation how these values were viewed around the world is discussed in the COMSIS report commissioned by the CPSC and published in 1989. (<http://www.cpsc.gov/Media/Documents/Research--Statistics/Technical-Reports/Sports--Recreation/Playground/Development-of-Human-Factors-Criteria-for-Playground-Equipment-Safety-p1/>)

These standards place children at a very high risk of significant injury that will have fatal or life changing consequences, therefore it is critical the measurements are accurate.

ASTM F1292 provides Appendix X1, which plots the risk and severities of injury as measured using the Abbreviated Injury Scale (AIS). This appendix outlines the types of injury that could be expected and the risk of that injury at various values of HIC. The sobering fact is that a value of 1000 HIC comes with a 16% risk of AIS >4 that is described as “Cerebral contusion, loss of consciousness for more than 12 hours, with intracranial hemorrhaging and other neurological signs, recovery uncertain.” Being able to measure this risk accurately and consistently is the purpose of all of the technical detail of ASTM F1292.

In Europe, the surfacing standard follows the automotive path and the introduction for the EN1177, 2008 includes the following; “NOTE: The HIC value of 1000 is merely one data point on a risk severity curve where a HIC of 1000 is equivalent to a 3% chance of 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 adult male.” In the 2008 revision there was the addition that the duration calculated for HIC must be greater than 3ms, which prevented hard surfaces that would not meet the 200 g threshold in ASTM F1292 to also fail in the EN1177.

There is the same device and generally the same thresholds around the world, but that is where the similarities end. The laboratory test in ASTM F1292 is designed to help the purchaser of playground surfacing systems determine the system that is most suitable to them by requiring the determination of the Critical Height (the point at which the surface exceeds 200g of 1000 HIC) to be at 25°F, 72°F and 120°F to show how the system performs in most conditions throughout the year. The EN1177 laboratory test is performed at 74°F. The key to the laboratory test results is that when the data is presented that no matter where in the world that the testing is performed it is accurate and consistent. Of all of the laboratories in the world performing the testing, TUV Sud America (also the IPEMA validator) has 1 Triax-2015 system and 2 Triax2010 systems, Testing Services Inc. has 2 Triax2015 systems, TUV Austria, AIJU Spain, Belgium national lab, TUV Sud PSB (Singapore), CCEP Australia amongst many others all have Triax-2000, 2010 or 2015 systems, ensuring consistency of the test results around the world. A full list of testing laboratories is available on www.Triax2015.com.

The ASTM F1292 requires that the system installed must be identical in all respects to the system that is installed. One advantage of the IPEMA testing, although a slight modification of the full F1292, is that they also publish the thickness of the surface to allow preliminary site inspection that should then be followed with a field test using a compliant system. For the field test F1292 allows for the owner to select a drop height greater than the fall height and to select lower values for g and HIC provided this is done prior to purchase. These options provide functional longevity and better injury prevention for the surfacing system. Given that there are more than 400 Triax2000, 2010 or 2015 systems around the world it should not be difficult for someone to find a device that meets both the ASTM and En Standards and provides the values they need to protect their children and avoid liability.

Both the ASTM F1292 and EN1177 require calibration at least every two years and procedures in each standard ensure that the devices are performing certain self-checks and confirmation tests including prior to use drop tests on a known reference surface (MEP). This is outlined in great detail in Annex A1 of F1292. This ensures that the data that is collected and preserved along with the impact graphs are valid and traceable to the calibration of the accelerometer. Because persons performing the testing are not always trained laboratory technicians and well versed in or understanding of laboratory procedures, they will need to understand all of the nuances of

Standards. It is for this reason ASTM F1292 section 7 requires that the person performing the test also participate in training. For the Triax systems this full day training has been provided around the world through Alpha-Automation Inc. and Canadian Playground Advisory Inc., since 1999 with more than 2,000 people being trained including many national testing laboratories and consumer protection agencies such as the Taiwan Children's Commodities R&D, and AIJU in Spain and the US CPSC. There is a growing group of professionals who have completed the training and have access to the devices that can be used to protect children at play. A list of trained professionals performing testing in the field can be found at

www.playgroundadvisory.com

Lastly is the need to talk about regulation and regulatory requirements to test surfaces in the playgrounds. All US Federal Facilities playgrounds must meet the requirements of the CPSC Handbook for Public Playground Safety (doc325). Many States such as the California have also adopted the Handbook and this requires compliance with ASTM F1292 with the fall height for the playground being the fall height of the highest component in the playground. Further there are States that mandate compliance to ASTM F1487 and since F1487 requires compliance with ASTM F1292 at the time of design and installation as well as for the maintained surface, compliance to F1292 is automatic. Another major mandate for compliance with ASTM F1292 is the DOJ 2010 ADA Standards for Accessible Design. For the ADA the ground level accessible route must comply with ASTM F1292 as well as ASTM F1951 and other measureable requirements. There is not a playground in the United States that is not touched by some regulatory mandate to test to the requirements of F1292, using the device and procedures of F1292.

Effectively, playground surfacing standards have a long history based in automotive science and the prevention of head injuries. The common denominator for the provision of injury prevention in playgrounds are the Triax systems and now with the wireless Traix2015 testing and confirming that children are being protected is readily available. Failure to comply with ASTM F1292 or using approxi-

mations puts children at risk for severe injuries and owners at risk of not meeting regulatory requirements or falling afoul of a major liability claim. Costs associated with the medical treatment for brain injuries can exceed many other medical remediation and rehabilitation.

** paraphrased from Bertolt Brecht in the "The Life of Galileo"



Surface Impact Attenuation

Pre-Test

Unyielding compliance with the requirements and procedures detailed in ASTM F1292-13 is essential to accurate measurement of impact attenuation of playground surfaces. In limited cases a short cut procedure, while not strictly compliant, can be used for spot checking of surface conditions. This article explores the appropriate use of this procedure, and discusses its critical limitations.

Standards are all about measuring accurately. It is critical that prescribed test devices are used and test methods are followed^{1,2}. Using the test device as described in the Standard ensures that the values are consistent, no matter where in the world the test is performed. The results of the test are then compared to the pass/fail of a specification and the determination is made as to whether the surface is compliant or not³. Standards allow an owner/operator of an impact attenuating surface to choose lower impact values to provide better impact injury prevention and mandate them into their contract documents^{4,5}. Typically the impact values for surface performance is that the g value shall not exceed 200 and the HIC value shall not exceed 1000⁶. The 200g value is a 10% risk of skull fracture, while 1000 HIC is a 5% risk of a critical head injury, a 16% risk of a severe head injury and 55% risk of a serious head injury⁷.

Playing surfaces, whether they are playgrounds, sports fields, landing or sports mats, etc. have a primary objective, to protect the user from an impact that results in an unacceptable injury during the reasonably foreseeable use of the system or playing environment⁸. Since we are concerned with the prevention of injury at a very significant level of severity, it is important that the data collected and the science related to the test devices be accurate, to ensure that impact values can actually be associated with a level of injury that is being prevented. Since the surfacing systems are expensive to replace or can be associated with large law suits, it is important that the measuring instrument does not fail a system that would pass to the correctly performed test to the relevant standard. Alternatively passing a failed system could put users at risk of severe injury.

For impact attenuation of surfaces, there are two

major standards writing organizations in the world, ASTM International and CEN. For both of these organizations, the prevention of head injury traces its origins to the automotive industry and the work performed over more than six decades to prevent injuries. For the United States it starts with Col. John Stapp performing military testing and evolving to the development of the first test dummies to act as surrogates for humans. Along the way, non-human primates and cadavers contributed to the refinement of both the dummy shape, mass and the association with specific injuries to where we now have the hybrid III series of dummies that are widely used in testing throughout the world. These automotive test devices are expensive and not designed for outdoor use, with the result being the development of metal surrogates, in the 1970s and onward, that highly correlate to the performance of the automotive dummies⁹. This traceability in science and history allows for the confidence society has in the testing of surfaces.

The ASTM F1292 Standard was first published in 1991 and this Standard is utilized around the world for testing of surfaces. The Standard originally used a head shaped aluminum missile known as the ANSI C headform, established through testing in the 1970's for the US Consumer Product Safety Commission (CPSC) and others to generate g values, Severity Index (SI), and Head Injury Criteria (HIC) values that related to the automotive injury studies. Because of its shape and the need to impact the surfaces with the crown of the head, this device was used mainly as a guided system and when used in free-fall generally resulted in lower impact values and therefore could pass surfaces that under formal test conditions would fail. The guided test required a cumbersome guidance system that was difficult to bring to the field without considerable cost or difficulty. The solution was to look to Europe and their use of the 10lb aluminum hemispherical headform that does allow for a freefall test with the missile landing on the hemisphere and utilizing a triaxial accelerometer to generate data that was equal to that generated by the ANSI C. This validation of the two headforms took many years, a series of round robins involving many laboratories involved in the testing of surfaces and finally the determination of equivalency¹⁰. The free fall drop test was adopted into ASTM F1292 in 1999 and into En1177 in 2008 even though for playground surface testing, the procedure of the test is different the goal is the same, to protect children from HIC values over 1000.

Currently the ASTM F1292 Standard requires the completion of a three temperature laboratory test for surface systems, which cannot be easily performed in the field. As a result F1292 provides a field test to allow for every owner to test the surfaces their children are playing on and determine the potential of a severe injury. The

standard provides considerable detail as to the procedure and this will vary depending upon whether the surfacing is loose fill or unitary. The Standard requires the person performing the test to determine the most adverse locations and test the surface in its most conservative condition. That is one of the reasons why the Standard requires the performance of 3 drops from the same height to the same location¹¹. The first is a conditioning drop, while the average of the second and third drops are used to report the performance for that location in the playground. This is further complicated for materials such as sand that tend to pack and they are required to be tamped prior to the first drop. There are significantly more requirements to the performance of the test including collection of additional data and provision of reports and it is for this reason that the Standard requires that the person performing the testing be trained¹².

Formal testing of compliance of the surface to ASTM F1292 is the requirement of the CPSC Handbook on Public Playground Safety, ASTM F1487 and the ADA on the ground level accessible route. It will also be a requirement for any measure of contract or warranty performance and absolutely in the event of an injury that results in a law suit. Therefore formal testing of a surface and compliance to ASTM F1292 will require that all of aspects of ASTM F1292 be performed.

There are circumstances where an owner might want to test their surface in a determination of performance and prior to a formal ASTM F1292 test. This could be in support or confirmation of a full periodic field test to the standard. Care must be taken to ensure the factors that negatively influence the impact attenuation properties for the system under test are taken into consideration and that the threshold g and HIC values are set 30 to 50% below the contractual or standards threshold to determine when the formal test is immediately triggered.

Once the decision has been made to perform the full F1292 test there are the circumstance where the person performing the test needs to perform a number of pre-tests on a surface to finally locate the three areas that would be the most adverse for a play structure. This can be done using the ASTM F355 E missile with the data collection device attached to a hand drop device.

The ASTM compliant E missile must, whether the drop is a pre-test or full test, provide for each drop; the date and time of the drop, the peak g, the HIC, the angle and the velocity to confirm the drop height of the drop. Although it is virtually impossible to drop the E missile from the same height to the same point on the surface, if the pre-test is being performed without a supporting devices, this must be noted in the field notes and the data comments.

The pre-test is not the F1292 field test, but only to be used between field tests that impact attenuation properties have not changed significantly putting children at risk. If only one drop is being used, then this must be compared to the values for the first of a series of three drops for the surfacing system during the formal testing of the surface. A routine of frequent pre-testing followed-up with the formal test will ensure surfacing systems are functioning as intended. It also offers the opportunity to a system owner/operator to visit a site with a concerned parent or caregiver and provide the confidence that their child will not sustain an injury beyond the thresholds stated in the relevant standard.



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