5.7.1.3.3 Slide chute

The details of the sliding surface addressed by the guidelines are its slope and the height of side restraints. Other relevant issues include the width of the slide chute and its shape and depth.

5.7.1.3.3.1 Slide surface slope

Guideline content:

Both volumes of the guidelines address the slope of sliding surfaces. To provide for a reasonably safe sliding speed, average incline should not exceed 30 degrees. The technical requirements explain this slope in other dimensions as well: $H/L \leq 0.577$. In addition, no span of the sliding surface should have a slope that exceeds 45 degrees from horizontal. (Volume 1; Volume 2, 11.5.2.1)

Probable rationale:

Due to a lack of data, these recommendations were based on industry experience and existing equipment. The typical slide design found in the market at that time incorporated a sliding board which was twice as long as the slide was high, resulting in an average incline of about 26 degrees. These designs appeared to result in reasonably safe sliding speeds, and therefore, no significantly different slope was recommended. However, more research and data are needed to further understand sliding velocities and whether or not sliding slopes could be changed but still provide safe sliding experiences. (NBS, 1978b; NRPA, 1976a)

Issues:

Frost (1980) noted that when determining slope, the length of the sliding board needed to be taken into account. When slope and other factors remain constant, increasing the length will result in increased sliding velocities. In addition, he pointed out that "slides of 5 to 8 feet in length may well exceed the 30 degrees incline requirement." The only attention the CPSC guidelines give to the length of the slide chute is as it affects the slope, that is $H/L \leq 0.577$.

Several people involved in playground equipment design give their recommendations for slide surface slope, which demonstrates the need to address this variable. However, like the CPSC's recommendation, there do not appear to be any data supporting the inclines chosen.

The Play For All Guidelines (Moore et al., 1987) adopts the CPSC's recommendation for average incline. In addition, parallel to the CPSC's guideline for the maximum inclination of any span of the sliding surface, Play For All Guidelines notes that wave slides may have steeper segments, provided that the average slope requirement of 30 degrees is not exceeded; they do not, however, state a maximum allowable slope for these steeper portions. Also apparently following the rationale of the CPSC guidelines, the Seattle draft standards (1986) state that slide beds should be designed to be approximately twice as long as the height of the slide, not exceeding a slope of 30 degrees from the horizontal. Beckwith (1988) stated that the total incline must not exceed 30 degrees, as well.

Two playground designers have recommended maximum slopes which differ from that of CPSC guidelines. Esbensen (1987) stated that slides should have a slope of around 40 degrees, the only stated rationale being that this "will provide speed without endangering the child." Bowers (1988a; 1988b) suggested that playgrounds should have a variety of inclines which will address the different abilities of different age groups with an appropriate level of challenge. These inclines should range from gentle slopes to a maximum angle of 45 degrees. In general terms, he stated, "Flat slides should be placed at an appropriate angle which allows the child to control his rate of descent." The Play For All Guidelines also supports this idea of providing children with a variety of inclines in order to meet their various developmental needs. Another quite general age-related suggestion was that shorter slides with smaller slopes are appropriate for younger children, whereas taller and more challenging ones are suitable only for older children (Henniger, et al., 1982).

Several different specifications for slide surface inclinations are given in playground equipment standards, all of which permit slopes greater than the CPSC recommendation. It is unclear from these standards whether the maximum inclinations should be taken as an average slope, or whether they apply to any span of the sliding surface. The British standards (BS 5696: Part 2, 1986) allow slide surface angles of 37 degrees or less. In the German standards (DIN 7926, Part 3, 1979), 40 degrees is specified as the maximum inclination, unless there are curves, in which case the angle can be as great as 50 degrees. Only the Australian standards (AS 1924, Part 2, 1981) deal directly with preschool equipment, stating that slopes shall not exceed 40 degrees. It is interesting that this requirement intended for younger children allows for greater slopes than the CPSC guideline which addresses only children over 5 years of age; however, this is true only if the Australian standard is interpreted as an average slope.

The German standards also regulate the radius of curvature for changes in the angle of inclination of slide beds, stating that it must be at least 40 inches (this does not apply to the exit region). Although there is no actual specification for maximum slope in the Canadian draft standards (CAN/CSA-Z614, 1988), the radius of curvature variable is discussed. When the slope exceeds 30 degrees, any changes in the inclination must have a radius of curvature of at least 40 inches (which is the same as the German standards); when the slope is 30 degrees or less, this radius of curvature must be at least 30 inches. The start of the slope is not affected by these specifications.

Recommendations:

Unfortunately, the lack of data and sound technical research on sliding velocities which caused problems in the original development of a slope recommendation still exists. The detailed incident analysis cannot help in evaluating what slopes may cause unsafe sliding velocities, since the slide-related in-depth investigations reviewed contained limited information on the height of slides or the length of slide chutes, so that the slope of the sliding surfaces involved could not be determined.

Age-related characteristics of sliding velocities have not been studied, so no distinctions can be made for preschool equipment. Future research should be geared toward determining what these age differences are, because it is conceivable that slope recommendations should be different for various age groups. In the absence of such information, limiting the height of slides intended for preschool-age children should help to address the need to control their sliding velocities.

No changes in the recommendations for slide surface slope are warranted until research has been completed and can serve as a technical support for such revisions.

5.7.1.3.3.2 Slide surface width

Guideline content:

The only comment in the guidelines referring to the width of sliding surfaces is the following: "Some short slides are wide enough to permit children to slide side by side." This appears to be a description of certain slides rather than a recommendation. (Volume 1)

Probable rationale:

Not applicable.

Issues:

Although no specific dimensions are given in the literature, there is a great deal of support for slides with wide chutes which allow more than one child to slide at a time. Many experts believe that wider slides are not only safer but also provide better play experiences because they stimulate more complex, cooperative play (Beckwith, 1988; Bowers, 1988a; Brown, 1978; Frost, 1980; Henniger et al., 1982; Moore et al., 1987). One of Bowers' basic premises of design is that "play equipment which allows only one child at a time to climb, slide, or swing in a singular prescribed way severely limits imaginative play." Wider slides are also suggested in the Seattle draft standards. They recommend the use of slides wide enough for two children to use together, and, for high use play areas, they suggest placing two slides side by side. Paired slides are noted in the Play For All Guidelines (Moore et al., 1987) as preferable to wider slides for accessibility and integration.

Two advantages to wide slides are noted in the Play For All Guidelines: unlike traditional narrow slides, wider slides allow an adult to slide down with a child between their legs; and, wider slides allow for group play experience. However, they also suggest that wider slides are sometimes threatening to younger users.

Certain foreign standards do give width dimensions for slide chutes. The Australian standards specify that the width shall be at least 14 inches, for public equipment, but give a minimum of 10 inches for domestic or preschool equipment. These minimum widths appear to be for single-use slides, and because no maximum is given, their regulation of multiple-use slides is not clear. The German standards state that for slides with chute sections over 60 inches in length, the width must be 16-20 inches for single slides and at least 40 inches for multiple slides. The British standards also specifically address slides intended for use by more than one child at time. However, rather than regulating the width, they state that the maximum allowable length of such slides is 11.5 feet.

Recommendations:

When slides are for use by only one child at a time, the width should be a minimum of 12 inches if intended for younger children, or a minimum of 16 inches for older children. When slides are for use by more than one child at time, the width should be a minimum of 30 inches if intended for younger children, or a minimum of 40 inches for older children.

The single-use slide chute widths recommended above correspond to the shoulder breadth of the maximum user for each intended age group, which is the 95th percentile 5-year-old for younger children and the 95th percentile 12-year-old for older children. Shoulder breadth was chosen as the criterion measure to accomodate children sliding down head first and to provide some allowance on either side of the buttocks for sliding down feet first.

The minimum width recommendations for multiple-use slides are based on twice the shoulder breadth of a maximum user for the intended age group, with some allowance included for space between users. For the older children, the above recommendation is identical to the German standards. A 6-inch tolerance was added to the shoulder breadth measure for younger children in order to determine the minimum width recommendation for preschool multiple-use slides. This allowance is proportionally the same as the 8-inch tolerance used for older children.

5.7.1.3.3.3 Sides of slide chutes

Guideline content:

Both volumes of the guidelines address the height of sides for slide chutes, recommending a minimum of 2.5 inches for the entire length of the sliding surface. Volume 1 specifies that this recommendation applies to slides over 4 feet, but Volume 2 does not. Furthermore, Volume 1 states that these barriers also serve as hand and foot guides to help prevent falls over the edge of the slide. (Volume 1; Volume 2, 11.5.1)

Probable rationale:

The intent of this recommendation is to reduce the risk of lateral discharge from the slide. However, determining the height of the sides and how far they should extend down the slide bed was one of the most controversial issues faced by the NRPA development panel. Simply trying to decide what constituted safe sides brought about substantial differences of opinion. For example, while some members advocated side restraints at least as high as the seated center of gravity of the maximum user (10.6 inches) which extended at least one third of the way down the sliding surface, others believed that such restraints would create more problems than they would solve. It remains unclear what these problems would be. Study of in-depth investigations did show that many of the falls from slides were over the edge of the chute. However, the data were incomplete since most cases failed to identify the point along the sliding board where the user fell. Thus, falls over the edge of the chute toward the top of the slide cannot be distinguished from falls over the edge at the middle or bottom of the chute. Falls from the top section of the chute, where fall heights tend to be greater, are addressed by recommendations for protective barriers on slides. (NBS, 1978b; NRPA, 1976a)

As illustrated above, there was a lack of detailed injury data to use as justification for recommending a certain type or size of side barrier. There was also a lack of sound technical rationale. Therefore, the requirements are based on "best judgment and experience by the industry to date." Investigation of slides on the market at that time, revealed that the height of side restraints varied from "slightly less than 2.5 inches to several inches." They also noted that some slides were totally enclosed for part or all of the sliding board length. (NBS, 1978b; NRPA, 1976a)

Assuming that the risk of lateral discharge decreases as the child progresses further down the slide, the top section of the sliding surface was determined to be the critical area. The recommendations made with regard to protective barriers at the slide surface entrance are intended to more specifically address this area (see the previous discussion of these guidelines, Section 5.7.1.3.2.2). The minimum side height, on both sides along the entire length, was intended not only to protect from lateral discharge, but also to provide a continuous hand and foot guide. It was determined that these two types of restraints, sides on the slide chute and barriers at the slide surface entrance, should be separate. The only rationale behind this separation is that it would enable the user to maintain better and more consistent control after the guard rails or barriers at the slide entrance ended. Therefore, this particular recommendation deals only with side restraints. (NBS, 1978b; NRPA, 1976a)

Issues:

Support for the CPSC's side height recommendation is limited. Brown (1978), the Seattle draft standards, and the Play For All Guidelines (Moore et al., 1987) all give the 2.5 inch minimum along the length of the sliding surface in their recommendations, parallel to the CPSC's. However, the Play For All Guidelines also notes the higher standard in England. Other designers have chosen not to adopt the CPSC recommendation. Esbensen (1987) specified that siding should be 3 to 6 inches high, running along the entire length of the sliding surface. Instead of giving a minimum height, Bowers (1988a) discussed two other ways to provide added safety: 1) slides which are full or half circle tubes have higher sides by nature of their design, while giving the children a different sliding experience; 2) horizontal platforms, adjacent to either side of the slide chute, used in addition to side runners help minimize the potential distance of a fall over the edge.

There is also direct criticism of the CPSC guideline for side height. T. Sweeney (1980; personal communication, February 1989) felt that there was no justification for the 2.5 inch requirement, noting that it was clearly unrelated to children's seated center of gravity. She stated that their seated center of gravity is at least 6 inches above the sitting surface; and therefore, the recommended sides do not contain the user's center of gravity and would not help to prevent falls over the edge. Like the NRPA, she argued that the top of a slide chute is the most dangerous, particularly the upper third, and that this justifies requiring extra protection in that area. In the NRPA's discussion of side restraints, some wanted the height to contain the maximum user's seated center of gravity, listed as 10.6 inches. For younger children, using the 95th percentile 5-year-old as a maximum, the seated center of gravity is 8.7 inches. As Sweeney pointed out, this dimension evidently was not taken into account in the CPSC's final recommendation.

It is relevant to note that the seated position of a child sliding down a slide chute varies and will generally differ from the posture in which the seated center of gravity is measured, which is upright and perpendicular to the ground. When descending a slide in the typical seated fashion, a child's legs are extended in front and down the inclined surface. This causes his seated center of gravity to be pulled forward in the x-direction and down in the y-direction. Also, observational data showed that children often lean either slightly forward or back when sliding which would further alter the location of their center of gravity, pulling down the vertical component in both cases. Therefore, it seems the seated center of gravity would be an overestimate for the height of sides. This is especially true if the sides are intended to serve as hand and foot guides, because sides corresponding to the maximum user's seated center of gravity would be uncomfortably high for use as guides.

Frost (U. of Texas, 1989, unpublished manuscript) discussed foreign standards and concluded that the higher sides they require are more reasonable than the 2.5-inch CPSC recommendation. The Canadian draft standards state that sidewalls with a minimum height of 4 inches should be provided. An interesting parallel can be drawn to the CPSC's recommendation with regard to the intent of the Canadian specification which states: "all sliding surfaces should have sidewalls to control and guide descent and prevent the lateral discharge of the child during descent." The German standards frame the requirement for side height in the context of the sliding board's length. Where chute sections are up to and including 60 inches long, sides must have a minimum height of 4 inches; where chute sections are more than 60 inches long, the sides must have a minimum height of 6 inches.

The British standards employ a similar method. For slides up to 21.3 feet long, the sides should not be less than 4.8 inches high; for slides over 21.3 feet long, the sides should not be less that 5.5 inches high. The Australian standards do have a specification lower than the CPSC's 2.5 inches, but it does not apply to all slides. They require different minimum side heights based on the height of the slide: slides up to 8.2 feet high should have retaining sides not less than 1.96 inches high, slides higher than 8.2 feet should have retaining sides not less than 3.93 inches high. In addition, the Australian standards make a separate specification for domestic and preschool slides, stating a minimum of only 0.75 inches.

The question of how far down the slide bed the sides need to extend is also dealt with in certain foreign standards, reflecting views other than that expressed by the CPSC guideline. However, the Australian standards require that the sides extend from the top to a point 3.3 feet above ground level, while the British recommend that the sides extend from the top to a point 5 feet above ground level or to the start of the transition section of the slide, whichever is lower. After this point, both standards agree that the sides may be gradually diminished. The Canadian draft and German standards join the British standards in specifying that the sides do not have to be fitted to the exit region.
Although the shape of the side walls is not addressed by the CPSC guideline, some of the standards do make specific recommendations. The Canadian draft standards say that the

edges should be rounded off, not presenting any sharp edges. The German standards are more detailed, requiring that the top edges of the side walls be rounded with a radius of at least 0.12 inches (3 mm); and furthermore, if hollow sections are used, they must be closed off. The British standards address a different characteristic of the sides. They state that the sides may either be perpendicular to the sliding surface or curved at an obtuse angle to the sliding surface.

CPSC has reported one case of a child whose finger was amputated when it got caught between the side and the slide chute. Therefore, it is important that the sides are an integral part of the chute, with no gaps between the sides and the sliding surface. Both the Australian and British standards also state that the sides must be "an integral part" of the sliding surface.

Recommendations:

The NBS rationale gave two reasons for providing sides along the slide chute: prevention of falls over the edge of the sliding board, and their function as continuous hand and foot guides (NBS, 1978b). Recommendations for protective barriers which extend down the slide chute (see Section 5.7.1.3.2.2) address the critical region for falls, from the top of the platform and from the top section of the chute. Recall also the NBS assumption that the risk of lateral discharge decreases as a child continues down the slide (NBS, 1978b). The recommendations for sides along the entire length can, therefore, focus more on providing continuous hand and foot guides. For younger children however, at least some degree of protection from lateral discharge remains important all the way down the sliding surface because they cannot maintain good balance as well as older children.

Although there is a lack of detailed injury data and biomechanical analyses, it does seem reasonable to increase the minimum recommendation for side wall height to be more comparable with other standards which are more conservative. Therefore, it is recommended that sides which are a minimum of 4 inches high extend along both sides of the chute for the entire length of the sliding surface. The sides should be an integral part of the chute, without any gaps between the sides and the sliding surface.

The 4-inch minimum side height provides an adequate hand and foot guide for all users. In addition, relative to the current 2.5-inch minimum side height recommendation, this provides some added protection for younger children, who are at greater risk of falls over the edge.

5.7.1.3.3.4 Chute shape and depth

Guideline content:

The current CPSC guidelines do not address the details of chute shape and depth.

Probable rationale:

Not applicable.

Issues:

The Play For All Guidelines (Moore et al., 1987) and Bowers (1988a) advocate the inclusion of a variety of inclines on playgrounds, in order to meet the various developmental needs and abilities of children of different ages. This recommendation has a bearing on chute shape and depth, because what they mean by a variety of inclines goes beyond the width or slope of the slide bed, which is the context in which their ideas were previously mentioned.

The Play For All Guidelines lists many options for slide design which supplement traditional straight slides: wave, spiral, wide, tunnel, bannister, and roller slides. Wave slides were discussed as a means of varying slide slopes. Caution is warranted when purchasing roller slides, and the Play For All Guidelines does not recommend their use at schools. Children tend to use roller slides for "surf riding" play, so installation from 4 foot decks is preferred. They state that these slides do not normally present a pinch hazard, but further attention to the possibility of clothing entanglement would seem important. Two specific recommendations are made regarding roller slides: they should not use ball bearings; rubber mats are the best resilient surfacing underneath roller slides, and pea gravel should be avoided.

Bowers (1988a) also recommended innovative chute designs such as tunnel or tube slides, which are semi-cylindrical or totally enclosed, because they can provide safe and exciting sliding experiences. An especially attractive component of these slides is their greater side height along the sliding surface. In addition to these advantages of enclosed slides, Brown (1978) also noted that they give protection from the elements. Unfortunately, there are many disadvantages for this design as well. Like many other slides, tunnel or tube slides are typically single-use, which others would agree is not optimal. Brown further explained that children often climb on these structures, which is equally or more hazardous than traditional slides because the potential fall height is increased. Similarly, Esbensen (1987) recognized the danger of children not only climbing on top of a tunnel slide, but actually sliding down the top outside surface. The observational study supports these ideas, because children were seen both climbing and standing on tunnel slides as well as actually using the outer surface as a slide chute. The possibility of impact with the interior of the enclosure also creates a new hazard, as noted by Brown. Lastly, since children can hide within the tunnel, they may not be visible to the next child entering the tunnel, increasing the potential for collisions. Supervision would also be hampered by this lack of visibility.

A new slide design was recently developed by J. Beckwith (personal communication, March 1989): the bannister slide. He believed that this can be used more safely while encouraging more diverse play patterns. Although thousands have been installed, Beckwith was personally unaware of any accidents having occurred on bannister slides.

Embankment slides are those built into hills. They are frequently recommended as a safer alternative to slides which are above grade (Esbensen, 1987; Frost, 1980; Frost, U. of Texas, 1989, unpublished manuscript; King and Ball, 1989; Moore et al., 1987). Because so many specific recommendations for embankment slides are given and certain details of their design are regulated by the standards, they are discussed in a separate section (see Section 5.7.1.4).

Spiral slides are distinctly different than straight slides, and are treated separately by the CPSC guidelines, and therefore also by this report (see Section 5.7.1.5).

Chute shape and depth are addressed by the foreign standards in various degrees of detail. The British standards acknowledge the issue, but state that requirements for "chute profiles" have not yet been developed. The Australian standards are general, specifying simply that the transverse section of the chute must be designed with a shape and depth that will reduce the risk of falls out of the chute when the child is sliding seated and facing forward. The only detailed standards are from Germany. For chute sections over 59.1 inches long, they recommend that the slide profile (cross section) be designed so the short arm of the template can always remain horizontal. The template consists of two straight edges, 2 inches and 3.9 inches in length, forming a right angle.

Recommendations:

The previous discussion of slope, width, and side height is intended to ensure that flat slides are designed to provide safety from falls and excessive sliding velocities. Other slide designs should incorporate chute shapes and depths which provide at least as much protection from these and other hazards.

5.7.1.3.4 Exit region

Guideline content:

The guidelines address four characteristics of the slide chute exit region: slope, length, height, and radius of curvature. These recommendations pertain only to slides which have a vertical drop height above ground or an entrance height above the slide exit which is greater than 4 feet. (Volume 1, Volume 2, 11.5.3)

Probable rationale:

It was determined that if slides which had heights not exceeding 4 feet complied with the exit region recommendations, the user might stop on the sliding surface, and thus be in the way of the next child sliding down. The general intent of this section is to reduce the user's speed and essentially eliminate the vertical component of the velocity, and in doing so ensure that the user is able to maintain balance upon exiting from the slide. The NBS technical rationale documents acknowledge that too little is known about the behavioral and physical characteristics to fully assess the efficacy of these exit region recommendations. Therefore, as previously stated in discussion of the slide chute, more research on sliding velocities is warranted. (NBS, 1978b; NRPA, 1976a)

Issues:

Both British (BS 5696: Part 2, 1986) and German (DIN 7926, Part 3, 1979) standards express the same general intent for their sections pertaining to the exit region. Furthermore, Brown (1978), Blenk (1987), and Esbensen (1987) pointed out that the severity of injuries which occur at the end of slides can be reduced by providing exit regions which reduce exit speeds.

Several slides without exit regions were included in the observational study. These slides simply run straight into the ground, not leveling off at all. This design causes children's feet to jam directly into the ground with the force built up by their acceleration from sliding down the chute, which could potentially injure children's knees or possibly spinal cords due to the sudden impact. This assumes children are sliding feet first, while they are known to also descend slide chutes head first. In that case, there is the potential for children to hit their heads or jam their hands or elbows. Further, young children tended to stop at the end of these slides without finishing the transition from sitting while sliding to standing, so that other sliders are in danger of colliding with those who are crowded at the bottom.

While some slide-related injuries in the NEISS 1978 Special Study appeared to have been caused by an inappropriate exit gradient (Brown, 1978), the mode of use associated with these injuries is unknown. In her analysis of NEISS-based in-depth investigations, Butwinick (1980) found that 12% of all slide injuries were associated with exit landings. As far as can be determined from the detailed incident analysis, 8% of slide injuries occurred in the exit region. Thus, injuries in the exit region do not appear to be as common as injuries associated with access ladders and slide platforms.

Frost (1980) stated that "shorter slides" may not need an exit region, given appropriate treatment of the ground covering, However, it is unclear whether Frost was referring to height above ground or length of the sliding surface with his mention of "shorter slides." If he was referring to the length, it would seem that his point has already been incorporated into the guideline. Assuming that the length of the slide bed is typically twice the height of the slide (NBS, 1978b), shorter slides would have lower entrance heights and, therefore, be exempt from the guideline's 4-foot rule.

No discussion in the literature uses slide height to determine whether or not exit region recommendations are applicable, other than the CPSC guidelines. The British standards do use the slide's height and angle of inclination to determine what length the run-out should be (as discussed below) but not to exempt a slide from having an exit area.

In addition to the details of slope, length, height, and radius of curvature, one more issue is discussed in this section. Although the CPSC guidelines do not address slide exit edges, it is dealt with in several foreign standards as well as by certain playground equipment designers.

Recommendations:

Additional research on sliding velocities and their implications for design of the exit region is needed. It is especially important to investigate more thoroughly how exit speeds are affected by the height of slides to determine the efficacy of requiring exit regions only for slides over 4 feet high. Because these questions regarding sliding velocities have not been studied further since the original development of these guidelines, no changes to the recommendation to provide exit regions for slides above 4 feet in height, as specified by the following requirements for slope, length, height, and radius of curvature below, can be suggested at this time. However, the current recommendations are only intended to address children over 5 years of age.

Different recommendations are warranted for children 2 to 5 years old. The rationale for providing exit regions is two-fold: to redirect the velocity of the user to the horizontal component by eliminating the vertical component; and, to enable the user to maintain good balance upon leaving the sliding surface. It is more difficult for younger children to maintain balance than older children, particularly when they experience horizontal momentum as they exit a slide chute. In order to facilitate the transition from sitting to standing for younger children, exit regions should be provided on *all* slides, regardless of their height. One additional reason for this recommendation is the tendency for preschool-age children in particular to go down slide chutes head first. Without an exit region parallel to the ground surface, a child's head would be directed into the ground during this foreseeable use of the slide.

5.7.1.3.4.1 Slope of the exit region

Guideline content:

The current guidelines state that the exit region should be essentially parallel to the ground. More specifically, the slope should be between 0 and -4 degrees, as measured from a plane parallel to the underlying surface. (Volume 1; Volume 2, 11.5.3.1)

Probable rationale:

An exit surface approximately parallel to the ground should redirect the velocity of the maximum user to the horizontal component, eliminating the vertical component. This reduces the child's speed as he or she exits from the slide, which is the main intent of the exit region recommendations. The limits on the slope (0 to -4 degrees) provide a manufacturing tolerance and should not compromise the goal of reduced exit velocity. If the slope were anything greater than zero, above horizontal, water or other debris might accumulate in this area of the slide, which would then present an unnecessary hazard. (NBS, 1978b; NRPA, 1976a)

Issues:

The technical literature consistently supported the use of a horizontal slope for the exit region (Frost, U. of Texas, 1989, unpublished manuscript; Oliver et al., 1981; Simpson, 1988; D. Thompson, personal communication, February 1989). The Australian standards (AS 1924, Part 2, 1981) also require that the run-out section be approximately horizontal, for all public as well as domestic and preschool equipment.

Beckwith (1988) repeated the CPSC limits on slope, stating that the chute run-out must be within 0 to 4 degrees of horizontal. Similarly, both the British and Canadian (CAN/CSA-Z614, 1988) standards specify the angles allowed for the exit portion: the British recommend horizontal to -2.5 degrees in the direction of motion, while the Canadians recommend inclinations between -1 and -5 degrees to the horizontal plane. This Canadian draft standard is the only recommendation which always calls for a slope below horizontal. The German standards allow the largest range of slopes, 0 to -10 degrees. They also stipulate that the exit region must not have any curves or undulations.

M. Ridenour (personal communication, February 1989) suggested that different techniques need to be investigated for reducing exit velocities for older children in particular. Two new design ideas she noted were slides with slopes which go down and then back up (e.g., a wave slide) and slides with a textured surface at the end. However, with the latter design, there is some concern that such a surface might wear out with extended use.

Recommendations:

The exit region should be essentially parallel to the ground, as currently stated in the guidelines, for older as well as younger children.

5.7.1.3.4.2 Length of the exit region

Guideline content:

The current guidelines state that the exit region should be at least 16 inches in length. (Volume 1; Volume 2, 11.5.3.2)

Probable rationale:

Similar to the slope recommendation, the justification for the length recommendation is to control the exit velocity of the user. The minimum of 16 inches was chosen to correspond to the maximum user's thigh length, specifically the distance between tibiale and trochanter. (NBS, 1978b; NRPA, 1976a)

Issues:

Oliver et al. (1981) specifically stated that extending the length of the exit region is an effective way to reduce impact injuries after slide descent. As previously mentioned, reducing exit velocities can help reduce the severity of injuries. Two of the foreign standards frame their length specifications in terms of exit velocity. The Australian standards require exit regions to be of sufficient length to reduce the exit velocity to 8.2 feet/second, approximately walking speed. The Canadian draft standards are similar except they discuss a velocity of 10 feet/second as approximate walking speed, and specify a minimum length of 12 inches.

Like the Canadian draft standards, the German minimum length is below the CPSC's; however, this does not apply to all slides. The German standards state that the length of the run-out area must be determined by the length of the slide chute: if the chute section is less than 60 inches long , then the run-out must be a minimum of 12 inches, otherwise the minimum exit length is 20 inches.

The British standards are slightly more complex. The recommendations are made for 37 degrees slides with a total sliding length L; height is defined as the vertical distance between the starting section above ground level at the run-out section. For slides up to 8.2 feet high, the run-out should be at least 0.2L; for slides over 8.2 feet but less than 16.4 feet high, the run-out should be at least 0.25L; for slides over 16.4 feet high, the run-out should be at least 0.3L. It is noted that slides with inclinations less than 37 degrees may not require the full exit length indicated. To compare these British standards to Germany's, assume a slope of 37 degrees. For slides less than about 5 feet in height, the German standards require the reverse is true. For example, British standards require a minimum exit length of 24 inches for a 37-degree slide that is 8.2 feet high, whereas German standards specify a minimum of 20 inches.

Only one source recommended a minimum length of 16 inches for the exit region, which is what the CPSC guidelines specify (Beckwith, 1988). In contrast, there are two examples of criticism of the CPSC's length guideline. The <u>Play For All Guidelines</u> (Moore et al., 1987) notes the CPSC specifications for length and height and raises objections because they assume that children will use the slide in the prescribed manner. Moore et al. recommend a shorter exit region. Also supporting a shorter run-out area, the Seattle draft standards (1986) call for slide exits to be between 12 and 16 inches. Only the maximum length of 16 inches would be consistent with the CPSC minimum length.

Recommendations:

The current guideline for the minimum length of the exit region corresponds to the thigh length of the maximum user, a 95th percentile 12-year-old, which is 16 inches. This measurement is the distance between tibiale and trochanter. The recommendation, as stated, adequately addresses slides for older users.

For preschool slides, the minimum length of the exit region needs to be based on the thigh length of a 95th percentile 5-year-old, in order to accommodate children aged 2 to 5 years. This measurement is 11 inches. Therefore, slides intended for younger users should have an exit region at least 11 inches long.

5.7.1.3.4.3 Height of the exit region

Guideline content:

The current guidelines state that the height of the exit region should be at least 9 inches but no more than 15 inches above ground. (Volume 1; Volume 2, 11.5.3.3)

Probable rationale:

While the slope and length specifications are aimed at controlling the exit velocity, the height specification is intended to assure that the user can maintain good balance when making the transition from sitting to standing, walking, or running upon exit from the slide. If the slide exit is too high, younger children may experience the equivalent of a short fall, possibly resulting in injury. If the slide exit is too low, older children's feet or legs may contact the ground too early, possibly causing a loss of balance and consequent fall. Based on this reasoning, the distance between the heel and the back of the knee was chosen to determine the exit region's height above ground. These measurements are 9 and 15 inches for the minimum and maximum user, respectively. (NBS, 1978b; NRPA, 1976a)

Issues:

There are many recommendations for the exit region's height above ground. Unfortunately, no two are the same. Most give a range of acceptable heights: 12-16 inches (D. Thompson, personal communication, February 1989); 9.8-13.8 inches, except it can be lower if the user's motion is brought to a halt in the run-out area (German standards); 9-18 inches for school-age children but 4-10 inches for preschoolers (Canadian draft standards); 7-15 inches for older children but 7-12 inches for preschool children (Seattle draft standards). The British standards only give a maximum of 16.5 inches.

Frost (U. of Texas, 1989, unpublished manuscript) noted that the Seattle guidelines which give different recommendations for younger children were more realistic.

As mentioned above, the Play For All Guidelines raises objections to the CPSC specifications for length and height and recommend a shorter exit region placed at surface level. The advantages of this design were listed as "a) children were prevented from falling back on the exit lip of the slide, b) children tended to move out of the path of following players more quickly, and c) better exit transitions were provided for nonambulatory children." However, in practice it would seem that an exit region at ground level would be more dangerous. Because a child's forward momentum would be eliminated upon contacting the ground surface, the transition from sitting to standing is stopped midway rather than facilitated as intended by the CPSC guideline; therefore, it is conceivable that children would take even longer to move out of the path of the next slide user. Furthermore, when trying to stop themselves upon exiting a slide chute already at ground level, the impact children's feet would have with the surface could exert excessive shock and force on their knees. Younger children often slide down head first, and this design would cause their faces to hit the ground, without giving them much chance to protect themselves. Considering that surfacing below slides, and other equipment, is not always as soft and cushioning as it could be, this could cause serious facial injuries. When the exit region is raised above ground level, children have more opportunity to catch themselves with their hands during this foreseeable and common pattern of use.

Recommendations:

The main purpose of the height recommendation for the exit region is to enable a smooth change in posture from sitting to standing. The current guideline corresponds to the distance between the heel and the back of the knee, 9 and 15 inches respectively, for minimum and maximum users, addressing children over 5 years of age. This appears to define a reasonable range. As discussed throughout this report, for the older age group the minimum user should be a 4-year-old. Therefore, slides intended for use by older children, those aged 4 to 12 years, should have an exit region between 8 and 15 inches above ground.

Younger children, those aged 2 to 5 years, need a separate recommendation. Tibiale height was used to estimate the distance between the heel and the back of the knee. For the minimum user, a 5th percentile 2-year-old, this measurement is 7 inches; for the maximum user, a 95th percentile 5-year-old, this distance is about 11 inches. Therefore, the height above ground of the exit region for preschool slides should be at least 7 inches but not more than 11 inches.

5.7.1.3.4.4 Radius of curvature of the exit region

Guideline content:

The current guidelines state that in the exit region, the radius of curvature of the sliding surface should be at least 30 inches. (Volume 1; Volume 2, 11.5.3.4)

Probable rationale:

The minimum radius of curvature of 30 inches was chosen to ensure a smooth transition from the inclined slide chute to the horizontal exit surface. No rationale for this determination is given beyond the idea that an "abrupt change" in inclination might cause the user to lose his balance at this point which is critical to exiting safely. (NBS, 1978b; NRPA, 1976a)

Issues:

This dimension is not discussed in the literature, and it is not regulated by any of the standards.

Recommendations:

Due to a lack of data, there is no justification for changing the recommendation for the exit region's radius of curvature. However, it should be noted that the rationale behind this guideline does not provide adequate technical support for the radius chosen.

5.7.1.3.4.5 Slide exit edges

Guideline content:

The current guidelines do not address the details of the slide exit edges.

Probable rationale:

Not applicable.

Issues:

In order to prevent lacerations caused by sharp edges, rounded or curved slide exit edges have been recommended (Esbensen, 1987; Oliver et al., 1981; Simpson, 1988). Esbensen specifically stated that the edge should be rounded and then wrapped underneath the sheeting, or else terminate in the sand (assuming that is the surface below).

Several standards support this idea and describe the edge in greater detail, but each make different recommendations. The German standards state that the end should be turned down toward the base, with a minimum radius of 2 inches, or in an arc of at least 100 degrees. The Canadian draft standards recommend a minimum radius of 3/8 inch and no sharp edges. The Seattle draft standards suggest that the exit edge be rounded to at least a 1/4-inch diameter.

Recommendations:

Slide exit edges should be rounded or curved, to prevent lacerations or other injuries which could result from impact with a sharp or straight edge.

5.7.1.3.5 Slide suppport structures

Guideline content:

The current guidelines do not have any recommendations pertaining to the support structures of slides.

Probable rationale:

Not applicable.

Issues:

Bowers (1988a) observed that children often climb on the support structures of slides. The Seattle draft standards (1986) evidently recognized this as well because they recommend that slide support structures should not have side bracings which can be climbed. German standards (DIN 7926, Part 3, 1979) are quite specific mandating that in the area where head and feet will be, slanting struts are not permitted in the main direction of travel (i.e. the direction of access to or descent from any equipment part).

Another suggestion regarding supports and other bracing structures is that they should be padded and covered (Bruya and Langendorfer, 1988). This would not only make the structures more difficult to climb but also help to prevent injuries from impact.

Recommendations:

It is recommended that the support structures of slides not be readily climbable.

To prevent potential impact injuries when falls do occur, supporting struts should not extend beyond the perimeter of the slide structure. That is, slide designs should not be such that if, for example, a child fell from the top of the slide chute, he or she could impact a support post before landing on the ground surface.

5.7.1.3.6 Materials

Guideline content:

The guidelines make no specific recommendations as to what materials should be used to construct slides.

Probable rationale:

Not applicable.

Issues:

Esbensen (1987) recommended the use of single-sheet stainless steel for sliding surfaces whenever possible; the Seattle draft standards (1986) specifically require the use of 16 gauge, minimum, stainless steel. One caution is that metal slide beds can get extremely hot, especially in some climates, and can cause second degree burns (Esbensen, 1987; Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987). The Play For All Guidelines notes that this tendency makes placement of the slide crucial to its safety, as discussed in the context of spacing and layout issues. Frost further stated that the hazards of extreme heat or cold are causing steel slides to be replaced by plastic ones. One other problem Frost discussed is that "the edges of metal slide beds may work loose and allow fingers to cap over the edge, creating a sharp cutting effect as the child slides down, resulting in serious cuts and occasional amputation of fingers." The Play For All Guidelines also mentions that razor sharp edges are sometimes exposed when low grade stainless steel fails.

Both Esbensen (1987) and the Play For All Guidelines discuss plastic slides, which can add color to playgrounds and do not have the burn hazards of metal slides. However, they are not as durable: plastic creates a fire hazard because it is flammable, and is also subject to impact fracture which could leave sharp edges. The Play For All Guidelines suggests colorful high density polyethylene as an alternative for slide construction. Although it is not combustible, it will melt if a fire is built around the slide. Furthermore, if polyethylene slides are poorly made, they can be light sensitive, or damaged by sand or heavy objects thrown onto them. Moore et al. warn their readers that stainless steel slides should be replaced by polyethylene slides only after careful consideration. Beckwith (1988), on the other hand, specified a preference for high density polyethylene slides over stainless steel.

Fiberglass slides were criticized by Esbensen (1987), who noted several defects of this material. Extensive maintenance is required to ensure that the surface does not wear down, because if it does, glass fibers which are dangerous splinters can be exposed. Like plastic, fiberglass can break leaving sharp edges, and is flammable. There is also an added hazard of electrostatic shock. Esbensen does not recommend the use of either plastic or fiberglass slides on public or unsupervised playgrounds. Beckwith (1988) agreed that fiberglass is not a good choice, also noting its tendency to splinter under stress. He added that these slides are easy to vandalize.

In order to protect against abrasions, the Canadian draft standards (CAN/CSA-Z614, 1988) recommend that there be no rough textures nor joints capable of cutting or abrading human skin along the seating or sliding surface. They point out that fiberglass or wood slides should not be used unless a protective surface on the chute can be maintained. The German standards (DIN 7926, Part 3, 1979) state: "The surface of the slide shall be made of a material that will not undergo any changes that can cause injury even under the effects of weather and harsh stress." In addition, it must not have any recesses, openings, or raised areas which might jeopardize safety. Esbensen (1987) and the Australian standards (AS 1924, Part 2, 1981) both give the same general recommendation. The Australian standards then state that seating and sliding surfaces must not contain joints unless the length makes this impossible, as with long slides. The Play For All Guidelines and the British standards (BS 5696: Part 2, 1986) also recommend seamless or one-piece slides. When jointing must be used, lap joints are preferable to butt joints in order to provide a continuous surface, since butt joints offer greater opportunity for objects to lodge in the cracks and protrude into the sliding area.

Recommendations:

When the sliding surface cannot be seamless, joints should be lap joints, not butt joints, to minimize the possibility of protrusions.

No specific recommendation is made as to what material is best for slide surfaces; however, the following advantages and disadvantages should be considered carefully when choosing what material to use.

Stainless Steel

Advantages:	Durable. Not flammable.
Disadvantages:	Hazards of extreme heat or cold, including potential for burns. Potential exposure of sharp edges when the steel deteriorates.

Plastic

Advantages:	No burn hazards. Colorful.
Disadvantages:	Some may be very durable, while others are not as durable as stainless steel. Some are flammable, while others such as polyethylene are not flammable but will melt if surrounded by fire. May be subject to impact fractures which can leave sharp edges. Sand may cause excessive wear due to abrasion.

Fiberglass

Advantages:	No burn hazards. Colorful.
Disadvantages:	Not as durable as stainless steel. Extra maintenance required. Potential exposure of glass fibers, which are dangerous splinters. Electrostatic shock hazard. Subject to impact fractures which can leave sharp edges. Sand can cause excessive wear due to abrasion.

5.7.1.3.7 Layout and spacing of slides; use, fall zones

Guideline content:

Volume 1 contains only a general discussion of the spacing and layout of equipment. However, there are two references in the section on slides which are relevant. First, metal slides should be placed in shaded areas or facing north. This can prevent burns from metal slides left in the sun, and can prevent slides from reflecting the glare of the sun which could interfere with vision. Second, it is recommended that slide exits be placed in uncongested areas, out of the way of other playground traffic. (Volume 1)

Probable rationale:

No specific rationale is stated for these recommendations as they are self-explanatory.

Issues:

The literature showed consistent support for the CPSC guidelines recommending that slides be placed in shaded areas or facing north in order to prevent metal slide beds from becoming too hot and potentially causing burns (Aronson, 1988; Beckwith, 1988; Esbensen, 1987; Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987). In addition, Brown (1978) and Esbensen (1987) both recommended that slide exits be placed in areas with little or no congestion so as not to interfere with play traffic patterns. Brown explained that this was necessary so that children would have ample room to regain balance, given the way they are propelled from slides.

Playgrounds need to be arranged to accommodate children's traffic patterns and allow for safe entry to and exit from each piece of equipment. The current guidelines do not specify what the exact use or fall zones should be for slides, but various recommendations were found in the literature. Esbensen (1987) stated that the safety zone of a slide should extend more than 6 feet beyond the exit and a little more than 3 feet beyond both sides of the slide surface. Although Esbensen did not specify the zone behind the slide access, others have included it in their discussions. Burke (1980, 1987) suggested that the fall zone necessary for slides should provide protective surfacing extending 11 feet in the direction of motion from the slide's exit, as well as 6 feet to the rear and 6 feet to each side of the structure. Beckwith (1988) noted that the use zone at entrances to traditional slides is generally 6-10 feet long in order to accommodate a line of children waiting to use the slide. Also, he specified that typical use zones extend 6 feet past the end of the slide and to both sides. Preston (1988) gave the NRPA recommendations for slide use zones, which included 11 feet in the direction of motion and 6 feet in other directions. More specifically, protective surfacing must extend 6 feet behind the access to the slide and on both sides of the slide structure, and 5 feet in front of the exit; an additional 6 feet are then required as a "no encroachment" zone beyond the 5 feet of protective surfacing at the slide exit. The Canadian draft standards (CAN/CSA-Z614, 1988) are identical, with the exception that protective surfacing is required for 6 feet in front of the exit instead of 5, making the total use zone 12 feet in that direction.

The Seattle draft standards (1986) only mandate that the exit end of the slide have a minimum use zone of 8 feet. Similarly, the German standards (DIN 7926, Part 3, 1979) also only deal with the exit region; however, in addition to specifying that the safety area must extend for a minimum of 80 inches in the direction of the slide chute, it is also required that this area extend 40 inches beyond the width of the slide on both sides. These dimensions are comparable to those recommended by Esbensen (1987).

The German standards regulate a different aspect of slide placement: the clearance zone. The intent is to provide an invisible bubble or shield which no other equipment can break. No other equipment or other parts that might cause injury can come within 34 inches of the side enclosure, as measured from the top of the side wall in all directions as far as the vertical overhead line. Also, a clearance of 60 inches must be maintained above the seat area, the chute section, and the run-out. The general idea of a clearance zone was supported by Preston (1988), who noted that strangulation has occurred when a child on a slide became entangled with components of adjacent structures. Esbensen (1987) recognized the need to eliminate other climbing equipment, such as horizontal ladders or bars, from the area of slides, to avoid having children who are swinging across the ladders or bars kicking or otherwise impacting a child descending a slide chute.

Recommendations:

As currently stated in the guidelines, all slides should be located in uncongested areas of the playground. Also, metal slides should either be in shaded areas or face north to prevent burns and glare problems caused by direct sun on the slide chute.

The fall zone requiring protective surfacing for slides should follow the general recommendations presented for all equipment (see Section 5.3.2.2).

The structure and play patterns associated with slides suggest that special attention should be given to use zones (see Figure 5.7.1 - 4). In order to accommodate children lining up at the slide access, the use zone should extend 12 feet behind the access. When children exit the slide chute they need extra space to regain balance and control their forward momentum; therefore, the use zone should extend 12 feet beyond the end of the slide chute in the direction of motion. If a slide is less than or equal to 4 feet in height, then the use zone in front of and behind the slide can be reduced to 8 feet. The fall zone on the sides of the slide structure should always extend at least 6 feet; the use zone on the sides does not need to extend beyond the minimum fall zone.

Three clearance zones are recommended to prevent other equipment or children from impacting a child using the slide (see Figure 5.7.1 - 5). The intent is to provide an invisible bubble which protects the user from hazardous protrusions into this "space." First, a clearance of 63 inches for older children, or 46 inches for younger children, should be maintained above the platform, chute, and exit region. Second, as measured in all directions from a vertical height of 21 inches above the platform around its perimeter and above the slide chute at its edges, no other equipment or children should come within 20 inches, for older children. The parallel recommendation for younger children is that from a vertical height of 16 inches as stated above, no other equipment or children should come within 15 inches from any direction. The second clearance measurement (20 inches for older children and 15 inches for younger children) should also be made in all directions from the top of the sides along the chute, so as to include the potentially hazardous area under the slide in the clearance zone. However, because the height of the exit region above ground (see Section 5.7.1.3.4.3) is lower than what this clear distance should be, the exit region of the slide is exempt from this particular specification. Note that the first two specifications for the clearance zone do apply to the exit region.

The maximum user for all clearance zone recommendations is a 95th percentile 12-year-old for the older age group and a 95th percentile 5-year-old for the younger age group. The clearance to be maintained above the platform, chute, and exit region corresponds to the maximum user's stature in each age group. The vertical height corresponds to the sitting mid-shoulder height of the age group's maximum user. The dimension for which no protruding elements, equipment, or children should be allowed, corresponds to the approximate lateral grip reach from the shoulder, also of each age group's maximum user. This dimension was estimated by subtracting the shoulder breadth from the lateral grip reach. The purpose of this recommendation is to ensure that the user's lateral reach from the slide structure is unobstructed, as he or she slides down the chute in a sitting position. The clearance measurement made directly from the sides of the chute is to ensure that a child who slides down the chute lying on his or her stomach or back is protected against entanglement or impact incidents with structural supports or other components under the chute.

5.7.1.3.8 Protective surfacing

Guideline content:

The guidelines do not address protective surfacing requirements specifically for slides.

Probable rationale:

Not applicable.

Issues:

Ridenour's (1987) safety inspection of 57 Philadelphia area elementary schools found that 25% of slides had asphalt or concrete surfaces while 75% were packed earth. The conclusion which can be drawn from these results is that none of the slides had acceptable surfaces. This highlights the need to disseminate information about safety surfaces.

The AALR Survey also reported the surfaces found under slides at elementary schools (Bruya and Langendorfer, 1988). These results showed a greater range of surfaces: sand, 28%; clay, 19%; grass, 14%; hard packed dirt, 14%; pea gravel, 13%; asphalt, 4%; tan bark or mulch, 4%; large gravel, 3%; rubber matting, 2%.

Although sand is often recommended as a shock absorbing surface, the British standards (BS 5696: Part 2, 1986) state that slides should not be adjacent to sand. Children's clothes and shoes would inevitably deposit sand onto the sliding surface, resulting in excessive wear due to abrasion.

The only other references specifically to surfacing under slides were in the context of the exit region. Frost (U. of Texas, 1989, unpublished manuscript) recommended that the resilient surfacing material in the exit area be extra deep, up to two feet, to protect against wear and pitting. The German standards (DIN 7926, Part 3, 1979) are also conservative in its treatment of surfacing for this area. They insist that the safety area at the run-out be horizontal and have the shock absorbing properties as required for free heights of fall in excess of 80 inches, as explained in Part 1 of the German standards.

Recommendations:

All recommendations with regard to surfacing are made in a general section (see Section 5.1).

5.7.1.4 EMBANKMENT SLIDES

Guideline content:

The guidelines do not make any separate recommendations for embankment slides, except for noting that the requirements for protective barriers on slides may not be appropriate when slides are built into hills. (Volume 2, 11.5.4.2.2)

Probable rationale:

Not applicable.

Issues:

Building slides into hills is one way to provide a variety of inclined play experiences for children. As previously mentioned, many people recommend the use of embankment slides as a safer alternative to slides above grade (Esbensen, 1987; Frost, 1980; Frost, U. of Texas, 1989, unpublished manuscript; King and Ball, 1989; Moore et al., 1987). These slides are generally thought to be safer because they eliminate the potential for falls from height, which is the leading cause of slide-related injuries.

Australian, British, New Zealand, and the Seattle draft standards also all recommend that embankment slides be used whenever possible (AS 1924, Part 2, 1981; BS 5696: Part 2, 1986; NZS 5828: Part 1, 1986; Seattle, 1986). The British standards state further that the mound on which they are installed must be properly consolidated, explaining that "where slides are installed on existing embankments, the manufacturer of the slide should be provided with details of the contours of the embankment. When an artificial mound is required, it should be constructed in consultation with the manufacturer to suit the slide."

None of the sources which address embankment slides give an entirely separate set of recommendations for them. Instead, they only highlight general slide specifications for which embankment slides require different treatment. These exceptions are discussed below.

<u>Access</u>: Although embankment slides do not always have stairways leading to the top of the hill on which they are mounted, there are sometimes steps built into the same hill adjacent to the sliding surface. The need to separate slide access stairways from slide chutes was emphasized earlier (Esbensen, 1987; Seattle, 1986). In the case of embankment slides, this is particularly important because it would be quite easy, but dangerous, for children to go from the steps to the chute part way up and vice versa. The British standards maintain that if access is provided adjacent to the chute of an embankment slide, it should not be closer than 3.33 feet. Also, they recommend that any access steps be hard surfaced to avoid wear.

<u>Entrance</u>: Unlike regular slides above grade, embankment slides do not generally have an entrance platform. However, as recommended in the British standards, adequate flat space should be provided at the top. Esbensen (1987) also addressed this area at the top of embankment slides, noting that it is important for the sliding experience to begin without the hazards of crowding.

Height above ground: Both the British and Australian standards regulate the maximum vertical height above adjacent ground level for any point along the length of an embankment slide. However, they are quite different: the British standard recommend a maximum of 19.7 inches, while the Australian doubles that to recommend a maximum of 39.4 inches.

Slope: The Seattle draft standards state that embankment slides are an exception to the maximum slope specification: provided that "the outrun is designed to give sliders space and time to move from the path of others," the slope of hillside slides may exceed 30 degrees.

Length: It is suggested in the Seattle draft standards that all slides longer than 12 feet be installed on grade.

Side barriers: The recommendation for side height given in the British standards for embankment slides is different than that for other slides. When measured perpendicular to the sliding surface, sides should not be less than 4.40 inches. Note that this is slightly lower than their recommendations for other slides (minimum 4.92 for slides up to 21.67 feet long or minimum 5.60 inches for slides longer than 21.67 feet). The British specifications for all slides stipulate that the sides must be an integral part of the sliding surface, and extend from the top to a point 5 feet from ground level or to the start of the transition section, whichever is lower, and then they may be diminished. For embankment slides, they further explain that this is taken as the ground level below the run-out section.
The Australian standards which regulate the height of sides on slides are similar to the British standards, except no separate specification for embankment slides is given. An equivalent definition explaining how far the sides must extend on embankment slides is given; however, according to the Australian standards, the sides must extend from the top to a point 3.33 feet above ground level rather than 5 feet as stated in the British standards.

Exit region: The only specific recommendation for exit regions referring to slides built into hills addresses slide exit edges. The Seattle draft standards note that "the preferred slide end on-grade is turned down for a radius of 2 inches and buried into the ground."

Recommendations:

Embankment slides have safety advantages over other slides. One reason for this is that their design basically eliminates the hazard of falls from height. Embankment slides should follow all of the recommendations given for straight slides.

Many embankment slides do not have a distinct platform at the entrance to the chute. However, those which do have platforms should follow the recommendations previously stated for platforms on straight slides.

5.7.1.5 SPIRAL SLIDES

As previously discussed, spiral slides are one of the alternatives to straight slides and a means for providing children with a variety of inclines and sliding experiences. The current guidelines devote an entire section of the technical volume to spiral slides. The requirements for the slide surface entrance as well as those for the exit region of spiral slides are simply referred back to the guidelines for straight slides; however, additional technical specifications for the chute are given in detail (Volume 2, 11.6).

The general rationale is explained as follows:

> The intent is to reduce the risk of lateral discharge of the user. Centrifugal force is what induces the likelihood of lateral discharge when descending through turns. Depending on the chute contour, the user may tip or slide off the edge. Many factors influence the likelihood of lateral discharge including the geometry of the sliding surface and user, the coefficient of friction between the sliding surface and user, the banking angle, the slide inclination and height, and the user's actions. (NBS, 1978a)

Mathematical models were, therefore, constructed to describe the tipping and sliding modes of lateral discharge, over the outer or inner edge of a spiral chute, as a function of measurable parameters.

None of the foreign standards include a section comparable to that of the CPSC guidelines for spiral slides. In fact, the British (BS 5696: Part 2, 1986), Canadian (CAN/CSA-Z614, 1988), and German (DIN 7925, Part 3, 1979) standards only mention them as an alternative to straight slides, without giving any specifications for spiral slides in particular. Similarly, both Frost (U. of Texas, 1989, unpublished manuscript) and the Play For All Guidelines (Moore et al., 1987) acknowledge spiral slides as a design option but do not make any recommendations for them. The Australian standards (AS 1924, Part 2, 1981) do not contain any references to spiral slides.

The Seattle draft standards (1986) include one recommendation for spiral slides: "locate access ladder and supports away from both sides and end of a spiral slide to prevent injury to dangling arms and legs." Esbensen (1987) also recognized that spacing next to the structure, side supports, and head clearance can pose serious problems for spiral slides. These issues are important for all slides, straight, spiral or otherwise, and have been addressed in the section on straight slides with recommendations regarding clearance zones and support structures.

Esbensen (1987) noted that final deceleration from spiral slides was a problem as well. The current guidelines specify that spiral slides should follow the exit region specifications for straight slides. Given the different forces which act on a child who is descending through banked curves rather than straight down a flat chute, it is conceivable that sliding velocities on spiral slides will differ; however, further research is needed to clarify the implications of any such effects on the design of the exit region, as discussed below.

The CPSC has been criticized for the complexity and/or arbitrariness of restrictions in the spiral slide recommendations, as presented in the current handbooks. The detailed physics and mathematics involved are extremely difficult for most readers to understand. For example, Davis (1980) stated that "an inordinate amount of coverage has been given to requirements and tests for spiral slides. Some of this data might be useful to an engineer--but to no one else." He further pointed out that nothing in the hazard analysis of slides has suggested a serious design problem for spiral slides. Similarly, Preston (1988) reported that "it is alleged that the CPSC guidelines for spiral slides have unnecessarily stringent design parameters to prevent lateral discharge of the user."

A recent CPSC draft analysis of spiral slides also appears to question some of the assumptions underlying the recommendations (Ramsey, 1988, draft). Ramsey concluded that the guidelines erred in assuming that weight acts in the plane normal to slide descent, rather than in the vertical plane, as well as in assuming that "the velocity equations for spiral and straight slides are one and the same." She recognized that the most significant problem was that certain parameters were assigned specific values, as opposed to allowing a range.

> It is apparent that many combinations of vastly different slide parameters can all result in "safe" slides, at least from the theoretical view. To restrict or assume the value of any parameter, even for the sake of simplification, results in classification of numerous "safe" slides as unsafe, simply because they do not "fit" the assigned parameters.

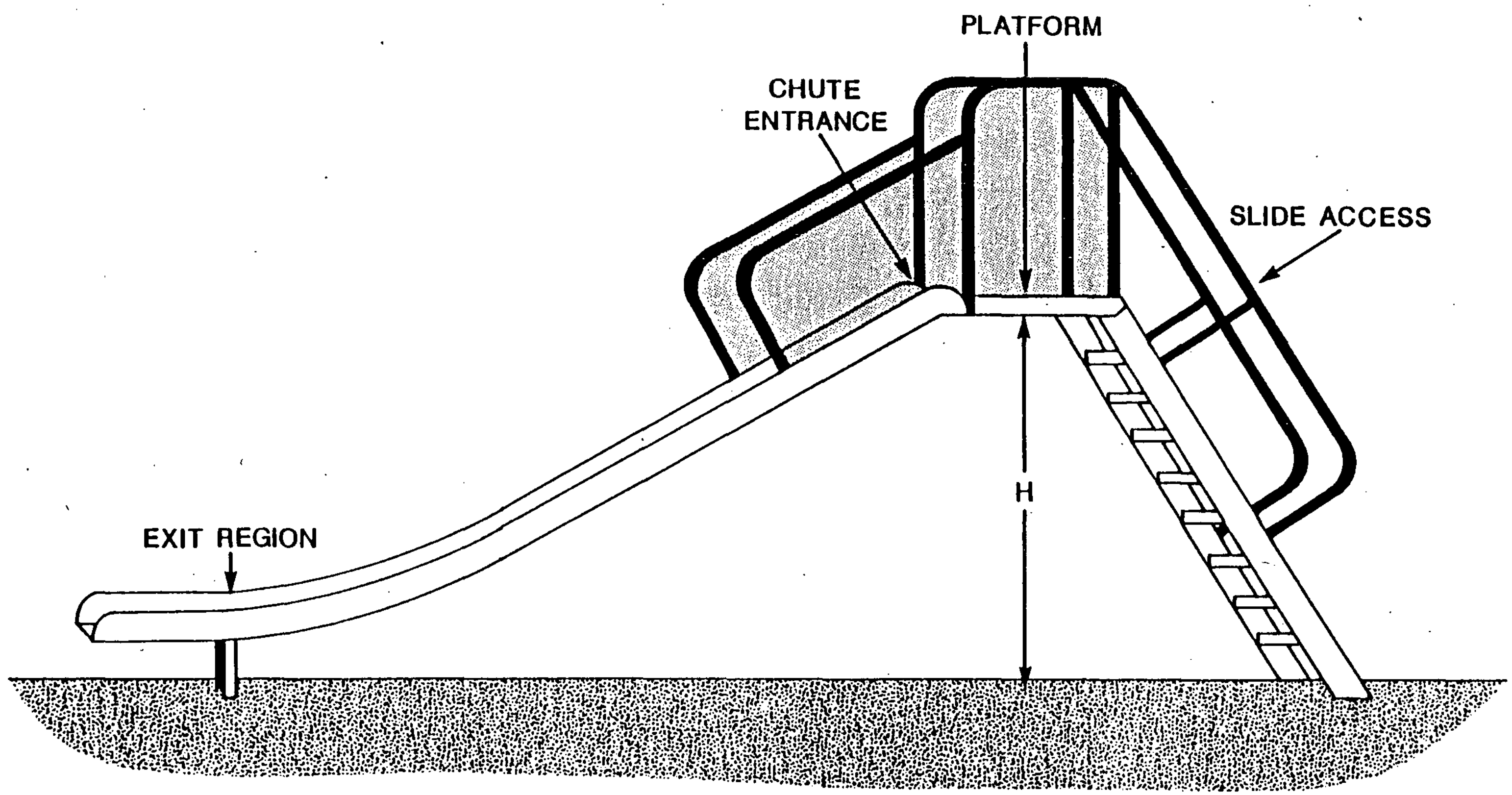
Response to criticisms regarding the model on which the current guidelines are based is likely to result in even more complex formulae and test procedures. The CPSC draft report referred to above defined 21 variables for spiral slides. Ramsey stated that "it is apparent that the ejection velocity of the user must be limited by requiring exit region length as a function of slide height, descent angle, and banking angle." Several problems arise in this method: although it is suggested that a safe exit velocity would be comparable to the average running speed of a minimum user, this speed is not known; the equation for the length of the exit region "varies significantly" with friction, and a reasonable value for this coefficient remains unknown; the effects of limiting the minimum banking angle are unclear. As recognized by Ramsey, research is needed to clarify these issues. It was also recommended in this draft analysis that age-appropriate anthropometric test dummies be developed and used during the testing procedures. While such complexity may improve the validity of the guidelines, it further compounds the problem of the treatment of spiral slides in the handbook. The issue becomes more acute since it is recommended elsewhere that the current two-volume format ("General" and "Technical" handbooks) be replaced in favor of a single volume.

It is therefore recommended that the extensive design specifications for spiral slides be deleted from the handbook because: a) the discussion is not aimed at the appropriate audience; b) extensive space in a booklet of limited size is devoted to a minor problem (about 20% of Volume 2 addresses spiral slides); and, c) the adequacy of the recommended specifications remains unclear. Instead, it is recommended that spiral slides follow the recommendations for straight slides, with special attention given to design features which may present problems unique to spiral slides. Such a treatment is consistent with foreign standards and is certainly suitable for a handbook with the scope of the present document.

The text should warn that adequate support is required to prevent lateral discharge, and that consideration must be given to the ability of the user to regain good body balance and control prior to exiting the chute. Younger children have less ability to maintain balance and postural control, and therefore, spiral slides are not appropriate for this age group. In addition, the exit region of a spiral slide should be clearly visible to children at the top waiting to enter the chute; this will help eliminate collisions at the bottom of the slide.

When the CPSC engineering review of the current spiral slide guidelines is finalized, if the findings indicate that detailed specifications are warranted, they could be included as a technical appendix to the guidelines.

FIGURES



Note: Protective barriers should be designed to prevent small children from falling through the barriers. This can be achieved through infilling or other measures, so long as they are consistent with the recommendations that protective barriers be non-climbable and preclude the possibility of entrapment.

FIGURE 5.7.1 – 1: TYPICAL STRAIGHT SLIDE

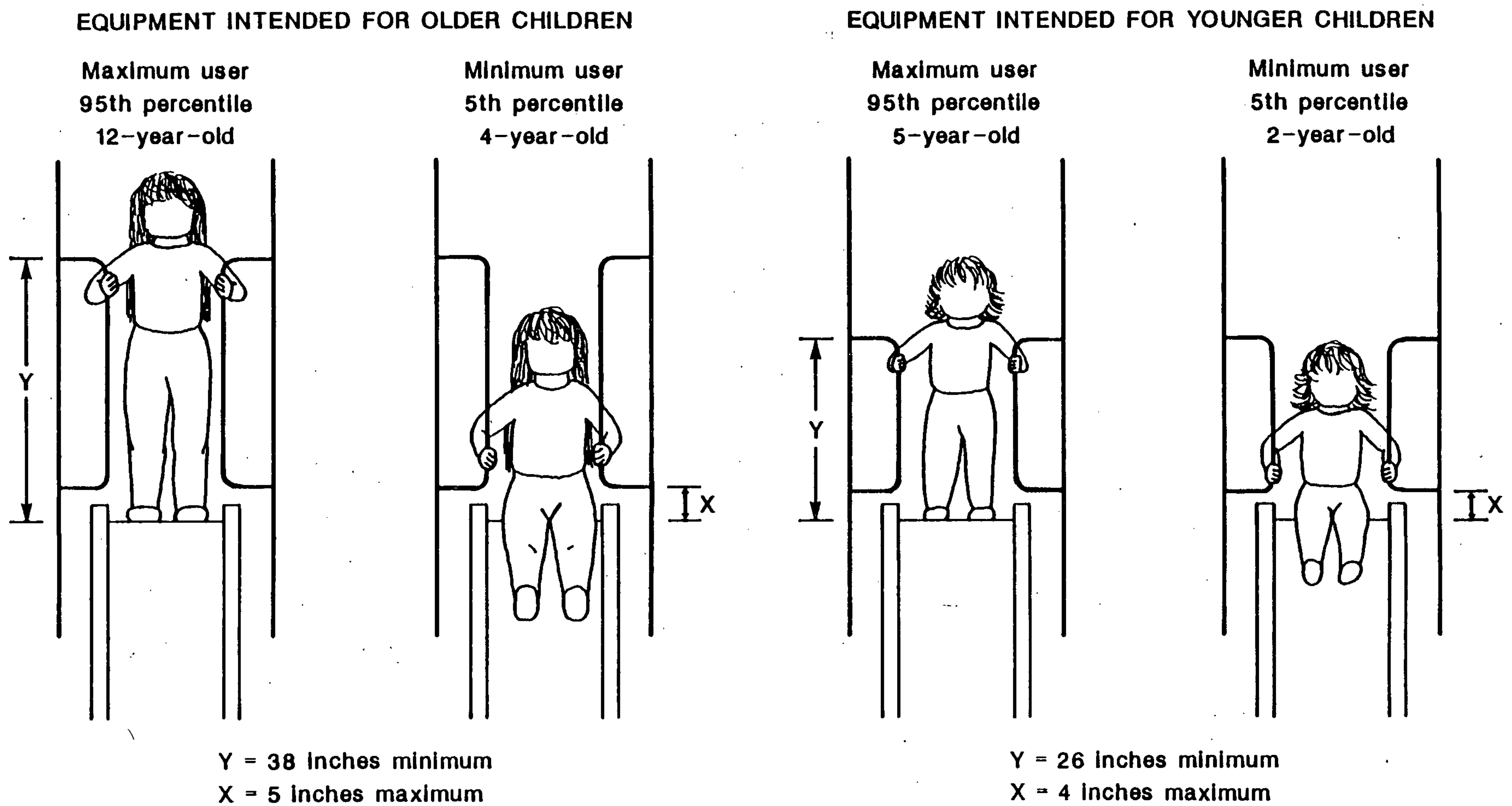
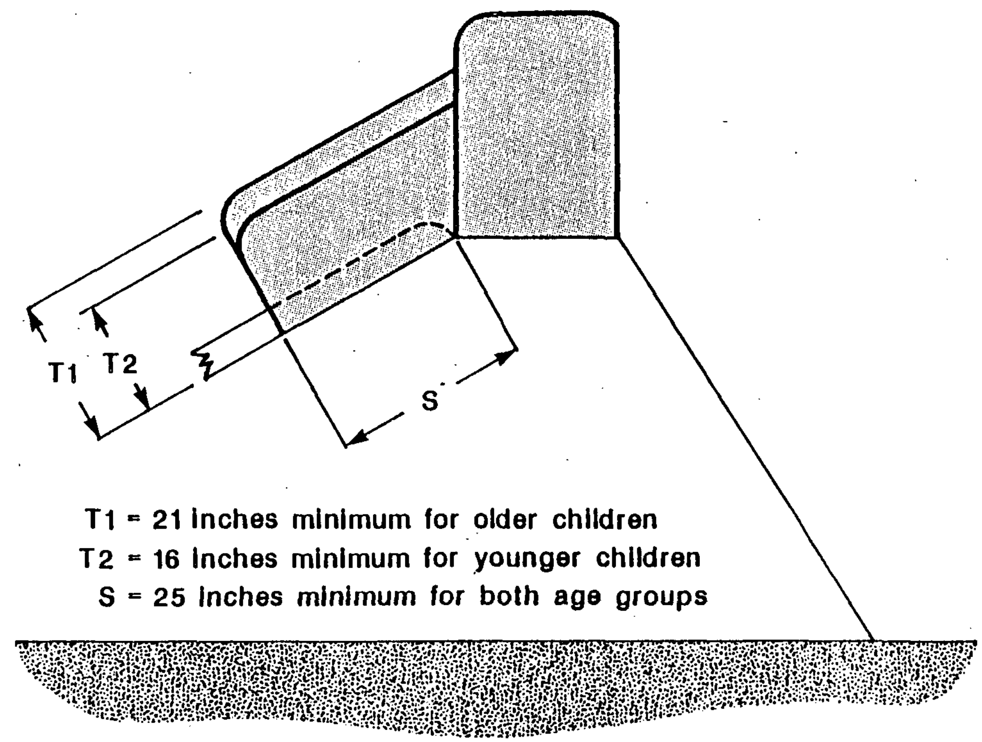


FIGURE 5.7.1 - 2: VERTICAL HANDHOLDS AT THE CHUTE ENTRANCE



Note: Protective barriers should be designed to prevent small children from falling through the barriers. This can be achieved through infilling or other measures, so long as they are consistent with the recommendations that protective barriers be non-climbable and preclude the possibility of entrapment.

FIGURE 5.7.1 – 3: PROTECTIVE BARRIERS EXTENDING DOWN THE SLIDE CHUTE

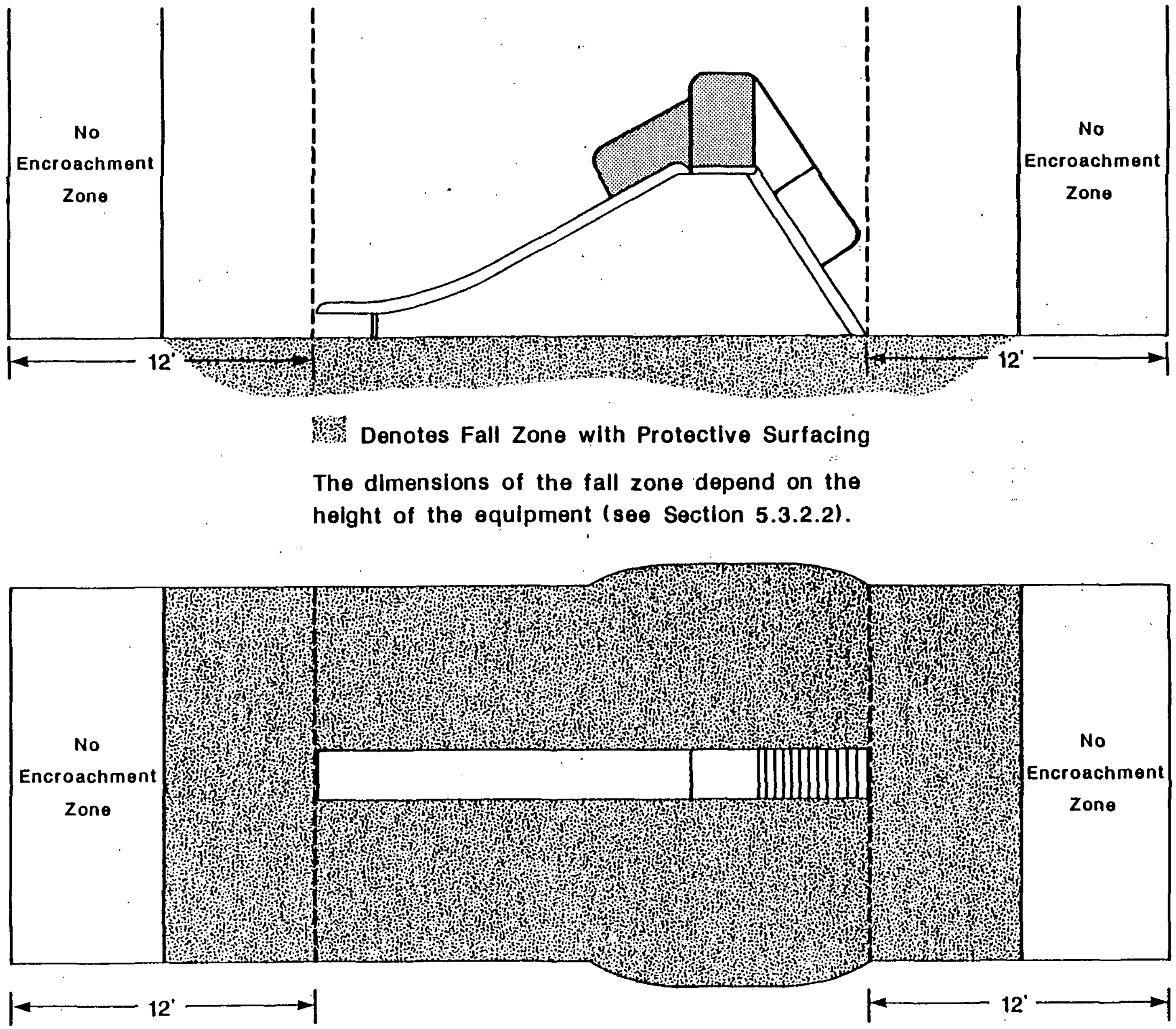
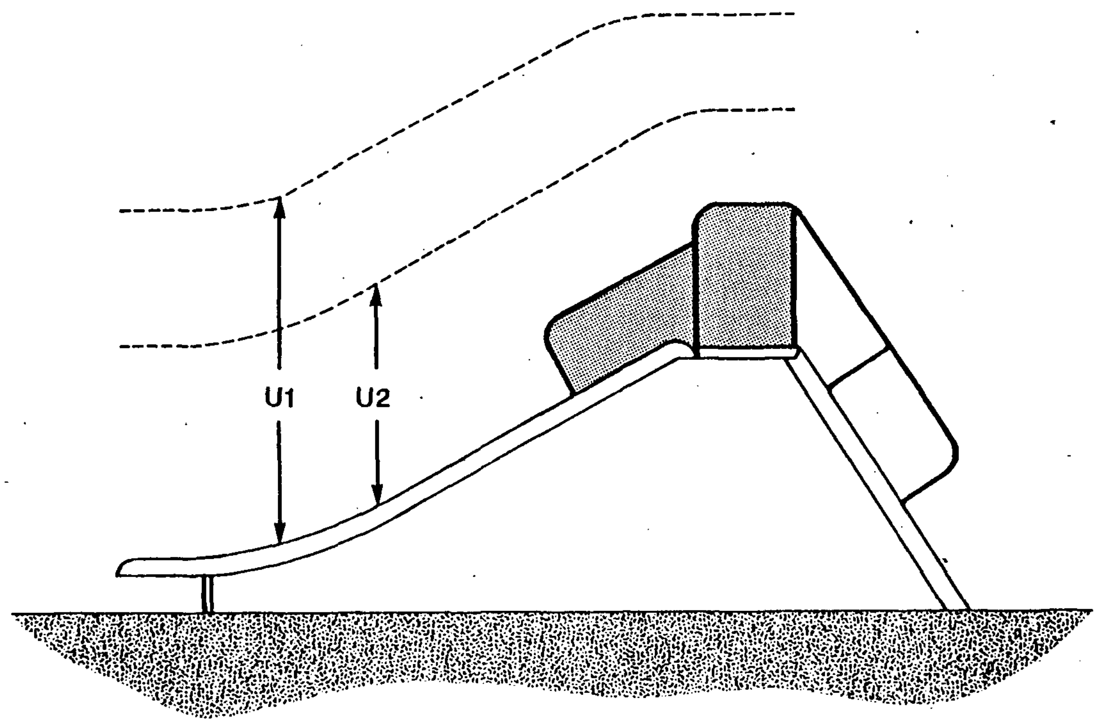
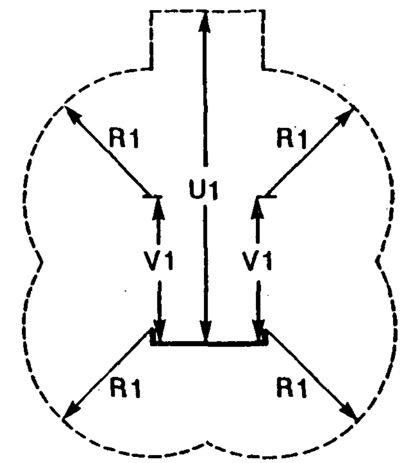


FIGURE 5.7.1 – 4: USE AND FALL ZONES FOR SLIDES OVER 4 FEET IN HEIGHT
(See Section 5.7.1.3.7 for recommendations applicable to slides less than or equal to 4 feet in height.)

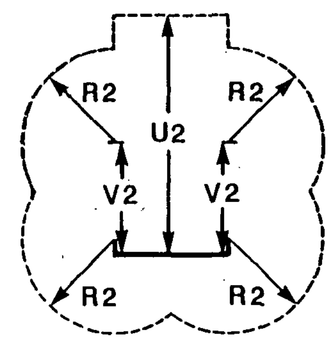


U1 = 63" for Older Children
U2 = 46" for Younger Children

Frontview of slide chute



V1 = 21" for Older Children
R1 = 20" for Older Children



V2 = 16" for Younger Children
R2 = 15" for Younger Children

FIGURE 5.7.1 – 5: CLEARANCE ZONE FOR SLIDES

5.7.2 SWINGS

5.7.2 SWINGS

5.7.2.1 PATTERNS OF SWING USE

5.7.2.2 REVIEW OF SWING INJURY DATA

5.7.2.3 SWINGS

5.7.2.3.1 Swing seats
5.7.2.3.1.1 Design considerations
5.7.2.3.1.1.1 Lightweight, impact absorbing materials; no sharp edges; no protrusions
5.7.2.3.1.1.2 Dimensions of seat surface
5.7.2.3.1.1.3 Handholds
5.7.2.3.1.1.4 Tot swings
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5.7.2.3.3 Minimum clearances

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5.7.2.3.4.1 Design of structure
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5.7.2.3.5 Layout and spacing of swing structures

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5.7.2.3.7 Protective surfacing

5.7.2.4 GLIDER SWINGS

5.7.2.5 MULTI-AXIS TIRE SWINGS

5.7.2.5.1 Impact injuries

5.7.2.5.2 Other design considerations

5.7.2.5.3 Suspending elements, hardware

5.7.2.5.4 Minimum clearances

5.7.2.5.5 Support frames

5.7.2.5.6 Layout and spacing of tire swings

5.7.2.5.7 Use, fall zones

5.7.2.6 ROPE SWINGS

5.7.2.7 SWINGING EXERCISE RINGS AND TRAPEZE SWINGS

5.7.2.1 PATTERNS OF SWING USE

The traditional swing is a seat suspended from its structure by means of two chains, one on each side of the seat. Children sitting on the seat can swing forward and back, along a single axis of motion. Several different kinds of swings are generally available on playgrounds (see Figure 5.7.2 - 1). The Play For All Guidelines explains that swings vary depending on the type of seat, the suspending elements, the length of arc, and character of take-off and landing. Esbensen (1987) stated that "swings have undergone a tremendous evolution in the past two decades." He remarked that older wooden seats are being replaced by plastic or strap-type seats as well as rubber tires. Also common are tot swings designed to provide extra support and protection for very young children with chair or bucket-type seats. Other types of single-axis swings include animal swings, gliders, swinging exercise rings, and trapeze swings.

In a study of children's choice of playground equipment, Peterson, Bishop, Michaels, and Rath (1973) found swings to be the most popular. Further, their results indicated that children do have stable and reliable preferences which can be correlated to the actual use of playground equipment. Another study on play and equipment choices conducted by Frost and Campbell (1978) also placed swings at the top of popularity rankings for conventional playgrounds. In addition, the SCIPP survey in Massachusetts identified swings as the most popular type of equipment (Helsing et al., 1988), as did a 1983 User Survey in Seattle (Stoops, 1985). The Play For All Guidelines (Moore et al., 1987) concludes that "the traditional double-hung swing (with a reinforced vinyl seat) is still probably the most popular piece of play equipment ever invented."

Brown (1978) noted that swings are a traditional part of playgrounds and that a playground cannot be considered complete without them. Both Brown and Frost (1986b) recognized that a swing set is typically one of the large, fixed structures on playgrounds, and that it frequently stands as a separate unit.

"Developmentalists advocate the use and presence of a swing and contend there are many benefits to be gained from its use," such as small and large muscle development and the awareness of one's body in space (Brown, 1978). Bruya and Langendorfer (1988) further explained that the use of swings contributes to vestibular and proprioceptive stimulation. "Acceleration of body movement provides stimulation to the inner ear and apparently contributes to basic perceptual and motor development in some subtle, but important ways." The acceleration and deceleration experienced during the pendulum motion of swinging also aids the development of balance and movement for young children. Further, the speeds and forces generated while swinging are not experienced by young children during other activities. This produces great thrills for some children, and fear for others. Brown also recognized that the sensations of swinging are generally enjoyed by children. She noted, however, that sensory adaptation does occur, causing other creative play patterns to emerge, such as jumping from the swing or attempting to do a "wrap around." Because a swing is a simple unit, intended for one particular use, these alternative behaviors can greatly increase the risk of injury.

Age-related characteristics of swing use can best be described by common injury patterns, which are discussed in detail in the following section. Two scenarios are especially important: younger children, those 2 to 5 years of age, are very often involved in moving impact incidents because they inadvertently walk into the path of moving swings; older children, those 6 to 12 years of age, are at greater risk for injuries resulting from falls, because they are more likely to engage in uses such as standing on or jumping from swings.

Results of the observational study support the belief that younger children are often putting themselves at risk of moving impact injuries by standing, walking, or running into the path of moving swings. It was extremely common to see children who were approximately 2, 3, and 4 years old, simply wandering into the swing area, without any attention to other children swinging. Frost (U. of Texas, 1989, unpublished manuscript) explained that impact injuries "are particularly frequent for younger children who have not yet developed sufficient cause-effect thinking required to anticipate hazardous events. The swing is out of sight in the other direction so the temporarily unoccupied space may be considered safe by the prelogical thinker."

Another play behavior seen repeatedly in the observational study was young children (approximately 3 and 4 years old) swinging in strap-type seats on their stomachs. In some cases it appeared as though they chose to swing on their stomach because they were unable to get up onto the seat to sit. Further, those who were sitting in the seat (sometimes after being helped into it by an adult) did not do very much. They could not get the swing moving by themselves, and unless they were pushed, most just sat, not really swinging. Children were also observed having difficulty getting down from swing seats. Therefore, it seemed that these younger children had more fun on their stomachs since they could actually swing by using their legs to push off the ground. The movement of this swinging included much more side-to-side motion than swinging generally does when the user is seated. This could interfere with other swings in close proximity and put both the child on his or her stomach and the other swingers in danger.

In addition to young children seen swinging from their stomachs and walking through the swing area, the other behaviors most frequently noted in the observational study are as follows: children twisting swings, both those with empty seats and occupied seats, and then letting them unwind; children standing on swings, usually multi-axis tire swings or animal swings.

When the children were slightly older, (approximately 4, 5, and 6 years) they were able to very successfully "pump" themselves to great heights on conventional swings, as seen during the observational study. Brown (1978) concluded that the coordination, balance, strength, and general motor responses required for swinging are well within the capabilities of a 5-year-old. She also reported that "once the youngster is in the actual act of swinging there is little if any interaction between users," and that this is even more pronounced in older, school-age users.

Tire swings are becoming increasingly popular on today's playgrounds. They are typically suspended horizontally using three suspension chains or cables from a swivel mechanism for 360 degree rotation and, therefore, have multi-axis movement, in contrast to conventional single-axis swings (Frost, 1980, 1986b, U. of Texas, 1989, unpublished manuscript). The rotational movement of multi-axis tire swings provides a different play experience than that of conventional back-and-forth swings. Further, the nature of the seat and suspension system make them more of a climbing apparatus, whereas other swings are not designed for such actions. Brown (1978) reported that clustered play units often include tire swings and Frost (1986b) noted that swing structures are sometimes attached to multi-use equipment. These tire swings, Brown explained, allow for more than one child to swing at a time. The current guidelines also recognize that tire swings are popular because they are multiple occupancy seats (Volume 1).

5.7.2.2 REVIEW OF SWING INJURY DATA

Based on injury data from various studies, including the detailed incident analysis of 1988 data, swing-related injuries can be characterized in the following ways: 1) at least one third of swing-related injuries involving public equipment were sustained by children under 5 years of age; in this age group, swings were associated with the highest percentage of all equipment-related injuries (Rutherford, 1979). 2) Falls from swings have been the predominant mode of injury, accounting for more than one half and up to two thirds of all swing-related injuries. 3) Most studies attributed about one quarter of swing-related injuries to impact with moving swings; there is some indication that this mode of injury occurs more frequently among children under 6 years of age than among older children. In addition, a high percentage of impact injuries involved young children walking or running in the path of a moving swing. 4) Relative to other equipment types, swings have accounted for high rates of head injuries; however, the proportion of serious head injuries (concussion, internal head injury, skull fracture) sustained on swings tends to be somewhat lower than that reported for slides or climbing equipment. 5) The pattern of swing-related injuries was different for younger children (0-4 years of age) than for older children (5-14 years of age): injuries to the head and face were more frequent among younger children than among older children, while upper limb injuries were more common among older children (King and Ball, 1989).

Studies cited in this section are more thoroughly discussed in the Injury Data Overview (see Section 3). Although Rutherford's (1979) analysis of 1978 NEISS data only addressed injuries which occurred on public playground equipment, most other data sources such as King and Ball's (1989) discussion of 1982-86 NEISS data, 1987 NEISS data, and 1982-86 CAIRE data, addressed injuries associated with both public and home playground equipment. Therefore, these data are presented only to give a general impression of typical age-related injury patterns and scenarios and are not intended to be directly compared. The detailed incident analysis of 1988 data for swing-related injuries is based on a review of 63 cases. These injuries occurred in connection with the following types of swing structures: 42 conventional back-and-forth swings, 10 2-person or 4-person gliders or pendulum swings, 4 swing support structures (e.g., cross-bar, overhead support), 2 animal swings, 2 tire swings, 1 rope swing, 1 pair of swinging ring handles, and 1 trapeze swing.

Swing-related injuries. The NEISS-based 1978 Special Study of public playground equipment attributed 23% of all equipment-related injuries to swings (Rutherford, 1979). Several Australian studies of emergency room injury data have shown comparable proportions (23%-25%) of swing-related injuries (Royal Alexandra Hospital, 1981, cited in King and Ball, 1989; Oliver et al., 1981; Pitt, 1988, reported in King and Ball, 1989). Other data reported by King and Ball (1989) have shown high estimates for the percentage of equipment-related injuries associated with swings (35%, 1982-86 Canadian CAIRE data; 41%, 1982-86 NEISS data).

Data regarding the availability of swings on playgrounds is limited. Rutherford (1979) reported that swings comprise 20% of all public playground equipment units; he concluded, therefore, that the frequency of swing-related injuries is roughly proportional to the availability of swings on public playgrounds. A recent survey of elementary school playgrounds yielded an estimate of 13% for swing availability (Bruya and Langendorfer, 1988).

Age of victims. Rutherford (1979) reported that 34% of the swing-related injuries in the 1978 Special Study were sustained by 0- to 4-year-olds. Further, more than two thirds of all swing-related injuries were sustained by children under 8 years of age. Consistent with this finding, the average age of children injured on swings has been reported as 6 years (Illingworth, Brennan, Jay, Al-Rawi, and Collick, 1975, and Pitt, 1988, reported in King and Ball, 1989). Other estimates of the proportion of swing injuries among younger children (0-4 years of age) ranged between 18% (Morbidity and Mortality Weekly Report, 1988) and 46% (Royal Alexandra Hospital, 1981, cited in King and Ball, 1989); most estimates were higher than one-third.

Mode of injury. Falls were the predominant cause of swing-related injuries, followed by impact with moving swings. Pinch points, protrusions, sharp edges and sharp points, and finger entrapment were implicated in a small proportion of the injuries.

The 1978 NEISS Special Study (Rutherford, 1979) showed that 69% of swing injuries on public equipment were due to falls, primarily falls to the surface. Falls from height accounted for 61% of all swing-related injuries in the 1982-86 CAIRE dataset (reported in King and Ball, 1989).

In the detailed incident analysis, falls were the primary mode of injury in 34 of the 63 swing-related cases; falls were involved in 40 of the 63 swing injuries.

There is some indication that falls from swings or swing support structures are more common among children over 5 years of age than among younger children. In the detailed incident analysis, over two thirds of swing injuries sustained by older children (6-14 years of age) were caused by falls, as compared to one third of swing-related injuries among younger children (0-5 years of age).

Factors which have contributed to falls from swings include jumping from swings, standing or kneeling on swings, being pushed out of swings, being hit by swings, loss of grip, and structural failure, including failure of suspending elements or fasteners (Brown, 1978; the detailed incident analysis; Illingworth et al., 1975, cited in King and Ball, 1989). During the detailed incident analysis, in-depth investigations of swing injuries involving falls were analyzed for cause of fall; Table 5.7.2 - 1 shows the number of falls attributed to different causes. Because CPSC guidelines for swings address the climbability of support frames, falls from swing support structures were classified as swing-related injuries. Injuries attributed to a loss of grip included falls from a rope swing and a trapeze swing. "Other" causes of falls included swinging very high, hitting a protruding bolt on a support pole, and a 3-year-old attempting to use a swing designed for an older user. Structural failures involved suspending elements or fasteners, primarily for conventional swings suspended by chains, but also for a tire swing. In the AALR survey of elementary school equipment (Bruya and Langendorfer, 1988), 65% of moving parts for swings were rated as "being in good working condition and not in danger of breaking." However, L. Witt (personal communication, March 1989) pointed out that chain links, S hooks, and swing hanger hardware must be inspected very carefully to determine the extent of wear; inspection at eye level is not adequate. The procedure used by raters in the AALR survey to examine moving parts was not specified.

Impact with moving equipment accounted for one quarter of all swing-related injuries in the 1978 Special Study of public playground equipment (Rutherford, 1979). The 1982-86 CAIRE dataset (reported in King and Ball, 1989) implicated impact with moving equipment in one third of all swing-related injuries. A frequent cause of impact with a moving swing involved the victim standing, walking, or running in the path of a moving swing (Australian National Injury Surveillance and Prevention Project (NISPP), 1988, cited in King and Ball, 1989; Brown, 1978; Illingworth et al., 1975, cited in King and Ball, 1989; the detailed incident analysis). Bruya and Langendorfer (1988) reported that 94% of the elementary school playgrounds in their survey had no barriers to minimize the risk of children running into moving swings.

The detailed incident analysis indicated that 0- to 5-year-olds have been injured more frequently due to impact with moving swings than 6- to 14-year-olds: this mode of injury represented 13 of 33 swing-related injuries for younger children, in comparison to 3 of 30 swing-related injuries for older children. The differential rates of falls and impact with moving swings for younger and older children can be linked to the perceptual-motor capabilities that characterize each age group. Children under 5 years of age cannot "accurately estimate time, distance and speed of an approaching swing" (Brown, 1978) and do not recognize the hazards posed by moving swings (Rutherford, 1979); these characteristics put them at greater risk for impact. By contrast, older children are better able to anticipate and avoid potential impact with moving swings, but tend to use swings in ways (e.g., standing on or jumping from the swing seat) that put them more at risk for falls from swings than for impact with moving swings.

In the detailed incident analysis, 10 out of 11 injuries that resulted from standing, walking, or running in the path of a moving swing were incurred by children under 6 years of age. In addition, the swing was occupied in all but one of these 11 cases, although the majority of injuries were reported as caused by the swing seat and not by the occupant. That children tend to be struck by occupied swings is corroborated by Rutherford's (1979) analysis of injuries due to impact with moving swings.

Less common causes of impact with moving swings in the detailed incident analysis included being struck while pushing a swing, after jumping from a swing, or falling from a swing. Brown (1978) reported that children are sometimes struck while attempting to run under swings.

In the 1978 Special Study of public playground equipment (Rutherford, 1979), pinch points, protrusions, sharp edges, and sharp points accounted for about 1% of all swing-related injuries. The detailed incident analysis indicated that 9 of the 63 swing-related injuries were caused by pinch points, protruding bolts, and sharp edges; 6 of these injuries were associated with gliders or pendulum swings. Survey data showed that about one quarter (26%) of swings on elementary school playgrounds had sharp corners, edges, or projections on the swing seat, suspending chains, or swing structure (Bruya and Langendorfer, 1988). In addition, 91% of the swings suspended by chains did not have covered chains, and thus presented pinch point hazards. A survey of public playground equipment in several Massachusetts communities (Helsing et al., 1988) revealed that more than half (56%) of the playgrounds sampled had swings with finger traps. This hazard category excluded swing chain entrapment hazards, but may have included suspending hardware which tends to be associated with pinch and crush injuries. In the detailed incident analysis, the two pinch/crush injuries that were reported involved a swing hanger mechanism, one for a tire swing and one for a glider swing.

Protrusions alone accounted for 6 of the 63 swing-related injuries in the detailed incident analysis; 5 of these injuries due to protruding bolts were associated with glider swings. The protruding bolts were located on swing support structures (3 cases), on an adjacent swing (1 case), and on the vertical supports of a glider (1 case).

Other causes of swing injuries in the detailed incident analysis included finger entrapment in a swing chain link (2 cases) and impact with a swing set support pole (1 case). Impact with stationary equipment represented a small proportion (1%) of swing-related injuries in the 1978 NEISS Special Study (Rutherford, 1979). Helsing et al. (1988) reported that more than two thirds (71%) of playgrounds in their survey had swings with chain links greater than 5/16 of an inch in width, a size which they identified as a finger trap hazard.

Other characteristics of incident. The detailed incident analysis indicated that more than one third of swing-related injuries occurred during primary use of the swing by the victim; another one third of swing-related injuries occurred when the swing was not being used by the victim; the remaining one third of swing-related injuries occurred while the victim was getting on or off the swing. Older children were more often injured during primary use of swings (e.g., falls from swings), whereas younger children were more often injured when they were not using swings (e.g., moving impact incidents). Moreover, younger children were twice as likely as older children to be injured when another person was actuating the swing.

Glider-related injuries. Most studies which include injuries on home equipment do not analyze glider-related injuries separately from other swing injuries. An exception is the 1978 NEISS data on home playground equipment (Rutherford, 1979, cited in King and Ball, 1989). In this study, impact with moving equipment was the predominant cause of glider-related injuries, accounting for more than two thirds (68%) of glider injuries, followed by protrusions (16% of glider injuries).

Although the detailed incident analysis includes only 10 injuries directly or indirectly caused by gliders, a few patterns are of interest. Half of glider-related injuries were caused by protruding bolts located either on the glider itself, or, more commonly, on a support pole adjacent to the glider. In 4 cases the victim contacted a protrusion while playing on a glider or while dodging a moving glider. In another case, the victim contacted a protrusion on a glider while playing on an adjacent cross-bar of the A-frame. Thus, in this sample, the high rate of protrusion injuries associated with gliders was due, at least in part, to the close proximity of gliders and swing set support structures. Two additional injuries involved the victim being able to reach the top of the glider's vertical supports from an adjacent slide.

Injury patterns. Swings were associated with high rates of head injuries relative to other equipment types, as reported by King and Ball (1989). When swing-related head injuries are classified by severity of injury, superficial head injuries such as contusions and lacerations predominate swing-related injuries; the proportion of serious head injuries (concussion, internal head injury, skull fracture) tends to be somewhat lower than that reported for slides or climbing equipment.

Discussion by King and Ball (1989) of 1985-86 NEISS data, 1987 NEISS data, and 1982-86 CAIRE data allows an age-related comparison of injury rates classified by body location of the injury and severity. Head and facial injuries were much more common for 0- to 4-year-olds than for 5- to 14-year-olds. Moreover, facial injuries among younger children were about twice as frequent as they were for older children. In contrast, upper limb injuries were sustained by older children at more than twice the rate they were sustained by younger children. With regard to severity, superficial facial injuries were the predominant type of swing-related injury for children under 5 years of age; the next most frequent types of injury among younger children were superficial head injuries and serious head injuries. The two most common types of injuries sustained by 5- to 14-year-olds were upper limb fractures and superficial facial injuries.

These injury patterns were supported in the detailed incident analysis: 0- to 4-year-olds and 5- to 14-year-olds most frequently sustained superficial facial injuries and upper limb fractures, respectively.

Between 1973 and 1978, eight swing-related deaths were recorded in the U.S. (Rutherford, 1979); causes of these fatalities included hanging by the suspending chains, falls, impact with moving swings, running into stationary equipment, and two cases of structural failure that resulted in equipment falling on the victim. A special report on accidental ligature strangulations investigated cases involving children under age 5 from 1973 to 1980 (Rutherford and Kelly, 1981). Play equipment was involved in a total of 29 incidents, 27 of which were fatalities. In 6 of these cases, the play equipment was the primary cause: "the victim was entangled with a rope or chain which was an integral part of the equipment." It is unclear whether any of these cases were included in Rutherford's (1979) analysis of death certificates from 1973 to 1978.

King and Ball (1989) reported that 17 out of 28 fatalities occurring between 1985 and 1987 in the U.S. were associated with swings. More than two thirds of the swing-related deaths were due to asphyxiation or strangulation; one prominent injury scenario was described as children accidentally hanging themselves from swing chains or ropes. In one case, a swing raised to a position 10 inches below the overhead support bar provided a head opening that caused suffocation. Other fatalities were attributed to impact with moving swings which resulted in head fractures, and falls from swings.

Additional in-depth investigations provided by the CPSC included two 1987 cases in which children entangled themselves in the suspending chains or ropes of a swing. One of these was fatal and involved a 5-year-old with Down's Syndrome. (This case may have been included in the sample of 1985-1987 deaths reviewed by King and Ball (1989), as discussed above.) The other case was a 3-year-old who suffered lacerations on his neck caused by sharp edges or protrusions on the chains.

5.7.2.3 SWINGS

5.7.2.3.1 Swing seats

5.7.2.3.1.1 Design considerations

5.7.2.3.1.1.1 Lightweight, impact-absorbing materials; no sharp edges; no protrusions

Guideline content:

Volume 1 of the handbook states that "seats should be constructed of lightweight material such as plastic, canvas, or rubber," since children can incur serious head injuries if they walk into the path of a freely swinging, empty seat. Further, in discussion of making existing playgrounds safer, it is recommended that all heavy swing seats be replaced by lightweight ones. A detailed testing method for the impact of moving swing seats is given in Volume 2, which is discussed below (see Section 5.7.2.3.1.2). (Volume 1; Volume 2, 9)

In addition to recommending lightweight, impact-absorbing materials, Volume 1 also recommends that seats have "smoothly finished or rounded edges" in order to prevent cuts or scrapes. Volume 2 explains that any point or edge considered "questionable," with regard to its injury-causing potential, should be considered sharp. More specifically, in the case of suspended members, a minimum radius of curvature of 1/4 inch is recommended for all corners and edges; however, this does not apply to flexible components such as belts, straps, and ropes. (Volume 1; Volume 2, 7.1)

Test methods to determine exactly what constitutes a hazardous protrusion are outlined in Volume 2. One of the exclusions to the general test is protrusions on the front and rear surfaces of suspended members of swing assemblies. A separate test for these is suggested. No surface in the potential impact region of the suspended member should protrude through the hole beyond the face of the specified gauge, when tested in accordance with the recommended procedure. This test method is addressed in a general discussion of protrusions (see Section 5.2.3). (Volume 2, 7.3.3.2)

Probable rationale:

As mentioned above, a test method was developed by NBS to determine the impact of moving swings and to establish a criterion by which the safety of various seats could be judged. Three types of seats were subjectively evaluated and then tested by the CPSC Engineering Laboratory using the suggested method and criteria. The three classifications, prior to testing, were as follows: a) "those that appear to be dangerous, such as metal, wood, or other rigid members;" b) "those that appear to be safe, such as flexible suspended members;" and c) "those that appear to be questionable, such as padded metal suspended members." Based on the peak acceleration measure of 100 g's as specified in the test procedures, the data obtained by the CPSC Engineering Laboratory agreed with the subjective determinations. Suspended members classified as "safe" were well below the criterion acceleration level; the "dangerous" ones were well above; and, the "questionable" ones fell slightly above. It is important to note that "additional padding would probably allow the borderline members to pass the test." (NBS, 1978b)

Given this information regarding the test performance of the various types of swing seats, one can infer that the CPSC recommended lightweight materials such as plastic, rubber, and canvas because only these would undoubtedly pass the moving impact test. Similarly, their recommendation to replace heavy swings with lighter ones also reflects the results of the testing in which metal and wooden seats failed to meet the criterion for safe impact accelerations. The basic rationale is stated directly in the text of the guideline: to help prevent serious head injuries caused by impact when children wander into the path of an empty swinging seat.

Regarding the recommendations for no sharp edges, the general intent is also explicitly stated: to help prevent cuts and scrapes. The specific minimum radius of curvature is intended to "insure that suspended members do not have corners and edges that are judged to be capable of producing injuries as a result of small area impacts." (NBS, 1978b)

The most sensitive part of the head has been determined to be the zygoma, which is slightly below the temple region. Direct impact to the zygoma can cause skull fractures under conditions of much lower accelerations than those when the impacted area is large enough to circumscribe the bone. The protrusion recommendation is designed to "insure that suspended members do not have protrusions that are judged capable of impacting the zygoma directly without bearing on other parts of the head." (NBS, 1978b)

Issues:

As discussed in the review of swing-related injuries, incidents involving impact with moving swings are very common, more so for younger children than for older children; most studies indicated that these account for between one quarter and one third of all swing-related injuries. The detailed incident analysis includes 11 injuries incurred when a child was standing, walking, or running in the path of a moving swing. Ten of these 11 cases involved children under 6 years of age. Overall, moving impact injuries accounted for 10 of the 26 swing-related injuries for children 1 to 5 years old in the 1988 dataset.

Many other sources also address the hazards of moving swings and the dangers they pose, especially to younger children, who have not yet developed the perceptual and motor skills needed to anticipate these events (Brown, 1978; Frost, U. of Texas, 1989, unpublished manuscript; J. Frost, personal communication, February 1989; Geiger, 1988; Moore et al., 1987; Rutherford, 1979; T. Sweeney, personal communication, February 1989). The high rate of moving impact injuries illustrates the importance of safe swing seat design, because as long as there are swings, younger children will inadvertently walk into their paths of movement.

Several sources report information provided by the CPSC. Included are cautions that hard, heavy seats can strike a dangerous blow; therefore, lightweight seats, such as rubber, plastic, or canvas should be chosen, and any hard seats already installed should be replaced or at least inspected to check that metal seats do not have pointed edges if replacement is not possible (Stoops, 1985; Sweeney, 1982, 1985, 1987; Werner, 1982). Frost (U. of Texas, 1989, unpublished manuscript) discussed the current CPSC guidelines, and concluded that they "seem acceptable for most common applications." The <u>Play For All Guidelines</u> (Moore et al., 1987) simply states that the CPSC guidelines for impact and protrusion are the minimum requirements for swing seats. They note that "even empty swing seats with significant mass and/or sharp edges can cause injury when thrown."

The Play For All Guidelines also goes beyond the scope of the CPSC recommendations, suggesting that all seats except the rubber belt type and auto tires which are triple hung should be removed. Further, if the belt seats are reinforced with steel, they should not allow sharp edges to be exposed. The Seattle draft standards (1986) make a parallel recommendation, requiring reinforced rubber, sling-type seats.

Many others, while not specifically referring to the current CPSC guidelines, also made similar recommendations calling for the use of lightweight, resilient materials for swing seats (Aronson, 1988; Esbensen, 1987; Frost, 1986b, personal communication, February 1989; Frost, Wortham, 1988; Goldberger, 1987). Aronson further recommended that seats be "non-cutting"; Frost and Wortham also mentioned that seats should not have any protruding elements. Both Esbensen and Goldberger addressed the hazards of wooden and metal seats, and Esbensen specifically stated that these hard seats should not be used. T. Sweeney (personal communication, February 1989) made related comments, referring to heavy metal swings as "50 pound unguided missiles" which definitely need to be eliminated from all playgrounds. One other interesting requirement was given both by Beckwith (1988) and in the Seattle draft standards: swing seats must be slash-proof. This is most likely an effort to protect against vandalism, because if seats with steel reinforcements were slashed, the exposed metal could present a sharp edge, as noted above.

The Australian standards (AS 1924, Part 2, 1981) are comparable to the general CPSC recommendations. They require that seats either be made of impact-absorbing materials or at least be provided with impact-absorbing surfaces on all potential contact points, and that seats be light in mass. Furthermore, seats should be proportioned such that the leading edges and corners are relatively large in possible contact areas. The intent of these Australian specifications is to minimize the effect of any impact of a moving swing seat on a child in its path.

Canadian draft standards (CAN/CSA-Z614, 1988) also address the mass of swing seats, stating that the suggested maximum mass be 3 pounds. If a seat is heavier than 3 pounds, it should be constructed of impact-absorbing materials, or all conceivable contact areas should be covered with an impact-absorbing surface. In their discussion of swings, the Canadian draft standards state that "an excess of 50 J of energy in an impact of a swing seat against a child's head can cause serious injury." The above regulation regarding the maximum allowable mass is an effort to reduce this risk of head injury.

The issue of retrofitting, or replacing heavy swings with new lightweight designs, is very important because there are a significant number of these dangerous swings still on playgrounds. Bruya and Langendorfer (1988) reported that the AALR survey of elementary school playgrounds found seats made of metal or wood on 15% of swing structures. Butwinick (1980) addressed retrofitting and pointed out that the actual process of changing swing seats is "particularly easy." Consumer costs could actually be reduced because lightweight swings are generally less expensive than heavier rigid ones. She also stressed that even a mandatory action would not cause "substantial changes in the line of most manufacturers," assuming that they already offer the lightweight seats as an option.

Butwinick concluded that there was a clear relationship between specifications requiring lightweight seats and the reduction of injury.

Frost (U. of Texas, 1989, unpublished manuscript) also noted how easy it was to eliminate the problem of severe impact injuries by simply replacing wooden or heavy seats with lightweight belt-type seats made of canvas or rubber. Citing a 1974 analysis of company catalogs completed by Butwinick, Frost reported that "swing seats are constructed from rubber, canvas, polyethylene, wood, aluminum, and other metals and they weigh from 2 to 56 pounds." It is unclear exactly what types of swing seats this range includes (i.e., flexible, flat, tot, tire, animal swings, etc.). Another interesting advantage of the belt-type seats over rigid ones which Frost recognized is it that the latter encourages standing on the seat and thereby increases the risk of falling from a moving swing.

A current review of playground equipment catalogs indicated that most swing seats on the market today, which are suspended from non-rigid components, are the strap- or belt-type design. They are usually made of rubber which is reinforced with steel inserts of various kinds. Many manufacturers advertise these seats as slash-proof, which is to minimize damage due to vandalism. Although not as common, canvas or rubber seats without these reinforcements are available from a few manufacturers. Only three examples of flat or straight seats were found: they are all rubber, two of them have cast-in frames, and the same two have edges around the perimeter of the seat described as impact- or shock-absorbing. Information regarding the weight of swing seats was not given in most catalogs. However, based on limited data, it appears that the strap-type or flat, rubber seats weigh from 3 to 4 pounds.

Animal swings: The current guidelines make no explicit mention of animal swings. However, in an illustration depicting methods for the impact test, a horse swing is shown (Volume 2, 9.2.3). Such animal swings, which are usually suspended from rigid bars, swing back and forth along a single-axis. More importantly, they are generally constructed of metal parts and, therefore, are very heavy. It is not clear whether animal swings are included in the CPSC's recommendation to replace all heavy metal swings with lightweight ones.

Frost (1980) noted that animal or theme swings were a common source of injuries, sometimes serious, in Texas. Some of these swings are easily broken and then left in a possibly hazardous state because there is no simple means for repair. In a discussion of the movement to modernize playground equipment, Frost (1986b) observed that "heavy animal seats with projectile-like noses and legs became battering rams, later responsible for many playground injuries. Many commercial firms still offer a wide selection of these hazardous swing seats." Review of current catalogs revealed two sources of animal swings in today's playground market. It is relevant to note that the various designs offered (lion, squirrel, seal, or pony) each weigh 28 pounds, or when including the hanging rods, 43 pounds.

Frost (U. of Texas, 1989, unpublished manuscript) commented that although the CPSC does not specifically exclude them, several foreign standards include regulations which would preclude the sale or use of animal swings. He believed that all animal swings should be removed from playgrounds because they are dangerous. J. Frost (personal communication, February 1989) also recently stated that animal swings should be outlawed.

The Los Angeles City Parks and Recreation Department does not allow the use of animal swings on their playgrounds (Goldfarb, 1987). Beckwith (1988) stipulated that suspended masses, such as animals, cannot be used unless they pass the CPSC impact test, as established by documentation provided with the swing.

During the observational study, several children were seen standing on moving animal swings, which put them at great risk for falls. Further, one child used the horse's head as a step up to the horizontal bars on the front of the apparatus and proceeded to climb these while holding onto the suspension rods; he was high enough to reach the top cross beam. This climbability adds another dangerous hazard to animal swings.

Exerglides: Frost (U. of Texas, 1989, unpublished manuscript) and the Seattle draft guidelines (1986) both acknowledged that special features must be considered to make swings appropriate for various needs groups as well. One such design is the exerglide. Frost remarked that exerglides appear to be safe, even though they are constructed of metal, noting that they are partially protected by a rubber bumper. However, he cautioned that "this conclusion could be modified by long-term experience and emerging injury data." As explained in the Play For All Guidelines, an exerglide "can be operated without lower body movement, however upper body strength must be robust."

Only one of the current playground equipment catalogs reviewed included exerglides as a swing option. The catalog describes the movement of exerglides as a double pendulum action, permitting travel only in a straight path. Further, it is noted that use of an exerglide aids in the development of upper body strength and timing. It is also suggested that this design discourages jumping from a moving swing and prevents side-to-side collisions. One of the safety features, as recognized above by Frost, and stated in the catalog, is a rubber bumper on the rear of the exerglide. The photographs of the exerglides in use lead the reader to believe that they are intended for younger users. In addition, some show two children on the swing together, seated one behind the other, which does not appear very safe. The swing itself and the suspending elements look as though they would be readily climbable, especially for older children, which creates major hazard potentials. It would also be easy for children to hit their heads against any of the rigid bars which extend up along both the front and the back of the seat while swinging in the intended manner. One other potential problem with the exerglide design is that the two parallel front bars could impose an entrapment hazard, depending on the distance between them. Overall, it does not seem as though exerglides are a safe alternative swing seat design for any children.

Recommendations:

The current CPSC recommendations regarding materials for swing seats are warranted as an effort to reduce the severity of impact injuries, which are especially common among younger children. Swing seats should be constructed of lightweight, impact-absorbing materials, such as rubber, canvas, or plastic. It is especially important to replace heavy, hard hitting swings with new lightweight designs. To help prevent cuts and scrapes, seats should have smoothly finished or rounded edges. Further, no suspended member should have any hazardous protrusions, as tested in accordance with the guidelines (see Section 5.2.3).

It appears that the flexible, strap-type seats are particularly safe. These are often of "slash-proof" design, which has the advantages of protection against protrusions from metal reinforcements and of being less susceptible to vandalism.

Animal swings are not recommended because of the potential for injury caused by their substantial weight and large protruding components. Further, the moving parts of these swings present pinch hazards and possible entrapment areas.

More research is needed to evaluate the safety of exerglides. Until they can be determined to be safe, they are not recommended for use on public playgrounds.

5.7.2.3.1.1.2 Dimensions of seat surface

Guideline content:

The current guidelines do not address the dimensions of swing seats.

Probable rationale:

Not applicable.

Issues:

The only source which specifies dimensions for swing seats are the Canadian draft standards. They state that the minimum width of the seating surface should be 12 inches, and that the minimum depth should be 4 inches.

Recommendations:

The width of the seating surface for swings, which is the distance between the hardware that connects the suspending elements to the seat at either end, should be at least 13 inches for older children or at least 9 inches for young children. These minimum values are based on the hip breadth of the maximum user in each age group (a 95th percentile 12-year-old and a 95th percentile 5-year-old, respectively).

5.7.2.3.1.1.3 Handholds

Guideline content:

The CPSC handbooks do not mention the use of handholds for single-axis swings.

Probable rationale:

Not applicable.

Issues:

The German standards (DIN 7926, Part 2, 1984) mandate that when swings have several seats, grips must be installed for every possible user. This regulation, however, clearly addresses multiple occupancy swings, such as a porch swing or perhaps a tire swing, and specific details are not explained. Similarly, the Canadian draft standards recommend that "a means of holding on should be provided for each intended user." However, in the case of single-axis swings, they emphasize that seats are intended to be designed for use by only one person at any time. Again, the type and location of the handholds they are suggesting is not clear. The Australian and British (BS 5696: Part 2, 1986) standards both discuss the location of handholds; however, these regulations appear to address glider or pendulum-type swings, because dimensions of footrests are also discussed (see Section 5.7.2.4).

King and Ball (1989) mentioned a 1988 Australian draft standard published by the Adelaide Working Party which suggests that "given the popularity among children of using swings while standing, hand grips should be attached at suitable levels for all ages to prevent children from falling." It would seem that such handholds would serve only as added motivation for a hazardous pattern of use, and that although standing on swings is a predictable use it is not one which should be encouraged. Furthermore, grips such as those suggested could introduce new hazardous uses. For example, children may be creative and choose to use them as toeholds rather than handholds. Children may also attempt to support their entire weight by gripping the handholds, when the height and load capacity of the handholds might be unsuitable for this use.

Recommendations:

Handholds in addition to the swing's suspending chains for which swings are intended for one user do not seem warranted.

5.7.2.3.1.1.4 Tot Swings

Guideline content:

Because they were intended to address children over 5 years of age, the current guidelines do not discuss tot swings.

Probable rationale:

Not applicable.

Issues:

In a design checklist for playground equipment, Beckwith (1988) included the following point: "Swings with seats designed for proper positioning and support are preferred." This issue of providing support is more important for younger users than older users. Younger children do not have the same capabilities as older children do for maintaining balance and body position, especially when the situation is complicated by the motion of a swing. The Canadian standards specify that "baby swing seats should be provided with seats that support the child on all sides and between the legs." The Seattle draft standards recommend that infant seats give adequate back support. Further, they suggest that all playgrounds which have swings should provide infant seats.

Review of current catalogs indicated that there are several types of swings on the market today designed especially for tot users. Unfortunately, this does not mean that these tot swings are readily available on playgrounds. The AALR survey of elementary school playgrounds reported that 51% of the play areas did not have swings designed for younger children, whom they refer to as the "primary users" of swings; of the play areas that did have swings for younger users, only half had separate structures for these swings (Bruya and Langendorfer, 1988). The question in the survey instrument which generated this information asks: "how many of the swing structures are lower, smaller type swings, which accommodate young children?" Further, it is important to recognize that the only definition of "younger children" given is "younger elementary children." Because it is unclear whether the elementary schools surveyed had kindergarten or preschool level facilities, it is difficult to interpret the actual age of children who were referred to as "younger elementary." Therefore, one cannot assume that "swings designed for younger users" necessarily meant tot swings in this survey, especially given the survey question's reference to lower, smaller swings.

One modern design offered by many manufacturers is a totally enclosed "bucket-style" tot seat. L. Witt (personal communication, March 1989) stated that this is the only tot seat used in Montgomery County, Maryland, because the child cannot tip over or fall out of this kind of swing seat. Two advantages of these fully enclosed seats can be illustrated by the Canadian draft standards: "the seats should not contain any movable or adjustable elements that would permit the child to fall off the seat"; and, "the baby seat should hold its shape so that an adult can lift the child into the seat without being required to hold the seat open." In contrast to the more traditional chair-type tot seats with a bar or chain across the front, there is nothing to lift up or open to be able to place a child in the bucket seat. Furthermore, in chair seats, children can slip out underneath the chain or bar, even if it is closed properly. If a child does not fall all the way out, a chain across the front of a seat could pose a strangulation hazard.

The design of these bucket seats includes leg cut-outs on both front and back, and the seat itself comes up high enough to provide support all around the child and to aid in maintaining an upright position. One manufacturer explained that the leg holes are larger on one side than on the other so the seat can still be used for larger or perhaps older children with special needs. However, it does not appear that the two sets of cut-outs could actually vary much in size, due to the small size of the overall seat. Adults may not see this size difference and consequently be confused as to which direction to seat the child so that his or her legs are in the appropriate pair of leg holes.

A variation on the bucket-style seat is offered by several manufacturers, as seen in current catalogs, sometimes in addition to the totally enclosed version described above and sometimes in place of it. This is a half-bucket design, only encompassing 180° rather than 360°, which then encloses only the back of the seat. Because the the front is then left open, some sort of containment device is necessary. Frost (U. of Texas, 1989, unpublished manuscript) noted that all infant seats should have safety straps. Similarly, the Seattle draft standards specify that "4/0 chain safety bars" be used. All but one of these seats depicted in the catalogs had a chain across the front. It is intended that the chain be unlatched to place the child into the seat and then secured as a safety device to prevent falls out of the seat. L. Witt (personal communication, March 1989) recognized several problems with the partially enclosed design. When a very young child leans back in these seats, they tend to flip over; or, if the child leans forward, they tend to slide out under the restraining chain. The latter problem is also common on the traditional chair-type tot swings with similar safety bars or chains, as noted above. Witt also stated that some parents seat the child backwards in the seat, with his or her back against the chain. This confusion is reasonable since the design of the partially enclosed seats includes what appear to be leg cut-outs on the back. In fact, during the observational study, an adult was seen trying to place a young child backwards in a half-bucket seat which had a chain across the front; however, she did eventually orient the child correctly. Another interesting behavior observed was two children, approximately 4 or 5 years old, attaching two of these tot seats together by connecting their support chains. They then each sat in one of the swings and were swinging while attached. This is certainly not an intended or safe use of the chains.

The Seattle draft standards require the use of heavy molded rubber seats for tot swings. All of the totally enclosed bucket-type seats as well as the partially enclosed designs found in current catalogs are constructed of rubber with steel reinforcements. Four of the five bucket or half-bucket swings for which weight was specified, were between 4 and 5 pounds, not including the suspending chains. The remaining seat was a fully enclosed design weighing 10 pounds.

The only chair-type seat in the catalogs for which details were given is constructed of cross-linked polyeythlene and weighs 6 pounds. Rutherford (1979) noted that several of the swing-related moving impact cases he studied during his Hazard Analysis involved the chair-type infant seat. He suggested that this design may be quite heavy, and that the investigated seats had hard corners or ridges as added hazards.

Analyses of the tot swings shown in catalogs indicated one other issue which warrants attention. These swings, full or half-bucket designs as well as chair seats, typically have suspension systems which incorporate a large triangular section of rods to connect the seat itself to the suspension chains. It is important that such designs meet all of the entrapment requirements, especially because the children's heads are in close proximity to these openings.

The British standards (BS 5696: Part 3, 1979, Amended, 1980) strongly recommend that toddler seats should not be mixed with regular seats on the same unit. Also, "swings designed specifically for use by younger children should be separated from those intended for the older age groups."

Recommendations:

Tot swings are seats designed for very young children to use with adult assistance. The seats and suspension systems of these swings, including the related hardware, should follow all of the other criteria for conventional swings; exceptions are noted in the relevant sections. Special attention is drawn to any potential entrapment areas, which should be designed in accordance with the specifications given in the entrapment discussion (see Section 5.2.6).

Tot swing seats should provide support on all sides of the user. It is important that such supports do not pose a hazard of strangulation. Designs intended for sitting in only one orientation should be such that an adult is unable to seat the child in the wrong direction. That is, if a swing is not designed to provide equal support for alternate seating positions, there should not be any openings which could be confusable with the leg cut-outs, and therefore, lead to improper orientation of the child in the seat.

It is recommended that tot swings be suspended from structures which are separate from those for conventional swings, or at least suspended from separate sections of the same structure.

5.7.2.3.1.2 Impact testing

Guideline content:

The technical volume of the guidelines gives detailed specifications for testing procedures to measure the impact of moving swings. These are presented below. (Volume 2, 9)

> When tested in accordance with the suggested test method specified below, a suspended member should not impart a peak acceleration in excess of 100 g's to the test headform. This recommendation is intended to apply to any potential impact region of a suspended member having a clearance height [above ground] of less than 64 inches.
>
> Suggested test method.
>
> Ambient Laboratory Condition - Ambient laboratory conditions are required for the test (62-82° F). Expose all test equipment and suspended members to these conditions for at least four hours prior to test.
>
> Test Equipment.
>
> Headform and Support Assembly - The peak acceleration imparted by a suspended member is determined by impacting an instrumented headform with the suspended member. The size "C" headform specified in the Federal Motor Vehicle Safety Standard No. 218 is used for this test.
>
> Construct the headform support assembly in such a manner that the total headform and support assembly weight does not exceed 10.5 pounds. Mount an accelerometer at the center of gravity (C.G.) of the headform and support assembly combination with the sensitive axis of the accelerometer aligned to within 5 degrees of the direction of travel of the headform.

Guidance structure - The motion of the headform after impact must be restricted to horizontal travel with the headform centerline remaining in the central plane. Use a six-inch I beam (6I 12.5 American Standard I Beam) or an equivalent structure as the primary support structure to provide the required headform motion secured in such a manner that it is stationary during the test. The static coefficient of friction between the headform support assembly and the stationary guidance system structure must be less than 0.02.

Instrumentation - Select and operate the instrumentation for this test, including the accelerometer, signal conditioner and oscilloscope, according to SAE Practice J211, Channel Class 1000.

Step 1. Index Mark - Affix an index mark to the side of the suspended member to indicate its mass center (C.G.) projection in the side view. To determine the location of the index mark, the suspended member must be suspended in two successive alternate positions as illustrated. The mark location is determined by the intersection of the projection of vertical lines passing through the suspension point when the member is suspended at the successive alternate positions.

Note: Flexible belt-type suspended members require a brace to maintain seat configuration during this procedure and during impact testing. The weight of the brace must not exceed 10% of the weight of the suspended member.

Step 2. Assembly and Installation - Assemble and install the suspended member to be tested according to the accompanying instructions, using the hardware and the maximum length suspending elements supplied with, or specified for, the equipment.

Step 3. Position of the Suspended Member - Allow the suspended member to assume its free hanging rest position and adjust the relative positions of the suspended member, headform, and guidance system to meet the following conditions:

> The centerlines of the headform and guidance structure, and the impact point of the suspended member must lie in the central plane.
>
> The lower edge of the headform must be horizontal, with the headform contacting the impacting surface of the suspended member.
>
> The suspended member's impacting point shall be in line with, and adjacent to, the impact point on the headform. The impact point is that point on the headform which lies in the central plane and is tangent to the vertical.

Step 4: Placement of Suspended Member - Place the suspended member in the test position indicated by one of the following methods.

Test Position 1 - Raise the suspended members which are supported by chains, ropes, cables, or other non-rigid suspending elements along their arc of travel until the side view projection of a straight line through the pivot point and index mark forms an angle of 60 degrees with the vertical. Once the suspended member is raised to the test position, some curvature will be produced in the suspending elements. Adjust the suspended member position to determine that curvature which provides a stable trajectory.

Test Position 2 - Elevate the suspended members which are supported by rigid suspending elements along their arc of travel until the side view projection of the suspending element, which was vertical in the rest position, is at an angle of 60 degrees with the vertical, or at least at the maximum angle attainable, whichever is less.

Additional instructions - In the use of either of the test positions specified above, caution should be exercised to prevent damage to the test equipment. If an unusually heavy or hard suspended member is to be tested, preliminary tests should be made at lower angles (e.g., 10 degrees, 20 degrees, 30 degrees, etc.) If the recommendations [regarding a peak acceleration of 100 g's] are exceeded at a lower test angle than that specified above, the member does not agree with the guidelines and no further tests are necessary. Additionally, if there is doubt concerning the suspended member trajectory or stability, the headform and/or guidance structure should be set aside to allow trial releases without impacting the headform.

Step 5. Support of Suspended Member - Support the suspended member in the test position by a mechanism that provides release without the application of external forces which would disturb the trajectory of the suspended member. Prior to release, the suspended member and suspending elements must be motionless. Upon release, the assembly must travel in a smooth downward arc without any visible oscillations or rotations of the suspended member which will prevent it from striking the headform at the impact point.

Step 6. Collection of Data - Once satisfactory system operation and calibration are obtained, collect data for ten impacts. Measure the peak acceleration in g's for each impact. If the data for any two of the ten impacts do not meet the recommendations [regarding a peak acceleration of 100 g's], the suspended member does not agree with the guidelines.

Probable rationale:

The probable rationale for each section of the test method outlined above was not explicitly stated. Therefore, discussion here is limited to the specifications for which the NBS documents gave justification.

Impact injuries represent 26% of swing-related emergency room treated injuries, according to the 1978 Special Study. Children have been struck while running in front of or behind a moving swing, while pushing someone in a swing, and while trying to run under a moving swing. Some swing impact injuries can be attributed to young children's inability to accurately estimate the timing, distance, and speed of an approaching swing. (Brown, 1978)

The NBS rationale documents simply state that "the intent of this requirement is to reduce the risk of serious head injuries that can result when a suspended member impacts a child's head." Suspended members with a ground clearance height greater than 64 inches are excluded from the impact requirement because they are not likely to impact a child's head. This dimension was based on the height of the maximum user, which is 63.2 inches. Suspended members which are lower than 64 inches can potentially strike a child's head and, therefore, present a risk of serious head injury. "Such an impact can result if the child is in the path of an empty suspended member that has been set in motion by that child himself or by another person." Because impact-induced skull fractures and cerebral concussion are much more serious than superficial injuries to the scalp or injuries to other parts of the body, they are what needs to be protected against most. (NBS, 1978b)

The immediate post-impact effects which lead to head injuries are relevant to an understanding of the methods and criteria chosen to determine the moving swing impact requirement. The following discussion of these effects is taken directly from the NBS (1978b) supporting rationale documents submitted with their proposed safety requirements.

> When an object strikes the head, the head is subjected to an impulsive force. The magnitude, direction and duration of this impulsive force depends primarily upon the striking momentum, as well as mechanical properties of both the head and the object. Depending upon the impact site on the head and the area of contact, the force generated during impact may cause deformation of the skull, linear acceleration of the head, change in intracranial pressure, rotation of the head with respect to the neck and torso, or combinations of these.
>
> Deformation of the skull may be expected when the contact area is sufficiently small and may contribute to skull fracture and concussion. These deformations are usually accompanied by head acceleration. Head acceleration without significant deformation is likely to result when the impulsive force is distributed over a large area.
>
> Linear acceleration may cause relative motion of the brain with respect to the skull and changes in intracranial pressure. Either of these effects can lead to concussion. The severity of the resulting concussion will depend on the magnitude and duration of head acceleration. For example, the Wayne State University acceleration-time tolerance curve gives threshold values for moderate or survivable concussion in terms of effective or average acceleration of the head and pulse duration. This curve has been described by defining the Severity Index...An SI = 1000 has been used as concussion tolerance, and SI's as low as 565 have been observed with frontal skull

fracture. In some cases, skull fracture and concussion may occur simultaneously.

Rotation of the head with respect to neck and torso produces stretching of the neck ligament, cervical cord, and brain stem. It may also produce relative motion between the skull and changes in injury to the neck, cervical cord, and brain.

Suspended members typically used in swing assemblies were examined. It was determined that if a suspended member hit the head, the contact or impact area could be small enough to result in skull deformation; skull fracture must, therefore, be considered a likely consequence of swing seat impacts. Therefore, skull fracture data should guide the development of performance requirements for such suspended members. "Since acceleration is measured in the ANSI test method system, it is desirable to utilize those studies where tolerance measurements were made when the impact load was increased to fracture." (NBS, 1978b)

The performance requirements were based on zygoma fracture data, while also taking into account other possible skull fractures and injuries. The reason for this is that the zygoma was determined to be the weakest area of the skull, and because the most comprehensive set of tolerance measurements available regarding head acceleration as mentioned above were, coincidentally, made for the zygoma. A graph of these data is presented in the NBS report, showing the head acceleration required to produce zygoma fracture plotted as a function of impact duration. The data represent the use of a small impactor (an area of one square inch) which was aimed directly at the zygoma; however, one of the data points was obtained using a larger impactor (an area of 5.2 square inches), which due to its size, produced a load bearing not only on the zygoma but on other areas of the skull as well. Data obtained with the small impactor indicate that as the duration of head impact increases, the head accelerations required to produce zygoma fracture tend to decrease. In addition, it is important to note that when using the larger impactor and thereby increasing the loading area enough to circumscribe the bone, the head acceleration required to cause fracture was three times greater than that when using the small impactor on the same cadaver. The single data point representing the trial using the larger impactor "was also one of relatively long duration." (NBS, 1978b)

The conditions expected when a swing seat impacts a child's head are, of course, not identical to the experimental conditions in which the zygoma skull fracture data were collected. However, the data reported above can be applied to the potential conditions of impact with swing seats such that a criterion for peak acceleration of the suspended element can be determined. (NBS, 1978b)

The impact criterion must protect against serious head injury arising from two possible situations of impact, the first being more likely than the second. First, during an impact incident, suspended members will most likely introduce a load on other areas of the skull in addition to contacting the zygoma, due to their large size. Further, "the more resilient or padded the suspended member, the more likely the zygoma will be 'circumscribed.'" The duration of impact will also vary with different suspended members, depending on their resiliency. "Experience suggests that the more resilient or padded the member, the longer the duration of impact." These two presumed conditions for potential swing seat impacts are parallel to the situation represented by the data point obtained using the larger impactor: large contact area, circumscribing the zygoma, and long duration of impact. Second, an incident in which a suspended member contacts the zygoma alone will be a rare occurrence, and this would require a precise set of conditions. However, although the likelihood of this is small, a hard impactor could potentially contact a small area for a short duration. This situation is best approximated in the experiment by the short duration impacts produced by the small impactor. (NBS, 1978b)

Given the above information, the existing zygoma fracture data along with the expected conditions of swing seat impact should guide the performance requirements. The conclusion is that head accelerations which exceed either the small area/short duration data or the large area/long duration data should not be allowed. "A single peak head acceleration level of 100 g's appropriately satisfies both of the above concerns." Furthermore, it can be seen that a 100 g acceleration falls below the reported concussion level, SI = 1000, and that over the broad range of data it will also fall below the lowest observed level for frontal bone fracture, SI = 565. (NBS, 1978b)

<u>Headform and support assembly</u>: "There is a history of test method development for various products, usually protective headgear. All of these methods incorporate an impact to the test headform and measurement of some acceleration or force response. Due to time and resource constraints, it is necessary as well as desirable to take advantage of the technology already developed in this field." (NBS, 1978b)

There are several different test headforms which have been used including the ANSI rigid headform, the Wayne State University humanoid headform, and the University of Michigan Highway Safety Research Institute resilient head-neck system. A common application is to test to the adequacy of protection provided by various designs of headgear. In current headgear standards, the ANSI headform has been frequently specified, because it has demonstrated reasonably repeatable results and it can be easily reproduced. Furthermore, under certain conditions, the ANSI rigid headform has been shown to correlate with the Wayne State humanoid headform, and the acceleration responses have also been similar. When differences did occur, the metal headform gave higher accelerations, on the order of 20%. "In the interest of simplicity and reproducibility, it is proposed to assess the injury potential of suspended members by an impact test utilizing the ANSI metal headform." (NBS, 1978b)

<u>Position of the suspended member</u>: "The acceleration imparted to the test headform by a given suspended member depends on the velocity with which the headform is impacted." Impact velocity depends on the length of the swing's suspending elements, the maximum angular deflection of the suspended member from its rest position, and the location of the child's head in the swing's arc of travel. The latter two factors can vary significantly from one situation to another, making it difficult to specify impact velocity in the test procedure. In order to simplify the test procedure and ensure reproducible results, the angular deflection of the suspended member and the location of the headform in the swing's arc of travel were specified rather than impact velocity. (NBS, 1978b)

Furthermore, "the test procedure requires that the test headform be positioned so that the impact point of the headform is in contact with the impact point of the suspended member when the suspended member is in its rest position. The position is easily established and yields maximum velocity impacts for a given angular deflection of a suspended member." (NBS, 1978b)

Placement of the suspended member: It is assumed that children will not be able to cause an empty swing seat which is supported by non-rigid elements to deflect more than 60 degrees from its rest position, under normal play conditions. Test position 1, for such suspended members, specifies an angular deflection of 60 degrees because it "approximates the angle that would be achieved if a maximum user pushed the suspended member of an 'average' swing assembly along its arc of travel to his or her maximum reach height." An average swing assembly is defined as one whose seat has a ground clearance height of 2 feet in its rest position and has suspending elements 8 feet in length. (NBS, 1978b)

Test position 2 is specified as 60 degrees in Volume 2 of the handbooks, but the NBS rationale discusses an angular deflection of 45 degrees for swings supported by rigid suspending elements. The NBS specification was "based on the assumption that the maximum angular deflection of such members is generally restricted by design." (NBS, 1978b)

Issues:

Davis (1980) of the NRPA stated: "We consider the NBS work on moving impact requirements for swinging elements to be one of the most important and substantial improvements over the original standard. Hazard Analysis supports the need for this requirement and many manufacturers have gone to more resilient swinging elements." The review of current playground equipment catalogs discussed previously also suggests that many manufacturers are producing more seats geared toward preventing impact injuries.

Butwinick (1980) also gave a fairly supportive review of the impact test: "with only minimal modification, the swing impact requirement is one that clearly is capable of reducing injury and should be made mandatory." She noted that the 100 g peak acceleration appeared adequate, but suggested changes to the angular deflections specified by the two test positions for the placement of the suspended member.

With regard to the test position for swings suspended from non-rigid elements, Butwinick (1980) recommended that the suspended member be elevated to a position 90 degrees from the vertical, as opposed to 60 degrees as specified by CPSC. She believed the assumptions used to justify the 60 degree angular deflection were questionable. "It seems a child could push a swing higher than his or her maximum reach height if enough force were applied."

Additional examination of the situation described by the NBS (1978b) rationale also suggests that their reasoning was questionable in choosing a test angle of 60 degrees. NBS assumed suspending chains 96 inches long and a ground clearance of 24 inches, which means the total height of the swing structure would be 120 inches. They stated that a maximum user could push an empty swing assembly with the above dimensions to only his or her maximum reach height, which is approximated by an angular deflection of 60 degrees. Presumably then, the test is measuring the impact with which the seat would strike during its return through its rest position (zero degrees) from a position of 60 degrees. A 95th percentile 12-year-old has a vertical grip reach of 78 inches; therefore, the highest point to which a maximum user could raise a swing seat is 78 inches. This corresponds to an angular deflection of approximately 64 degrees from the vertical. The physical behaviors of an empty swing seat can be expected to be similar to those of a pendulum apparatus. Consequently, if a maximum user were to hold an empty swing seat at an angle of 64 degrees and then let go, the seat would travel to an angle of 64 degrees on the other side of its rest position. Because the NBS assumed a user would *push* the empty seat rather than simply let go of it, external forces would be applied and thereby cause the swing to attain an even greater angle. This means that an empty swing which impacts a child at its rest position, during return from the angle attained by a push from the maximum user's vertical grip reach, would have an excursion of greater than 64 degrees prior to impact. An occupied swing could achieve angular deflections even greater than this, because the added weight would increase momentum of the assembly and, therefore, the distance traveled.

Butwinick (1980) explained that the NRPA's standard to the CPSC stipulated a 90 degree test angle. They had agreed that a swing seat could reach an angle of 90 degrees and that, therefore, children should be provided protection from the level of impact associated with this angular deflection.

In addition, Butwinick (1980) recognized another important flaw in the test procedure which supports her recommended modification: the test is for empty swing seats, but when occupied, swings can attain angles as high as 90 degrees. She also commented on Rutherford's 1979 Hazard Analysis, in which he addressed swing-related moving impact injuries. He observed that although some children who suffered from these injuries were struck by a swing rather than the occupant of a swing, many were in fact struck by an occupied swing which would carry greater force than an unoccupied swing (Rutherford, 1979). Butwinick concluded that "certainly, there should be some attempt to protect the child against impact injury with a seat that is occupied and can therefore attain a greater height." This criticism of testing swings in an unloaded state is supported by Sweeney (1980), who also commented that occupied swings are more dangerous.

The detailed incident analysis included 11 cases of moving impact injuries, as previously discussed, which occurred when children were standing, walking, or running in front of or behind swings. All but one of these cases involved occupied swings. Although the majority of injuries were reported as caused by the swing seat and not the occupant, this is relevant because the weight of the occupant would still increase the force applied upon impact.

Butwinick (1980) made one other point in order to strengthen her argument for a 90 degree test angle. Referring back to the subjective classifications for swing seats which were then tested by the CPSC Engineering Laboratory, she noted that the hard, heavy seats padded with resilient materials on their contact edges, described as "questionable," would not pass an impact test if suspended from a 90 degree angle. Being "borderline" in tests from 60 degrees, these seats would certainly impart greater accelerations than 100 g's from 90 degrees. It is important that these dangerous seats not be used because of their potential to cause serious injuries.

With regard to the second test condition, Butwinick (1980) recommended that it be modified to test swings suspended from rigid elements from their maximum attainable angle. She stated that there was no need to make assumptions about what this maximum angle was, but rather that each such suspended member should be tested based on its own arc of travel and the maximum height it could reach. This would then be testing the swing for its maximum impact velocity, which is parallel to her recommendation to test non-rigid elements from 90 degrees.

Another problem with the impact test as it is currently written in the guidelines was identified by Preston (1988). He observed that the headform specified is no longer available, referring to the size "C" headform from the Federal Motor Vehicle Safety Standard No. 218. However, he added that "this Federal standard has recently been revised and now references 3 headforms in sizes 'small, medium, and large.' The medium size headform is identical to the previous size 'C' headform."

Although not discussed in the literature, it is important to recognize that the zygoma fracture data used in determining the 100 g peak acceleration criterion was most likely obtained with adult cadavers. The NBS (1978b) rationale suggested that cadavers were in fact used, and it can be assumed that they were adults since child cadavers are almost impossible to acquire for use in such studies (King and Ball, 1989). Given that it is children who are injured by moving swings and that their less developed skulls are probably more susceptible to fracture, it would seem more appropriate for the data which determine the impact requirements to be based on children. However, the head injury data currently available for children pertain to head-first falls, and so are more suitable for evaluating the impact attentuation of surfaces under playground equipment (see Section 5.1 on surfacing).

The British standards (BS 5696: Part 1, 1986) mandate a test for the moving impact of swings which is very similar to that of the CPSC guidelines. The principle of their test is as follows: "the swing seat impact test assesses whether the weight and construction of the seat is such that the effect of impact on a child in its path of motion is minimized." The procedures required throughout the British test are comparable to the CPSC's, and in some sections the wording is actually identical. However, there are three notable exceptions. The first, and perhaps most important, difference is that the peak acceleration allowed is 50 g's rather than 100 g's. Also more stringent is their determination of whether a seat passes the test or not: the British stipulate that a suspended member is not acceptable if any one of ten accelerations measured is in excess of their peak value, 50 g's. The "Collection of Data" specifications in the CPSC test allows rejection of a seat only after two accelerations fail to meet their requirement, 100 g's. The third difference helps to place these other two in perspective, at least to some extent. Instead of using a headform for the impact test, the British standard defines the test weight as a regular bowling ball, with a mass of 16 pounds. This certainly has implications for the velocities needed from the suspended member to produce various impact accelerations, thereby making it more difficult to interpret the difference in peak criteria. Further, the British standards' use of the 16 pound bowling ball causes another inconsistency between the tests because the CPSC procedure allows a maximum weight of only ten pounds for the headform and guidance structure together.

A test method is also discussed in the German standards which state: "seats or platforms shall be designed such that the acceleration transmitted to the test head in the test does not exceed 50 g and the average surface compression does not exceed 90 N/cm^2." The test head used is a freely suspended wooden sphere, with a mass of 11 pounds (5 kg), a diameter of 9.5 I .04 inches (240 $\pm$ 1 mm), and density of approximately 0.0005/lb^3 (0.69 g/cm^3). Again, this difference in the weight and density of the headform limits the direct comparison of the German 50 g criterion to the CPSC 100 g criterion. Data collection and interpretation also differ, because the German standard requires only five trials and uses an arithmetic mean to determine the mean acceleration as well as the mean surface compression, a variable which is not even addressed by the CSPC procedure. Otherwise, the general method is similar: swinging an unloaded seat from an angle of 60 degrees so that impact occurs at maximum speed hitting the middle of the test head.

Recommendations:

Because the current method does not model the typical accident scenario, development of a more realistic impact test may be warranted. The most common pattern of impact injury involves a younger child (2 to 5 years old), who inadvertently walks or runs into the path of a moving swing and is hit by the swing seat, which is usually occupied. Although the 100 g criterion appears reasonable, given current data on adult tolerance to head injury, research is needed to determine whether it would be suitable for testing a loaded swing. Further research may indicate that 100 g's is inappropriate for this application, because a child's head may not be able to tolerate the same levels of acceleration as an adult's head. One additional factor which has implications for a more realistic procedure is the exact location of impact on the child's skull; such data, however, are not currently available.

Even in the absence of further research, one change to the impact test is needed. The method is designed to test the maximum potential acceleration imparted to a headform by a swing seat, which is dependent on the impact velocity. Three factors affect the impact velocity and, therefore, the acceleration: the length of the suspending elements, the location of the headform, and the angle from which the seat is released. The first can be controlled by specifying a particular length for the suspending elements; the rationale defined an "average" swing assembly as one with suspending elements 8 feet long. The procedure also already addresses the second factor in specifying that the point of impact must occur at the rest position of the swing (zero degrees from the vertical), which will yield the maximum impact velocity for a given angular deflection. However, in limiting the excursion of swing being tested to 60 degrees, the potential acceleration has been restricted to the maximum acceleration attainable for that particular angle. In order to ensure that the maximum potential acceleration is measured, the test positions should be as follows: swings with non-rigid suspension elements should be released from an angular deflection of 90 degrees from vertical; and swings with rigid suspension elements should be released from their maximum excursion.

5.7.2.3.2 Suspending elements, hardware

Guideline content:

Although no specific mention of swings is made, Volume 1 addresses S hooks, recommending that open ended S hooks be avoided because they can catch clothing. If S hooks are open, the ends should be pinched tightly together to close them. Illustrations depict both open and closed S hooks for clarification. Volume 2 discusses individual swing assemblies in its section on the strength of individual components and structures: "hooks, shackles, rings, and links should not open more than one-half of the cross sectional diameter of the component that they are intended to constrain." (Volume 1; Volume 2, 6.1)

Volume 2, in a general discussion of hardware, also recommends that fasteners or connecting devices should not loosen or be removable without the use of tools, when torqued and installed according to the manufacturer's installation instructions. (Volume 2, 5.4)

Probable rationale:

The basic rationale for the S hook recommendations is given directly in the guidelines: to prevent entanglement incidents. The NRPA rationale noted that the news media had "played up" the open S hook problem, but that accident data did not indicate that these S hooks or other hardware had failure problems that had resulted in significant injuries. (However, the NRPA document was produced over thirteen years ago. More current injury data from the detailed incident anaylsis do implicate the involvement of swing assembly hardware in several incidents.) Regardless of the injury data, NRPA went on to explain that "any open hooks or other devices do represent a potential problem and should not exist on the equipment." (NRPA, 1976a)

Discussion of strength requirements for swing assemblies recognized that testing for breakage should include any deformation of parts that could adversely affect the safe use of swings. Emphasis was placed on the possibility that connecting devices such as hooks, shackles, and rings, might open under stress. Detachment of the suspended member could result, creating the potential for injury, if deformation occurred to the extent that the contiguous component could pass through the opening. The guideline is intended "to preclude this hazard and to insure against partial openings that may accelerate wear and effect the same hazard." (NBS, 1978b)

The general hardware recommendation in Volume 2 "is intended to eliminate the loosening of critical bolts and other hardware either on its own or by a child." (NRPA, 1976a)

Issues:

Esbensen (1987) explained that chains, cables, and ropes are commonly used as suspending elements for swing seats. Further, depending on their location, vandal-proof suspension systems will be more important for some playgrounds than others. Moore et al. (1987) also suggest that all fasteners on playground equipment be vandal resistant. The German standards (DIN 7926, Part 2, 1984) note that chains, ropes, or bars can be used as suspension cables, adding that ropes are not recommended for use on unsupervised playgrounds due to the risk of them being destroyed. Rigid suspension elements such as bars are discussed in the context of glider swings (see Section 5.7.2.4).

The Seattle draft standards (1986) require that suspension chains be galvanized 4/0 minimum straight link chains, and links must be welded and have a smooth surface. Based on current catalogs, most manufacturers specify this type of suspension chain for swings. One manufacturer provides new heavy-duty cables as a design option for swing suspension. They are constructed of strands of steel wire, tightly wrapped with nylon yarn. The catalog describes these cables as very durable, as sturdy as the heaviest chains, and smooth to the touch, while they also have the advantage of adding color to the playground. In addition, they are described by the manufacturer as basically vandal-proof design which also eliminates the pinching and wear problems of traditional chains.

The Canadian draft standards (CAN/CSA-Z614, 1988) address the chain links themselves: "chain links should be sized to minimize the risk of pinching, entrapment, or should be closed with a protective covering." Esbensen (1987) made similar recommendations but was more specific. Where chains are used, openings in the links should be 5/16 inch or less, which is small enough to prevent entry of children's fingers. Otherwise, a plastic tube should cover the chain to avoid pinching hazards for fingers. In contrast, the German standards state that the minimum opening allowed in one direction on chain links is 0.31 inches, with the same intention of preventing finger entrapment. In their survey of some Massachusetts playgrounds, Helsing et al. (1988) classified links that were greater than 5/16 inch in width as finger traps. There were two cases of finger entrapment in swing chain links in the detailed incident analysis, one of which involved a chain with a 0.44-inch opening.

A few manufacturers do currently offer chains with a plastic tube such as Esbensen (1987) recommended, at least at the seat-end of the chain. Others offer chains with a plastic coating, but not a tube, along the entire length.

L. Witt (personal communication, March 1989) recognized an important characteristic of swing suspension chains: that all of the wear tends to occur at the first six to eight links on either end, near the top or near the seat. However, he noted that most inspectors only look at the chain at eye level, and consequently may not notice a failing chain link. The New Zealand standards (NZS 5828: Part 1, 1986) also acknowledge that chain links should be inspected regularly for wear.

There is a substantial amount of support for the CPSC guidelines for S hooks. In fact, several sources reported information provided by the CPSC: open ended S hooks, especially those on swings, should be avoided because they can catch children's skin or clothing; any open S hooks found on equipment should be pinched tightly closed (Stoops, 1985; Sweeney, 1982, 1985, 1987; Werner, 1982). Others also simply noted that open S hooks can be hazardous and recommended that they be closed (Beckwith, 1988; Goldberger, 1987). Goldberger went on to state that S hooks should be closed to a 1/4-inch opening. Gilje (1989) and Kane (1989) both focused on the possibility of clothing entanglement in their articles which disclosed the details of a recent strangulation death of a 3 1/2-year-old caused by an open S hook on a home swing set.

Esbensen (1987) recommended using "reliable fastenings (shackles or rings -- not S-type hooks) on suspension mechanisms, that will not open under stress and can be secured against any unauthorized loosening." This is in agreement with the CPSC's general guideline regarding hardware which cannot be opened without the use of tools.

Both Beckwith (1988) and the Seattle draft standards make a point to address S hooks in the context of maintenance requirements, noting that they must be checked regularly for wear and to ensure that all are securely closed. Furthermore, the Seattle draft standards also state that lightweight S hooks should be replaced with 3/8-inch by 2-inch models. L. Witt (personal communication, March 1989) remarked that the CSPC guidelines needed to be more specific about how S hooks are inspected. For example, on a tall swing set, the inspector must use a ladder to examine S hooks at the top. The first S hook at the top of the suspending chain should be detached from the cleaves, or swing hanger, to check it for wear, and this procedure is also necessary to thoroughly inspect the hanger mechanism itself. In addition, each link at the top foot of the chain should be separated and examined for wear, because, as previously noted, the two ends of the chain are the most susceptible to deterioration. Witt believes that Montgomery County, Maryland, is far ahead of others in its procedure for inspecting S hooks. Maintenance personnel elsewhere are generally not allowed to change an S hook until it breaks, so that broken swings will only get fixed if someone drives by a park and notices it. One fall injury in the detailed incident analysis was due to failure of the swing suspending chain.

To install S hooks and to ensure that they are closed properly, several manufacturers offer special S hook pliers in their catalogs designed to facilitate this task. At least one manufacturer specifically stated that S hooks should not be reopened and closed again after the initial installation, but rather, once opened, an S hook should be replaced.

L. Witt (personal communication, March 1989) explained that S hooks are also used to connect strap seats to their chains, typically by inserting the S hook into an eyelet at each end of the seat. He recalled that strap seat failure was one of the earliest and most common problems in Montgomery County. This problem was caused by poor design, because most strap seats have S hooks which are too small, rather than simply being the result of old age. When these small S hooks are pinched closed, as recommended by the CPSC, they tend to break the rubber seal of the eyelet or wear a hole in the rubber. This allows moisture to seep into the seat and consequently corrode the metal reinforcement inside of it. After two or three months or such corrosion, the strap seat will fail. Moreover, Witt reported that it is virtually impossible to detect this deterioration, unless it is known what to look for. Montgomery County now only uses the strap seats manufactured by one particular company, because these have special S hooks to attach the seat to its suspending chains. The design is such that when the S hooks are closed, they will not wear against the rubber of the seat. Witt noted that since the county has begun using these strap seats, incidents of swing seat failure have almost ceased. The detailed incident analysis included one fall-related injury attributed to the failure of the S hook joining the swing seat and suspending chain.

The Seattle draft standards address the attachment between swing seats and suspension elements: "limit the opening between swing seat and triangular support system where the seat is attached to the chain to 2 inches or less." Presumably this is to prevent entrapment incidents.

Failure of suspending mechanisms can cause injuries, sometime serious, if swings are occupied. In the detailed incident analysis, one fall from a conventional swing was reported as caused by failure of the swing suspending hardware. The Canadian draft standards recognize that all moving parts do wear, but that they should be designed to reduce such wearing action. The German standards are more specific, stipulating that low-wear fixing points such as roller or sliding bearings must be used. Both the Canadian and German standards also require that swing suspending hardware be protected against unauthorized loosening or detachment, or that which is unintentional. These terms are very similar to the general recommendation in the CPSC handbooks regarding hardware, except that they specifically address swing-bearing hangers.

The Play For All Guidelines (Moore et al., 1987) states that "moving joints are one of the most troublesome maintenance features on playgrounds." They recommend that all moving joints have bearings, rather than metal-to-metal S hooks. Further, they note that modern nylon bearings perform better than the more traditional roller or bronze bearings. "But despite much improvement, any bearing will eventually fail," and, therefore, must be checked regularly for wear.

Also regarding maintenance, the Seattle draft standards state: "check swings to ensure that all bearings are secure with bolts in place, show no signs of wear and are well lubricated." L. Witt (personal communication, March 1989) observed that swing hanger mechanisms, or cleavises, are the type of swing hardware which fail most often. In fact, on heavily used swings, the cleavises must be replaced every two to three months. Also according to Witt, aluminum swing hangers wear out almost immediately. To protect against injury-causing failure, inspection of the hangers must be thorough and include the process mentioned earlier of removing the top S hook from the cleavises. Again, Witt emphasized that these inspection procedures should be detailed in the guidelines.

One final issue for swing-suspending elements is addressed in the Canadian draft standards: "to achieve a straighter arc movement, bearing hangers should be hung wider than the overall length of the seat, in a loaded condition." A similar requirement is made in the German standards. Further, one manufacturer's catalog promotes a wide-track chain design, with the goal of reducing side-to-side swinging problems. In line with the above recommendations, this design, as illustrated in their catalog, hangs the suspending elements at a wider distance on the cross-beam than that between them at the seat level.

The British standards (BS 5696: Part 2: 1986) also address the potential for a swing to deviate laterally from its arc. Detailed test procedures are specified; a swing passes the test if its lateral deviation is less than one half of the swing seat's length. This test is also discussed in relation to minimum-clearances.

Recommendations:

Suspending chains should be designed to prevent finger entrapment. Preferred treatments would not provide any accessible openings large enough for children to insert their fingers in. Possible designs include using solid cables instead of linked chains, covering chain links with a protective sleeve, or ensuring that openings are less than 5/16 of an inch (which would preclude entry by the index finger of a 5th percentile 2-year-old). The current CPSC recommendation to avoid open S hooks is very important but should contain specific reference to S hooks on swings. The guideline given in Volume 2 regarding hooks, shackles, rings, and links of individual swing assemblies should also be repeated.

Parallel to the general discussion of hardware (see Section 5.5.3), swing hanger mechanisms should be attached securely and protected against unauthorized or unintentional loosening; when installed according to the manufacturer's instructions, they should not be removable without the use of tools. Further, any other hardware, such as that joining the seat and suspending elements, should also be secured against detachment and not contribute to corrosion of seat materials, such as metal reinforcements inside strap-type seats. Because moving parts are subject to substantial stress, swing hanger mechanisms should be inspected frequently for wear to avoid failure which could cause injury. Bearings should be easy to lubricate and maintain.

Swing hangers should be hung wider than the width of the swing seat (see Section 5.7.2.3.1.1.2) to reduce side-to-side movement.

5.7.2.3.3 Minimum clearances

Guideline content:

Volume 1 recommends an 18-inch minimum clearance between the outside edges of adjacent swings and between swings and nearby structural components. It is further explained that this clearance may need to be greater for tire swings or other swings which move in more than the forward-backward direction. In addition, "if the clearance is insufficient, swings may accidentally bump one another or other pieces of equipment. On the other hand, too wide a clearance might encourage a hazardous flow of traffic," such as between moving swings. (Volume 1)

Volume 2 repeats the 18-inch minimum clearance and includes a diagram showing where the measurements should be made. The clearance distances are to be measured from the outer edges of the swing seats. For support poles installed on an angle, or for suspension elements which hang on an angle, the clearance distance should be measured from a vertical projection taken a minimum of 33 inches above the swing seat. The illustration only depicts flat, horizontal seats. This discussion of minimum clearance for swings is found in the technical volume's section on swing assemblies in "Strength of Individual Components and Structures." (Volume 2, 6.2.1.7)

Ground clearance is not addressed in the current guidelines.

Probable rationale:

Spacing of swings was generally not implicated in moving impact injuries. Rutherford (1979) found that the distance between moving components of the equipment involved was usually between 18 inches and 24 inches. It is important to note that none of the children were injured while "running between broadly spaced components."

Users colliding with each other or with nearby components is a potential problem, and this recommendation is, therefore, intended to reduce the risk of injuries incurred during such situations. An Iowa study suggested that the minimum horizontal clearance should be 24 inches. In contrast, the original industry standard was only 12 inches. The minimum of 18 inches recommended is intended to lessen the potential for contact with adjacent swings, without encouraging hazardous traffic between such moving elements. "It is recognized that this separation requirement will not completely prevent intentional reaching and contact with swinging elements. However, wider spacing which would be necessary to preclude that type of contact might well result in more serious injury potential from traffic between adjacent elements." (NBS, 1978b)

Supporting structures and suspending elements of swings are sometimes inclined. In either of these cases, the horizontal distance between adjacent components of the swing set varies with height. The 33-inch minimum height above the seat of the suspended member, for measuring the clearance between components, was based on the head height of the seated maximum user, in order to insure that protection is provided up to that point. (NBS, 1978b)

Issues:

The only support for this CPSC guideline was a recommendation by Beckwith (1988), who repeated the minimum clearance of 18 inches for the same two distances described in the handbooks.

Frost (1980) noted that "experience says that 18 inches between suspended elements such as swings is not sufficient to prevent accidental bumping injuries." In fact, Frost (U. of Texas, 1989, unpublished manuscript) reported that swings are often placed as close together as 12 to 17 inches. Frost (1980) considered as unsound the NBS rationale that if given wider distances, children could be injured when tempted to walk between moving swings. He reasoned that "children are much more likely to become injured in a 'tangled mess' of moving equipment than in a spacious context." The AALR Survey of elementary school playgrounds reported that the average distance between swings surveyed was 26 inches (Bruya and Langendorfer, 1988).

All of the standards reviewed require greater separations than those recommended by the CPSC. The Canadian draft standards (CAN/CSA-Z614, 1988) suggest that both the distance between adjacent seats and the distance between seats and support frames should be a minimum of 29.5 inches. Similarly, German standards (DIN 7926, Part 2, 1984) specify a minimum of 27.5 inches for the same distances; however, except if the equipment is intended for younger children, the minimum is 24 inches. The Seattle draft standards (1986) give different specifications for the two distances: a 24-inch minimum between adjacent seats and a 36 inch minimum between seats and end supports. The Australian standards (AS 1924, Part 2, 1981) also have different requirements for these separations; however, they require a greater minimum clearance between adjacent seats than between seats and support structures. Further, like the German standards they have different specifications for equipment used by different age groups. The clearance between side-by-side swing assemblies must not be less than 24 inches for domestic or preschool equipment or not less than 35.4 inches for public equipment. The clearance between any rigid or non-rigid swinging assembly and the adjacent fixed structure must not be less than 16 inches for domestic or preschool equipment or not less than 24 inches for public equipment. Note that the Australian requirements for public equipment are the converse of those given in the Seattle draft standards.

The British standards (BS 5696: Part 2, 1986) give minimum clearance requirements based on a swing's potential deviation or lateral movement from its equilibrium position. This deviation, t must not exceed $L/2$ (where L is the length of the swing seat), on application of the specified load, when tested in accordance with clauses 2 and 5 of BS 5686: Part 1, 1986. The minimum clearance, in the equilibrium position, between adjacent seats must be $2t + 4$ inches; the minimum clearance between seats and the adjacent structure must be $t + 4$ inches. Thus, adjacent seats are required to be farther apart than a seat and an adjacent structure are, similiar to the Australian standards.

Frost (U. of Texas, 1989, unpublished manuscript) reported many of the above standards and concluded that reasonable separation requirements would be 24 inches between swings and 36 inches between swings and support structures, which is identical to the Seattle draft standards. Frost added that "extra space can be secured by positioning the swing supports at an angle with the supports leaning toward one another." Esbensen (1987) recommended that independently swinging seats hanging side-by-side should be spaced at least 27.5 inches apart, "to diminish side-sway bumping." He also recommended a minimum clearance of 27.5 inches between the frame and any part of the swinging assembly. These distances are the same as those required by the German standards.

One other clearance-related issue was also addressed by both Esbensen (1987) and the German standards. Each recommended that there should not be more than two seats on an individual frame which is not divided into separate sections. Esbensen explained that this should minimize bumping incidents. Current catalogs show that swings sets are typically arranged with two or three swing seats on a frame. One manufacturer offers a T-shaped frame which includes one seat on either side of a middle support. There is also a dome-shaped design in two of the catalogs: one includes five swings, each on one side of a pentagon, while the other has six swings evenly spaced around a hexagon. This does not appear to be a particularly safe design, because the risk of collisions or moving impact incidents in the center of the structure seems high.

Bruya and Langendorfer (1988) explained that in order for swings "to optimally serve young children and promote motor development, the equipment must be sized appropriately to the children's body measures and their developmental status or skill level." The height of a swing seat above ground is one distance which is important to such age appropriateness, because a young child will not be able to safely mount or dismount a swing if its seat is too high. The AALR Survey found that 32% of the elementary schools included had swings greater than 20 inches above ground. Frost (U. of Texas, 1989, unpublished manuscript) observed that "seat heights range from just above ground to 3 or more feet high, rarely being fitted to the sizes of children."

Although the CPSC guidelines do not address the minimum ground clearance of swings, some of the standards and other designers have regulated this dimension. The Seattle draft standards recommend that a minimum clearance of 12 inches be maintained below a swinging element. Both Esbensen (1987) and the German standards suggest at least 16 inches, and the German standard states that this is regardless of user age. The Canadian draft standards stipulate that "all seats should have a clearance of not less than 14 inches nor more than 18 inches when occupied by the user." This loaded condition is based on a weight of 165 pounds. However, an exception to the above height requirement is made for those swings which necessitate adult assistance, such as tot swings, "where the height should be convenient for the adult assisting the child." The British and Australian standards have identical specifications for ground clearance, which is to be measured while the seat is loaded to 50 pounds. The lowest part of the seat must not be less than 13.8 inches above ground, and the seating surface itself must be between 18 and 25 inches. For cradle seats, the seating surface should be a maximum of 19 inches high, with no minimum given except that of the ground clearance for the lowest part of the seat, as noted above.

Recommendations:

The 18 inch minimum horizontal clearances currently recommended do not seem adequate, given the consensus among current standards on clearances greater than or equal to 24 inches for older children and 16 inches for younger children. Anthropometric data, as discussed below, also indicate that longer minimum clearances are warranted. However, the guidelines for measuring the clearances up to a height of 33 inches, in order to assure protection up to the maximum user's seated height, are appropriate. Illustrations to help clarify these distances should depict both flat and strap-type seats (see Figure 5.7.2 - 2). The separation between adjacent swinging components should be at least 24 inches; this accommodates the shoulder breadth of a 95th percentile 12-year-old (16 inches) with some tolerance on each side, but it is not so large as to encourage children to run between moving swings. The separation between a swing seat and an adjacent structural component should be at least 30 inches; this gives additional protection against impact with a rigid structure and also minimizes the possibility of children climbing between the frame and swings. It would be beneficial for younger children to have proportionally more space due to their lower developmental and motor abilities, so that the separations designed for older children would also be appropriate for younger children. Therefore, these clearances are intended to address equipment for children of all ages.

A swing seat's height should be determined by the height at which it would be comfortable for a child to get on, without being so low that a child would hit his or her feet on the ground while swinging. The measurement for seat height should be made from the sitting surface of an unoccupied swing to the ground. When equipment is intended for older users, the recommended seat height for swings is a minimum of 18 inches. This corresponds to the tibiale height of a 95th percentile 12-year-old. The gluteal furrow height of a 5th percentile 4-year-old is 15 inches, so the minimum user of the older group would still be able to mount the swing without too much difficulty given a seat height of 18 inches. However, if the distance from the seat surface to the ground is much greater than 18 inches, 4- and 5-year-olds will face difficulty when trying to get on the swing. When conventional swings are intended for younger users without the assistance of adults, the seat height should be between 12 and 15 inches. This accommodates the tibiale height of a maximum user, a 95th percentile 5-year-old, and the gluteal furrow height of a minimum user for this type of swing, a 5th percentile 4-year-old. Tot seats should be at a height which is convenient for the adults who assist the very young users of such swings.

5.7.2.3.4 Support frames

5.7.2.3.4.1 Design of structure

Guideline content:

Volume 1 states: "support frames for all swing sets should be designed to discourage climbing."

Probable rationale:

Presumably, the intent of this recommendation is an effort to prevent injuries children may sustain if they were to climb on the support frames of swings.

Issues:

It is not unusual to see children, especially those who are older, using the frame of a swing set as a climbing apparatus. In fact, as discussed earlier, the detailed incident analysis included several cases in which the child was injured while climbing on or swinging from the support structures. The most common scenario involved a fall from either a horizontal bar of an A-frame or the top cross beam.

Similar to the CPSC recommendation, the Seattle draft standards (1986) require that swing supports be designed without any intermediate climbable parts on frames, which would appear to preclude the use of cross-bars on A-shaped supports. The German standards (DIN 7926, Part 2, 1984) note that support frames sometimes function as playthings themselves, but in that situation the supports must be at least 5 feet away from the nearest swinging component.

Esbensen (1987) suggests that A-shaped supports be used for swing sets. The German standards also mandate the design of A-frames. However, this specification is given for swings with rigid suspension cables, "so that it is difficult to run directly into the swinging area."

Frost (1980) recognized that "no mention is given to anchors for swing supports." He further explained that swing supports are typically installed in concrete; however, the anchors supplied by some manufacturers are so flimsy that they can be displaced with repeated motion.

Recommendations:

Swing support structures should be designed to discourage climbing, as currently stated in the guidelines. A-frames of swing support structures should not have horizontal cross-bars.

5.7.2.3.4.2 Maximum height of structure

Guideline content:

The current guidelines do not address the height of support structures for swinging elements.

Probable rationale:

Not applicable.

Issues:

Swings should be designed to accommodate children of various ages; the height of the top cross beam is one variable which affects such design considerations, because it is correlated to the potential swinging height (Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987). The Play For All Guidelines further explains that different heights provide a range of movement: "don't assume that small swings will always be used by small kids. Big kids often enjoy the quicker 'period' of small swings; therefore, they should be made just as robust as big swings."

Moore et al. (1987) believe that high swings are not acceptable for public playgrounds, because although they appeal to children, the dangers of falls and collisions are too great. They recognize the need for research to explore how the height of swing structures affects other variables such as swing throw, jumping-off distances, separation between swings, and the fall zones required. In conclusion, they state that "height limits are necessary to minimize the dangers of swing use and falls by children who climb to the swing beam." However, no recommendation is made in the Play For All Guidelines as to what a reasonable maximum height would be. As previously discussed in the review of injury data, falls generally account for a majority of swing-related injuries; and, older children (over 5 years of age) are usually at greater risk for falls, often because they stand on or jump from moving swings.

The German standards do regulate the height from the middle of the fulcrum of the suspension cable (the top beam) to the surface installed below the structure. In general, for public equipment this height is greater than 79 inches; but if the equipment is intended for younger children, 79 inches is the maximum height allowed. They also stipulate that, in general, "the free height of fall shall not exceed 79 inches at any point in the swinging area up to the 60° excursion."

Review of current catalogs indicated that many manufacturers offer swing structures whose top height is 8, 10, or 12 feet above ground, with 8 feet being the most common. However, one catalog advertised a 6-foot swing set and another advertised a 7-foot structure. Even in catalogs which specifically address whether the swings are intended for older or younger users, these same heights are generally found for the younger users.

Recommendations:

Data are lacking on how factors such as swing throw and jumping-off distances are affected by the height of swing structures. In order to address the risk of falls from swings to the surface, swings should follow the age-specific maximum height recommendations given for all types of playground equipment (see Section 5.1.3.6).

5.7.2.3.5 Layout and spacing of swing structures

Guideline content:

Volume 1 explains that "swing sets should be located away from other activities or equipment to help prevent children from running into moving swings while chasing balls or when distracted from other activities." (Volume 1)

Probable rationale:

In discussing the 1978 Special Study data, Brown (1978) noted the following factors as possible causes of some swing-related injuries: "location of swing(s) or swing sets is too close to other play activities; too many children, not swinging, are in close proximity of the swing sets." She then concluded that locating swings away from other activities or equipment was one potential strategy which could help reduce injuries.

Issues:

As previously discussed, children walking into the path of moving swings is a common injury scenario. Younger children are especially at risk for these moving impact injuries. Attention to this problem is important when choosing the layout and spacing of playground equipment. However, as noted by T. Sweeney (personal communication, February 1989), it is impossible to always control where children will walk. Several sources agreed with the CPSC recommendation that swings should be separated from other equipment, away from the traffic of other activities (Frost, 1986b; Goldberger, 1987; Moore et al., 1987; Canadian draft standards, CAN/CSA-Z614, 1988; Werner, 1982). Further, the Play For All Guidelines stipulates that swings should not be combined with multi-use play structures. The current catalogs show that although most manufacturers produce separate swing sets, a few do install swings as part of superstructure combinations. Potential hazards of these designs include the traffic of other play events in close proximity to moving swings and the possibilty of children climbing onto decks and using adjacent swinging components to swing down from them or using the structure as means to get onto the top cross beam of the swing section.

Many designers suggested that providing a low barrier, such as a fence, is an effective way to control traffic flow patterns and, therefore, to help prevent children from walking into moving swings (Esbensen, 1987; Frost, U. of Texas., 1989, unpublished manuscript; Moore et al., 1987; British standards, BS 5696: Part 3, 1979, Amended, 1980). In addition to low fences, suggestions included hedges (Esbensen, 1987) or a vertical tire barrier (Frost, U. of Texas, 1989, unpublished manuscript). In order to more fully protect against through traffic, Esbensen also recommended providing only one or two accesses through the barrier. The British standards are more specific, stating that the entrances should be at the corners of the enclosure, closest to the center of the playground, and that the entrances should be designed to restrict the speed of entry. Moore et al. also note that the entrance into the swing use zone should maximize visibility: if there is a logical 'front' such as a view of the playground itself, this should be the location of the entrance." Further, the Play For All Guidelines also recognizes the danger of the barrier itself becoming a play event, so turning bars, for example, would not be appropriate; with similar reasoning, the British standards recommend that the barriers "be designed to discourage their use as gymnastic apparatus, and to prevent unintended access."

Recommendations:

As currently stated in Volume 1, to help prevent young children from inadvertently running into the path of moving swings while chasing balls or distracted by other activities, swing seats should be located away from other equipment or activities. Due to these hazards and others noted above, attaching single-axis swings to multi-use structures is discouraged.

Additional protection from hazardous through traffic can be provided by means of a low barrier, such as a fence or hedge. Such barriers should not be an obstacle within the use zone of the swings or hamper supervision by blocking visibility.

5.7.2.3.6 Use, fall zones

Guideline content:

There is a general discussion of layout issues in Volume 1. It includes a reference to swings while explaining use zones, recommending that sufficient space should be allotted to accommodate the largest arc of the swing's motion, taking a child's extended legs into account. (Volume 1)

Probable rationale:

No specific rationale is stated for the above recommendation. However, it can be assumed that the general intent is similar to that of separating swings from other equipment or activities: to help prevent impact injuries caused by children inadvertently walking or running into path of a moving swing.

Issues:

Addressing swing use zones, the Play For All Guidelines (Moore et al., 1987) states that "the minimum setback requirement for swings is two times the height of the swing beam from any edge or obstacle. For tire or tot swings with low beams, this distance can be reduced slightly." It also explains that distinct differences in ground texture can help define such swing areas. Esbensen (1987) recommended that swings have an area of at least 20 feet by 20 feet to minimize the hazards of impact incidents. A diagram showed this area to include a minimum of 10 feet in front and in back of the swings, measured from the top bar.

Frost (U. of Texas, 1989, unpublished manuscript) noted that a resilient surface must be maintained in all swing fall zones, the dimensions of which would vary with the potential swing height. Burke (1980, 1987) suggested that impact-absorbing material should extend 7 feet beyond the longest horizontal extension of the seat as well as 6 feet to each side of the structure. The Seattle draft standards (1986) recommend that protective surfacing extend at least 14 feet from the swing's largest arc of travel which includes a child's extended legs, both in front of and behind swings. In contrast, the safety area described by the German standards (DIN 7926, Part 2, 1984) prescribe shock-absorbing surfacing for a minimum of 79 inches in both directions of motion when measured from the swing extended in a 90° position. They also require a safety zone on each side of the swing set; however, its dimensions are unclear in the diagram provided.

Other sources stipulate both fall zone specifications as well as the dimensions required to provide a safe use zone for swings. Similar to the German standards, the Canadian draft standards state that for single-axis swings, protective surfacing should extend 6 feet beyond the swing, front and back, when positioned in an arc of 90°. It should also extend 6 feet from each side of the structure, measured from the midpoint of the outer-most seat. Further, a no-encroachment zone to complete the use zone should go another 6 feet beyond the surfacing in both directions of the swing's motion. Similarly, Preston (1988) noted that the space needed and appropriate size of use zones for swings should be specified in the guidelines. He reported that the NRPA recommendations were as follows: protective surfacing 7 feet beyond the extended swing, front and back, with an additional no-encroachment zone of 6 feet. The New Zealand standards (NZS 5828: Part 1, 1986) call for a larger area for the safe positioning of swings. The fall zone with shock-absorbing surfacing should cover 10 feet from the largest arc of the swing with a child's legs extended, in both directions of motion; the use zone should include an additional 6.67 feet beyond that, as well as 5 feet on both sides of the swing structure.

The German standards also address other important considerations for the safety zones of swings. They define a head clearance zone above the structure, in which no other equipment can enter: measured from the cross-beam at the point of suspension, this clearance zone extends up through an arc of 20 degrees to each side. The German standards also recognize that there should not be any obstacles in the other safety areas either.

Recommendations:

The fall zones for swings should incorporate protective areas for both the support structure and the suspended member. For the support structure, the fall zone requirements should follow the general recommendations based on the height of the equipment (see Section 5.3.2.2). For the suspended member, protective surfacing should extend in both directions of motion, starting from a point 42 inches beyond the seat at its maximum attainable angle, and should also extend from each side of the seat's outer edge (see Figure 5.7.2 - 3). The 42-inch specification accommodates the extended legs of a 95th percentile 12-year-old. The distance the surfacing should extend is determined by the height of the seat at its maximum excursion and the general recommendations for that height (see Section 5.3.2.2).

The use zones for swings should include a fall zone as defined above as well as a no-encroachment zone in front of and behind the swing structure. The use zone should not have any obstacles except the support structure and other swings suspended from the same structure. The no-encroachment zone should extend 6 feet beyond the protective surfacing in both directions of motion (see Figure 5.7.2 - 3).

5.7.2.3.7 Protective surfacing

Guideline content:

The current handbooks do not address the surfacing required under swings separately from the general discussion of protective surfacing.

Probable rationale:

Not applicable.

Issues:

The Canadian draft standards (CAN/CSA-Z614, 1988) simply state that "swings should be installed over protective surfacing." The Seattle draft standards (1986) are more specific, requiring that impact sand be placed under swings, according to the fall zone dimensions, with a minimum depth of 12 inches. The British standards (BS 5696: Part 3, 1979, Amended, 1980) state that "swings should not be placed adjacent to sand." In contrast, Frost (U. of Texas, 1989, unpublished manuscript) suggested extra depth, up to 2 feet, for loose materials directly under swings, due to pitting effects.

The AALR Survey of elementary school playgrounds found the following surfaces under swings: sand, 27%; grass, 18%; pea gravel, 17%; clay, 15%; hard packed dirt, 9%; hard packed rocks, 4%; asphalt, 4%; tan bark or mulch, 3%; rubber matting, 2% (Bruya and Langendorfer, 1988). It is difficult to assess the level of protection these surfaces were able to provide because the survey did not measure the depth of the surfaces, which is very important in the case of loose materials such as sand and also rubber matting.

Recommendations:

All recommendations with regard to surfacing are made in a general section (see Section 5.1).

5.7.2.4 GLIDER SWINGS

Guideline content:

The handbooks do not address glider, or pendulum, swings separately. Recommendations for various components of gliders are included in the section on structural integrity in Volume 2.

In discussing the hazards of pinch, crush, or scissor-like areas, Volume 1 notes that unprotected moving parts on gliders can be especially dangerous. (Volume 1)

Probable rationale:

It can be assumed that cautions regarding pinch hazards are intended to prevent injuries caused by moving parts of gliders.

Issues:

The term "gliders" refers to two different types of pendulum swings (see Figure 5.7.2 - 1D), both generally suspended by rigid components and capable of travel only in the back-and-forth direction: 1) a board or pole which has seats on either end with handholds and foot rests or pedals; 2) a gondola-type glider which has chair seats facing each other to accommodate either two or four children.

The Australian (As 1924, Part 2, 1981), British (BS 5696: Part 2, 1986), and German (DIN 7926, Part 2, 1984) standards each regulate certain parts of gliders, in addition to requiring that they adhere to all other swing specifications.

Both the Australian and British standards explain that any swinging equipment which necessitates the operation of mechanisms using the feet, hands, or both, should be designed so that the swings can be operated by the user or users while seated. In addition, they suggest that foot rests or pedals be proportioned to provide an adequate means for exerting the necessary power. Both specify that foot rests or pedals must have a width between 3.5 and 5 inches if intended for use by one foot, or between 6 and 8 inches if intended for use by two feet side-by-side. The British standards also state that if foot rests or pedals are intended for use by more than one child, a minimum of 12 inches should be provided between them. Dimensions for handgrips are also specified. The Australian standards recommend that a grip be between 0.51 and 1.49 inches in diameter. In contrast, the British standards mandate that the grip diameter must be between 0.71 and 1.57 inches. Both standards specify that the clearance of such handgrips above the upper surface of the seat should not be less than 3.93 inches.

As previously discussed, the German standards require that hand grips be provided for all possible users with regard to multiple occupancy swings. The German standards also regulate several other dimensions of glider swings, which are referred to as Type 3 swings. The only specification for conventional swings that the German standards exempt gliders from is in the case of gondola-type swings which children can enter from both sides: the minimum separation between adjacent gliders must be 55 inches, which is double that for other swings. Other regulations include the following: the maximum width allowed is 27.5 inches; the maximum distance allowed between seats on opposite sides of the swing is 19.7 inches; any openings in the platforms must not exceed 1.18 inches; the angle between the backrest and the seat must not change when the swing is in motion; the clear distance between the backrest and the seat must not be less than 2.36 inches nor more than 2.95 inches when measured in one direction.

The last two German specifications above highlight the possibility of a dangerous entrapment area. This is substantiated by eight IDI reports and complaints regarding entrapment of children between the seat and backrest of glider swings from 1980 to 1986, all of which involved children under 5 years of age. The smallest space involved was approximately 2.75 inches, while the largest was approximately 5 inches. Given these IDIs, attention to this potential entrapment area on gliders is especially important.

With regard to the rigid suspension bars on gliders, the German standards require that the diameter of the tubes be between 1.00 and 1.33 inches. Further, such bars should be designed so that there are "no jerky braking and/or spring-back at the dead centers," and the excursion should be limited to 60 degrees to the vertical.

Pinch, crush, and shearing points: many sources recognize the dangers of moving parts and support the CPSC's attention to pinch points on gliders (Frost, U. of Texas, 1989, unpublished manuscript; Goldberger, 1987; Stoops, 1985; Sweeney, 1982, 1985, 1987; Werner, 1982). Gilje (1989) stated that although gliders often have dangerous pinch points in their hanger mechanisms if they have unprotected brackets, injuries can be prevented by installing guards. The detailed incident analysis included one pinch/crush injury involving the hanger mechanism for a glider swing.

The German standards specifying that the angle between the seat and backrest of gondola-type swings must not change when the swing is in motion is relevant here as well, because if the angle were to change it could create an potential pinch point.

Recommendations:

Gliders are rarely seen on public playgrounds; the absence of gliders in the catalogs reviewed indicates that they are not currently being manufactured for use as public playground equipment. The injury-causing potential of gliders appears to be unreasonably high, particularly for impact, pinch/crush, and entrapment injuries. However, glider-related injury data show that these incidents occur in home settings; for example, all ten of the gliders involved in cases in the detailed incident analysis of 1988 data were located at the victim's or someone else's private home.

Gliders are not recommended for use on public playgrounds.

5.7.2.5 MULTI-AXIS TIRE SWINGS

5.7.2.5.1 Impact Injuries

Guideline content:

Tire swings are referred to in the Volume 1 discussion of impact injuries. It is suggested that tire swings "may provide less potential for harmful impact." (Volume 1)

Probable rationale:

The immediate post-impact effects leading to head injuries were discussed in detail for the impact test rationale. Recall that deformation of the skull can contribute to skull fracture and concussion, and further, that such deformations are typically accompanied by head acceleration. It is important to recognize, however, that "head acceleration without significant deformation is likely to result when the impulsive force is distributed over a large area." This type of impact may occur if the head is struck by a rubber tire swing. (NBS, 1978b)

Brown (1978) observed that few injuries involving tire swings have been reported through the NEISS system. She concluded that although more research is needed, the use of tire swings could be a potential strategy to reduce swing injuries. Given certain materials and design considerations, the impact potential of tire swings is possibly lower than that of traditional seats.

Issues:

Frost (1980) commented that "We have installed tire swings (mostly horizontal) at over fifty playgrounds since 1974. There has been no report of injury resulting from their use." He also added: "during workshops conducted throughout Texas and other States during this period, I have heard no reports of serious injury from tire swing use."

<u>Materials</u>: The actual tires used as swing seats are important. L. Witt (personal communication, March 1989) recognized that old car tires can weigh as much as 50 pounds, and would, therefore, pose a serious impact hazard. For this reason, Montgomery County, Maryland, uses a simulated tire, made of lightweight plastic or rubber.

Both Esbensen (1987) and the Seattle draft standards (1986) noted another potential hazard of certain car tires. Steel-belted radial tires should not be used, because steel bands may eventually protrude through the rubber and then cause serious injury. Esbensen warned that if these tires were already in use, regular and thorough inspections were necessary so that any protrusions could be eliminated before injuries occurred. The Seattle draft standards also mentioned the need for regular inspections to ensure that "tires are not dangerously frayed or damaged."

Review of current catalogs indicated that most manufacturers use rubber tires for swings. The specifications in one catalog revealed that only new factory rejects are acceptable, and that they must not have any exposed metal protrusions, as in the case of steel-belted radials.

It was also explained that a steel pipe ring is installed in the tires for anchoring eyebolts solidly and distributing stresses evenly, in order to provide longer tire life. One other manufacturer offers a "made-for-play tire" made of lightweight, resilient polyethylene with a steel reinforcement.

Recommendations:

Tires used as swing seats should be constructed of rubber; to help reduce the hazards of impact, heavier tires should be avoided. Further, steel-belted radials should not be used because of the potential protrusions of their metal bands. Plastic materials can be used as an alternative to simulate actual car tires.

5.7.2.5.2 Other design considerations

Guideline content:

The current guidelines do not address any design considerations for tire swings.

Probable rationale:

Not applicable.

Issues:

The Seattle draft standards (1986) and the Canadian draft standards (CAN/CSA-Z614, 1988) each recommend that holes should be drilled in the bottom of all tires used as swings in order to provide for adequate drainage. The Canadian draft standards specify that such drain holes should be a minimum of 0.39 inches in diameter. Esbensen (1987) made a similar recommendation, suggesting small holes every 5 to 6 inches. He explained that it was necessary to allow water to drain to keep it from becoming "a breeding ground for mosquitoes or spiders in hot climates and from freezing solid in cold climates."

Two manufacturers offer tires which are cut in half in their catalogs, which are designed to eliminate the cavity in which water, dirt, and insects tend to collect. One manufacturer who uses new factory rejects requires the tires to have drainage holes.

Another consideration which is especially important for southern climates, is painting the interiors of tires white, to discourage nesting of poisonous spiders (Esbensen, 1987).

The Play For All Guidelines (Moore et al., 1987) recommends "strapping webbing to the bottom or inserting a plasticized canvas in the hole and bolting it in," to make tire swings more easily accessible and allow disabled children to also enjoy the use of these swings. Only one such tire swing was seen in current catalogs.

Recommendations:

Drainage holes for tire swings are a good idea; however, any such holes should not present an entrapment hazard for fingers (see Section 5.2.6.4).

5.7.2.5.3 Suspending elements, hardware

Guideline content:

No recommendations are made in the current handbooks for the suspending elements or hardware specifically for tire swings.

Probable rationale:

Not applicable.

Issues:

Moore et al. (1987), note that tire swing suspension hardware should be a high quality manufactured item. The following has been extracted from the Play For All Guidelines:

> Tire swing hangers are one of the most critical hardware items used on playground equipment. This is due to the stresses which are applied when multiple children utilize this activity at the same time. The amount of weight and centrifugal force which can be applied during normal use warrant extensive testing by manufacturers. Failure of these hangers is potentially catastrophic. Two types of hanger design are available: ball joint and universal joint. Each has their advantages and disadvantages.

L. Witt (personal communication, March 1989) also recognized the effects of multiple occupancy and rotational movement on tire swing hangers, noting that they generally wear out at double the rate of hardware on regular swings. In addition, he stated that most of the hanger mechanisms require a great deal of maintenance, which sometimes includes greasing.

Frost (1980) supported the use of durable ball bearing swivels for tire swings. He stated that inexpensive swivel designs which have metal to metal without ball bearings create the hazard of potential failure after extensive wear.

With regard to ball joints, the Play For All Guidelines describes the hardware as a "clean design" which does not present any pinch points. It then explains that a problem for ball joints has been wear and eventual failure caused by their limited degree of motion. "Tire swings require about 170° degrees of freedom and most ball joints provide only 145° degrees." Beckwith (1988) made a related comment, specifying that ball joint bearings used for tire swings must have "at least 170 degrees of swing."

The Play For All Guidelines states that universal joints do not have the same rotational limitations which cause problems for ball joints. The disadvantage of universal joints is their potential pinch points. This entrapment hazard was also noted by L. Witt (personal communication, March 1989); and the Canadian draft standards (CAN/CSA-Z614, 1988) require designs which prevent entrapment of fingers or heads for suspending hardware. The Play For All Guidelines further explains that "commonly, these [universal joints] are covered with a protective boot and, if well designed and maintained, provide satisfactory protection from the pinching." Beckwith (1988) stipulated that the bearings of universal joints must have a durable, flexible shield. Moore et al. (1987), conclude by recommending the use of universal joints which have protective covers; and, Witt reported that Montgomery County, Maryland, also preferred to use an enclosed hanger mechanism.

One other important consideration for tire swing suspending mechanisms was addressed by the Play For All Guidelines: movement of the mounting hardware can cause the swing to fall from the support beam. Therefore, "permanent positive attachment of the bearing to the beam is essential." Similarly, the Seattle draft standards (1986) require the use of at least two tamper-proof bolts to secure the swing bearings of multi-axis swings. They also note that all other specifications for regular swings regarding chains and hardware apply to tire swings as well, including special attention to inspections of swivels, S hooks, and chains.

The German standards (DIN 7296, Part 2, 1984) do not allow the use of rigid suspension elements for tire swings. Further, they mandate that the "fixing point shall be such that the suspension cables do not twist when they rotate about their vertical axis."

Recommendations:

The risk of hanger mechanism failure is increased for tire swings, due to the added stress of rotational movement and multiple occupancy; special attention to maintenance is, therefore, warranted. The hanger mechanisms for multi-axis tire swings should be designed to accommodate rotational movement without excessive wear, and should not have any accessible pinch points. Similarly, extra attention to the security of the connections between the suspending chains and the tire is warranted.

5.7.2.5.4 Minimum clearances

Guideline content:

After recommending a minimum clearance of 18 inches between adjacent swings and between swings and adjacent structural components, an exception is stated for tire swings. It is recognized that "clearance may need to be greater for tire swings or other swings that move in more than the traditional forward-backward direction." (Volume 1)

Probable rationale:

Multi-axis tire swings move in all directions, with 360 degree rotations, and therefore need greater clearances.

Issues:

"Never place a single-point tire swing next to another kind of swing on the same support beam. In the event you use one-point pivot swings, be sure the swing never hits the solid support beams or guard rails on structures" (Esbensen, 1987). The Canadian draft standards (CAN/CSA-Z614, 1988) also stipulate that, unless there is no danger of collision, multiple-axis swings must not be combined with other swings. However, neither of these sources suggested distances which would prevent the collisions mentioned.

Frost (1980; U. of Texas, 1989, unpublished manuscript) explained that separate guidelines for tire swing clearances should be given since their patterns of movement differ from that of regular swing seats which move only forward and back. Tire swings with 360° pivotal swivel assemblies can swing in all directions, and therefore the "space between the extended arc of the swing and the support beams must be extended for safe swinging action" (Frost, U. of Texas, 1989, unpublished manuscript). The Seattle draft standards (1986), which were reported by Frost, recommend that a minimum clearance of 48 inches be provided for the distance between a fully extended tire swing and supports. However, if a tire swing is hung from a top rail or if the support is higher than 6 feet, the clearance should be increased to at least 60 inches.

Beckwith (1988) and the Play For All Guidelines (Moore et al., 1987) gave identical recommendations for the span of support beams of tire swings: two times the length of the swing's suspending elements plus 48 inches. These horizontal beam span recommendations can be used to infer the suggested clearance between the tire and the support frame: with the swing extended fully, the separation from the frame should be 24 inches.

The German standards (DIN 7296, Part 2, 1984) require a minimum distance of 15.75 inches from a tire swing to its framework, measured at a height of 60 inches. The Canadian draft standards require even less separation than the German standards. They specify that when a tire swing is extended in an arc of 60°, there should be at least 6 inches between its outermost edge and the support frame. This clearance seems much too small to prevent children on the swing from impacting the adjacent structures.

Both the German standards and the Canadian draft standards state a minimum ground clearance specifically for tire swings, 15.75 inches and 13.5 inches, respectively. It is important to note, however, that these distances do not differ from those recommended for regular swings. Although the Play For All Guidelines does not address the ground clearance of regular swings, it depicts a tire swing suspended 24 inches above ground.

Recommendations:

Adjacent multi-axis tire swings should have non-overlapping use zones, as described in Section 5.7.2.5.6.2.

When measured from the outer-most edge of the tire in a position closest to the support structure, the minimum clearance between a tire swing and an adjacent structural component should be 36 inches if equipment is intended for older users and 28 inches if equipment is intended for younger users. These separations are designed to provide adequate space for children to reach out with their arms and legs or to lean back while sitting on the tire without impacting the support structures.

The seat height for tire swings should follow the minimum distances recommended for conventional swings: 18 inches for older children and 12 inches for younger children, measured from the sitting surface of the tire to the ground. However, no maximum is given because multi-axis tire swings appear to accommodate climbing activities more safely than conventional swings.

5.7.2.5.5 Support frames

Guideline content:

The design of structures to support tire swings is not addressed by the current guidelines.

Probable rationale:

Not applicable.

Issues:

The Play For All Guidelines (Moore et al., 1987) reports that a 12-foot span is common for the horizontal support beam. Given its recommendations regarding the span which were discussed in the context of minimum clearances, this would limit the length of a tire swing's suspending elements to 48 inches. Further, it also recommends a 72-inch height for the horizontal beam of tire swings, which is consistent with 48-inch chains and the 24 inches suggested for ground clearance.

Catalogs indicate that most manufacturers currently produce tire swing frames which range from 7 to 8 feet above ground. However, one manufacturer offers a design which is 12 feet high.

The Seattle draft standards (1986) require secure support frames. The German standards (DIN 7296, Part 2, 1984) stipulate that all structural components in the run-out area of a tire swing, which includes 78.75 inches in all directions from the extended swing, must be covered with shock-absorbing materials. However, the German standard shows the intended design of structures for this type of swing, and it is quite different from what is typically seen in this country (a horizontal cross beam supported by two parallel vertical beams), in that the tire is suspended from a single beam installed on an angle.

Recommendations:

Although all swing support structures should be non-climbable, the height of tire swing structures should follow the age-specific maximum fall height recommendations given for all types of playground equipment (see Section 5.1.3.6). This conservative measure takes into account the unpredictability of children's playground equipment use.

5.7.2.5.6 Layout and spacing of tire swings

Guideline content:

It is unclear whether multi-axis tire swings were intended to be included in the CPSC recommendation to separate swings from other activities and playground equipment, in order to reduce the risk of moving impact injuries. (Volume 1)

Probable rationale:

Not applicable.

Issues:

As previously mentioned, Esbensen (1987) recommended that tire swings should never be located on the same structure as other types of swings. None of the current catalogs reviewed showed tire swings on the same frame with other conventional swings.

The Seattle draft standards (1986) state that "tire swings are the preferred swings to be attached to a larger climbing structure." Most manufacturers who offer multi-use equipment include a tire swing suspended from a horizontal beam on these structures. A few also offer free standing tire swing frames.

Recommendations:

It is not recommended that multi-axis tire swings be suspended from a structure which also has single-axis conventional swings, due to the complex motion of the tire swings.

5.7.2.5.7 Use, fall zones

Guideline content:

The current guidelines do not discuss the use or fall zones needed for tire swings.

Probable rationale:

Not applicable.

Issues:

The German standards (DIN 7296, Part 2, 1984) require protective surfacing to cover a minimum 78.75 inches in all directions beyond a tire swing when it is extended to 90 degrees from the vertical. Furthermore, they stipulate that there may not be any obstacles in this same area, except for the structural components (which must be protected by shock-absorbing materials).

The Canadian draft standards (CAN/CSA-Z614, 1988) give a similar description of the fall zone of tire swings: 6 feet in all directions as the tire completes a full rotation of movement. This is measured from a point 6 inches beyond the outer-most edges of the tire extended in an arc of 60 degrees. A no-encroachment zone to complete the use zone is also required and consists of an additional 6 feet in all directions from the edge of the protective surfacing.

The Seattle draft standards only specify that resilient surfacing must extend a minimum of 8 feet beyond the extended arc of the tire swing in all directions.

Recommendations:

The fall zones for multi-axis tire swings should incorporate protective areas for both the support structure and the suspended member. For the support structures, the fall zone requirements should follow the general recommendations based on the height of the equipment (see Section 5.3.2.2). For the swing itself, protective surfacing should extend in all directions of motion from the outer-most edge of the tire as it completes a full rotation of 360 degrees, when it is at its maximum attainable angle (see Figure 5.7.2 - 4). The distance for which the surfacing should extend is determined by the height of the tire at its maximum attainable angle and the general recommendations for that height (see Section 5.3.2.2).

The use zones for tire swings should include a fall zone as defined above as well as a no-encroachment zone, in which there should be no obstacles except the support structure. The no-encroachment zone should extend 6 feet beyond the protective surfacing in all directions of motion (see Figure 5.7.2 - 4).

5.7.2.6 ROPE SWINGS

Guideline content:

The current guidelines do not address rope swings.

Probable rationale:

Not applicable.

Issues:

The Play For All Guidelines states that "although popular, swing ropes are not recommended in public playgrounds unless exemplary inspection and maintenance procedures are available." They also note that because close supervision is necessary with the use of rope swings, they should be removed from any playground for which supervision is not available.

The Canadian draft standards (CAN/CSA-Z614) include the following suggestion: "ropes should be selected on the basis of durability, strength, elasticity, weight, resistance to vandalism, likelihood of causing skin burns or abrasion and requirements for maintenance." With regard to maintenance, the New Zealand standards (NZS 5828: Part 2, 1986) recognize that ropes needed to be checked frequently for fraying, wear, and damage caused by vandalism, and that all unsafe ropes should be removed.

Sweeney (1979) discussed playground equipment-related deaths. Death certificates revealed that head entanglement in ropes and chains was a common cause of death. As previously mentioned, hanging from the suspending chains or ropes of swings was a prominent scenario for the swing-related deaths included in Rutherford's (1979) Hazard Analysis. Clearly, there is potential for this same problem with rope swings. Also recall that Rutherford and Kelly (1981) identified ropes as one cause of accidental ligature strangulation.

V. Brown (personal communication, June 1989) provided information from the CPSC death certificate file which also suggests that ropes on playgrounds are a serious hazard. A search of the death certificate file from July, 1973 to August, 1988 showed that 31 deaths during that period involved rope swings or other free hanging ropes on playground equipment. Twenty-five of these deaths resulted from asphyxiation or strangulation; the other 6 deaths each resulted from falls causing internal head injuries (four cases), skull fractures (one case) or a broken neck (one case). Home play areas were implicated in 25 of the rope-related deaths. Six of these involved rope swings which were suspended from trees.

Additional in-depth investigations provided by the CPSC included three rope-related deaths, all due to asphyxiation or strangulation, which occurred between May, 1985 and July, 1987. In a September, 1988 case, a child suffered abrasions on his neck while playing with a rope which was hung over the top bar of a swing set.

Recommendations:

To prevent strangulation incidents, free swinging ropes or any ropes which can be looped should not be on public playgrounds.

5.7.2.7 SWINGING EXERCISE RINGS AND TRAPEZE BARS

Guideline content:

In a general discussion of entrapment hazards, Volume 1 notes that swinging exercise rings can present such hazards if their diameters are between 5 and 10 inches and should, therefore, be removed from playgrounds. (Volume 1)

Trapeze bars are not specifically addressed by the guidelines.

Probable rationale:

The rationale for the swinging rings recommendation is stated directly in the guidelines: "if part of an accessible opening is too small to allow children to withdraw their heads easily and the children are unable to support weight by means other than their heads or necks, strangulation may result." (Volume 1)

Issues:

Sweeney (1982; 1985; 1987) reported nine hazards to which the CPSC alerts recreation officials, which when addressed can improve playground safety. Included is a warning that "swinging exercise rings with a diameter between 5-10 inches can entrap a child's head. Remove such rings and discard them where children will not find them."

The Canadian draft standards (CAN/CSA-Z614, 1988) state: "Any suspended element designed for grasping and swinging by the hands such as trapeze bars, rings, etc. should not be less than 66 inches above ground...Preschool elements for grasping and swinging should be 48 inches above ground." Further, they also recommend that such suspended elements be designed to prevent entrapment of either fingers or heads. It is also recognized that these swinging bars and rings should be installed over protective surfacing.

Both the British (BS 5696: Part 2, 1986) and Australian (AS 1924, Part 2, 1981) standards also regulate the height above ground for swinging members for children to suspend from as alternatives to seats for sitting on. The British standards require a height between 5.94 and 6.60 feet for an elevated bar. The Australian standards address elevated hand grips, and give different height specifications based on the intended user age group: for public equipment, the height must be not more than 7.87 feet nor less than 5.41 feet above ground; for domestic and preschool equipment, the height must be not more than 6.60 feet nor less than 4.29 feet above ground.

The Seattle draft standards (1986) simply recommend that swinging rings be installed "at an appropriate height for access by the intended age group using the area." In addition, they suggest that long chain lengths should be avoided so that these suspended elements cannot be flung around the top rail. They specify that the ring itself should have a 3/8-inch diameter and that heavy-duty S hooks should be used. It is noted that "all other conditions related to swings apply."

Recommendations:

The designs of swinging exercise rings and trapeze bars are often geared toward physical challenge, which may be desirable for older users; this equipment should be installed on playgrounds where adult supervision is available. It is not recommended that swinging exercise rings or trapeze bars be included on playgrounds which are intended for preschool age children.

The diameter of ring handles and the distance between a trapeze bar and its overhead support should not present entrapment hazards. Therefore, designs of this equipment should follow all of the general entrapment recommendations (see Section 5.2.6).