Playground Equipment: Classification & Burn Analysis

An Interactive Qualifying Project Report
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Abstract

This project examines the effectiveness of the Consumer Product Safety Commission's playground equipment categorization system and the dangers of thermal contact burn injuries that occur to children on playgrounds. This was accomplished by researching new playground equipment found in public places, interviewing Consumer Product Safety Commission personnel and American Society for Testing and Materials members, and by observing children's' interactions with the playground equipment. We observed playground equipment and children's interaction with the equipment by visiting eleven playgrounds in the greater Washington D.C. area; these playgrounds were selected based upon the available equipment at each location. With an infrared thermometer we gathered temperature measurements of the surfaces of different pieces of equipment at the playgrounds in order to compare differences in temperature between material types, color, and orientation. Also, we used In-Depth Incident Reports from the Consumer Product Safety Commission's databases to determine materials and equipment that were associated with reported thermal contact burns. Our research with respect to the categorization system concluded that the current system was out of date and needed updating for newer equipment. We recommended the creation of a more modern system that organizes equipment into categories based on the function of the equipment with new subcategories based on the different styles of equipment that serve the same function. A booklet, which will be distributed to the Consumer Product Safety Commission personnel, outlines our new classification system in detail. In regards to the dangers of thermal burn injuries, our research resulted in recommendations for increasing public and parent awareness. A burn awareness brochure for the public and an online fact sheet will help prevent these injuries from occurring. We concluded that the best way to prevent thermal burn injuries is to make parents and supervisors aware of the risk and verify that the equipment is at a temperature which will not cause harm to their children.

Authorship Page

Throughout this report, the members of the team provided equal contributions and thus deserve equal credit as authors. The following details the individual contributions of each student during this Interactive Qualifying Project.

Greg Ford focused on observing and researching childhood behavior on playground and how that is related to childhood injury. He is also responsible for the sections on interviews, interview protocols, and ASTM standards.

Adam Moriarty mainly focused on equipment types that the team saw in catalogs and how the standards and categories relate to the equipment. He also collected temperature readings on the selected playgrounds and organized the data into charts and figures as seen in the Results and Analysis.

Daniel Riches investigated many of the new types of playground equipment currently on the market and identified all of the playground locations we visited during the project. He is also responsible for sections on home and international playground standards, as well as outlining what equipment we saw on the playground and in catalogs.

Lastly, Sarah Walker focused on the issue of thermal contact burns and used the Consumer Product Safety Commission's numerous databases to collect reports and information. She made tables and charts from this data studied ways to reduce the number of thermal burns seen on playgrounds. She was responsible for creating the thermal burn brochure for the general public, conducting parent interviews, and writing the sections related to thermal contact burns and the data collected.

Executive Summary

After many years of work by manufacturers and Consumer Product Safety Commission employees to improve the design of playground equipment, childhood injuries on the playground are still a major concern. Childhood injuries can be debilitating, and in order to reduce the risk of sustaining severe injuries on the playground there have been many regulations and guidelines put in place to prevent such incidents. The problem with these regulations and standards is that they need to cover many different types of playground equipment in order to be effective. The current classification system for playground equipment is becoming outdated as new, more complex playground equipment appears on the market. While the popularity of this new equipment grows, it is still unclear as to what type of equipment certain models are. Although the government categories were thought to be broad when created, new equipment is being produced, and it cannot be placed in any existing category.

In addition, there are hazards associated with playground equipment and surfacing that can lead to thermal burns. Thermal burns resulting from playground equipment, while not a frequent issue, can result in serious injuries that have not been fully studied by the Consumer Product Safety Commission (CPSC) staff. Since there has been little study of the issue, there are few recommendations to help prevent these injuries.

The goal of this project was to make recommendations to the CPSC staff concerning the classification of new playground equipment and to identify standards that will help keep the playground equipment safe for children. In order to attain our goal, our objectives for this project were to: determine which types of playground equipment are misclassified or classified in a way that does not address all the possible hazards; determine why they do not meet other categories' requirements and standards and suggest a new classification system; and determine which materials, specific orientation of the equipment, and other playground equipment criteria cause the most thermal burn injuries.

To understand why equipment was misclassified in certain categories, one objective of the project was to evaluate the current classification system for playground equipment and determine the most feasible way to develop new categories. The CPSC suggests guidelines in the *Public Playground Safety Handbook* that reference American Society for Testing and Materials (ASTM) standards that govern what equipment manufacturers must follow to comply with accepted safety protocols. Through extensive literature reviews and data analysis, we examined the current classification system and the reasoning for setting it up in such a way. By examining catalogs made by equipment manufacturers and visiting playgrounds to determine the function of the equipment, we were better able to understand the problem and make accurate recommendations.

To make the recommendations to the CPSC possible, research on how the current classification system is organized was essential. We found that the CPSC has eight main categories for play equipment. If a piece of equipment does not fit into one of seven categories then it will be grouped in the eighth category: climbers. In addition to reviewing reports, documents, and analyzing data, we carried out interviews with CPSC employees regarding current playground equipment categories and thermal burn injuries sustained on the playground. Also, we interviewed industry professionals involved with manufacturing companies and ASTM committees. These interviews provided information and professional opinions on the improvement of classification categories and playground equipment safety features. In separate, informal interviews, the caregivers of children playing on playground equipment were asked a series of questions about any injuries their children have sustained on playground equipment. After speaking with these individuals about their safety concerns, it was clear as to which pieces of equipment pose more hazards to children and what could be done to prevent certain types of injuries, specifically thermal burns. These interviews also determined that a new classification system was necessary as the general opinion was that the system was not changing as needed to keep up with the more complex equipment.

Another research method that we used in collecting data on playground equipment and the injuries sustained on them was indirect observation. By observing how children on the playground interact with the equipment, it was easier to assess the risks associated with the equipment and to determine unsafe behaviors exhibited by the users. Also, using an infrared thermometer, we were able to measure the temperature of equipment at certain times of the day to look at equipment and surfacing temperature differences relating to thermal burns. From these methods we found that while children may misuse the equipment, modern equipment leaves room for interpretation which could lead to more misuse. Temperature data suggested that while color of the equipment did not have a significant impact on temperature, orientation played a large role in how the equipment and surfacing interacted with the sun. Equipment facing east and west were found to be the hottest, while north and south facing equipment were the coolest. Rubber and plastic materials were also found to be a noteworthy source of heat and could lead to thermal burns if a parent does not check the equipment before letting their child play on it.

This project provided insight into whether or not the playground equipment classification system needed to be rewritten and how to approach the injury hazard of thermal burns. Evidence supports that the system should be reclassified in order to prevent unnecessary injury and in order to provide more clear and detailed standards. However, the new system we propose need to be reviewed by the ASTM committee if it is ever to be implemented. Regarding thermal burns, we recommend that prevention is the key to reducing the number of burns. Parents should take responsibility for their child's safety. The caregivers should be notified of the hazard at the playground or through public safety pamphlets that explain all the risks and suggest safety tips to follow. Overall, the system of classifying equipment needs to be reorganized in order to reduce injuries and better comply with ASTM safety standards.

Acknowledgements

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We would like to give special thanks to the manufacturers that were able to give us information regarding current playground categories and potential solutions. In addition, a special thanks to the parents who took time to talk to the team and answer our questions.

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1. Introduction

Playgrounds have historically played an important role in the development of childhood social and physiological skills. While playgrounds are a main source of entertainment for children of all ages, equipment on playgrounds pose a certain risk for the users. In general, playground areas can be categorized into two classifications, public playgrounds which are supplied by community, local, or state organizations, and residential playgrounds provided by the homeowners. While there are differences in guidelines between both home and public playgrounds, they can be further catalogued into subcategories depending on the different characteristics of the individual pieces of play equipment (CPSC, 2010). The physical challenges presented to children by modern playground equipment are ever increasing due to the rising diversity of equipment designs and the demand for innovation.

As playground equipment becomes more innovative and their structures change, the current categories created by the Consumer Product Safety Commission (CPSC) (2010) for such equipment are unable to contain all of the original types of equipment. These categories encompass large ranges of equipment. However, some new playground equipment is being misplaced in the current category system because they have features that have not been seen on previous equipment, thus creating a gap in regulation and oversight. By not having manufacturing guidelines for specific pieces of equipment, this break contributes to the hazards associated with new equipment and to the injuries annually sustained by children. Despite efforts in reducing these injuries, every year approximately 200,000 children require hospital attention from injuries acquired on playgrounds (Roderick 2001, O'Brien, 2009). Specifically, the CPSC is the main government agency responsible for categorizing equipment and setting guidelines for contractors and homeowners to follow when building a playground area (CPSC, 2010). New classification sections would greatly aid in the CPSC's endeavor to create more in depth guidelines for playground equipment.

Although the CPSC staff has taken measures to make playground equipment safer throughout the agency's existence, and there has been a large reduction in playground incidents, for many varieties of playground equipment the guidelines are too generalized. There are many categories and guidelines put in place by the CPSC. However, new equipment is unable to be correctly placed in current groupings due to the innovation by manufacturers and designers (CPSC, 2010). By not being able to be placed into specific categories, safety standards and guidelines cannot accurately be made for such playground equipment. Currently the CPSC divides playground equipment into many categories including balance beams, climbing and upper body equipment, log rolls, merry-go rounds, slides, spring rockers, seesaws, and swings. For example, one category that has specifications is the balance beam category. The CPSC (2010) sets guidelines for balance beams in order to determine the appropriateness for children of different ages (Section 5.3.1). For instance, balance beams less than twelve inches off of the ground are designated for preschool age children. Balance beams for school age children can be up to sixteen inches off of the ground. This height selection is chosen to decrease the number of falls occurring on the equipment. Every category of equipment has many guidelines in place in order to protect children playing on the playground equipment.

One of the main issues for the CPSC staff is the lack of clear categories in the standards for the new equipment and the unproven safety for the new equipment. There may be new safety hazards associated with certain aspects of the new equipment. Thermal burn injuries have been occurring even with a change in building materials. However, there is not enough information on these injuries to determine which specific material or other factor is causing the burns. By properly classifying the equipment and investigating the materials being used, oversight by regulatory agencies and the standards can be improved. There is a need for more detailed categories to prevent such incidents from occurring. A new classification system that specifically states standards and safety hazards for each piece of original equipment would increase the effectiveness of the safety standards.

The goal of our project was to make recommendations to the CPSC staff concerning the classification of new playground equipment and to identify standards that would keep the playground equipment and children safe. In order to attain our goal, we considered the following objectives: determine which types of playground equipment are misclassified; determine why they do not meet other categories' requirements and standards and suggest a new classification system; and determine which materials of the playground equipment, specific orientation of the equipment, and other playground equipment criteria cause the most thermal contact burn injuries. In order to achieve these objectives and make recommendations, we interviewed CPSC staff, industry professionals, and parents, conducted archival research through the CPSC, and observed how children interact with equipment on the playground. With our recommendations, the CPSC staff will be able to create new classification standards, increase the safety of home and public playgrounds, and promote understanding of how materials used in playground equipment relate to injuries.

2. Background

In order to fully understand the need for a more refined classification system for playground equipment and identification of injury causing equipment materials, it is critical to be familiar with all aspects of playground safety, regulations, and standards. In this chapter we begin by discussing the existing legislation surrounding public playgrounds and playground equipment classifications. Then we review the safety features of public versus home equipment. It is imperative to understand the correlation between injuries and particular pieces of playground equipment in order to better understand how to classify playground equipment according to potential hazards and equipment function. Finally, we discuss injuries and risks associated with playground equipment.

2.1 American Society for Testing and Materials

The Consumer Product Safety Commission works with ASTM International (ASTM), formally known as the American Society for Testing and Materials) to ensure safety on playgrounds through the use of equipment standards. The CPSC employees are responsible for overseeing safety issues relating to different product categories (Earls, 2011, para. 9). In most cases, the CPSC is required by law to use a voluntary standard rather than a mandatory standard. Voluntary standards are used if it is believed they will satisfactorily reduce the present hazard and will be used appropriately (Earls, 2011). However, while these standards are voluntary, insurance companies overseeing the building of a new playground may enforce these standards to avoid liability concerns. If the CPSC is in need of a safety standard, they will approach the ASTM committees and then the development of a new or revised ASTM International standard can be commenced. This process begins with the CPSC providing the ASTM with a list of people who would be interested in this new standard. If the stakeholders agree with this, the ASTM will form a committee or a subcommittee based on the new regulation. They will also ask for industry professionals and organizations to become involved in the process. The participants in the committee work on different aspects of the standards such as safety performance provisions, labeling, and testing protocols.

After this process is completed, the CPSC incorporates the new standard into the existing ASTM standards and any additional safety provisions are then added to the CPSC mandatory rule (Earls, 2011).

The ASTM standard that is currently used for public playgrounds is ASTM F1487-Standard Consumer Safety Performance Specification for Playground Equipment for Public Use. This document provides safety and performance standards for different types of playground equipment across the United States. It is meant to reduce life-threatening and debilitating injuries through voluntary standards. The categories that these standards refer to are balance beams, climbers, upper body equipment, sliding poles, slides, swings, merry-go-rounds, roller slides, seesaw, spring-rocking equipment, log rolls, and track rides. Among the standards included for these categories are height, length, and distance requirements. Specifically, the equipment that the ASTM F1487 focuses on is meant to be used by two to twelve year old children (ASTM, 2007).

2.2 Current Categories of Playground Equipment

Playgrounds feature a wide variety of different types of equipment. In order to provide safety standards for the equipment, the CPSC (2010, Section 5.3) and the ASTM (2007) have created a set of categories that are used to group the equipment and provide standards for each category.

2.2.1 Balance Beams

Balance beams are straight, narrow beams that are intended to be walked upon while balancing (CPSC, 2010, Section 5.3.1). This equipment is not recommended for toddlers, but it is appropriate for preschool-age children on the condition that the beam is less than twelve inches high. For school age children, a fall height of sixteen inches or less is appropriate. Fall height for this equipment is defined to be the distance between the walking surface of the beam and the protective surface beneath it. The ASTM (2001, p. 9) has similar standards and also states that support posts for balance beams should not pose a tripping hazard. Figure 1 below shows an example of a balance beam. This balance beam consists

of three segments that are set at angles to each other and has the middle section raised higher than the outer sections.

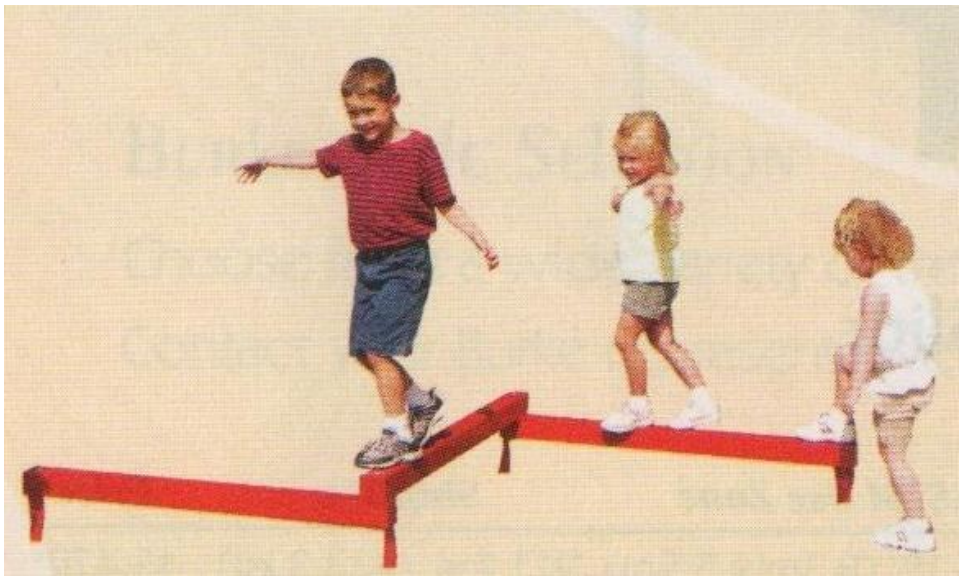

Figure 1: An Example of a Balance Beam (Burke, 2010, p. 102)

2.2.2 Climbing and Upper Body Equipment

Climbing and upper body equipment encompasses all equipment that "requires the use of the hands to navigate up or across the equipment" (CPSC, 2010, p. 24). By far this is the most general category and is often used as a catchall for equipment that does not exactly fit into another category. The ASTM (2001, p. 9) suggests that rigid rungs, used for hand support during ascent and descent of climbing apparatus, should be between 0.95 in. (24.1 mm) and 1.55 in. (39.4 mm) in diameter and should not twist/rotate about its own axis. Also, the fall height of climbers used for access/egress from composite play structures is defined as the distance between the highest part of the climber intended for foot support and the protective surface below. Finally, the fall height of free standing climbers (e.g. geodesic domes, free standing climbing walls, etc.) should be the distance between the highest part of the climbing component and the protective surface below.

The ASTM (2001, p. 9-10) suggests that the center-to-center distance between rungs on upper body equipment with fixed handholds should be no greater than 15 in. (381 mm). The horizontal distance from the leading edge of the take-off or landing structure to the first handhold of upper body equipment should be no greater than 10 in. (250 mm). In addition, where the take-off or landing point is accessed by rungs, the horizontal distance to the first handhold should be at least 8 in. (200 mm) but no greater than 10 in. (250 mm). The maximum height of upper body devices intended to be used by two to five year olds should be no greater than 60 in. (1520 mm), which is measured from the center of the grasping device to the top of the protective surfacing below. The maximum height of upper body devices for use by five through twelve year olds should be no greater than 84 in. (2130 mm). The maximum height of the take-off/landing structures for upper body equipment should be no greater than 18 in. (460 mm) or 36 in. (910 mm) above the protective surfacing on equipment for two to five year olds and five to twelve year olds respectively. Equipment support posts with no designated play surfaces are exempt from this requirement.

Arch Climbers

"Arch climbers consist of rungs attached to convex side supports" (CPSC, 2010, p. 27). These climbers can be either freestanding, which is not recommended for toddlers or preschool-age children, or used as an access to other equipment. Figures 2 and 3 below show two examples of arch climbers. The first is a freestanding arch climber. The second example is an arch climber used to provide access to a platform.

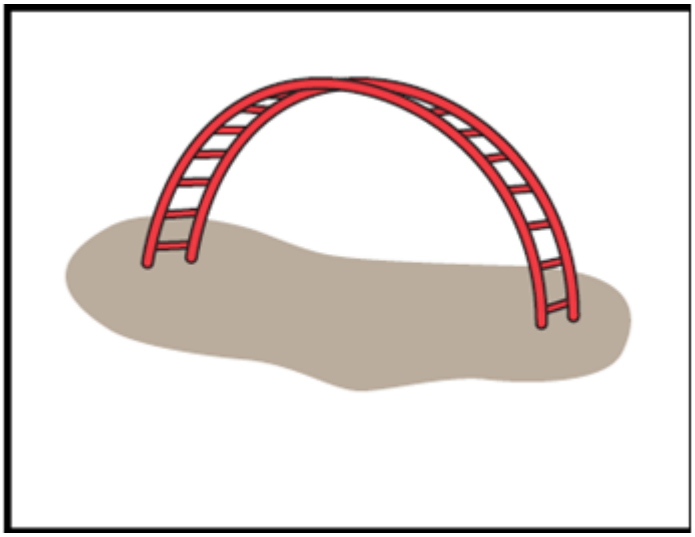

Figure 2: Freestanding Arch Climber (CPSC, 2010, Section 5.3.2.2)

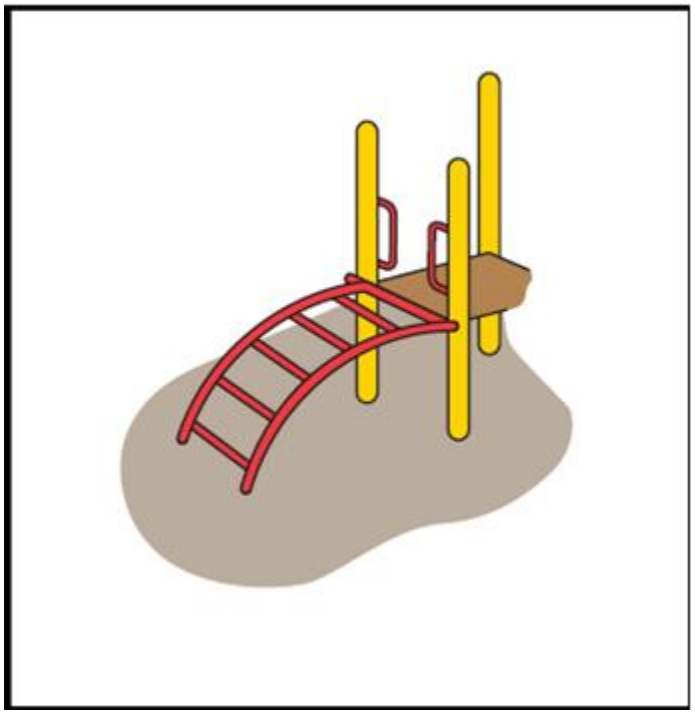

Figure 3: Arch Climber Access (CPSC, 2010, Section 5.3.2.2)

Flexible Climbers

Flexible climbers consist of a grid-like material with openings large enough to be used as footholds (CPSC, 2010, Section 5.3.2.3). These footholds are not rigid, so this piece of equipment requires greater balancing abilities in order to be used safely. In order for flexible climbers to be safe,

they must be securely anchored at both ends, have secure connections between each grid, and not form an entrapment hazard. An example of a flexible climber and possible entrapment hazards can be seen in Figure 4. In this figure, the flexible climber provides access to a platform with an attached slide. The figure also notes that the perimeter of the holes in the flexible climber should either be less than 17 inches or greater than 28 inches. If the perimeter is less than 17 inches, a child's torso will not be able to fall through in the hole. If the perimeter is greater than 28 inches, the child will be able to fit parts of his/her body in the hole, but he/she will not be able to become entrapped because the head will also fall through.

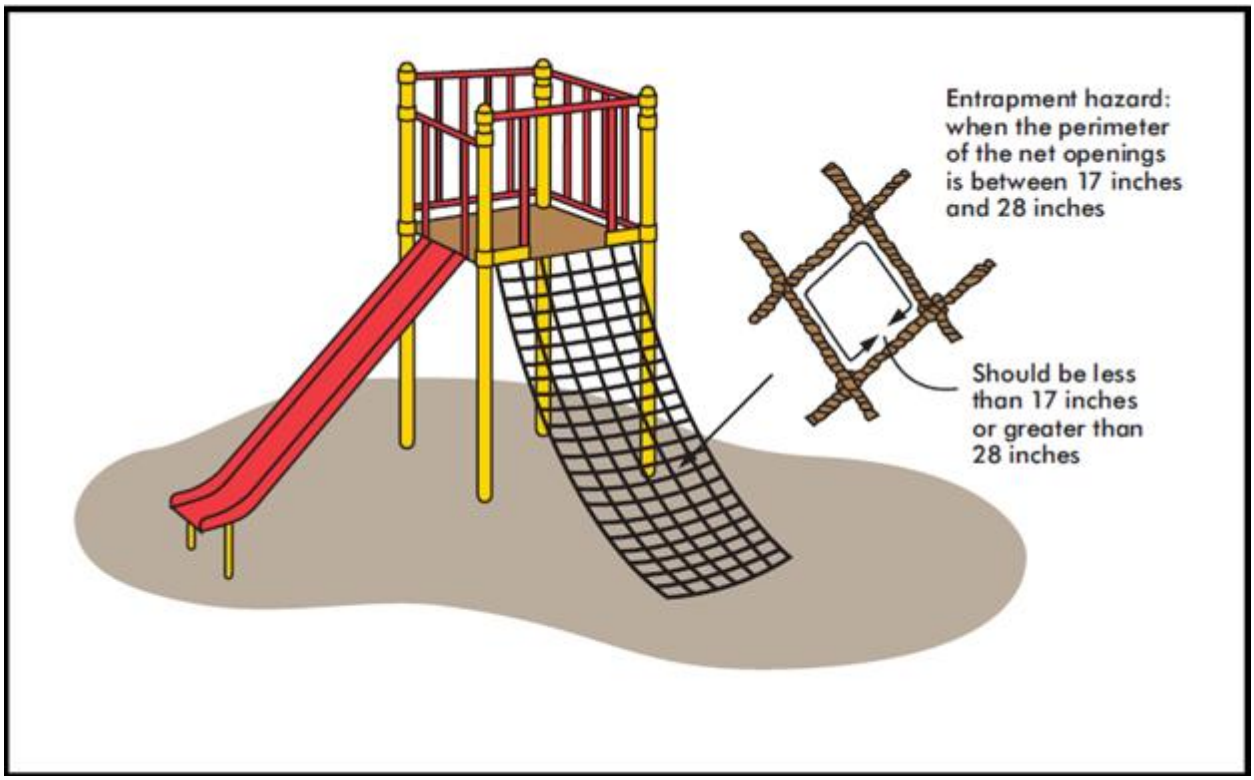

Figure 4: Entrapment Hazards in Flexible Climbers (CPSC, 2010, Section 5.3.2.3)

Horizontal Overhead Ladders

Horizontal overhead ladders are climbers that allow children to move across them from end to end using only their hands (CPSC, 2010, Section 5.3.2.4). These ladders are not recommended for children under four years old so they should not be used at playgrounds that are intended only for

toddlers. Figure 5 below shows an example of an overhead ladder. This overhead ladder is a standard overhead ladder with landing pads at each end.

Figure 5: An Example of an Overhead Ladder (Burke, 2010, p. 75)

Overhead Rings

Overhead rings are similar to overhead ladders in that they allow children to move across them using their hands (CPSC, 2010, Section 5.3.2.5). However, they differ due to the fact that the handholds of overhead rings are not static like the handholds of the overhead ladders. The handholds swing in an arc that brings the child closer to the next handhold. Figure 6 shows an example of overhead rings with trapezoidal shaped handles.

Figure 6: An Example of Overhead Rings (Burke, 2010, p. 73)

Sliding Poles

Sliding poles are used as exits from platforms (CPSC, 2010, Section 5.3.2.6). These poles are intended for one-directional use. Sliding poles are challenging because they require both strength and coordination to properly navigate without falling. For these poles, the fall height is the distance between the platform and the protective surface beneath it. Figure 7 shows an example of a sliding pole. This pole would be attached to an elevated platform and is intended to be used as an exit from the platform.

Figure 7: An Example of a Pole Slide (Playground Warehouse, 2011, p.1)

The ASTM (2001, p. 10) suggests that clearance distances from structures to the pole should be between 18 in. (460 mm) and 20 in. (510 mm). Upper access to the sliding pole should be from one height only. The sliding pole should rise 60 in. (1520 mm) or greater above the surface of the access structure. The pole should be no greater than 1.9 in. (48 mm) in diameter. The sliding portion of the sliding pole should be continuous, with no protruding welds, joints or abrupt changes in direction. The guardrail or protective barrier at a platform entrance/exit opening should have an opening with a maximum horizontal dimension of 15 in. (380 mm). The fall height of sliding poles accessed from a platform should be the distance between the platform and the protective surfacing below. Sliding poles not accessed from a platform should have a fall height of 60 in. (1520 mm) below the highest portion of the pole to the protective surfacing below.

Track Rides

Track rides are another piece of equipment that allows a child to travel using their hands (CPSC, 2010, Section 5.3.2.7). These differ from overhead ladders because of the handholds. On overhead ladders, the child moves from handhold to handhold. However, on track rides, the child takes hold of a

single handhold and moves with it along the track. These require significant upper body strength and should not be present on playgrounds designed for toddlers or preschool age children. The fall height for this type of equipment is the distance between the maximum height of the track ride and the surface beneath it. The ASTM (2001, p. 13) suggests that track rides locate the handle of the track at least 64 inches and at most 78 inches above the protective surfacing of the playground. The center to center distance between adjacent tracks should be at least 48 inches. Track rides with elevated platforms at the entrance should have an elevated platform at the exit that is at least 36 inches long to allow the child to land safely. The track ride should also have an unobstructed clearance zone that runs the length of the track. This ensures that the child will not collide with any components while using the track ride. Figure 8 shows an example of a track ride. Children use this track ride by grabbing onto a handle and using momentum to carry them from one end to the other.

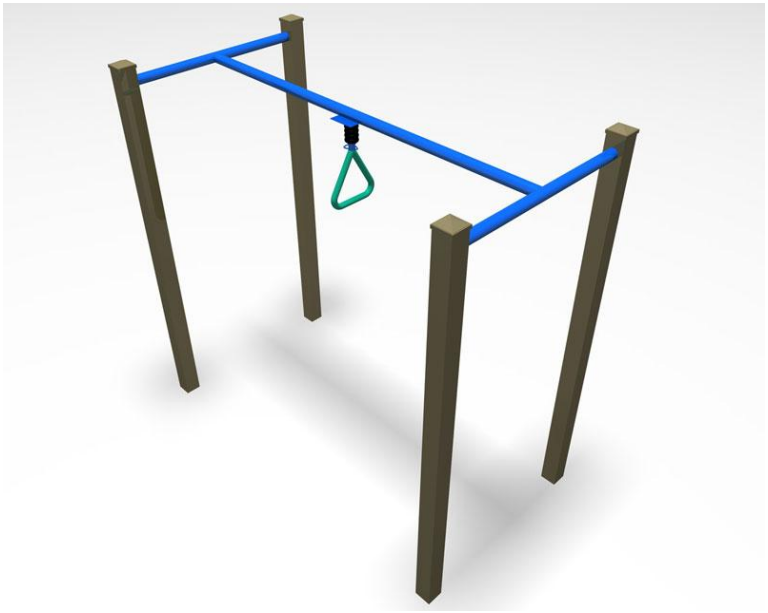

Figure 8: An Example of a Track Ride (Michigan Playground Equipment, 2011, p.1)

Climbers

The climber category is currently the home for nearly all playground equipment that does not fit into any of the other categories. This is due to the fact that the main requirement of the climber

category is that children must use their hands to play on the equipment. This general classification feature leads to incorrect categorization. An example of this can be seen in Figure 9 below. In this figure is a piece of equipment that appears to function as a slide and also has a flexible climber attached. However, this piece of equipment has been categorized as a climber because it does not meet the rigid specifications of the slide category.

Figure 9: An Example of a Climber

2.2.3 Log Rolls

Log rolls are cylindrical pieces of equipment that rotate freely and are secured between two posts (CPSC, 2010, Section 5.3.3). Children use this equipment by standing on top and moving their feet. By doing this, the cylinder rolls and the children attempt to maintain their balance atop the log. Because toddlers and preschool-age children have less balance and coordination, this piece of equipment is not recommended for children of these ages. Regardless of age, handholds are suggested to prevent injury. Fall height for this type of equipment is determined to be the "distance between the highest point of the log and the protective surface beneath it" (CPSC, 2010, p. 30). The ASTM (2001, p. 12) suggests that all log rolls have handholds available to help children mount and dismount the log roll. These handholds

should have a diameter between 0.95 inches and 1.55 inches to allow children to get a solid grip on the handhold. Finally, the top surface of the log roll should not be higher than 18 inches above the protective surface. Figure 10 below shows an example of a log roll. This log roll is attached between two poles as part of a composite play structure and has handholds on each side for children to hold onto while playing.

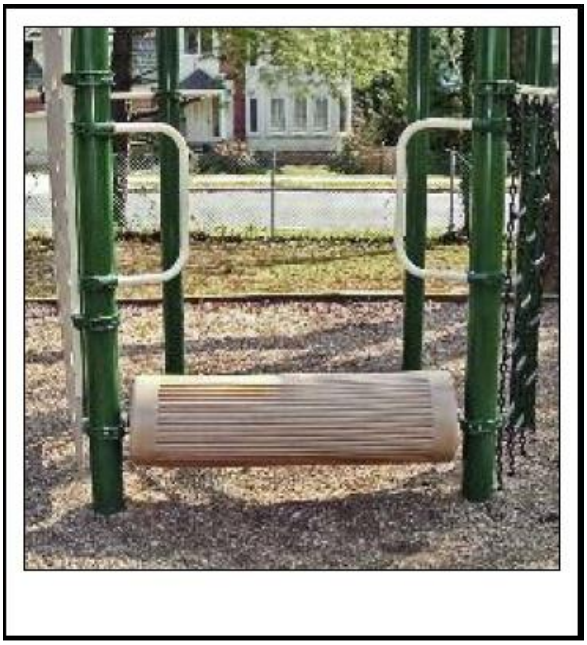

Figure 10: An Example of a Log Roll (CPSC, 2010, Section 5.3.3)

2.2.4 Merry-Go Rounds

Merry-go rounds are a type of equipment that children sit or stand on (CPSC, 2010, Section 5.3.4). Meanwhile, other children or adults stand around the edge and push the equipment in order to make it spin faster. This type of equipment is not recommended for children of preschool age and below as they are unable to exercise control over it while it is in motion. The usage zone for this type of equipment extends at least six feet from the edge of the merry-go round, and the fall height is determined to be the distance from the edge of the platform to the surface beneath it. Figure 11 shows an example of a merry-go round. Children typically use this merry-go round by either sitting on it and

having a third party push them, or by spinning the merry-go round themselves and sitting on it once it has reached full speed.

Figure 11: An Example of a Merry-Go Round (OC Mod Shop, 2011, p.1)

The ASTM (2001, p.12) states that merry-go-rounds are circular platforms that are close to the ground and rotate about a vertical axis. The platform should be configured such that no handholds extend beyond the outer edge of the platform and the platform is no more than 14 inches above the protective surface. Handgrips should be provided to help children maintain their balance on the merry-go-round. This equipment should not have any vertical motion while spinning.

2.2.5 Seesaws

Seesaws are a type of equipment that "consists of a board or pole with a seat at each end supported at the center by a fulcrum" (CPSC, 2010, Section 5.3.5). An example of this can be seen in Figure 12. The seesaw shown is a fulcrum type seesaw that has a bar in the middle with a plank attached for children to sit on. This particular seesaw also uses automobile tires below each seat to lessen the force of impact caused when the seat hits the ground. This type of equipment is not recommended for preschool aged children or below due to the required levels of coordination between the two children. However, other seesaws exist that prevent impact with the ground if one child left the seesaw. These

seesaws are suitable for preschool aged children. Fall height for this type of equipment is counted from the highest point of the seesaw to the ground.

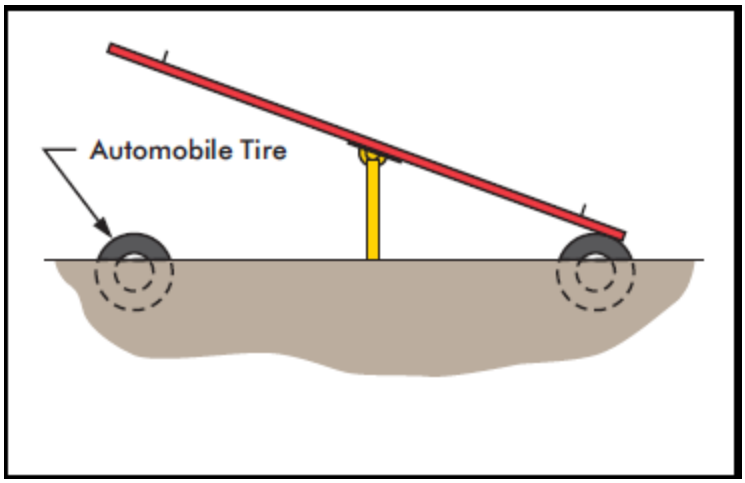

Figure 12: An Example of a Seesaw (CPSC, 2010, Section 5.3.5.1)

The ASTM (2001, p.12) states that all seesaws should have a shock absorbing material such as an automobile tire either attached to the bottom of the seesaw or in the ground where the seesaw would hit the surfacing. Every seat on the seesaw should have handholds available that are at least 3 inches long if intended to be held by one hand and at least 6 inches long if intended to be held by two hands. The maximum angle between the line between the seats of the seesaw and the horizontal should be at most 25 degrees and the seat should not rise 60 inches above the protective surface.

2.2.6 Slides

Slides are one of the most common types of playground equipment. These consist of a chute that is attached to an elevated platform and exits near the ground (CPSC, 2010, Section 5.3.6). These chutes can be straight, wavy or spiral shaped. An example of a wavy slide can be seen in Figure 13. Slide use is further varied due to the fact that children descend slides in different positions. Access to the slide varies depending on whether the slide is freestanding or not. If it is freestanding, there is a ladder or stairway attached that allows the child to climb. Should the slide be attached to a composite play structure, the slide is accessible from the structure. The fall height for a slide is calculated from the top

of the platform to the ground below it. Finally, slides can pose an entanglement hazard if they have protrusions or gaps that can catch clothing of children.

Figure 13: An Example of a Slide (Burke, 2010, p. 63)

The ASTM (2001, p. 10-11) has standards for five parts of slides. The first of these is slide transition platforms. The ASTM suggests that the depth of the transition platform on slides should be 14 in. (360 mm) or greater. The transition platform should have a width equal to or greater than the width of the sliding chute. The second category is slide chute entrance. The ASTM suggests that handrails or other means of hand support should be provided at the slide chute entrance to facilitate the transition from standing to sitting. At the slide chute entrance, there should be a means to channel the user into a sitting position (guardrails, hoods, etc.).

The third category for the slide standards involves the slide chute. The ASTM suggests that the height/length ratio of the sliding surface should not exceed 0.577. No span of the sliding surface should have a slope that exceeds 50°. The slide chute inside width should be 12 in. (300 mm) or greater for two through five year olds, or 16 in. (410 mm) or greater for five through twelve year olds. All slides with a curved cross section should minimize the likelihood of lateral discharge (for example, spiral slides and

other slides that change in horizontal direction; slides with a wide, shallow chute; etc.). The internal diameter of tube slides should be 23 in. (580 mm) or greater.

The fourth category is the exit region. The ASTM suggests that slides should have an exit region length of 11 in. (280 mm) or greater. The slope of the exit region should be between 0 and -4° as measured from a plane parallel to the underlying surface. For slides with an elevation of no greater than 48 in. (1220 mm), the height of the exit end of the sliding surface should be no greater than 11 in. (280 mm) above the protective surfacing. For slides with an elevation greater than 48 in. (1220 mm), the height of the exit end of the sliding surface should be between 7 in. (180 mm) and 15 in. (380 mm) above the protective surfacing. The radius of curvature of the sliding surface in the exit region should be 30 in. (760 mm) or greater.

The final category involves slide clearance zones. The ASTM suggests that a clear area, free of equipment, should surround the slide chute. Spiral slides and tube slides are exempt from this standard. The clear area should extend through the exit section. Spiral slides should maintain a clear area 21 in. (530 mm) wide. The fall height of slides should be the distance between the slide transition platform and the protective surface below.

2.2.7 Spring rockers

Spring rockers are a type of equipment designed for use by toddlers and preschool-aged children. This type of equipment consists of a seat attached to a spring that allows the child to rock back and forth (CPSC, 2010, Section 5.3.7). The seat should be designed such that only the intended number of users can use the rocker at a time. The fall height for a spring rocker is determined as the distance between the seat and ground. The height of the seat depends on the age that the rocker is intended for. If the rocker is intended for a toddler, the seat should be between 12 and 16 inches high. If the rocker is going to be used by preschoolers, the seat should be between 14 and 28 inches high. The ASTM (2001,

p.12) suggests that each seat for the rocker should have a handgrip that children can hold onto while rocking. If the handgrip is intended to be held by a single hand, it should be no less than 3 inches long. If the handgrip is intended for two hands, it should be at least 6 inches long. Footrests for the rocker should be at least 3.5 inches long. Figure 14 shows an example of a spring rocker. This rocker is attached to the ground by a spring and features a seat with multiple handles that allow the child to safely hold on, and also ensures that only a single child will be able to sit on the seat at a time.

Figure 14: An Example of a Spring Rocker (CPSC, 2010, Section 5.3.7)

2.2.8 Swings

Swings are a very common type of playground equipment. They consist of a seat attached by chains or ropes to an overhead pole in such a way that the child can swing back and forth (CPSC, 2010, Section 5.3.8). An example of a swingset can be seen below in Figure 15. The fall height of a swing is determined to be the distance between the pivot point and the ground. In order for the hazards of swings to be minimized, the hardware used to support the swings should be completely secured. S-hooks should be closed such that there is no gap greater than 0.04 inches and the support structures should be designed in such a way that climbing is discouraged.

Figure 15: An Example of a Swingset (Burke, 2010, p. 94)

ASTM has recently changed the standards and test methods for some aspects of swings; however, this revision to the voluntary standard was not yet published at the time of this report. The following descriptions of the standard are for the 2007 publication of the 2001 standard. The ASTM (2001, p. 11) has standards for two kinds of swings. The first kind is to-fro single axis swings. Relating to placement, the ASTM suggests that to-fro swings should be located away from other play structures and circulation areas. Also, swings should not be attached to a composite play structure. The support structure should be designed to discourage climbing and should have no designated play surfaces.

There are also standards for the seats. No more than two seats should be located within a swing bay. There should be no limit on the number of bays provided in a single structure. Seats should be smoothly finished with blunt or rounded edges. Swing seats should accommodate no more than one user. Hard or heavy seats such as those made of wood or metal are not recommended. Hangers should have bearings, bushings, or other means of reducing the friction and wear of all moving parts and surfaces at the pivot point when moving in the intended direction of travel.

The second kind of swing the ASTM (2001, p.11) has recommendations for is the rotating swing. The ASTM recommends that rotating swings be located away from all other play and travel areas and they should not be attached to a composite play structure. The structure that supports the swing should

be designed in such a way that climbing is discouraged and such that only one rotating swing can be used in a single bay. In order to protect bystanders, the seat itself should not weigh more than 35 lbs. This seat is allowed to accommodate more than a single user, but should have blunt edges and should not be made of a hard material such as wood or steel. The swing should have a clearance zone that is 30 inches longer than the distance from the protective surfacing to the pivot point of the swing. The seat of the swing should have at least 12 inches of clearance between it and the protective surfacing below it.

2.2.9 Summary

The CPSC currently has categories of playground equipment that include balance beams, climbing equipment, log rolls, merry-go rounds, seesaws, slides, spring rockers, and swings. Although this is an extensive list, it is not exhaustive. Equipment exists that does not perfectly fit into any of these categories and is therefore categorized generally as a climber. Because this equipment does not perfectly fit into any category, it may have risks associated with it that are not discussed in the climber category. This is a problem both for playground designers and playground users as injuries could occur that were unexpected based on the categorization of the equipment

2.3 Playground Guidelines

In order to ensure that all public playgrounds have a minimum level of safety, the CPSC (2010) has developed a set of guidelines that the Commission recommends persons building the playground should follow. Guidelines provide protection from dangers that could arise from age differences in the children playing on the equipment and from incidents that parents could have prevented had they seen the incident occur.

2.3.1 Playground Location

For many reasons, the guideline that is most important to playground attendees is the location of the playground (CPSC, 2010, Section 2.1.1). The CPSC Handbook for Public Playground Safety (2010) provides suggestions for handling four main playground location factors. These factors include the paths

children take to the playground, nearby hazards such as traffic or lakes, sun exposure, and drainage. The major concern with the methods of accessing the playground is whether or not there are hazards, anything that could cause harm to a child, on the path. Should there be any hazards; the CPSC suggests that they be cleared before use. With respect to dangers near the playground, the CPSC recommends that a method of containment, such as a fence or shrubbery, be installed. This ensures that children will not encounter the problem either inadvertently or by wandering away from the playground.

There are two major considerations for handling sun exposure. First, equipment should be either kept in a shaded area in order to prevent it from becoming hot enough to burn, or, should this be infeasible, the equipment should be clearly labeled as potentially hot enough to cause burns (CPSC, 2010, Section 2.1.1). Second, if children are likely to be subjected to the sun during peak hours of the day, shade should be provided either in the play area or in a nearby location. Further, having shaded locations in a playground will aid in the prevention of sunburn which is known to significantly increase the likelihood of developing skin cancer later in life.

Finally, the CPSC (2010) suggests that the possibility of loose fill materials being washed away during rain be addressed. If this is an issue, proper drainage should be put into place such that the loose fill will not be washed away.

2.3.2 Accessibility

In order for the playground to be accessible to as many individuals as possible, it must meet the standards of the American Society for Testing Materials (ASTM) Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment, ASTM F1951 (CPSC, 2010). This standard refers to “equipment selection and location along with the type of protective surfacing” (Section 2.2.1). By meeting this standard, most children will be able to use the

playground regardless of whether or not they have disabilities. This is extremely important in order to provide an equally fun and safe experience for all children.

2.3.3 Age Separation

Many public playgrounds are intended to provide entertainment for children of all ages. However, equipment designed for older children is too challenging for young children, and equipment for young children is not challenging enough for the older children (CPSC, 2010, Section 2.2.2). These playgrounds accommodate all children by having different types of equipment for differently aged children. The CPSC recommends that these different types of equipment be separated by a buffer zone which includes shrubbery or a set of benches. By having this separation, it will not only be clear which types of equipment are suitable for which age group, but it will also provide protection to younger children from faster moving, older children.

2.3.4 Conflicting Activities

Playgrounds contain many different types of equipment that have varying levels of activities associated with them. For example, a sandbox has a relatively passive level of activity, whereas a set of swings has a relatively high level of activity. In order to compensate for this, the CPSC (2010) suggests in section 2.2.4 of the *Handbook for Public Playground Safety* that active and passive equipment should be separated from each other. Further, those pieces of equipment that are heavily used should be dispersed throughout the play area so that no single area becomes overly crowded. In addition, the Handbook provides recommendations for the layout of the playground with respect to specific types of equipment. Equipment that has a high degree of motion, like a swing or a merry-go-round, should be isolated to corners of the play area. Slide exits should be away from heavily trafficked areas to prevent collisions. Play structures that have multiple components should have similar pieces nearby in order to keep children of certain ages and skill sets separate.

2.3.5 Sight Lines

All playgrounds have risks associated with them; therefore, children should be supervised while they play. To accommodate this, the CPSC (2010, Section 2.2.5) suggests that playgrounds be laid out in such a way that visual barriers are as limited as possible. This ensures that supervisors will be able to see their children as often as possible while they are playing and, should there be an accident, they will be alerted as quickly as possible. Increasing line of sight for supervisors is accomplished by setting up the equipment in such a way that a significant amount of the playground is visible from park benches. Additionally, playgrounds with multiple play areas should be designed in such a way that all play areas are visible from all other play areas. This is especially useful for supervisors watching over multiple children in different age groups.

2.3.6 Signage

Although the age appropriateness of playground equipment can often be determined by a visual inspection, this is not always the case. Therefore, the CPSC (2010, Section 2.2.6) suggests that equipment be labeled in order to provide guidance to supervisors in the event of ambiguity. This is especially relevant in preventing unnecessary injury from occurring.

2.3.7 Surfacing

The material that the surface of the playground is made of can greatly reduce the risk of serious injury. The CPSC (2010, Section 2.2.4) suggests the use of shock absorbing materials for surfacing as opposed to hard surfaces. A fall from a piece of equipment onto a shock absorbing surface has a lesser chance of causing serious injury than a fall onto a hard surface. Unfortunately, serious injuries are a possibility regardless of the surface used. Because selecting a surfacing material is so important, the CPSC (2010, Section 2.4.2) provides a set of guidelines for choosing an appropriate material. There are two types of surface materials that are recommended, including unitary surfacing materials and loose-fill surfacing materials. Unitary surfacing materials are either made of rubber mats or tiles that have been secured in place by a binding agent. Some examples of loose-fill surfacing materials include

engineered wood fiber, which is similar in appearance to landscaping mulch, rubber mulch, sand, and pea gravel. The type of material to choose depends on the fall heights of the equipment in use. Table 4 contains examples of loose fill materials and the required depth of fill for a given fall height. This table shows that the depth of fill for any material should be at least six inches. However, six inches is only acceptable for recycled rubber which does not compress in the same manner as the other listed materials. Table 1 also shows that falls below four feet are protected by most materials, but higher falls are only protected by specific materials. Figure 16 shows some examples of materials that are acceptable for use as a protective surface and materials that are not acceptable. The materials that are acceptable are generally shock absorbing materials. The materials that are not acceptable are those that are solid in nature and will therefore not absorb shock well.

Table 1: Minimum Compressed Loose-Fill Surfacing Depths (CPSC, 2010, Section 2.4.2)

Inches	Of	(Loose-Fill Material)	Protects to	Fall Height (feet)
6*		Shredded/recycled rubber		10
9		Sand		4
9		Pea Gravel		5
9		Wood mulch (non-CCA)		7
9		Wood chips		10

* Shredded/recycled rubber loose-fill surfacing does not compress in the same manner as other loose-fill materials. However, care should be taken to maintain a constant depth as displacement may still occur.

Figure 16: Example Surfacing Materials (CPSC, 2010, Section 2.4.1)

2.3.8 Maintenance

As with all manmade structures, playgrounds deteriorate over time. As such, they must be maintained to ensure that they remain safe. The CPSC (2010, Section 4) has provided guidelines for proper maintenance of a public playground. The first step in the maintenance process is an inspection of the playground equipment. An example inspection checklist can be seen below in Figure 17. From this figure it can be seen that inspections are intended to discover any equipment that is broken, has deteriorated, or has been vandalized or modified. All of these problems cause the playground to be unsafe and, once the inspection is complete, repairs should be made to each piece of equipment that is in need. In addition, the loose-fill surfacing should be restored to its ideal level as it may have become compressed or displaced over time.

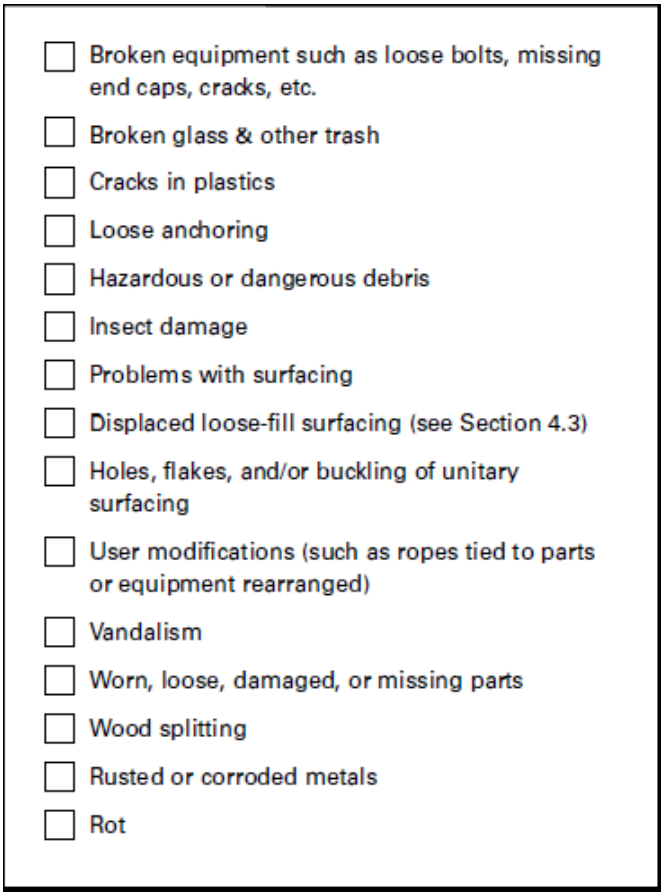

Figure 17: Routine Inspection and Maintenance Issues (CPSC, 2010, Section 4)

2.3.9 Summary

To reduce the likelihood of injury on playgrounds, the CPSC provides guidelines relating to playground location, accessibility, age separation, conflicting activities, sight lines, signage, surfacing, and maintenance. Playgrounds should be located in an area where hazards are removed and shade is present. They should be designed in such a way that all children are able to use them. Furthermore, equipment for children in specific age groups should be kept in the area for that age group, and equipment should be organized by its level of activity. To keep parents and supervisors aware of the safety of their children, sight lines should be maximized and signs should be placed on all equipment that could be hazardous in unforeseen ways. Finally, protective surfacing should be installed properly and should be checked as part of a regular maintenance plan. With this information, one can better understand the process that goes into designing and regulating a playground. This understanding can be

useful when considering the risks of various types of playground equipment and for creating new categories of equipment while at the same time considering the risks behind various materials used on the playground.

2.4 Home vs. Public Playground Guidelines

As with any commercial product bought in retail settings, there are many hazards associated with playgrounds and their use. However, the difference between community playgrounds and those found in private homes is that community playgrounds are accessed by a large number of children or by children not directly related to the owners of the playground, while home playgrounds are on private, homeowner property. Both of these types of playgrounds have voluntary standards that should be followed, and the CPSC has developed a handbook for home playgrounds also (CPSC, 2010a). It is reported that on average there are 51,000 children who go to the hospital due to injuries suffered from home playgrounds (CPSC, 2005, p.1). Within the perceived safety of a backyard, the number of injuries reported within a year is astounding. Working alongside the CPSC, the American Standard for Testing and Materials (ATSM) publishes revisions to standards to continually increase safety in home playgrounds (CPSC, 2010a, Sec. 1). The latest development by the ASTM is that swings and hanging structures cannot be hung from monkey bars. The idea behind this concept is to try to reduce strangulation due to ropes such as swings when children fall. With the ATSM creating new standards every year home safety will continue to improve as more studies are done.

2.4.1 Home Playground Setup & Assistance

Home playgrounds typically are composed of monkey bars, slides, and swings. Figure 18 shows a typical child playground in a residence.

Figure 18: Typical Playground Layout (CPSC 2010, p. 1)

When a playground is installed in a community, it is up to the town or city to make sure that the appropriate local regulations are followed such as the landing zone size for swings or the correct depth for absorbing materials for falls of different heights (Hudson, Olson, Thompson, 2004). When assembling a home playground, important tasks can be overlooked because homeowners who assemble their play set may not know the standards or understand the construction process. The Consumer Product Safety Commission works with voluntary standards organizations and publishes the Outdoor Home Playground Safety Handbook to help minimize injuries and deaths due to playgrounds. However, when setting up a typical home playground usually few consumers typically analyzes their yards to ensure the CPSC's guidelines are followed as recommended.

Putting together a playground can be complicated; however, options are available to ensure that it is put together correctly. The company that produced the home playground can put it together for you for a small fee or possibly even for free. The company is trained in assembling the playgrounds they sell, and may be more skilled in assembling the playground correctly than the average homeowner. Safety problems can occur when individuals who are not trained in construction put together the equipment and leave out key parts that may have seemed irrelevant to the homeowner. If the company does not assemble the playground then it is required of the company to provide all necessary

documents to ensure a safe installation (Mahajan, Bal M, 1978). These documents include photos, guidelines, and instructions. With a home playground, it is best to let trained individuals assemble the playground to ensure the safety of the children who will be playing on it.

2.4.2 Home Guidelines & Regulations

The Outdoor Home Safety Handbook (publication #324) provides guidance for home playgrounds in a similar manner to the how Public Playground Safety Handbook provides the guidance for public playgrounds. In addition, the CPSC (2011) has a reference sheet with safety tips for homeowners to follow. The Outdoor Home Playground Safety Handbook is a valuable reference from the CPSC; this handbook describes how to set up the equipment in accordance with known injury prevention techniques (CPSC, 2010b). The Consumer Product Safety Commission does not conduct home inspections when a playground is purchased. It is up to the buyer to ensure it is put together effectively and safely before a child plays on it. For example, in order to prevent a fall injury, the CPSC (2005) has guidelines for ground material according to the height of the equipment as shown in Table 2.

Table 2: Fall Heights and Depth for Material For Landing Zone (CPSC, 2005)

Fall Height In Feet From Which A Life Threatening Head Injury Would Not Be Expected			
Type of Material	**6" Depth**	**9" Depth**	**12" Depth**
Double Shredded Bark Mulch	6	10	11
Wood Chips	6	7	12
Fine Sand	5	5	9
Fine Gravel	6	7	10

2.4.3 Public Regulations

Public playgrounds have their own set of regulations that are different from home playgrounds. These regulations are not set nationally by the CPSC or the ASTM. The International Playground Equipment Manufacturers Association (IPEMA) ensures that playgrounds meet standards set by the ATSM; however, this is not a regulatory organization. Instead this organization tests the equipment for conformance to the voluntary standard. On the other side of the problem, the National Playground Safety Institute (NPSI) has licensed inspectors who inspect playgrounds to ensure they are installed

correctly. Playground regulations vary from state to state and depend on how the individual state government wants to set forth the regulation. California has the strictest regulations for playgrounds (California Department of Public Health, 2008). California regulations closely follow the CPSC Public Playground Safety Handbook and many of the handbook's suggestions are made mandatory by California state law. California prohibits procedures and equipment that the CPSC deems as "not recommended." Also California ensures that timely and effective inspections by licensed officials occur regularly. While California has the strictest laws surrounding playground safety, other states lack similar laws. Massachusetts, for example, does not have any set standards or regulations currently in place. The Massachusetts state government directs any inquiries regarding regulations towards the CPSC's Public Playground Safety Handbook as well as the National Program for Playground Safety. However, nothing from the Handbook is considered mandatory by law. The CPSC handbook is a voluntary standard that individual state governments can choose to follow or not. In summary, there are no nationwide regulations that govern the equipment on the playground.

2.4.4 Global Standardization

The Consumer Product Safety Commission works diligently with the American Standards of Testing and Material to provide standards to ensure safety. The committee that sets up standards does not only take notice of standards in the United States, they also look into standards in Canada. The ATSM works with the Canadian counterpart the Canadian Standards Association (CSA) to ensure standards that can be set across both borders. The committees will adjust their standards to be relevant to their own countries. If there are no differences in the countries' geographical layout, then they will set the same standard for both countries as one. This can affect Canada when major changes are made and not distributed through the CSA as needed to ensure an equal set of standards across North America.

As for The European Standards, the Consumer Product Safety Commission staff mainly looks at Canadian Standards for harmonization rather than standards from overseas. However, if relevant the CPSC will review specific equipment guidelines in relation to the equipment found in the United States. In Europe the set of standards is called the European Normalization playground safety standards (EN) (Christianson, 2001). These standards govern the fifteen members of the European Union. The standardization of these regulations across Europe has caused some concern due to confusion across the parts of the Europe because of the conversion of measurements and difference in each category. There are other countries around the world that have their own standards; however, more and more groups are starting to accept and look into combining their standards with either American or European standards. The Pacific Rim countries currently do not have set standards for playgrounds but are looking into American standards and how they can be implemented to help protect the public.

2.4.5 Summary

Both public and home playgrounds have voluntary standards and publications from the CPSC that seek to reduce the likelihood of serious death and injury on the playground. Public playgrounds, however, may be inspected by a NPSI certified inspector and the equipment is generally tested by IPEMA to ensure that it follows the voluntary standards and guidance. Home playgrounds, on the other hand, are generally installed on private property, by the homeowner, handyman, or paid installer, and may not receive any type of inspection after their installation. Although public playgrounds are generally certified by IPEMA and may be tested by a certified inspection, there are few regulations that ensure these standards are followed, and what regulations that do exist are generally at the state level. As playground voluntary standards are developed, CPSC staff and the voluntary standards committees consult playground standards in Canada and the European Union.

2.5 Injuries and Deaths on the Playground

Playground injuries are relatively common among children, and it is reported that 47% of childhood injuries result from injuries on a playground (Sacks, 1990, p. 1). The majority of injuries resulting from playground equipment are unintentional; however, there are approximately 200,000 injuries per year that require emergency room visits (O'Brien, 2009, p.5). This section focuses on injuries that are common on playgrounds among children.

2.5.1 Falls

According to a 2001 report, over three-quarters (79%) of all reported playground injuries involved falls from public playground equipment (Tinsworth & McDonald, 2001, p. iii). However, in 2009 it was found that the percentage of falls associated with equipment was reduced to 44% (O'Brien, 2009).The classification of falls ranges from unintentional falls, an incident where a child falls while using the equipment but not by any fault of the equipment, to falls due to weather conditions. Injuries resulting from falling off of or onto equipment include lacerations, fractures, sprains, facial and head bruises, and lower and upper trunk bruises (Macarthur, 2000, p. 3). Weather related falls occur when the equipment is wet and thus becomes slippery. While this factor is responsible for a small percentage of fall types, it can still result in serious incidents.

The majority of fall injuries occur on climbing and upper body equipment. In particular, falls occur most frequently on "monkey bars." Upper body equipment falls are usually more severe than other injuries due to the height from which the child falls. A study conducted in Toronto, Canada, concluded that "falls of greater than 150 cm were associated with a 2-fold increased risk of severe injury, compared with falls from 150 cm or less" (Macarthur, 2001, p.4). Table 3 reviews all equipment and factors that are commonly related with fall injuries. From this table, it is apparent that most falls generally occur on climber equipment (24%) and hanging equipment (57%). Typically, these falls are unintentional (93%) and do not have to do with the equipment being either wet (3%) or dry (97%).

Table 3: Characteristics of Equipment Regarding Injuries on Playgrounds (Macarthur, 2001, p.4)

Environmental characteristics of case and control playground injuries[a]

Factor	Cases (*N* (%))	Controls (*N* (%))	OR 95% CI	*P*-value
Playground site				
Public	31 (46)	31 (53)		
School	29 (43)	24 (41)		
Day care	3 (5)	2 (3)		
Apartment	4 (6)	2 (3)		0.678
Equipment				
Swing	7 (10)	5 (8)		
Slide	6 (9)	10 (17)		
Climbing	16 (24)	24 (41)		
Hanging	38 (57)	20 (34)		0.045
Breakdown factor				
Intentional fall	5 (7)	7 (12)		
Unintentional fall	62 (93)	52 (88)	0.60 (0.18, 2.00)	0.401
Condition of equipment				
Dry	65 (97)	57 (97)		
Wet	2 (3)	2 (3)	1.14 (0.16, 8.36)	1.000
Prior use of equipment				
At least sometimes	63 (94)	57 (97)		
Never	4 (6)	2 (3)	0.55 (0.10, 3.13)	0.684
Prior playground injury				
None	63 (94)	58 (98)		
One	4 (6)	1 (2)	0.27 (0.03, 2.50)	0.370
Adult supervision				
Yes	42 (63)	46 (78)		
No	25 (37)	13 (22)	0.47 (0.22, 1.05)	0.062

[a] OR, odds ratio; CI, confidence interval.

2.5.2 Entanglements and Strangulations

In the 2001 CPSC staff study, over half of all playground related deaths (56%) occur from entanglements and strangulations on the equipment (See Figure 19, Tinsworth & McDonald, 2001). These accidental deaths are typically due to the entanglement of clothing, ropes, cords, or leashes with the playground equipment. According to the CPSC, "Playground slides were most often involved, although climbing equipment and swing sets were also reported" (p. 20). The act of going down a slide can cause a hanging incident if something attached to the child is caught at the top of the slide. Similarly, if a child goes to jump off of a swing at the top of the arch and an item of clothing is wedged in some part of the equipment, unintentional strangulation could occur. The more recent 2009 CPSC study found that 27 out of 40 deaths (67.5%) of deaths were associated with hangings (O'Brien, 2009)

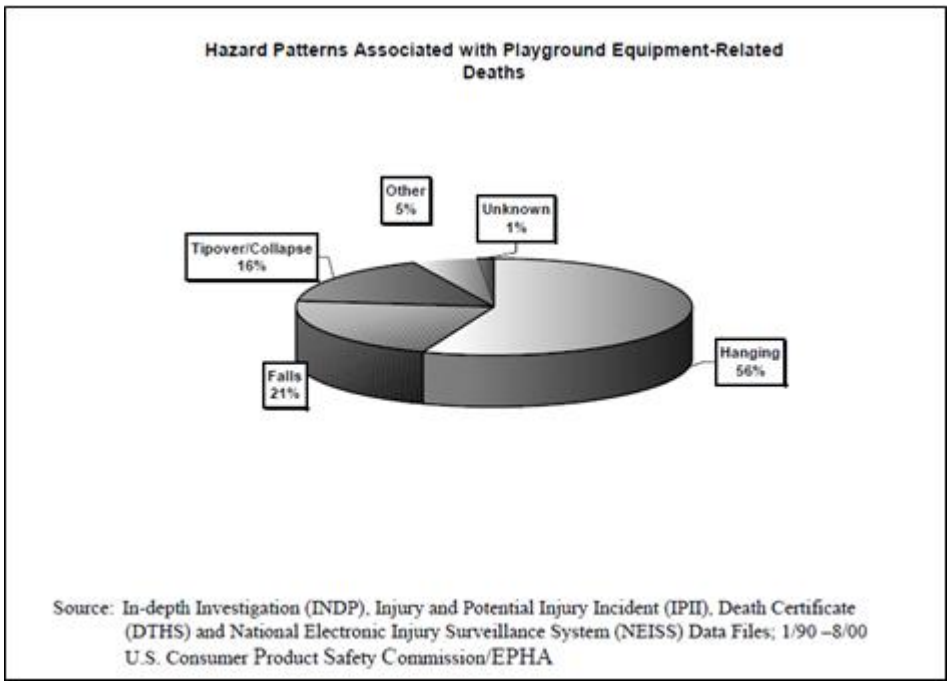

Figure 18: Patterns Related to Playground Deaths (Tinsworth & McDonald, 2001, p. 20)

Clothing is most easily caught on equipment and is one of largest problems associated with strangulations or entanglements. Specifically drawstrings on sweatshirts and scarves can tighten and cause unintentional death (CPSC, 2010, p. 15). Figure 20 provides an example of a warning to parents to remove such articles of clothing for their child's safety. This would usually be placed on the playground in an area where these types of incidents could occur.

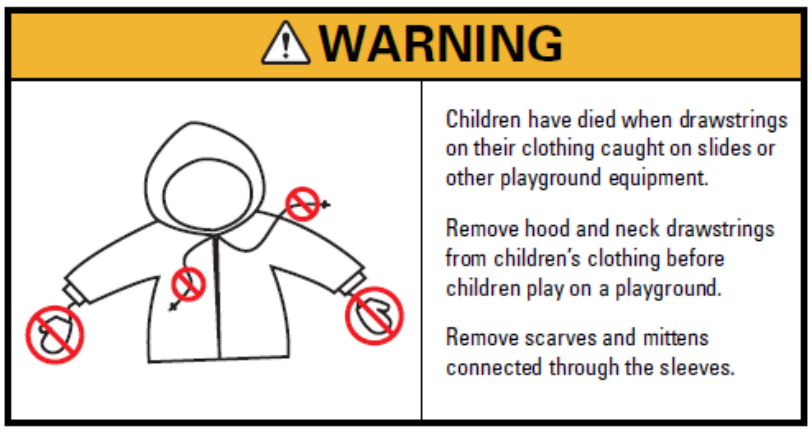

Figure 19: Warning Label for Playground Equipment (CPSC, 2010, p. 15)

While clothing may lead to the most common strangulation deaths, situations involving jump ropes, rope swings, and tire swings have occurred (Tinsworth & McDonald, 2001, p. 21). According to Craig O'Brien of the CPSC, slides are also a common source of strangulation and asphyxiation injuries (2009). Typically this has occurred when a rope or string was caught around the child's head or around the victim's neck.

2.5.3 Entrapments

Of all injuries resulting from playground equipment, entrapment of the head or neck is one of the less common injuries. However, these injuries are extremely hazardous because they can lead to strangulations. As explained by the CPSC (2010, p. 15-16), specifically two types of entrapment are most common: head first or feet first entrapment. Head first entrapment occurs when the child puts his/her head through an opening in bars or ladder rungs and then cannot remove his/her head. Feet first entrapment involves the child fitting his/her body into a space in which their head will not pass through. Another type of entrapment can happen when a child places his/her head into an opening with two bound sides, such as the angle of a fence. These types of situations can be exacerbated if the child is wearing any type of headgear like a helmet. A helmet enlarges the child's head size so that areas that would not normally cause entrapment could pose a threat to the child.

2.5.4 Contact Burns

Burn injuries through contact with playground materials account for few incidents, but are a troubling source of playground injuries. The CPSC (2010, p. 12) recognizes that the use of bare metal in playground equipment poses a risk for burns. Specifically, when the material is in direct sunlight for an extended period of time, the material may retain enough heat to cause severe contact burns. According to Craig O'Brien of the CPSC (2009, p. 5), of 29 reported thermal contact burns, 14 burns were the result of playground surfacing materials.

A study was conducted in Birmingham, UK, where there were two serious burn injuries documented in July 2006 (Strong, 2007, para. 2). During that month temperatures had reached unprecedented highs. In one case, a 19-month-old female was taken to the hospital for burn injuries sustained on her hand, knees, and abdomen. Figure 20 shows the burn injury approximately one hour after the injury was received. These dermal burns covered approximately 3-4% of her body and were severe enough to require a hospital stay of four days. In this occurrence, the child had been playing in a park that had a steel skateboard ramp. As she went to climb onto the ramp, she sustained the aforementioned injuries.

Figure 20: Picture of Contact Burn from Steel Equipment (Strong, 2007, p. 1)

In a second case, a 23-month-old male had been playing in the same park and received deep dermal injuries from the skateboard ramp (Strong, 2007, para. 6). His injuries were less severe than the female's injuries. However, these multiple injury occurrences suggest that the steel on the skateboard ramp was constantly exposed to direct sunlight and retained heat enough to cause deep burns in seconds.

In the CPSC's (2010) *Handbook for Public Playground Safety*, it is identified that a contractor should "avoid using bare metal for platforms, slides, or steps" (p. 12). In fact, it is suggested that if metal

is being used for one of the above options that it should either be covered or placed in such a way that it is not directly exposed to sunlight.

Burns resulting from contact with playground equipment are a serious problem. Many pieces of playground equipment are exposed to direct sunlight. This includes metal swings, slides, roundabouts, and even impact attenuating mats (Wilkins, 2008, para. 10). The temperatures of all of these can be high enough to cause severe thermal burns. Temperatures that extend well over 100 degrees can cause burns in less than a second.

Metal is not the only source of these contact burns. Plastic can also become overly heated. In 2008, a two-year old boy was playing on a playground in St. Louis (Zigman, 2008, para. 7). The boy immediately started screaming as he was going down a plastic slide. The skin on his hands turned very red and started blistering. Every one of his fingers, as well as his abdomen and his legs, received second degree burns. Upon closer examination of the slide, it was found to be at least 100 degrees (para. 4). Replacing the metal with plastic may reduce the amount of burns sustained, but it does not prevent them all. Another incident of a serious burn sustained from a playground involved an eighteen-month old boy in New York (Rosenberg, 2008, para. 11). In 2007, the toddler suffered second-degree burns when he ran out of a sandbox barefoot onto a black rubber mat. The burn was so severe that the doctor's initial diagnosis had been electrocution. This implies that the temperatures were high enough to cause severe burns.

Table 4 shows the types of equipment that children associated with reported burn injuries. This table also shows the relationship between the equipment and the severity of the burn.

Table 4: Thermal Burns Relating to Playground Equipment (O'Brien, 2009, p. 6)

Reported Thermal Burns Associated with Playground Equipment by Type of Equipment and Severity, 2001-2008

	Burn Severity			
Equipment Type	**2nd Degree**	**3rd Degree**	**Not Stated**	**Total**
Climber	1	0	1	2
Pipe	1	0	0	1
Platform	1	0	1	2
Slide	6	0	1	7
Steps	1	0	0	1
Surface	9	2	3	14
Swing	1	0	0	1
Tube	1	0	0	1
Total	21	2	6	29

Source: IPII and Death Certificates Databases, March 2009
Reporting is ongoing for 2006-2008

While these injuries are serious, there are ways to protect from the intense heat. If sun exposure is sufficient to burn children, then bare metal slides should be shaded or located out of direct sun (CPSC, 2010, p.5). Also, warnings should be provided on equipment and surfaces exposed to sunlight. Other sources suggest that this equipment should be placed in the shade, made of non-metal materials, and painted with light colors that help in reducing heat absorption (Strong, 2007, para. 10). Metal playground equipment has long been known to cause burns and playground manufacturers have almost entirely switched to using recycled plastic and rubber products. Metal is an excellent conductor, which is why it is able to transfer heat quickly causing extensive burns. Plastic and rubber are both insulators, which mean that they do not transfer heat as easily as conductors. However, in direct sunlight, these materials can reach temperatures that have potential to burn children. Although many precautions have been taken, children are still getting burned which suggests that more research has to be done in order to make playgrounds safer from the sun.

Another variable to consider when thermal burns are being investigated is the length of time a child is in contact with a piece of equipment at varying temperatures. At higher temperatures, it takes a

short period of time to cause second or third degree burns. The table below shows the relationship between time, temperature, and the severity of the burn.

Table 5: Relationship Between Temperature, Time and Burn Severity (AntiScald Inc., 2003)

Celsius Temperature	Fahrenheit Temperature	2nd Degree Burn No Irreversible Damage	3rd Degree Burn Full Thickness Injury
45°	113°	2 hours	3 hours
47°	116.6°	20 minutes	45 minutes
48°	118.4°	15 minutes	20 minutes
49°	120°	8 minutes	10 minutes
51°	124°	2 minutes	4.2 minutes
55°	131°	17 seconds	30 seconds
60°	140°	3 seconds	5 seconds

Despite this information, there is a lack of research regarding thermal burns and the materials that most frequently cause them. More of the injury research is based on general injuries because they are more prevalent than burns. The CPSC staff reported that the national estimate for the number of emergency room treated thermal burns was too small to report (O'Brien, 2009, p. 5). Although burn injuries don't occur as often as other injuries, they are still a very serious problem and need to be further documented.

2.6 Chapter Summary

With every year that goes by children become more curious with their play, and this causes companies to compete with each other to create more challenging playground equipment to keep children interested. Playground injuries are not uncommon; injuries occur due to many different circumstances such as misuse of the equipment or the material of the equipment. Because it is misclassified, the new equipment can have a poor design or be used in an inappropriate way; this misclassified equipment is often put into the climber category and can pose unforeseen risks. Although

the US works with Canadian standards, there are countries such as Japan that have no standards and are starting to look into adopting US or EN Standards. The attention to burns and injuries caused by playgrounds is a growing concern, and answers are needed as to how and why these injuries happen and what measures can be taken to prevent these types of injuries. The guidelines set by the CPSC are used to try to minimize injury to children, yet burns continue to be reported. The research we carried out provided information on how to classify existing equipment that does not currently fall into an appropriate category and also to provide some information on burns, why they continue to be a problem and what causes them. This type of research is needed by the CPSC in order to improve playground safety as well as for parents who are worried about their children sustaining one of the 200,000 yearly injuries that occur on playgrounds and playground equipment.

3. Goals and Deliverables

The goals of this project were to make recommendations to the CPSC concerning the classification of new playground equipment and to identify standards that would keep the playground equipment safe for children. In order to attain our goals, our objectives for this project were to: determine which types of playground equipment were misclassified; determine why they do not meet other categories' requirements and standards and suggest a new classification system; and determine which materials, specific orientation of the equipment, and other playground equipment criteria cause the most thermal burn injuries.

One of the final products that resulted from our project was a booklet detailing our recommendations for a new playground equipment classification system. This was provided to CPSC staff as a recommendation to possibly be presented to the ASTM subcommittee on a later date. Our other final product was burn injury prevention information that was provided to the general public in the form of a pamphlet and webpage. Also, through this detailed report our recommendations and possible solutions were made clear. Through these deliverables, we hoped to make playgrounds safer for children and provide a sense of clarity regarding classifying equipment.

4. Methodology

The goals of this project were to provide the Consumer Product Safety Commission with new ways to classify "climber" and other misclassified equipment and to identify standards that will keep the playground equipment and children safe. Furthermore, we identified playground equipment and surfacing types that cause contact burns and provided the CPSC with information regarding the burns and the associated equipment. In this section we describe the methods that the team used to collect data. These methods included interviews, observations, and archival research. From the results of our data collection, the CPSC was given final recommendations regarding the "climber" equipment and was presented with the types of equipment that cause the most contact burn injuries and information on how these injuries can be prevented.

4.1 Identifying Playground Equipment Categories and Standards

This section addresses how we analyzed the current manufactured playground equipment and categories that have been developed by CPSC. These methods aided the team in determining which types of playground equipment are misclassified, why they did not meet other categories' requirements and standards, and helped to identify which materials are being used to construct modern playground equipment. By examining the current categories that the CPSC has in place for playground equipment, we were able to develop suggestions for new categories that better classify the existing equipment. Understanding why new equipment does not fit in current categories is key to being able to propose suggestions for improvement of the classification system.

Specifically, using catalogs of equipment provided by the CPSC, we were able to view most of the playground equipment available nationally rather than just examining local equipment in Washington, D.C. These catalogs aided the team in determining which pieces of equipment are misclassified. By conducting archival research about classification categories and injury reports through the CPSC's archives, we were able to obtain information that greatly expanded the scope of the project

and broadened the area the project effects. The CPSC has many documents and reports regarding classification materials. To specify the manufacturing standards regarding playground equipment and surfacing, American Society for Testing and Materials (ASTM) documents were used to provide us with data on how playgrounds are supposed to be set up and what materials are being more frequently used to construct playground equipment according to voluntary standards. In order to gain information on thermal burn injuries, the team used In-Depth Incident Reports (IDIs) which outline the injury and equipment related to the burn. By using these documents, the team better understood the types of equipment involved, the material it was made from, the severity of the burn, and other important factors such as weather conditions on the day of the incident.

4.2 Determine Childhood Behavior Relating to Injuries

By personally visiting playgrounds and examining the equipment first hand, we were able to better understand how the equipment actually works and how the users interact with the equipment. In order to gather information about the children's safety on playgrounds, we used an unobtrusive method of observing. This type of observation occurs when the researcher does not physically interact or make their presence known to the subject (Trochim, 2006, para. 1). By studying children's behaviors on playground equipment we were able to collect data on how children used potentially hazardous equipment and if they acted safely on the equipment. This required us to observe the users on the equipment, while not directly interacting with them in any way. We sat in different areas of the playground and took notes regarding children's behaviors and how they played with the equipment. If they were using the equipment improperly it was noted in our findings.

In order to collect these data, we took pictures of the equipment to document the location and orientation of the equipment. Also, we employed Google Maps to visualize playgrounds through satellite imagery in order to gather information on the directional orientation of slides and other equipment to the sun. Through the use of an infrared thermometer we were able to measure the

differences in temperature between the air, surfacing materials, and equipment in selected playgrounds. By gathering this information we were better able to identify which pieces of equipment have a potential to cause contact burns.

4.3 Identifying Injuries and Playground Equipment Classifications

In this section we will explain how we determined which materials and designs cause the most burns and other injuries. Also, this information provided us with ideas on how to reclassify the playground equipment. Conducting interviews is an integral part of this project in order to gain different perspectives on the problem of classification issues and potential safety hazards. First, we interviewed our liaison, Hope Nesteruk, and other personnel working on playground safety within the CPSC on the subject of playground equipment classification and contact burns. At the CPSC there are many professionals with knowledge on these issues that were good candidates for our interviews. Specifically we interviewed, Marcy Mellors, a compliance officer who deals with the manufacturers for product recalls, Craig O'Brien, a mathematical statistician who previously wrote a report on thermal burns and injury on the playground, and Mark Kumagai, our co-liaison who studied playgrounds for many years. We asked these individuals about their opinions on the current classifications in order to see if they had any positive or negative comments on the process of classifying playground equipment. A sample interview protocol can be found in Appendix C.

Also, we were able to communicate with experts in the fields of playground safety and ASTM standards. We interviewed an ASTM member who also works at a playground manufacturing company, and chairs from a task group chair for materials and signage for the ASTM public playground subcommittee. This task group has recently done some research on burns and finalized a warning sign to alert parents to the potential risks. In addition, we interviewed an independent playground consultant who also is very involved in both the home and public playground ASTM subcommittees.

In separate interview sessions, we interviewed parents on playgrounds to learn if their child has ever received a contact burn or injury on the playground and which equipment the child tends to play on most frequently. We conducted a convenience sampling of the adults at the playgrounds and asked them a set of standardized questions that did not reveal any personal information about them or their child. As a team we interviewed approximately five to ten parents per the 10 playgrounds we visited. We also interviewed parents of different age groups to ensure the data are varied. We visited playgrounds that have varying types of modern equipment to make sure that the parent's responses reflect many types of equipment. A sample interview protocol for interviewing parents can be found in Appendix F. The location of playgrounds was chosen based on the equipment at each playground. Since we were focusing on modern equipment that causes problems with classification, we went through playground manufacturer's websites in order to determine the addresses of equipment in the area. Also, we received suggestions of sites to visit from the interviews conducted at the CPSC. The interviews with parents at playgrounds were completely anonymous as we were only concerned with their responses and not any distinguishing factors. This knowledge was key in determining which equipment and materials are the most hazardous and have the potential to burn or injure children. This greatly aided our team in the decision on how to reclassify different areas of playground equipment.

After completing data collection, we collected important information that aided us in identifying standards for playground equipment safety and determining the most efficient way to restructure the current playground equipment classification system set up by the CPSC. After review of our final recommendations to the CPSC, we hope that playground safety will increase from the new standards that we created and from the standards that will be created and clarified from our new classification system.

5. Results & Analysis

In this section, we discuss the results of our research pertaining to the problems and gaps in knowledge about playground equipment classification and thermal burn injuries. We discuss the injury data we researched, current playground equipment on the market, classification methods and categories, and the data collected from playgrounds. Also, we discuss the results of interviews the team conducted with various individuals.

5.1 Thermal Burn Data Obtained from Databases

In order to determine the materials and the equipment involved in thermal burn injuries, we used the In-Depth Investigation File (INDP) and the Injury or Potential Injury Incident File (IPII) databases to search for In-Depth-Injury Reports (IDIs). These detailed reports explain when an injury occurred, the severity of the injury, the equipment involved, and any other important or relevant facts surrounding the case. These could include police reports, witness statements, hospital records, and pictures of the area involved.

Using product codes for specific genres of equipment and diagnosis codes, we were able to narrow down our search. Specifically we used equipment codes:

Table 6: Product and Diagnosis Codes

Number	Equipment	Product Codes
1	Monkey bars, playground gyms or other playground climbing apparatus	1244
2	Seesaws or teeterboards	1243
3	Slides or sliding boards (excl. swimming pool and ground water slides)	1242
4	Swings or swing sets (excl. portable baby swings)	3246
5	Other playground equipment	3219
6	Playground equipment (not specified)	3273
7	Thermal burns	51

Also, we were provided with a spreadsheet containing the case numbers of all IDIs collected from 2001-2008. From this spreadsheet and our research in the INDP and IPII database, we were able to gather a list of 38 thermal burn reports from 2001-2011. After careful examination of each report, 14 of the 38 reports involved a female child while the other 24 indicated a male child was injured. Ages of the children range from 0-10 years of age. Mainly the reports indicated that younger children (under the age of 3) received burns more frequently. The potential for younger children to receive thermal burns may be greater because they have not learned what to do when they experience pain. They cannot yet understand the difference between hot and cold and what injury could occur if they do touch something hot. Cause and effect responses have not yet been learned. Typically when toddlers and young children are injured, they will stay put and cry until a caregiver checks on them. This action of staying where they are can result in more severe burns.

From these 38 cases, the incidents were further divided into the equipment that contributed to the burn injury. The main equipment that caused burns (21 of 38 cases) was a walking surface. This includes both impact attenuating surfacing, such as mats, “pour-and-play,” and poured in place, and

pathways made of asphalt and concrete, etc. The next piece of equipment that contributed to a large portion of the data (11 of 38 cases) was slides. This was expected because, according to our interviews, this is the most common equipment that parents and caregivers think can burn their child while on the playground. Also, in past years, metal slides were the most frequent cause of thermal burns. Other hazardous equipment that was reported was climbers (2 cases), platforms (2 cases), swings (1 case), and steps (1 case). While many of these types of equipment are self explanatory, climbers can include a wide variety of equipment and materials, of which the exact type was not clearly identified in the IDIs. Figure 18 shows the data with the equipment percentages according to the researched reports.

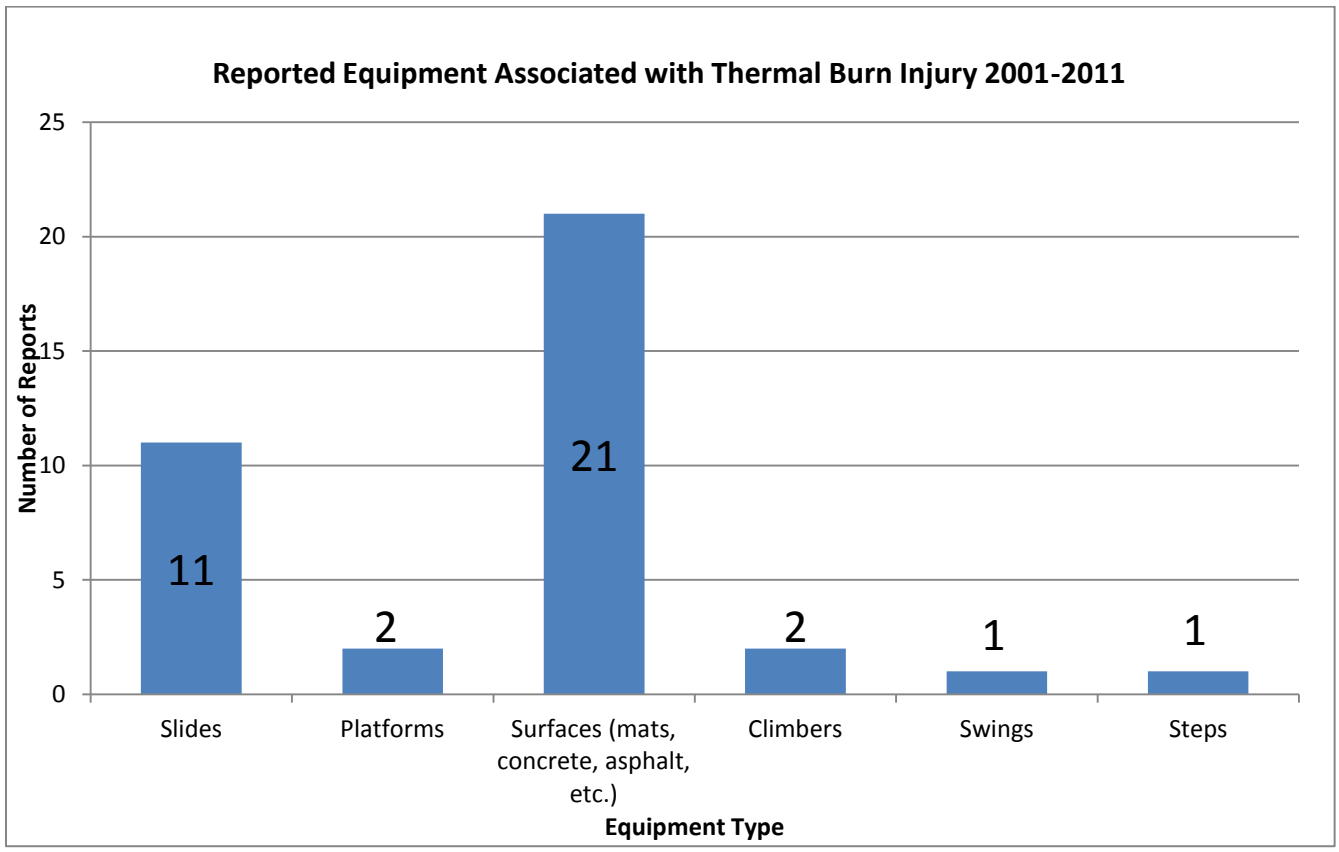

Figure 21: Reported Equipment Associated with Thermal Burns

The material composition of the reported equipment was also determined from these reports. While some of the reports stated that the material was unknown, many other reports labeled the

material as either rubber, metal, plastic, pavement, or concrete. A summary of these findings can be found in Figure 22. Rubber accounted for 24% of the data and was mainly shown as black or dark blue mats for surfacing purposes. Metal accounted for 18% of the data and was used on platforms, slides, and swings. Plastics were the next largest section and this was used in the manufacturing of slides and steps. Concrete and pavement were surface materials on areas such as sidewalks.

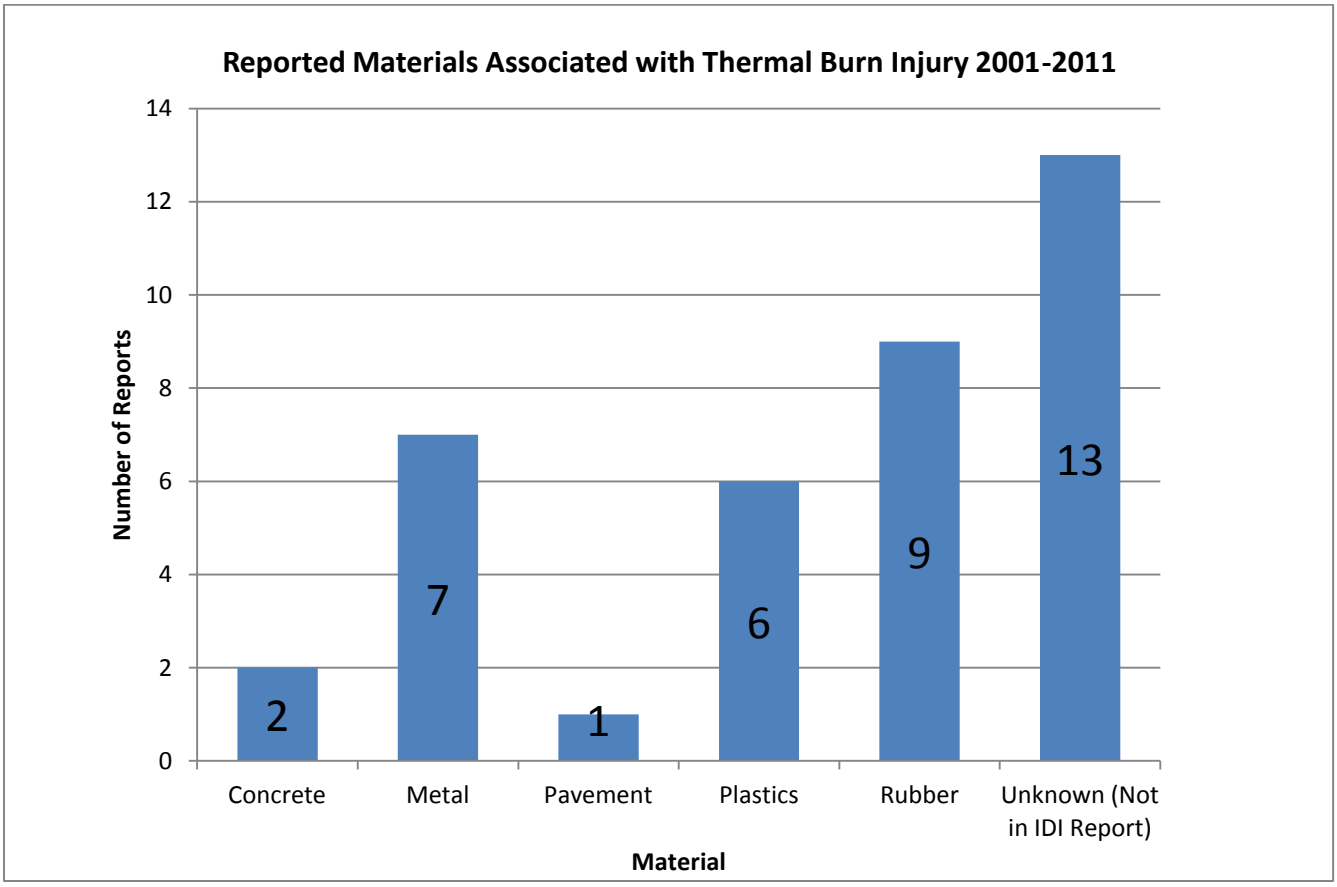

Figure 22: Materials Associated with Thermal Burns

Metal has long been known to cause burns due to its ability to conduct heat and it is strongly suggested by the CPSC that manufacturers avoid using this material uncoated or bare. Currently rubber and plastics are the materials being most widely used for equipment and surfacing needs, and this report finds that severe burns can occur even on these materials. While one purpose of switching equipment from bare metals to plastics was to avoid thermal burns and other injury due to their

lowered ability to retain heat, severe burns still occur as these reports show. Specifically, dark colored mats and equipment were found to have more reported burns associated with them.

While the small number of IDI reports writen over the past ten years have shown that burns are not a frequently occuring injury, they are still severe and can cause great bodily harm to a child. It is important for children to experiment with equipment and make mistakes, however it is more of an importance for them to fail safely. Thermal burn injuries are not usually a result from a child's behavior and thus need to be researched more fully by manufacturers of the equipment. Materials and equipment choices need to be made that will reduce the risk of these types of injuries.

5.2 Catalogs

In order to determine the range of playground equipment that is currently available, we examined sales catalogs of several popular playground manufacturers. While examining these catalogs we recorded several characteristics of each piece of equipment. These included a description of the equipment, the material that the equipment was made of, the category the manufacturer placed the equipment in, and whether or not the equipment appeared to be in the correct category according to its function.

After looking at all of the available catalogs, we discovered that most of the equipment was properly categorized by the manufacturer. However there were pieces of equipment that were incorrectly placed or were in a generalized category. As decided upon by the team, there were two main reasons why a piece of equipment needed a new or more defined category. In the first case, the equipment varied slightly from the presently established categories. In this situation the equipment had the same function and intended use as equipment found in the appropriate category; however, it was missing an element that allowed it to fully be placed in the appropriate category. In the other case, a

proper category did not exist. Some new equipment was designed in such a way that it had a different intended use than that of any other category of playground equipment currently seen.

After determining which pieces of equipment needed a new category, we grouped the equipment with respect to similar functions. As shown in detail below, we identified seven types of equipment that were not properly categorized.

5.2.1 Spinning Overhead Hangers

Spinning overhead hangers function by having children hold a handhold that is above their head and hang while the equipment rotates. An example of a spinning overhead hanger can be seen in Figure 23. This currently falls into the climber/upper body category, but the climber category does not address the spinning motion of the equipment. As a result, the guidelines for this piece of equipment may not fully encompass the hazards associated with the equipment.

Figure 23: Spinning Overhead Hanger

5.2.2 Gliders

Gliders are similar in function to slides, but they do not have proper side walls or transition platforms that would designate a true slide and therefore, manufactures do not categorize them as slides. An example of a glider can be seen in Figure 2. Because gliders do not fit in the slide category and

are dissimilar to equipment in all other categories, they are designated as climbers. Climbers have guidelines associated with them that do not protect from the hazards of slides.

Figure 24: Glider

5.2.3 Single person spinners

Single person spinners are most closely related to the function of merry-go rounds due to the fact that both types of equipment spin. However, single person spinners function in a different manner than merry-go rounds and do not meet the ASTM standards for merry-go rounds due to the differences in design. An example of a single person spinner can be seen in Figure 25. This equipment is currently categorized as a climber, but the climber category does not address the hazards of spinning motions.

Figure 25: Single Person Spinner

5.2.4 Standing Seesaws

Standing seesaws are similar in function to standard seesaws, but are used by children in a standing position. An example of a standing seesaw can be seen in Figure 26. These are currently categorized as a seesaw, but this category does not have guidelines that are necessarily appropriate for a standing child.

Figure 26: Standing Seesaw (Raj Equipment, 2011)

5.2.5 Multi Level Balance Beams

Multi level balance beams are balance beams that have two or more segments at different elevations. An example of a multi level balance beam can be seen in Figure 27 below. Because there are multiple levels to the balance beam, it may require different consideration for fall height than if it were treated as a single level balance beam.

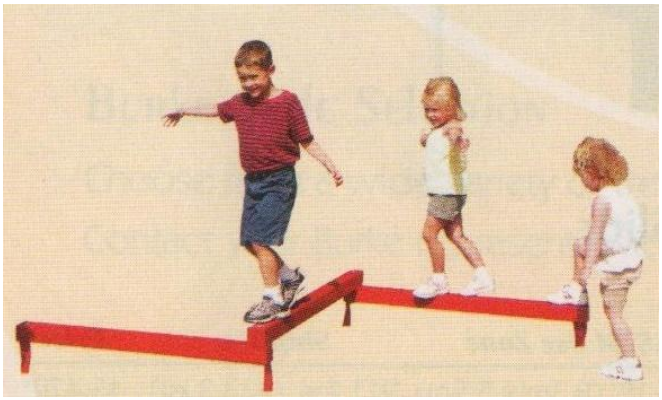

Figure 27: Multi Level Balance Beam (Burke, 2010, p. 102)

5.2.6 Motion Balance Beam

Motion balance beams are similar to balance beams in function, except that the beam is designed so that it rocks laterally as the child attempts to walk on it. An example of a motion balance beam can be seen in Figure 28 below. Because motion balance beams rock as the child attempts to cross them, there are additional hazards present that are not present for all balance beams.

Figure 28: Motion Balance Beam

5.2.7 Inclined Roll

Inclined rolls have a similar function to log rolls in that children stand on them and run while maintaining balance. An example of an inclined roll can be seen in Figure 29 below. This type of equipment does not fully fit into any current category and as such will have unaccounted for hazards associated with it regardless of which current category it is placed in.

Figure 29: Inclined Roll (PhinneyWood, 2009)

5.3 Interviews

One of the ways we collected additional data about the current classification system and burn injuries was by conducting interviews. In order to gain different perspectives on the matter, we contacted three different types of people. We spoke to CPSC personnel, parents, and manufacturing and ASTM professionals. By doing so, we gained information from people across the field.

We conducted several interviews with personnel within the CPSC. A sample interview protocol for CPSC personnel can be found in Appendix C. The first interview conducted was with Mark Kumagai. He is the Division Director for Mechanical Engineering. Mr. Kumagai is part of a technical group working in the lab within the Engineering Science Directorate. Another interview we conducted was with Marcy Mellors. Ms. Mellors is a compliance officer who handles cases including all equipment types excluding slides. As a compliance officer, she finds the failures within equipment, how it could potentially cause an injury, and improves the safety of the equipment. She works closely with technical staff and over time has come to believe that modern equipment does not fit into the ASTM standards. The final CPSC employee we interviewed was Craig O'Brien. Mr. O'Brien is a hazards analysis statistician who specifically works with chemical hazards. In the past he worked closely with the subject of playgrounds and wrote a report about playground injuries.

We conducted two interviews with ASTM members (See appendices D and E for interview notes). The first interview was with a playground manufacturer and task group chair for materials and signage for the ASTM public playground subcommittee. He focuses on compliance standards and equipment categorization. The other interview we conducted was with a playground design and safety consultant who consults with playground designers to ensure that they follow ASTM and CPSC safety standards for residential and public playground equipment. She is also vice-chair of an ASTM subcommittee responsible for the development of ASTM F15.29.

Our final set of interviews was conducted with 20 parents and caregivers at playgrounds. Parents and caregivers are the ones who watch over their child as they play on the playground. They typically become witnesses to injury or equipment misuse by children. By speaking to parents on the playground, we were able to see their point of view and gain information about their opinion on equipment and childhood injury. The only personal information asked of them was the age of their child. A sample interview protocol for parents is located in Appendix F.

5.3.1 Categorization and ASTM Safety Standards

The consensus amongst those who are familiar with the current playground equipment categorization system is that it needs to be updated. Mr. Kumagai noted that the system has not been updated in a long time and that, while the classifications have remained static, playground equipment has evolved greatly. Mr. O'Brien believes that the system is inconsistent and needs improving. Our contact who is on the ASTM public playground subcommittee believes a new classification system would increase the safety of children through more clear standards. He says that he has seen free standing boulder products that have characteristics of a climber and would not easily fall into another category. The areas at the top of the equipment would be considered the platform, but there are no barriers to prevent falls. Finally, the playground consultant we interviewed is also of the opinion that the current classification system needs to be improved upon. The Public Playground Safety Handbook has been adopted as law in a number of states which means that, in those states, every recommendation in the handbook is mandatory. However, the categories are too restrictive. New equipment does not fit into the standard categories or subcategories. With respect to the ASTM Safety Standards, she believes that the safety standards are not in need of improvement. This is because the current standards have eliminated all major causes of death and seriously debilitating injuries. The standards and guidelines should be less restrictive in order to increase design creativity and allow for more challenging equipment.

When parents and caregivers were asked if they liked or disliked certain characteristic of playgrounds, answers were varied due to personal preference. However, some pieces of equipment or playground features were common among their answers. For example, at the Park A, the parents interviewed appreciated the fact that there was a wide variety of equipment, but they expressed concerned with the safety of a climbing net structure and a section of fence that was open by concrete ledge. Across all playgrounds visited newer equipment that the parents were not personally familiar with and had never used when they were children was usually the main area for concern. It was noted that the parents did not know what the equipment was called or how to properly use the equipment. According to the parents, there was no visible sign showing proper use or even the name of the equipment.

5.3.2 Thermal Burn Hazards and Suggested Solutions

Each of the people we interviewed with respect to thermal burn hazards noted that, while thermal burn injuries are serious, they do not have a high rate of occurrence. Mr. Kumagai noted that the cases he is familiar with dealt predominately with children burning themselves on slides. Ms. Mellors stated that she has only seen one or two reported cases in the year that she has been working as a compliance officer. One of the reasons she gave for there being so few cases was that metal slides have been taken out of playgrounds and have been replaced with plastic slides. This supported what we had already researched. While plastic does get hot in direct sunlight, it does not transfer heat as quickly as metal and therefore does not cause burn injuries as often. Both ASTM involved individuals we interviews pointed out that young children do not have a cause and effect response that is as quick as older children. This will cause them to stand still on a hot surface, resulting in an even more serious burn. The playground consultant believes that the parents are at fault in these cases for not ensuring that their children have appropriate footwear and that the equipment they are using is an appropriate

temperature. Older children are aware of the risk and check the temperature on their own, but young children do not have enough understanding of the potential for injury to check for their own sake.

We asked the interviewees if they had any suggestions relating to reducing the rate of thermal burn injuries. Mr. Kumagai suggested looking into ways to notify parents of the potential danger. Mr. O'Brien, similar to Mr. Kumagai, suggested using signs to help prevent burns from playground materials. Preventative measures that our contact on the ASTM subcommittee for public playgrounds discussed included using light color materials, properly shading the equipment with hoods or trees, and orienting the equipment away from the sun. While these solutions are mentioned in the CPSC handbook, he said that the solution the ASTM subcommittee arrived at was parent notification. In the subcommittee's opinion, a warning sign alerting parents to the hazards of burns should be posted in accessible areas of the playground. This is because, as the playground consultant pointed out, attempts have been made to determine what air temperatures cause equipment to be hot enough to burn, but there are too many variables for a temperature to be determined. The suggestion of alerting parents to the danger was emphasized after talking with parents. Most were aware of the hazards of this injury, but many did not know that it could occur on a mild temperature day. Many parents knew about the danger of slides placed in the sun but few thought of surfacing reaching temperatures hot enough to burn their children. From these questions, it is apparent that the parents are aware of the problem to some degree, but they do not know when or on what equipment thermal burns are most common.

5.4 Playground Data Collection

The main element of data collection the team completed was at a variety of playgrounds in the area. In traveling to these playgrounds we hoped to gather information regarding the equipment, temperatures, and childhood behavior. In looking at the equipment we wanted to know how children interact with the equipment as well as if it is being misused. We also wanted to learn about

temperatures at the playgrounds in regards to thermal burns and how surfaces react to sunlight in different directions.

The playgrounds we visited were selected for specific reasons. Through suggestions made by CPSC employees and parents, we were able to compile a list of eleven playgrounds in the area. Specifically we were looking for playgrounds that had modern equipment that was classified as a "climber." Appendix G shows the overall locations, addresses, and satellite views of the playgrounds we visited.

5.4.1 Playground Equipment Findings

At each playground we took numerous pictures of the equipment and also examined each piece of equipment to determine its function, how the consumer would use the equipment, and interpret any possible misuses. With most of the equipment we saw, we were unable to place it in a category because we believe that the existing classification system is not specific enough.

The first playground we visited was Park A which was installed in September 2011. Most of the equipment on this playground would be categorized as "climbers" because it had many elements that did not fit into other categories. While the flexible net in Figure 30 is currently classified other equipment, like the upper body spinner, while extremely different in design, would be classified as a climber.

Figure 30: Three-Dimensional Flexible Net Climber

The structure of the net is similar to a spider web. As shown in Figure 31 the netting is interwoven and has many layers to it. As with similar structures, the main type of injury that can occur is a fall or entanglement. These nets are accounted for in a 3-Dimensional Matrix Net category under the current climber category.

Figure 31: Net Structure

The overhead spinner, Figure 32, is used by one's upper body to grab and hold onto; therefore it fits into the climber category. The problem with this is that just being classified as a climber doesn't help

with setting the proper guidelines to keep children safe. This piece of equipment is unique in that it uses one's upper body but has aspects of a merry-go-round as well. Figure 33 shows the effect of motion on a person's body. Making a new sub-category for the climbers and giving it a combination of climber and merry-go-round guidelines to follow would best ensure the safety of children for this piece of equipment; this sub-category could be called rotational hangers.

Figure 32: Overhead Spinner and Surrounding Surfacing

Figure 33: Overhead Spinner Function

A rotational climber that was continually brought to our attention was the piece of equipment shown in Figure 34. The wheels are attached to a horizontal pole that are elevated and will rotate when

ones weight is put on a side of the wheel. From observations of children on the playground, these are used like monkey bars, but may also have injury patterns from the spinning motion that would not be seen on monkey bars. This piece of equipment would also fit into the suggested sub-category rotational hangers along with the overhead spinner pictured and previously discussed.

Figure 34: Rotating Upper Body Equipment

Another type of equipment we came across at playgrounds are spinners that are meant for single person use. These perform the same function as a merry-go-round, which is to spin on a single axis. Figure 35 shows the spinner discussed above. This spinner relies on people using their mass to propel them around the axis. The same motion is used for the spinner shown previously in Figure 25 and the one shown in Figure 35. Although these fit into a merry-go-round category, the best solution would be to make a sub-category for single person spinners to help better formulate guidelines and standards

for this equipment. While different from true merry-go-rounds, single person spinners can employ some of the same ASTM standards as the merry-go-round category.

Figure 35: Single Person Spinners

A piece of equipment that CPSC employees expressed concern about was a new type of slide called gliders. These slides have characteristics of slides but the manufacturers tend to classify them as climbers. Figure 24, shown previously on page 54, shows the glider and Figure 36 shows an informational sticker representing the correct way to use this equipment. This glider is supposed to be used by straddling the slide and using one's balance to maneuver down the chute. There are classification problems with this slide because it doesn't meet requirements set forward by the ASTM for slides. These deal with the issues of a hood to guide users into a sitting position and the need for walls to prevent lateral discharge. Creating a new sub-category for a slide and having a new set of

standards will help to minimize injury to children. The category could be called balance slides and would take into account banister rails which function similarly to gliders.

Figure 36: Proper Use Notification

While researching playground manufacturer equipment catalogs, a rotating structure that the child stands on, shown in Figure 29, caught our attention. This is a mix between a merry-go-round and a log roll. It's used to promote the development of balance in a fashion similar to a log roll. On the structure, the user runs along the surface to cause the platform to move. Standards would need to be created in terms of speed, height, and angle. This type of roller would fit into the sub-category of inclined rollers for the log-roll category.

While looking at a new playground which was recently installed in the Northwest section of Washington D.C. we found equipment that would not be able to be classified in the current system. A piece of equipment classified as a single person spinner, shown in previously in Figure 35 is the same concept as the spinners described earlier in which they are meant for one person to rotate themselves

around using their own force. Another piece of equipment that was improperly classified is a balance beam-like structure, which is shown in Figure 37.

Figure 37: Tilted Balance Beam

This structure is a platform which sits on an inclined plane and can rotate a certain amount of degrees depending upon where the user places his/her weight. This equipment is used to promote balance in children and functions like a balance beam and climber. If a sub-category of inclined beams was added to the current category for balance beams then this equipment would fit into that group. Realistically it will be very challenging for any child regardless of age or experience to walk up this equipment. When testing this equipment ourselves, we had to use both our arms and legs to promote balance and in order to prevent a fall (Figure 38).

Figure 38: Testing of the Tilted Balance Beam

5.4.2 Observations

The main portion of our observations was recorded at Park C. Instead of testing the equipment and taking pictures, we observed children and their interactions with each other and the playground equipment. The playground was heavily populated which prevented us from getting pictures of the equipment without alarming parents. While observing, we saw children falling off the modern equipment more often than on the older equipment. However, the children were not seriously hurt and we believe this is why children must be allowed to fail safely in order to recognize mistakes. We also observed many misuses of equipment such as children climbing on structures they were not supposed to and climbing up a slide rather than riding the slide down. Parents were cautious when it came to newer equipment and knew when to set limits for their children but still let them experiment in order to learn and develop skills.

5.4.3 Misuse of Equipment

Mainly, our concern regarding injury was the misuse of equipment. We made sure to take note of any misuse of the equipment and witnessed an interesting observation. With wooden playgrounds, such as the one shown in Figure 39, it appears that there is less misuse then on metal playgrounds. This is due to the fact that wooden playgrounds are made in such a way that there is not as much room to

interpret the function of the equipment. The limitations of the material prevent certain designs from being made. With metal playgrounds they tend to be a lot less constricted by design aspects and thus there are more possibilities to explore and use the equipment in manners it isn't designed for.

Figure 39: Wooden Playground in Germantown, MD

Playground misuse also causes the equipment to wear down quicker and be more of a hazard for children. As shown in Figure 40 and Figure 41, equipment misuse and poor maintenance can affect the equipment. In this figure the ball joint used to keep the net secure and in place is not in place. This type of problem can lead to fall issues because the net is not as tight as it would be if the ball joint was in place. On other playgrounds we saw many cases where the surfacing had been depleted or worn out (Figure 42). While this is mainly a maintenance issue, it does cause a problem because if there is no material to absorb shock, then children are more likely to get injured from a fall.

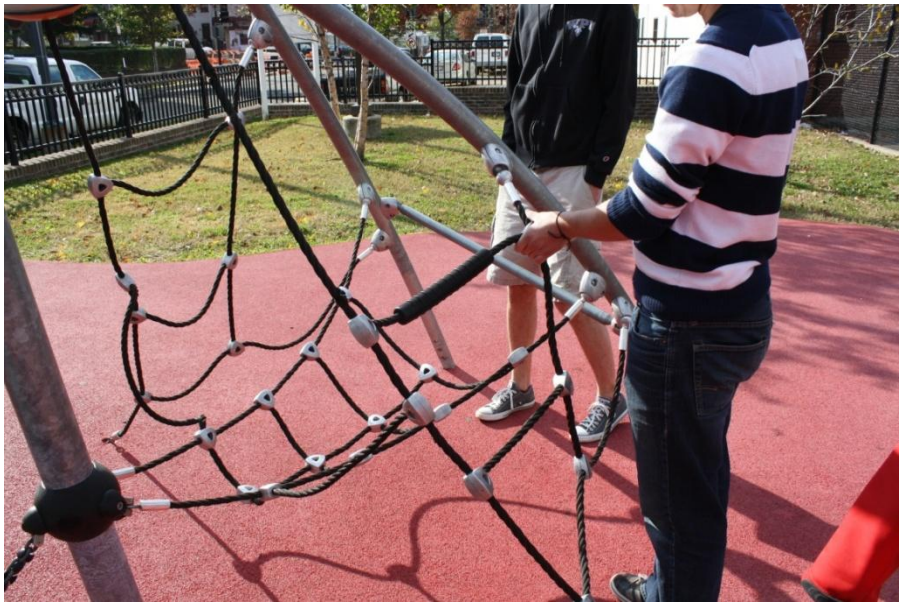

Figure 40: Poor Equipment Maintenance

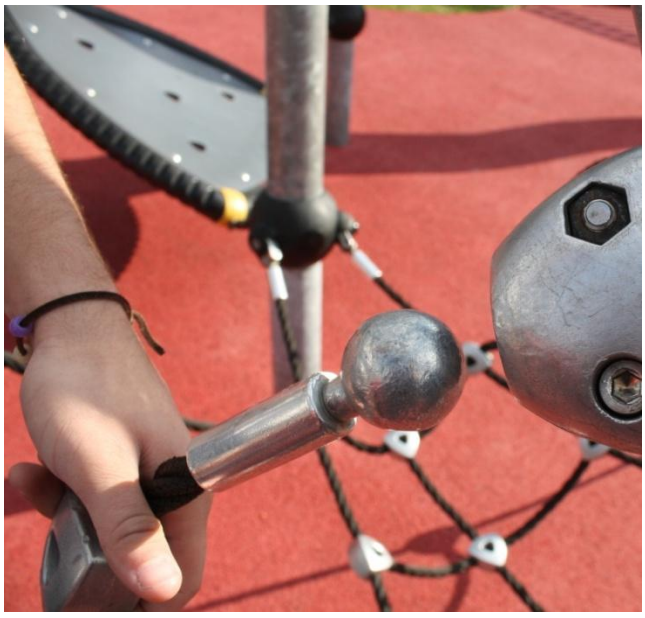

Figure 41: Ball Joint Removed due to Poor Maintenance

Figure 42: Worn Out Surfacing Around Swings

5.4.2 Temperature Measurements

Contact burns on playgrounds are caused by excessively heated surfaces. To determine which pieces of equipment are likely to succumb to excessive heating, we measured and recorded six attributes of the equipment we observed. These six attributes included a description of the equipment, the ambient air temperature, the temperature of the surface of the equipment, the material used to construct the equipment, the orientation of the equipment, if applicable, and the playground at which each piece of equipment was found.

After we had collected all of our measurements we analyzed the results to determine if specific colors, materials, equipment types, or orientations led to hotter equipment temperatures. This analysis was performed by first determining the difference in temperature between each piece of equipment and the air temperature at the time the measurement was taken. The data were then sorted for each factor of comparison. After the sorting, the average temperature difference for all equipment with that factor was taken and the results were collected in a chart.

Color

After comparing the temperature difference of the equipment we observed in reference to equipment color, we determined that yellow and red colored equipment were the warmest equipment that we measured, as can be seen in Figure 44. However, on average all equipment colors apart from silver (bare metal) were found to be warmer than the temperature of the air. Further, there was only found to be a ten degree difference between the tan and red colored equipment. Because this difference is so small, no conclusion can be accurately drawn about a specific color being more likely to cause burns than any other color.

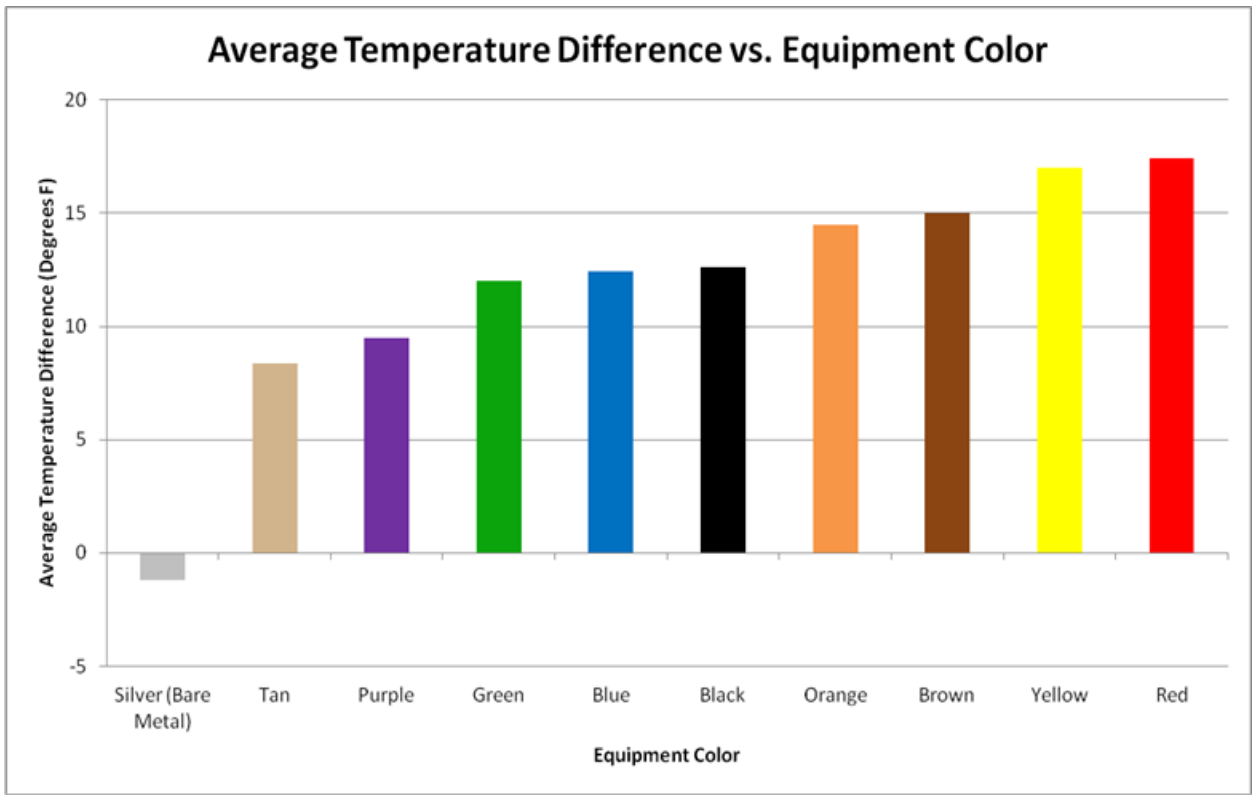

Figure 43: Average Temperature Difference vs. Equipment Color

Material

Different materials absorb different amounts of energy from the sun. As can be seen in Figure 44, equipment that was the hottest due to the sun was generally made of rubber or plastic products. Meanwhile, materials such as brick, cement, and asphalt were found to be the coolest of all. Metal was

not the hottest of all the materials, but this may be because of the outside air temperature and the fact that this material does not retain heat well.

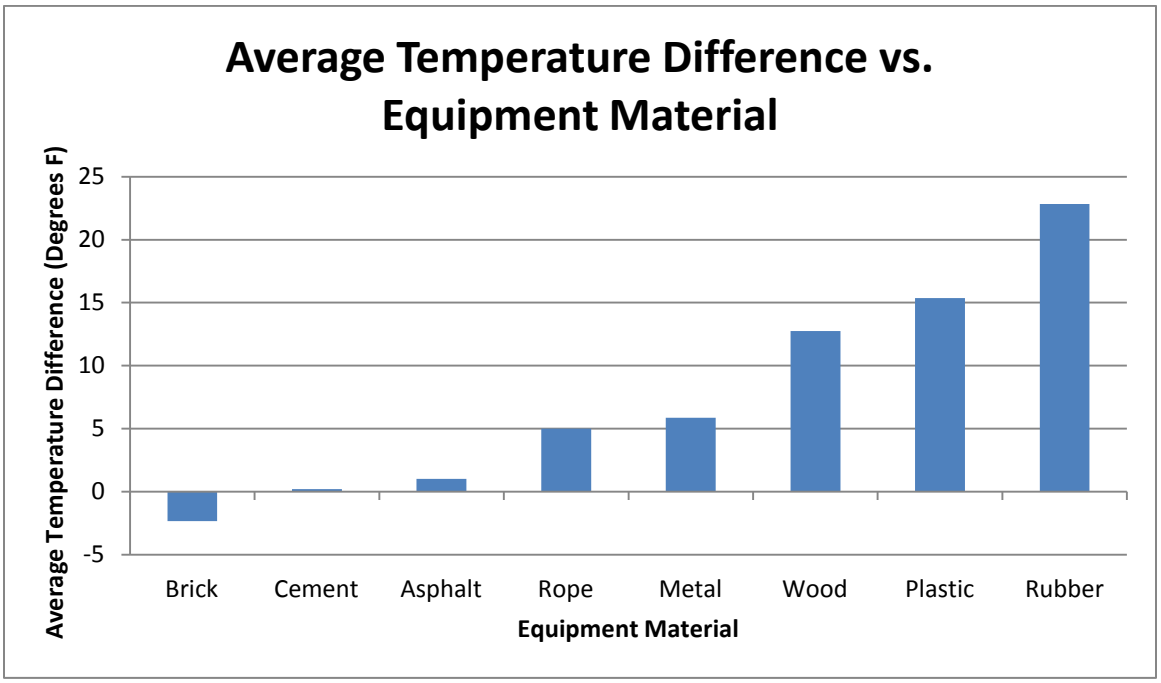

Figure 44: Average Temperature Difference vs. Equipment Material

Equipment Type

We sorted the data based on equipment type in order to determine if any specific type of equipment would be more prone to excessive heating than any other. As can be seen in Figure 45, slides and protective surfaces were found to have the greatest average temperature difference. This result is due to the fact that slides and surfaces generally have the greatest surface area and are therefore the most exposed to the sun. Further, slides and protective surfaces are often made of plastic or rubber, which were also found to have greater temperature differences than other materials.

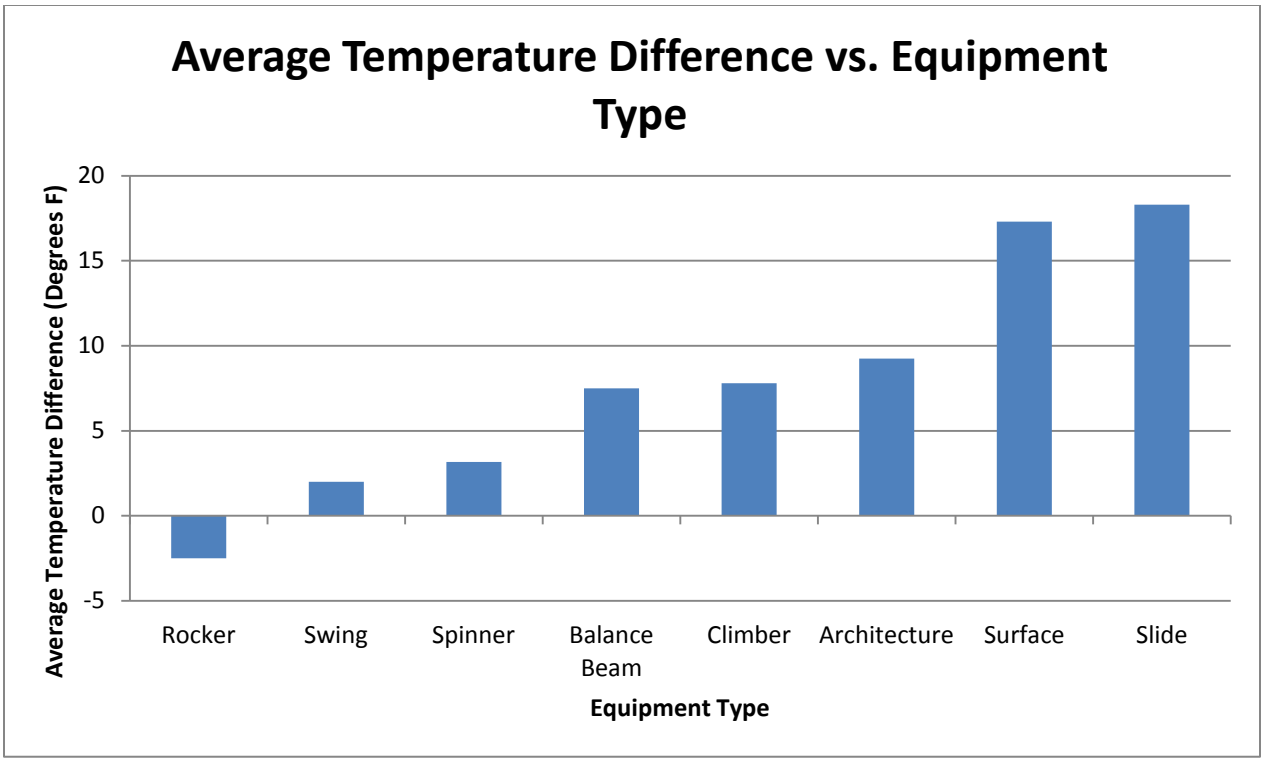

Figure 45: Average Temperature Difference vs. Equipment Type

Orientation

The angle of the sun's rays was found to be another contributor to heating of playground equipment. Of all the equipment observed, pieces of equipment that were facing east were found to be the warmest. Figure 47 shows that all observed orientations apart from the east orientation had approximately the same average temperature difference while equipment facing east had a greater average temperature difference. This may be a result of the sun predominantly being in the east at the time of the measurements (mornings in the fall at mid-latitudes). Equipment that was facing east experienced the most direct sunlight at the time and therefore gained the most heat. Meanwhile, equipment that was not facing east received less direct sunlight and was not given as much heat.

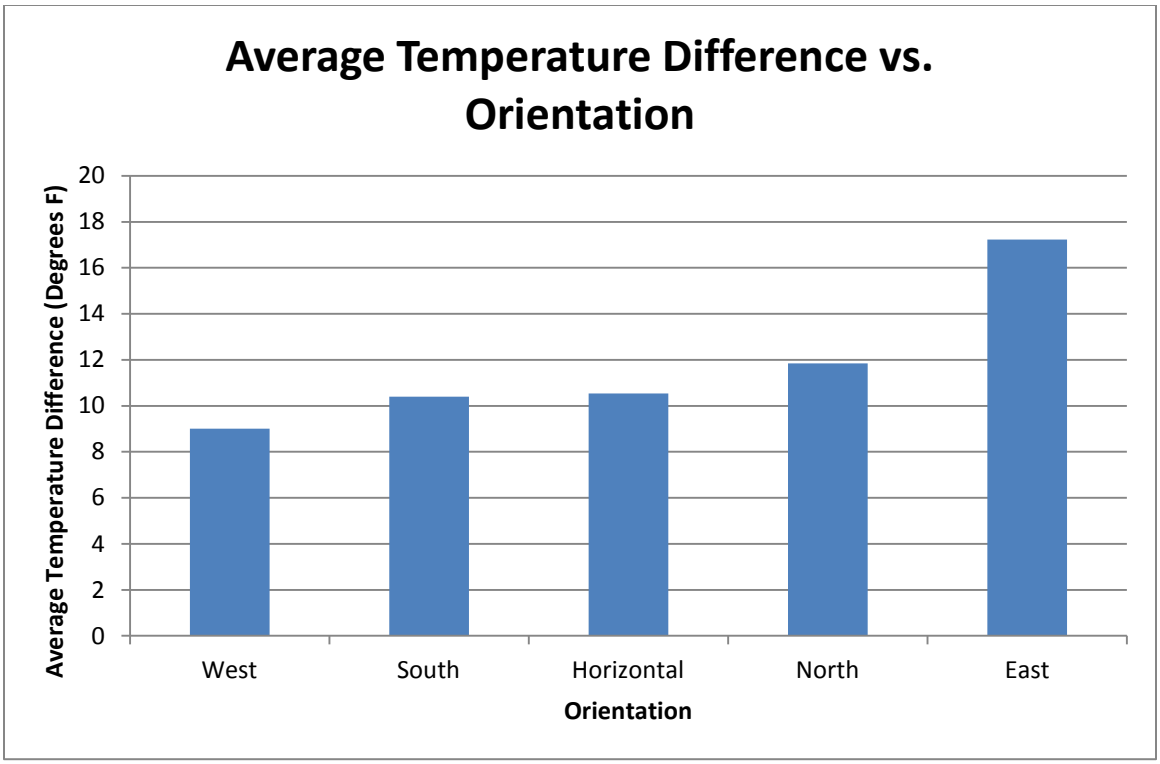

Figure 46: Average Temperature Difference vs. Orientation

Summary

After analyzing the data we collected we were able to make conclusions regarding which aspects of equipment led to hotter temperatures. We found that the color of the equipment does not play a significant role in the increase in temperature of the equipment. We determined that equipment made of rubber and plastic materials are more likely to be hotter than others. We also found that slides and protective surfacing, which are made of plastic and rubber, were the hottest types of equipment. Finally, we determined that east facing equipment is generally warmer than equipment facing other directions.

6. Conclusions and Recommendations

The purpose of this project was to research the current classification system of playground equipment and determine whether or not a new classification system was needed. We have also researched thermal burns resulting from contact with playground materials and what injury patterns are associated with these burns. We collected data from CPSC injury databases, visiting playgrounds, and interviewing professionals as well as parents. After completing our research, we analyzed the results in regards to playground equipment, and burn information and statistics. From this study, we have formed the following conclusions and recommendations for the Consumer Product Safety Commission staff.

6.1 Conclusions

The following conclusions are based from the data that was collected from archival research, interviews, and visits to playgrounds. From these methods we drew conclusions for both playground classification issues and thermal burn injuries.

6.1.1 Classification system

Based on the data collected from manufacturer equipment catalogs, manufacturers mainly classify the playgrounds equipment and accessories correctly. There were, however, several types of equipment that we were not able to be placed into categories and were classified either incorrectly or generically as a climber. An example of this is the Board Climber which can be found in Appendix H. It is classified as a climber, but it does not clearly state how the equipment functions or the proper safety protocol for this type of equipment.

We have concluded that there is a need to make amendments to the current classification system because the current system does not account for the newer type of equipment that is being created by manufacturers today. With this new classification system, the CPSC should work in conjunction with the ASTM in order to make more detailed standards for the new categories. A reason for this new classification system is that when we visited the playgrounds, we saw equipment that we

could not accurately categorize based on the current classification system. One example of this is the spinning overhead hanger we found at Park A. As we stated in section 5.4.1, it uses one's upper body strength but also has aspects of a merry-go-round. Therefore, it cannot properly fit the safety standards of a regular climber. Another example is the glider. As also previously stated in section 5.4.1, it does not meet the requirements set by the ASTM for slides. This is another safety hazard for children. Creating sub-categories for equipment that cannot be properly classified will help the playground area be safer for children.

6.1.2 Burns

In searching through IDI reports derived from the incident databases, we found 38 reports relating to thermal burns and burn injuries over the past ten years. However, the number of reports investigated since 2001 are relatively few compared to the large amounts of other injuries that are reported annually. From this we can conclude that thermal burns are not a frequent issue, but they do result in serious injuries. Besides the small amount of reports collected, some of the reports did not provide sufficient information which material or manufacturer was involved. Surfacing, slides, and platforms accounted for the largest portions of the equipment involved. These are pieces of equipment that children are most likely to come into contact with and thus need to be monitored more carefully. From the other data collected, the team was able to infer that rubber and plastic equipment are becoming more susceptible to cause burns due to the fact that metal slides and equipment are being replaced with equipment made from these materials.

From speaking with parents of children on playgrounds, it was apparent that they were not aware of all the risks relating to thermal burns and playground equipment. From this finding we were able to conclude that parents need to become more aware of the dangers that their children may face before any injuries could be prevented. Parents of younger children need to be especially careful because these children have not yet learned how to react when they feel pain which could lead to a

more serious burn occurring from their inaction. As noted when analyzing IDI reports, many of the children involved were under the age of three when the thermal burn incident occurred. In general, we concluded that parents must take responsibility for their child's safety on playground equipment. Being aware of the hazards that hot equipment may pose will hopefully ensure that parents are proactive with their child's safety relating to thermal burns.

Four aspects of playground equipment were examined in order to determine the features that cause equipment to become hot. The first aspect examined was the color of the equipment. It was determined that the color of the playground equipment does not play a significant role in causing equipment to heat up. The material of the equipment was found to be an important factor in the thermal interaction with the sun. Pieces of equipment made from rubber and plastic are the most likely to be at higher temperatures. Similarly, the type of equipment was found to be important. The hottest equipment observed were slides and surfaces which were made from plastic and rubber. Finally, the orientation of the equipment was found to be very significant. Equipment facing the sun, notably east or west, were determined to be the most likely to be hot. Meanwhile, equipment facing north or south does not receive direct sunlight and was less likely to be hot.

6.2 Recommendations

The following section details the recommendations that we are making to the Consumer Product Safety Commission staff. Our recommendations are based upon the conclusions that we drew from research through the injury databases, interviews, and data gathered from playgrounds and playground equipment catalogs. These recommendations are also based upon the known hazards associated with playground equipment and the current safety protocols associated with each category of equipment.

6.2.1 Classification System

Recommendation 1: In order for the CPSC staff and manufacturers to continue classifying playground equipment in the most efficient and appropriate manner, the current classification system for playground equipment should be amended because the system is insufficient and too outdated to cover modern equipment that could have new hazards associated with it.

After looking through the catalogues and the current classification system it was clear that the current system was outdated and needs to be changed to fit modern play equipment. We developed recommendations to improve the classification system to adapt to the new equipment. We saw that in order to improve the system we needed to add sub-categories to the current categories to cover the newer equipment. In creating the new categories we looked into the equipment as it is intended to function as well as the way children use it. Our final deliverable booklet, which is not shown in this report due to its government approval status, details all of the new categories in a condensed version of this report.

When looking at slides, we came across innovative types of slides that were misclassified due to manufacturer design. Equipment such as gliders and banister rails currently are misclassified but would fit into a sub-category called Balance Slides. Balance Slides would encompass all slide-like equipment which requires its users to use their balance to get them safely down the slide. When looking at the standards we decided it was best to use the current slide standards, but to also adjust them as needed. We would recommend using the following ASTM standards which can be found in ASTM F1487 pertaining to playgrounds for public use: 8.5.2.3, 8.5.3.1, 8.5.4.1, 8.5.5.1-8.5.5.3, 8.5.5.5, 8.5.6.1-8.5.6.2, 8.5.7. The previous standards refer to slides and clearings (2001, p. 10-11). Table 6 shows recommended current standards for Balance slides. We would personally recommend standards being set specifically for slope angle as well as basic slide design to help avoid lateral discharge and injury.

Table 7: Recommended Current Standards for Inclined Balance Slides Sub Category

Balance Slides:

ASTM Standard	Adopted From (Category)	Deals With
8.5.2.3	Slide Transition Platform	Width of entrance platform
8.5.3.1	Slide Chute Entrance	Transition of user
8.5.4.1	Slide Chute	Height/length ratio
8.5.5.1	Exit Region	Height/Length ratio
8.5.5.2	Exit Region	Exit slope
8.5.5.3	Exit Region	Height with regards to Surface
8.5.5.5	Exit Region	Exit Region Shape
8.5.6.1	Slide Clearance Zones	Area around slide
8.5.6.2	Slide Clearance Zones	Area around slide
8.5.7	Slide Clearance Zones	Fall height
9.6.1	Slides	Use Zone
9.6.3	Slides	Use Zone
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area

The main category that needed to be reorganized and divided into separate categories was the climber category. For example, there were many climbers which had a multitude of different movements and components to them which made them misclassified. The two proposed new sub-categories for climbers are Moving Hangers and Multi-Level Climbers. The Moving Hanger sub-category covers the equipment in which the user will hang from the equipment while it has some sort of motion to it. The standards suggested from ASTM 1487 are standards: 8.3.1-8.3.5 which refers to upper body equipment as well as 8.8.1.3-8.8.1.6 which regard merry-go-rounds in terms of oscillation and speed (2001, p. 9-11). Table 7 shows our recommended current standards for Moving Hangers. The next suggested sub-category for climbers is Multi-Level Climbers. This category is for pieces of equipment that have multiple platforms at different heights. The Multi-Level Climbers would take into account boulder structures that have platforms at multiple heights but still serves a climbing function to children. Multi-Level Climbers would have standards similar to ASTM 1487 8.2.1-8.2.4 which regard hand and foot holds for the equipment (2001, p. 9). Table 8 shows our recommended current standards for Multi-Level Climbers.

Table 8: Recommended Current Standards for Inclined Moving Hangers Sub Category

Moving Hangers:

ASTM Standard	Adopted From (Category)	Deals With
8.3.1	Upper Body Equipment	Fixed handholds
8.3.1.1	Upper Body Equipment	Handgrips
8.3.2	Upper Body Equipment	Horizontal distance from edges
8.3.3	Upper Body Equipment	Maximum heights
8.3.4	Upper Body Equipment	Maximum heights
8.3.5	Upper Body Equipment	Fall heights
8.8.1.3	Merry-Go-Rounds	Handgrips
8.8.1.4	Merry-Go-Rounds	Clearance
8.8.1.5	Merry-Go-Rounds	Oscillation
8.8.1.6	Merry-Go-Rounds	Speed Limitations
9.3.2	Rotating Play Equipment	Clearance Zones
9.3.3	Rotating Play Equipment	Clearance Zones
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area
9.8.3	Placement of Equipment	Location of rotating /moving equipment

Table 9: Recommended Current Standards for Multi-Level Climbers Sub Category

Multi-Level Climbers:

ASTM Standard	Adopted From (Category)	Deals With
8.2.1	Climbers	Rigid Rungs
8.2.2	Climbers	Flexible Components
8.2.3	Climbers	Fall height
8.2.4	Climbers	Fall height
8.3.1	Upper Body Equipment	Fixed handholds
8.3.1.1	Upper Body Equipment	Handgrips
8.3.2	Upper Body Equipment	Horizontal distance from edges
8.3.3	Upper Body Equipment	Maximum heights
8.3.4	Upper Body Equipment	Maximum heights
8.3.5	Upper Body Equipment	Fall heights
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area

The next category we investigated was the Merry-Go-Round. While this group is fairly straightforward, we noted that adding a sub-category for Single Person Spinners would be the best way to update the system and best to make sure future equipment will be able to be classified. The Single

Person Spinner sub-category is meant for equipment that functions like a merry-go-round but is meant for single person use only instead of a group. Standards set for the Single Person Spinners could be taken from current Merry-Go-Round standards found in ASTM 1487 such as 8.8.1.3-8.8.1.6 which deals with speed and oscillation limits for merry-go-rounds as well as fall heights (2001, p. 11-12). Full recommended standards can be found for Single Person Spinners in Table 9.

Table 10: Recommended Current Standards for Single Person Spinners Sub Category

Single Person Spinner:

ASTM Standard	Adopted From (Category)	Deals With
8.3.1	Upper Body Equipment	Fixed handholds
8.3.2	Upper Body Equipment	Horizontal distance from edges
8.3.3	Upper Body Equipment	Maximum heights
8.3.4	Upper Body Equipment	Maximum heights
8.3.5	Upper Body Equipment	Fall heights
8.8.1.3	Merry-Go-Rounds	Handgrips
8.8.1.4	Merry-Go-Rounds	Clearance
8.8.1.5	Merry-Go-Rounds	Oscillation
8.8.1.6	Merry-Go-Rounds	Speed Limitations
9.3.2	Rotating Play Equipment	Clearance Zones
9.3.3	Rotating Play Equipment	Clearance Zones
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area
9.8.3	Placement of Equipment	Location of rotating /moving equipment

Similarly to the Merry-Go-Round category, when looking at the Seesaw category we decided it was best to add sub-categories to cover the equipment for future evolution. Separating the Seesaw category into Sitting and Standing Seesaws would eliminate the confusion and more accurately place different types of seesaws. The Sitting Seesaw sub-category would be for the current seesaw equipment which is typically found in playgrounds. As for Standing Seesaws, this sub-category is for newer seesaws which we found in catalogues. This equipment functions the same as regular seesaws but is used standing instead of sitting. Both these sub-categories can use the same standards taken from ASTM

1487 for seesaw such as 8.10.2-8.10.7 which deals with the handgrips and the necessary angles fall heights and fulcrums (2001, pg. 12). Full recommended standards can be found for Standing Seesaws in Table 10.

Table 11: Recommended Current Standards for Standing Seesaws Sub Category

Standing Seesaws:

ASTM Standard	Adopted From (Category)	Deals With
8.3.1	Upper Body Equipment	Fixed handholds
8.3.2	Upper Body Equipment	Horizontal distance from edges
8.3.5	Upper Body Equipment	Fall heights
8.10.2	Seesaws	Shock-absorbing material
8.10.3	Seesaws	Fulcrum
8.10.4	Seesaws	Handgrips
8.10.4.1	Seesaws	Handgrips
8.10.5	Seesaws	Footrests
8.10.6	Seesaws	Maximum angle
8.10.7	Seesaws	Fall height
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area
9.8.3	Placement of Equipment	Location of rotating /moving equipment

Dividing the Balance Beams into three sub-categories would help to ensure that the equipment is classified correctly. Splitting up the single category into Single-Level, Multi-Level, and Motion Beams will properly classify old and new equipment. While Single and Multi-level beams exist, the Motion Beams sub-category is meant for the equipment which has the function of a balance beam but has motion to it to provide an additional challenge. This works in the case of the balance beam that rotates from side to side depending upon where pressure is placed. Multi and Single-Level Beams can use the current Balance Beam standards found in ASTM 1487 such as 8.1.1-8.1.3 (2001, pg. 9). Motion Beams could use the same set standards but could also use upper body standards such as 8.2.1 and 8.3.5 for hand support and fall height distances (2001, pg. 9-10). We would also recommend a standard that would deal with the allowed incline and maximum degrees for maximum rotation of the beam. Tables

11 and 12 show our full recommendations based on the current standard for Multi-Level Beams and Motion Beams.

Table 12: Recommended Current Standards for Multi-Level Beams Sub Category

Multi-Level Beams:

ASTM Standard	Adopted From (Category)	Deals With
8.1.1	Balance Beams	Surface of Balance Beams
8.1.2	Balance Beams	Support Posts
8.1.3	Balance Beams	Fall Height
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area

Table 13: Recommended Current Standards for Motion Beams Sub Category

Motion Beams:

ASTM Standard	Adopted From (Category)	Deals With
8.1.2	Balance Beams	Support Posts
8.1.3	Balance Beams	Fall Height
8.2.1	Climbers	Hand Supports
8.3.5	Upper Body Equipment	Fall heights
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area
9.8.3	Placement of Equipment	Location of rotating /moving equipment

The final category that the CPSC deals with is the Log Rolls Category. Breaking this category into Horizontal and Inclined Log Rolls will contain current and more modern equipment. Horizontal Log Rolls will be well suited for the current log roll equipment. However the new sub-category of Inclined Log Rolls will be for the equipment which acts in the function of log rolls but the platform is inclined. These categories would use standards 8.12.2 and 8.12.4 from the Log rolls category (2001, pg. 12-13) as well as standards 8.8.1.5-8.8.1.7 from Merry- Go-Rounds found (2001, pg. 12) in ASTM 1487. We would also recommend a standard that relates to the degree of incline allowed. Table 13 shows our current recommended standards for Inclined Log Rolls.

Table 14: Recommended Current Standards for Inclined Log Rolls Sub Category

Inclined Log rolls:

ASTM Standard	Adopted From (Category)	Deals With
8.8.1.5	Merry-Go-Rounds	Oscillation
8.8.1.6	Merry-Go-Rounds	Speed Limitations
8.8.1.7	Merry-Go-Rounds	Fall Height
8.12.2	Log Rolls	Age recommendations
8.12.4	Log Rolls	Fall Height
9.8.1	Placement of Equipment	Space Limitations
9.8.2	Placement of Equipment	Circulation area
9.8.3	Placement of Equipment	Location of rotating /moving equipment

In order to provide adequate safety for children, there needs to be updated standards. However, for the new sub-categories the required standards can be a combination of standards or reference the current standards which can be adjusted as the equipment evolves.

6.2.2 Burns

Recommendation 2: Parents should be made aware of potential playground hazards associated with thermal burns not only at a playground, but also at their home or in a public setting.

Safety is the main concern for all parents regarding playgrounds. In order to maintain this safety, especially regarding thermal burns, signs identifying the rules and hazards of the playground should clarify the risk of thermal burn injuries on both the equipment and surfacing. The signs should explain that parents should check the temperature of the equipment or material before letting their child play on it. The warning should also stress that metal equipment is not the only risk associated with this injury and that plastic and rubber materials can cause severe burns as well.

The brochure we created (Figure 47), which explains the risks to parents, could be distributed at schools, through the mail, or be placed in a box at the playground for the general public to read. This would not only illustrate the hazards associated with thermal burns, but provide safety tips for the

parents to follow. Keeping children properly clothed and wearing the appropriate shoes on playground would decrease the tendency for younger children to receive burns on the soles of their feet. Among other safety precautions, phone numbers will be provided for a caregiver to call if their child is injured on the playground. Reporting the incident to the CPSC, as well as to the manufacturer, could help reduce the number of incidents occurring on certain equipment. In general, the team recommends that parents must be responsible for their child's safety regarding thermal burns because there are many variables associated with this injury type.

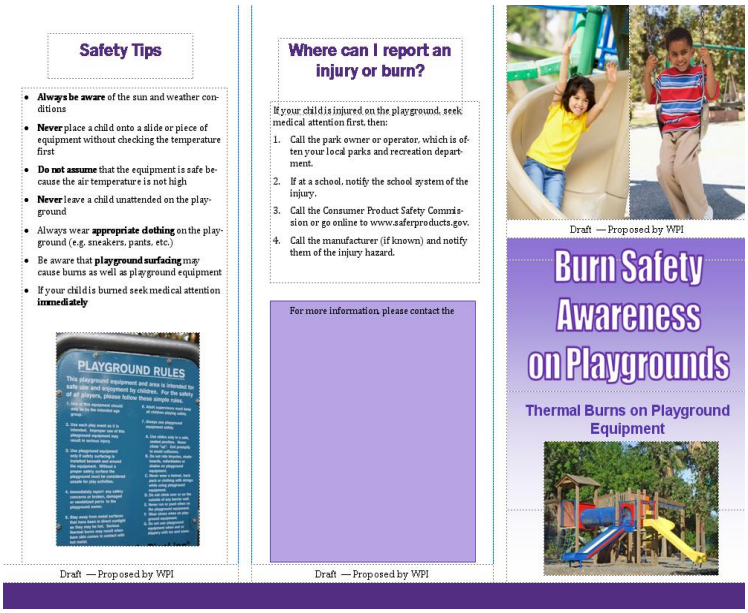

Figure 47: Burn Safety Brochure

Recommendation 3: In order to maintain safety from the sun and other hazards, playground manufacturers and the owner of the playground should ensure that the Consumer Product Safety Commission guidelines are followed regarding the *Public Playground Safety Handbook*.

Currently, the handbook published by the CPSC is not mandatory and it is up to individual states to implement the laws and rules regarding playground safety and design. If these guidelines were made mandatory, then the risk of a child receiving a thermal burn would be greatly decreased. As mentioned

in this handbook, slides should be facing either a north or south direction to minimize the amount of direct sunlight and heat received. The data the team collected supports this claim, and we concluded that either a north or south orientation does reduce the equipment temperature. Also suggested by the CPSC is that the equipment should be shaded by either artificial or natural shading. Planting trees or setting up a canopy shade would reduce the equipment and surfacing exposure to sunlight, thus making the children safer from thermal burn injuries. From the data the team collected, surfacing materials such as wood chips do not heat up as fast as poured-in-place rubber. While this type of surfacing requires more maintenance and may pose accessibility issues for children with disabilities, this allows for thermal burn injuries to be reduced. Following the handbook would allow for the playground to be safer and for children to not be injured as frequently.

6.3 Summary

In summary, the current playground equipment categories must be reorganized and the ASTM standards relating to each category will have to be changed to compensate for new categories and equipment types. Problems with safety, compliance, and classification issues would be solved by following the proposed classification system. Thermal burn awareness is necessary for the hazard to be decreased. Compliance with the CPSC safety guidelines would aid in reducing injury risks and safety hazards. Future research from injury reports is necessary to properly conclude which specific materials and equipment cause thermal burns. The size of the research space regarding thermal burns was limited to the 38 reports collected by the CPSC. More research in this area would yield more conclusive results. A broader approach is necessary to see the trends and correlations of thermal burn injuries nationwide.

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Appendix A: Consumer Product Safety Commission

Over the course of the past 39 years the Consumer Safety Product Commission has been keeping a watchful eye over society and the products we use in our everyday life. First signed into existence in 1972 by President Richard Nixon, The Consumer Product Safety Commission (CPSC) has made the safety of the public its number one priority. Throughout its history, the number of deaths or injuries due to consumer products has been reduced by half or more in each category that the CPSC tracks. This agency, which is setup and supported by the federal government, studies hazards found in products and enforces strict regulations in order to ensure the continual safety of consumers in America (CPSC, 2011). The CPSC's annual fiscal budget is decided by and voted on by the Congress of the United States. Every year the CPSC submits its safety and product report. From the report's findings, a budget is set for the following year. The CPSC's fiscal year 2012 budget has yet to be approved by Congress; however, the Commission's request for 2012 was $122 million and 610 full-time equivalents (FTEs).

This regulatory agency works diligently to ensure the protection of the public from more than 15,000 hazards (CPSC, 2011). Ensuring the success of the CPSC is Chairman Inez Tenenbaum, whose nomination in June of 2009 came from President Obama. Inez Tenenbaum was sworn in as Chairman on June 23, 2009, and will head the CPSC until October of 2013. To become the Chairman, Inez Tenenbaum was first nominated by President Barack Obama and was then voted on and confirmed by the United States Senate. Prior to her tenure at the Consumer Product Safety Commission, Ms. Tenenbaum was head of the School Department for the state of South Carolina. Along with the chairman, there are three commissioners who help

manage the CPSC. These include Commissioner Robert Adler, Commissioner Nancy Nord, and Commissioner Anne Northup. Typically, there is a fifth member of the Commission; however, this seat is vacant since the retirement of Commissioner Thomas Moore in October 2011. All of the commissioners are appointed to their position in the same manner as the Chairman; they are first nominated by the President and are appointed their positions after nominations are voted on and confirmed by the Senate. Working under these head officials is the executive director and other important staff members. Under these individuals are the Directors of Safety Operations and Directors of Operation Support. Figure 48 shows the structure of the CPSC.

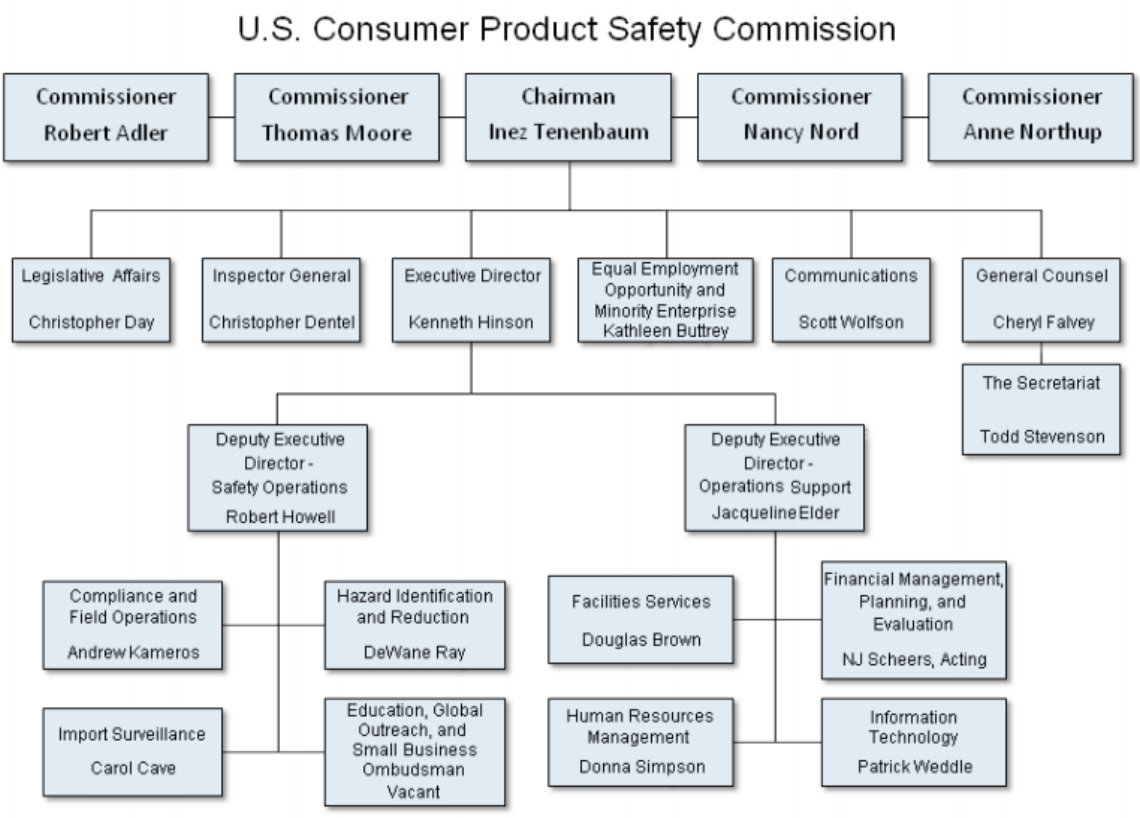


Figure 48: CPSC Hierarchy Chart (CPSC, 2011)

The CPSC (2011) works closely with ASTM International (formerly the American Standards for Testing and Materials). When the ASTM creates or revises a standard, the CPSC works with them to ensure products sold in the US meet those standards. Throughout the CPSC's existence they have worked with agencies such as the Centers for Disease Control (CDC), the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA). The CPSC has jurisdiction over consumer products from appliances to lawn mowers but not over cars or cosmetics, which is where these other agencies come into play. When we are conducting our research into playground hazards we will be working under the office of Division of Human Factors with Hope Nesteruk. This office seems most relevant to the problem we were given of child safety and the hazards associated with playgrounds and equipment classification.

Appendix B: What Is an IQP & How Is Our Project an IQP

An Interactive Qualifying Project, or IQP for short, is one of the requirements of a WPI education. An IQP poses a problem (Worcester Polytechnic Institute, 2011) to a student or group of students and requires their time and commitment in order to solve and provide a solution to the given problem. An IQP generally does not fall into a student's major, although it can. Through an IQP a student can learn many things. The most important piece of information a student learns is how a problem can affect the world. A student will learn how a small-scale problem can affect a large population or worldwide. It is also usually involves a combination of looking at technology and the social impacts technology has on a society.

Our project falls into the category of an IQP for many reasons. The first of these is that it is a small problem which has a possibility for a global impact. The Consumer Product Safety Commission realizes the problem with their classification system and its flaws with how playground equipment is classified. This problem with classification can lead to injuries because there are no set regulations or standards for equipment that is misclassified. One leading concern right now is burns due to the playground equipment. Through our studies we hope to find an alternative way to classify playground equipment to and possibly provide insights as to why burns are happening on playgrounds and what a possible solution might be.

Appendix C: Interview Protocol for CPSC Employee

Interview Protocol for

Consumer Product Safety Commission Employee

1. Introduce members of group
2. Describe our project

Questions:

A) What is your job at the CPSC?

B) What is your opinion of the current classification system for playground materials?

C) Can you think of any improvements that could be made to the current classification system?

D) Does the CPSC currently have any projects regarding playground safety?

E) What do you think about injuries that occur on playgrounds? Are they a serious issue?

F) What can be done to prevent future injuries to children on playgrounds?

G) Are burns resulting from contact with hot playground material a serious issue?

H) What can be done to prevent burns from playground materials in the future?

3. Thank interviewee for his/her time

Appendix D: Interview Notes A

Playground manufacturer and task group chair for materials and signage for the ASTM public playground subcommittee. This task group has done some recent work on burns and ended up with a warning sign alerting parents to the hazards.

(Interviewer): What is your job at your company?

My job is director of environmental engineering. It's a small group that focuses on compliance such as standards and categorization. We are in charge of environmental initiatives being compliant with things such as lead content and the environmental issues surrounded by materials beyond regulations. Put in a plug for what we've done. Our products are cradle certified by the NMDC, which looks at how to use good and recyclable materials for later.

(Interviewer): How does this role tie into being a task group chair for the ASTM subcommittee?

I feel it is important for us to be good corporate citizens and it is important for us to understand what the issues for the problems are rather than just be handed the standard and do it. They want to understand the issues, contribute, and try to help fix the problem. The ASTM subcommittee is a collection of expertise. ASTM is a great group because it takes in information from all project experts such as engineers and others.

(Interviewer): Are you familiar with the CPSC playground categories from the Playground Handbook? Can you think of any improvements that could be made to the current classification system?

The subcommittee has discussed the free standing boulder like products that have characteristics of a climber but do not fall into that category. Areas at the top would be considered the platform but they don't have barriers to prevent falls. Climber categories require full grip or grasps. The boulder is a reasonable product to have out on the playground. Not seeing injuries on it as much because of the lack of requirements as opposed to traditional arch climbers with rungs.

(Interviewer): With your role in the ASTM, do you feel there is a need to improve the standards for playgrounds?

Standards evolve and the CPSC project is a good example of that. As products are invented and motion becomes more important, subjects come up that aren't covered. Standards should evolve to protect that to help child safety and let others be aware of requirements.

(Interviewer): What do you think about injuries that occur on playgrounds? Are they a serious issue?

Injuries are certainly a serious issue because no one wants to get hurt. There has been a lot of discussion of risk vs. hazard. We want to minimize hazard while allowing risk. The children need to fail to learn and develop as they get older. They also need to develop wisdom which helps the learning curve. Trying to

reduce the hazards is an important part. Over the years that ASTM has been in place and the pendulum has been swinging in regards to safety. It is a balance of lowering hazards while reducing risks.

(Interviewer): We know that you have done some recent work with burns on playgrounds. In your opinion, are burns resulting from contact with hot playground material a serious issue?

Hope has worked on my committee and can reinforce what I will tell you. Burns are a serious injury and can scar a person for sure. The CPSC has a report on burn injuries that hope sent to me as part of work. From 2001-2008 there were 24 burns reported. There isn't too much of a pattern besides young people. One of the things we know is that a young child doesn't have a cause and effect response that's quick. If they walk onto a hot surface they will sometimes just stand there and get burned burn and cry. That's part of the situation we're a part of. 3 and under for age and the lack of response to the stimulus is one of the things we saw that was concerning.

(Interviewer): What can be done to further prevent burns from playground materials (not only signage)?

First thing we did was think there was an equipment solution that would cause the material not to heat up. We spent a lot of time on it to approach it that way. There were too many variables that affected a burn two of which were temperature and time. Lighter colors were slower to heat up then dark colors. The materials selected make a difference and the texture of the surface does too. What we concluded was that the surface, regardless of material, can get hot enough to burn you, and there is very few materials to prevent that. So what can we do? From equipment owners standpoint there is a couple things they can do. They can shade it with a structure like a hood or trees to prevent sun. They can also turn things like slides to face north so the angle of sun's rays aren't direct and you can choose light color for equipment. There are things to be done proactively. A real solution here has to lay with alerting people, especially caregivers, to give a heads up. Young children can't read and if they could they don't have the attention and wisdom to read the sign before they are affected. So what we did as a conclusion was to give a warning and expect that owner of playground will post a sign to give care owner heads up. Also put sign in position that far enough from hazard so they have time to react for equipment. They should take the sign and put it outside surfacing area.

We kicked around the idea of thermister to show temperature. The strips turn color if temperature is reached. What temperature should you start to warn people? This is a very elusive question. If you choose a temperature and set it as a limit and something happens, the systems fails, and the light doesn't come on then what happens? It is a special situation and that is why the signs came up and were discussed. Unless the temperature is less than 100 degrees you may not be able to warn people in time. It was really a difficult thing and we kicked it around for a while but there were too many variables. You can be scolded at 125 degrees. While it was an important thing to address we think we came up with best solution for the time. The day the material, the child, and the age are all factors.

Appendix E: Interview Notes B

Playground consultant and chair of the ASTM home playground subcommittee (F15.09). Also, she is very involved in public playgrounds.

1. What is your job at your company?
    a. I am a playground design and safety consultant.

2. How does this role tie into being a chair for the ASTM home playground subcommittee?
    a. It was through my consulting work that I became involved with ASTM. Much of what I do on a day to day basis is consulting relating to the safety standards and the CPSC Guidelines for both residential and public play equipment.

3. Do you work closely with public playgrounds at all? If so, what is your role?
    a. The majority of my work is with public playgrounds. I consult with manufacturers regarding new product design in regards to safety and developmental appropriateness. I have been involved in the development of the ASTM standards for both residential and public playgrounds from the beginning of the standard development. I am currently vice-chair of the ASTM F15.29 subcommittee responsible for the development of the public standard. I also have written the curriculum for the Certified Playground Safety Inspector course that is offered through the National Recreation and Park Association.

4. Are you familiar with the CPSC playground categories from the Playground Handbook? Can you think of any improvements that could be made to the current classification system?
    a. I am very familiar with the CPSC Handbook and the categories and yes I think the classification system needs a lot of work. In fact many of us in the industry feel that the CPSC should allow ASTM to handle the technical recommendations for playground equipment and remove specific design criteria from their handbook. CPSC should focus on the need for supervision, what equipment is appropriate for what age group and public information that benefits the consumer in making a decision on whether or not a playground is appropriate or safe for their child. Having said that, the existing classifications are very limiting. The CPSC handbook has been adopted as law in many states. This means that anything that is recommended in the handbook becomes a requirement under the law. Right now in many states all of the recommendations for merry-go-rounds for example apply across the board to all rotating equipment. Equipment is no longer just merry-go-rounds, swings, climbers and slides. Within these classifications there are many subcategories. There are many products on the market that rotate but are not merry-go-rounds. We have new types of swings. Not every swinging component falls into a to-fro or rotating category. ASTM has added “combination swings” as a category. We have so many different types of climbers. It would be nice for accident investigation purposes to have multiple categories such as: Upper body equipment, which would include sub categories of horizontal ladders, track rides, zip lines, ring treks, chinning bars. There are many types of climbers such as: 3-D matrix net climbers, net climbers, arch climbers, vertical climbers, and climbing equipment that does not fit into any of the previous categories such as artificial boulders and logs.

5. With your role in the ASTM, do you feel there is a need to improve the safety standards for playgrounds?
    a. No, I think we have eliminated the major causes of death and seriously debilitating injuries through our performance standards. We need to be less restrictive with our standards and guidelines for playground equipment as we are not making playground safer and adding lots of information that simply restricts design creativity and reduces challenge.

       Children will always fall and there is not much we can do about that other than address the surfacing. I believe that the greatest thing that CPSC could do to address safety would be to take another look at the recommendations for protective surfacing material. Many believe that the HIC and G-max criteria currently recommended, is not adequate to protect from serious head injuries. CPSC has done nothing to protect children from long bone fractures. They need to study surfacing types in relation to long bone fractures. My experience is that a loose material such as wood fiber, pea stone or sand is much more protective for long bone fractures than a unitary material such as tiles or poured in place rubber. With ADA being law we will see many of the traditional loose surfaces go away in favor of more accessible surfaces such as the rubber. I believe we will also see an increase in long bone fractures.

6. What do you think about injuries that occur on playgrounds? Are they a serious issue?
    a. I think that compared to the amount of time children spend on playgrounds in relation to other things they are exposed to that playgrounds are statistically very safe. If we applied the same stringency that we apply to playgrounds to children's sports such as basketball, no child would be playing basketball as we know it. I believe that playgrounds are very safe, maybe not challenging enough. When everything a child climbs is predictable (rung size, rung spacing, etc) they have no need to think about where they are placing their hands and their feet. When they are not allowed to climb much higher than they can reach children tend to create their own adventure by jumping off of things or climbing where we don't want them to be such as the roof tops of the play equipment.

7. What can be done to further prevent injuries to children on playgrounds?
    a. I don't think much can be done. Since CPSC published their first handbooks for public playground safety in 1981 we really have not seen much of a reduction in the number of overall injuries. When children try new things they sometimes fail which can result in an injury. The fact that injuries occur does not make a playground unsafe.
8. Are you familiar with the issue of thermal burns? In your opinion, are burns resulting from contact with hot playground material (surfacing, plastic, rubber, metal components) a serious issue?
    a. I am very familiar with this issue but don't think it is a new issue. We simply have more publicity for the injuries. All surfaces get hot when exposed to the direct sun, not just playground surfaces. When you look at the burns that have received the greatest attention on the news, they were very young children that did not understand what was causing their pain and they did not react to remove themselves from the hot surface. Most of the injures were burns to their feet from walking across a hot surface. I blame

the parent for not making certain that the child had shoes on. The issue with children being burned on metal or plastic slides has been around since probably the first slide was created. Parents simply need to check the surface temperature of a slide prior to allowing their child to slide down it. As children mature, they understand and check the surface themselves. It is the very young child that is most at risk for this type of injury. We have tried to determine at what outside temperature materials get hot enough to burn a child. This has proven to be impossible as there are so many variables. I would refer you to Curtis Cleveland for more information. You may be aware that the New York City passed a City Ordinance creating a committee which includes their health department to determine when playground surfaces are too hot. This happened last year. I do not believe they have had much luck in figuring that out but they have been tracking surface temperature compared to air temp.

9. What can be done to further prevent burns from playground materials (not only signage)?
    a. I would hate to see us shade the world as I think exposure to sun is also important. I think the best solution is to remind people to check the surfaces before playing.

Appendix F: Questionnaire for Parents at Playgrounds

Questionnaire for Parents at playgrounds

1. Introduce members of group
2. Describe our project and how it relates
3. Explain our project affiliation with the CPSC
4. How are you today?

Questions:

A. How often do you visit this playground?

B. Are there any characteristics of this playground you like? If so, what are they and why?

C. Are there any characteristics of this playground you don't like? If so, what are they and why?

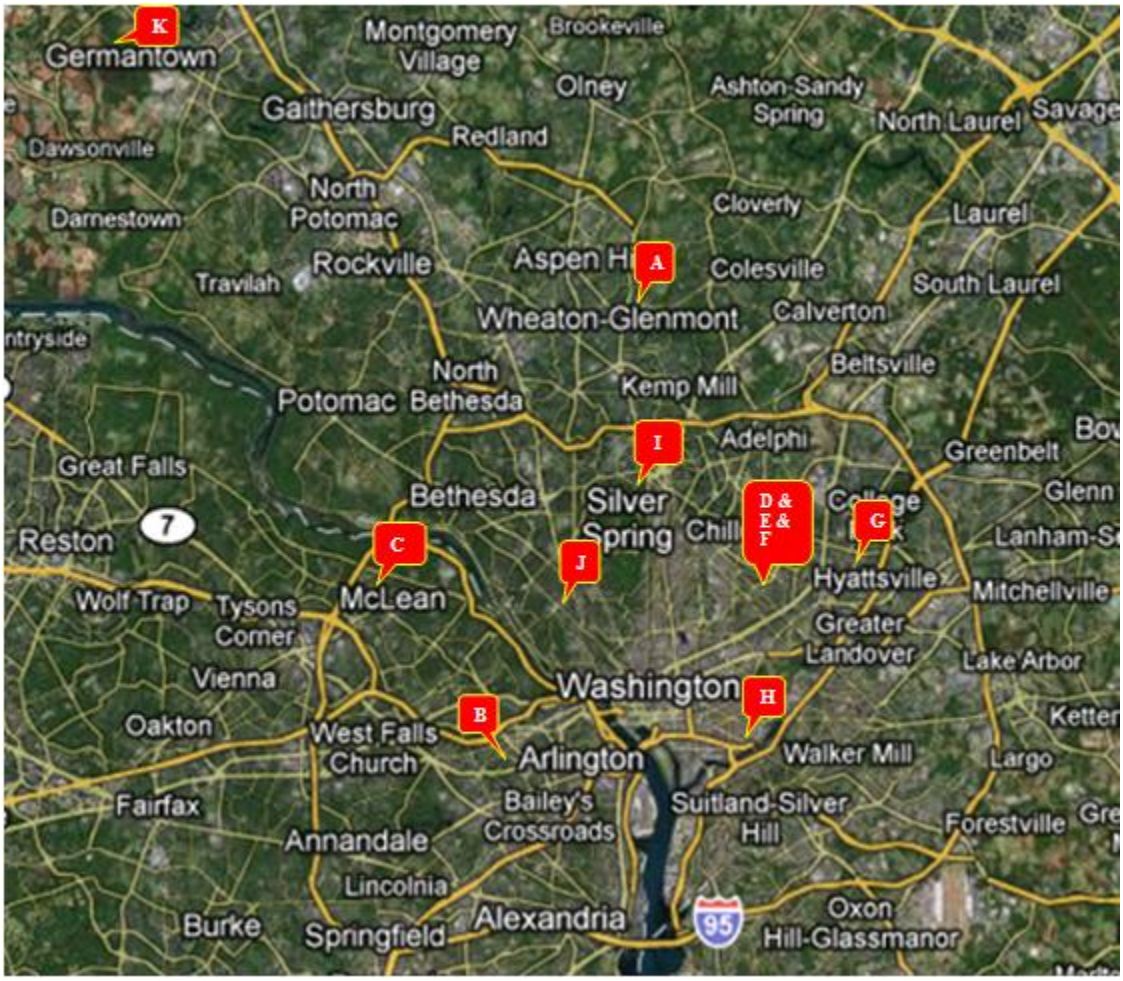
D. Has your child ever been injured while playing on the playground? If so, how did it occur and did the injury require treatment or hospitalization?

E. Has your child ever been burned while playing on the playground equipment? If so, how did the burn occur and what was the degree of it?

F. Is any of the equipment on this playground different from what you experienced when you were young? If so, what is different about the equipment? Do you think it is safer or more risky and why?

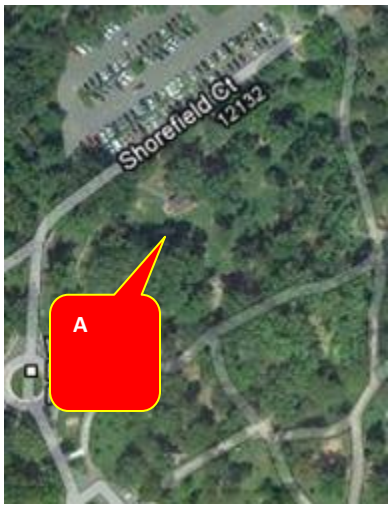
5. Thank the parent(s) for the interview

Appendix G: Playground Locations



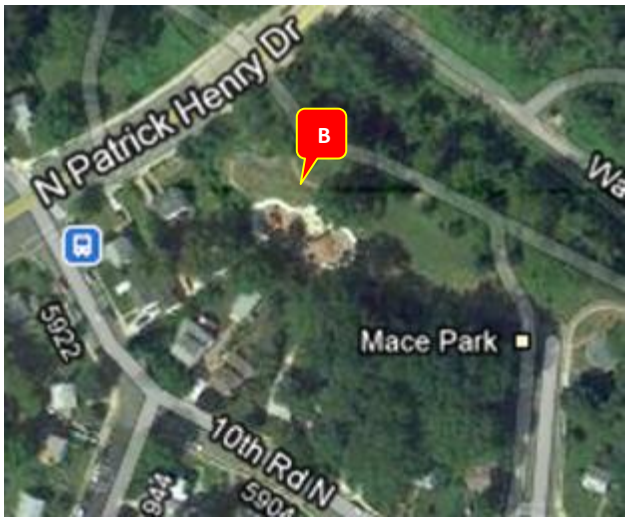
Location A:

Wheaton, Maryland



Location B:

Arlington, Virginia



Location C:

McLean, Virginia

Location D:

Washington D.C

Location E:

Washington D.C

Location F:

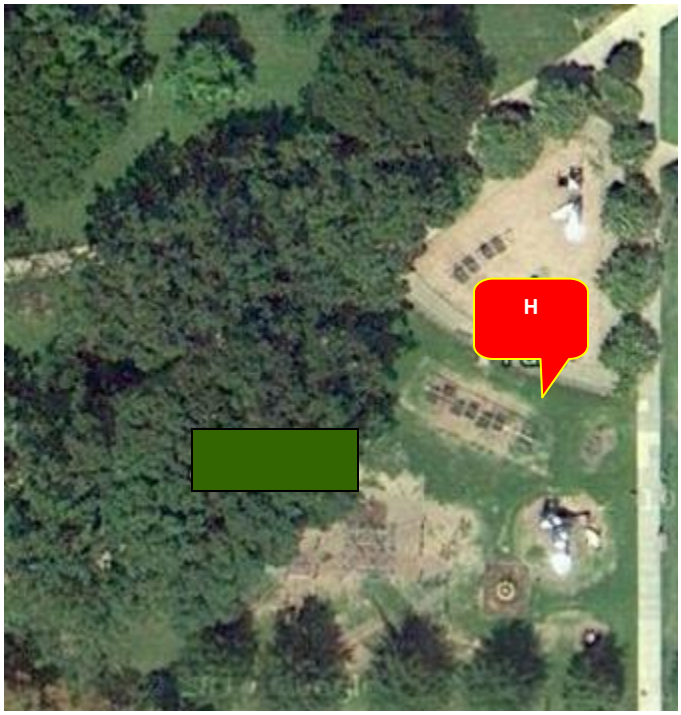
Washington D.C

Location G:

Washington D.C

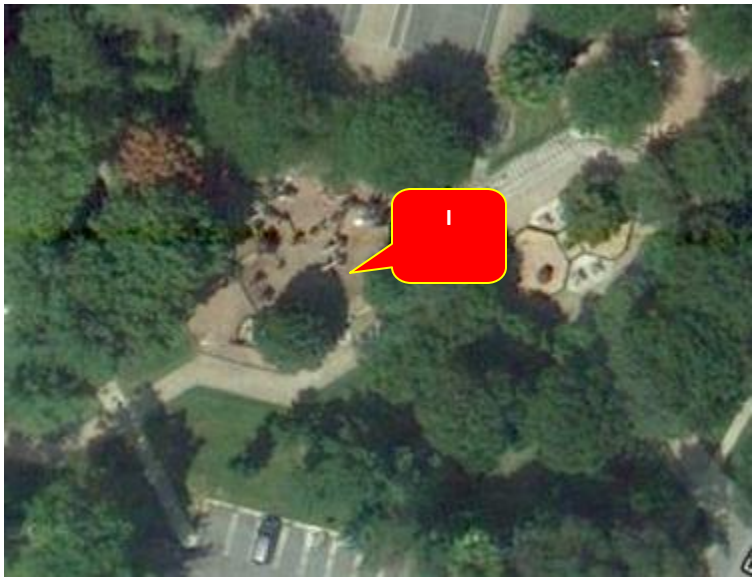
Location H:

Washington D.C



Location I:

Silver Springs, Maryland



Location J:

Washington D.C

Location K:

Germantown Maryland

Appendix H: Distribution of Playground Equipment in Catalogs

The pie chart on the following page shows the distribution of equipment observed in the equipment catalogs. The table below shows the specific types of equipment with the exact number of times that type of equipment was observed. As can be seen in the table, Climber equipment is by far the most prevalent followed by slides.

Table 15: Distribution of Playground Equipment in Catalogs

Equipment Type	Count
Bridge	1
Wall Climber	1
Climber/Sliding Pole	1
Ladder Climber	1
Tire Climber	2
Climber/Ramp	3
Ramp	3
Sliding Pole	4
Dome Climber	4
Log Roll	4
Track Ride	7
Merry-Go Round	8
Balance Beam	10
Tunnel	11
Seesaw	11
Swing	13
Swings	16
Spring Rocker	22
Flexible Climber	23
Step Climber	24
Arch Climber	39
Overhead Rings	46
Horizontal Overhead Ladder	49
Slide	76
Climber	154

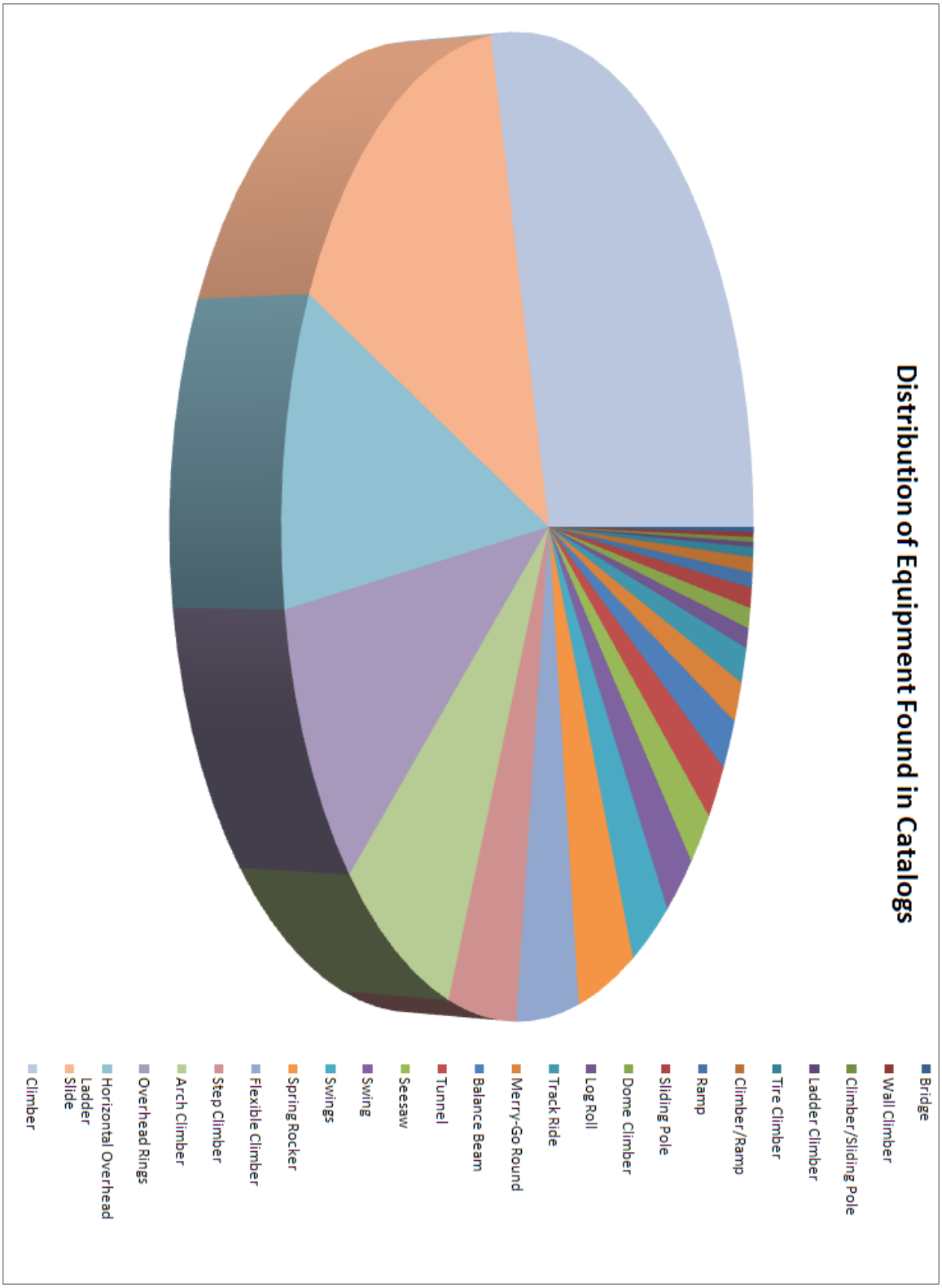


Figure 49: Distribution of Playground Equipment

Appendix I: Playground Equipment Temperature Measurements

Table 16: Playground Equipment Temperature Measurements

Equipment	Material	Color	Orientation	Temperature 1 (Air vs. Equipment)	Difference	Temperature 2 (Air vs. Equipment)	Difference
Climbing Net	Rubber	Black	E/W	47 °F vs 52 °F	5	54 °F vs 74 °F	20
Multi-person Spinner	Metal	Yellow	N/A	47 °F vs 48 °F	1	54 °F vs 67 °F	13
Climbing Mound	Rubber	Green	N/A	47 °F vs 39 °F	-12	54 °F vs 51 °F	-3
Tube slide	Plastic	Yellow	S	47 °F vs 57 °F	10	54 °F vs 80 °F	26
Overhead Rinds	Metal	Silver	E/W	47 °F vs 56 °F	9	54 °F vs 74 °F	20
Ring Hanger	Metal	Black	N/A	47 °F vs 59 °F	12	54 °F vs 69 °F	15
Monkey Bars	Metal	Orange	E/W	47 °F vs 61 °F	14	54 °F vs 70 °F	16
Parallel Bars	Metal	Orange	E/W	47 °F vs 60 °F	13	54 °F vs 69 °F	15
Whale Spring Rocker	Metal	Blue	N	47 °F vs 40 °F	-7	54 °F vs 56 °F	2
Dinosaur Spring Rocker	Plastic	Purple	N/A	47 °F vs 44 °F	-3	N/A	N/A
Camel Statue	Cement	Tan	N/A	47 °F vs 31 °F	-16	54 °F vs 38 °F	-16
Balance Beam	Metal	Silver	E/W	47 °F vs 48 °F	1	54 °F vs 68 °F	14
Ball seat	Plastic	Purple	N/A	47 °F vs 56 °F	9	54 °F vs 80 °F	26
Swing	Rubber	Black	NW/SE	47 °F vs 49 °F	2	54 °F vs 80 °F	26
Space Net	Rope	Blue and Black	N/A	47 °F vs 48 °F	1	54 °F vs 71 °F	17
Seat Swing	Plastic	Yellow	N	47 °F vs 58 °F	11	N/A	N/A
Climbing Tower	Metal	Blue	N/A	47 °F vs 42 °F	-5	54 °F vs 71 °F	17
Personal Spinner	Metal	Blue	N/A	47 °F vs 41 °F	-6	N/A	N/A
Personal Spinner	Metal	Green	N/A	47 °F vs 47 °F	0	54 °F vs 71 °F	17
Climbing Tower	Metal	Blue	N/A	47 °F vs 57 °F	10	54 °F vs 70 °F	16
Surface	Cement	Silver	N/A	47 °F vs 48 °F	1	N/A	N/A
Surface	Asphalt	Black	N/A	47 °F vs 52 °F	5	N/A	N/A
Surface	Wood	Brown	N/A	47 °F vs 66 °F	19	54 °F vs 61 °F	7
Surface	Rubber	Orange	N/A	47 °F vs 50 °F	3	54 °F vs 80 °F	26
Surface	Rubber	Blue	N/A	47 °F vs 54°F	7	54 °F vs 88 °F	24
Surface	Rubber	Purple	N/A	47 °F vs 52 °F	5	54 °F vs 87 °F	23
Surface	Rubber	Green	N/A	47 °F vs 58 °F	11	N/A	N/A
Surface	Rubber	Black	N/A	60 °F vs 112°F	52	66 °F vs 116°F	50
Surface	Rubber	Light Blue	N/A	66°F vs 99°F	33	N/A	N/A
Surface	Rubber	Red	N/A	60 °F vs 88°F	28	66 °F vs 100°F	34
Surface	Rubber	Yellow	N/A	66 °F vs 98°F	32	N/A	N/A

Surface	Rubber	Green	N/A	60 °F vs 107°F	47	66 °F vs 115°F	49
Surface	Rubber	Dark Blue	N/A	66 °F vs 108°F	42	N/A	N/A
Surface	Rubber	Tan	N/A	60 °F vs 83°F	23	66 °F vs 116°F	50
Slide	Plastic	Blue	E	60 °F vs 109°F	49	N/A	N/A
Slide	Plastic	Red	N	60 °F vs 91°F	31	N/A	N/A
Platform	Metal	Red	N/A	60 °F vs 88°F	28	N/A	N/A
Single Axis Tire Swing	Metal	Silver	N/A	65 °F vs 31°F	-34	N/A	N/A
Single Axis Tire Swing	Metal	Red	N/A	65 °F vs 65°F	0	N/A	N/A
Surface	Asphalt	Black	N/A	65 °F vs 68°F	3	N/A	N/A
Bench	Wood	Green	N	65 °F vs 70°F	5	N/A	N/A
Surface	Wood	Brown	N/A	65 °F vs 82°F	17	N/A	N/A
Rock Wall	Cement	Blue	S	65 °F vs 68°F	3	N/A	N/A
Rock Wall	Cement	Blue	E	65 °F vs 69°F	4	N/A	N/A
Rock Wall	Cement	Blue	N	65 °F vs 74°F	9	N/A	N/A
Surface	Asphalt	Blue	N/A	65 °F vs 61°F	-4	N/A	N/A
Surface	Asphalt	Blue	N/A	65 °F vs 65°F	0	N/A	N/A
Slide	Plastic	Green	N	65 °F vs 87°F	12	N/A	N/A
Arch Climber	Metal	Green	W	65 °F vs 74°F	9	N/A	N/A
Slide	Plastic	Green	E	65 °F vs 79°F	14	N/A	N/A
Surface	Brick	Black	N/A	65 °F vs 64°F	-1	N/A	N/A
Surface	Brick	Tan	N/A	65 °F vs 62°F	-3	N/A	N/A
Surface	Brick	Red	N/A	65 °F vs 62°F	-3	N/A	N/A
Surface	Rubber	Blue	N/A	65 °F vs 89°F	24	N/A	N/A
Wall	Plastic	Blue	E	65 °F vs 89°F	24	N/A	N/A
Bench	Wood	Tan	E	65 °F vs 81°F	16	N/A	N/A
Step	Rubber	Black	N	65 °F vs 76°F	11	N/A	N/A
Slide	Plastic	Green	N	65 °F vs 81°F	16	N/A	N/A
Swing	Rubber	Black	E/W	65 °F vs 84°F	19	N/A	N/A
Xylophone	Metal	Silver	N/A	65 °F vs 70°F	5	N/A	N/A
Climber	Rope	Blue	N/A	65 °F vs 66°F	1	N/A	N/A
Slide	Plastic	Blue	S	65 °F vs 69°F	4	N/A	N/A
Climber	Metal	Green	N/A	65 °F vs 66°F	1	N/A	N/A
Slide	Plastic	Blue	NE	65 °F vs 77°F	12	N/A	N/A
Slide	Plastic	Green	S	65 °F vs 83°F	18	N/A	N/A
Slide	Plastic	Green	S	65 °F vs 74°F	9	N/A	N/A
Rocker	Plastic	Black	N/A	65 °F vs 63°F	-2	N/A	N/A