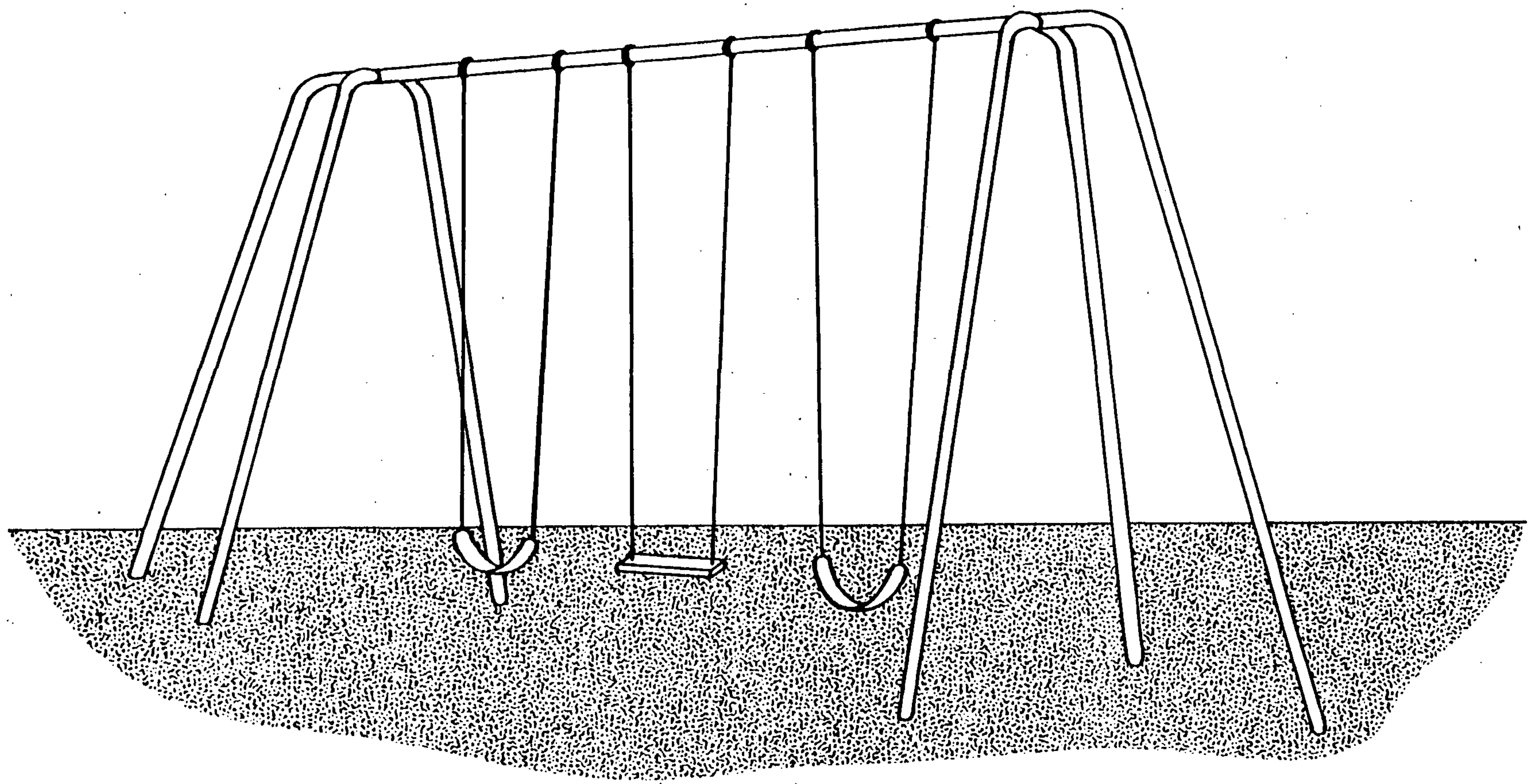
TABLES

TABLE 5.7.2 - 1

Causes of swing-related injuries involving falls in the detailed incident analysis of 1988 data

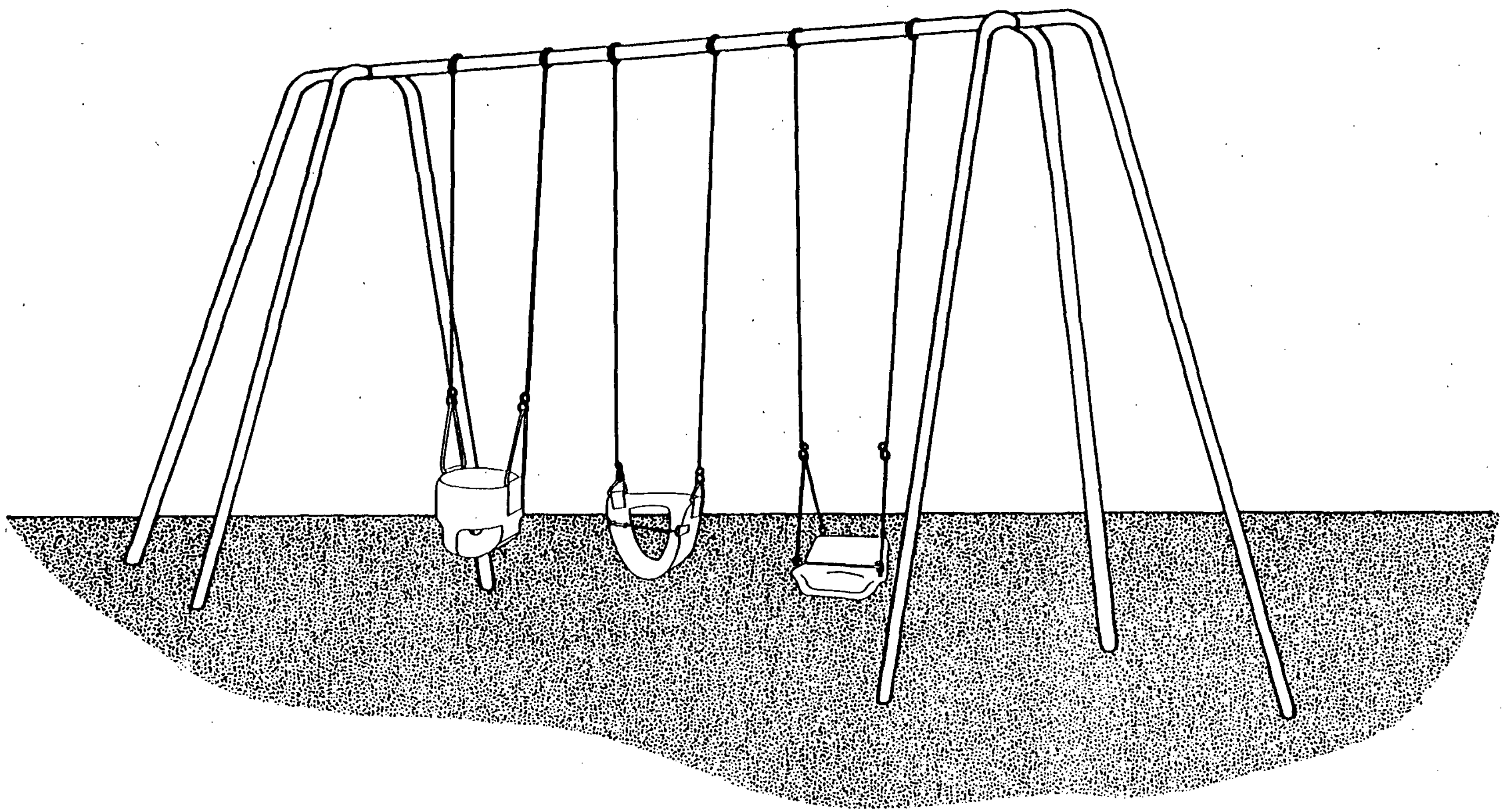
Cause of fall	Number of injuries
Jumping from swing	8
Loss of grip	5
Fall from swing support structures	5
o Cross-bar of A-frame (3)	
o Overhead supporting bar (2)	
Failure of suspending elements/fasteners	4
Standing on swing	3
Pushed out of swing	2
Impact with moving swing	2
Other	5
Unclear/unknown	6
TOTAL:	40

FIGURES



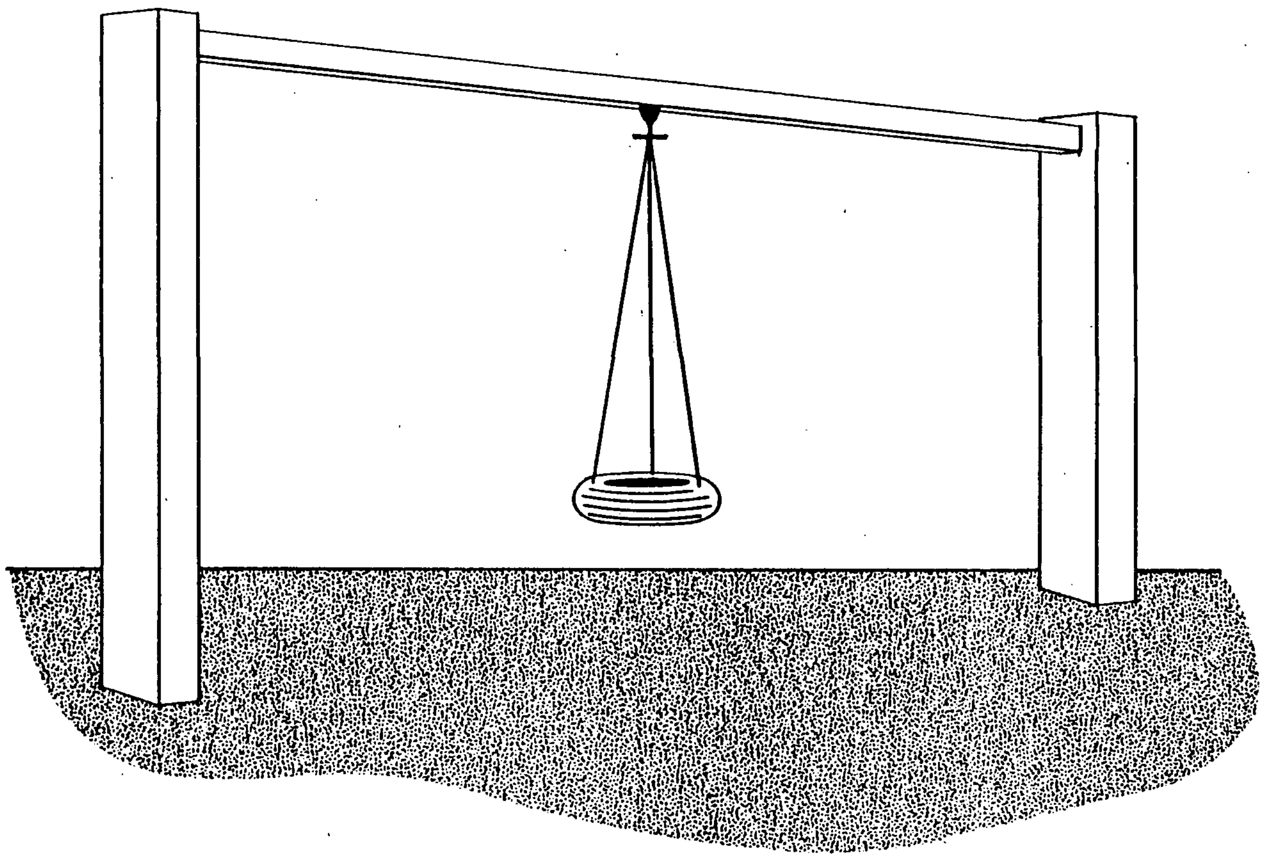
Flat and Strap-Type Seats

FIGURE 5.7.2 – 1A: TYPICAL SWINGS



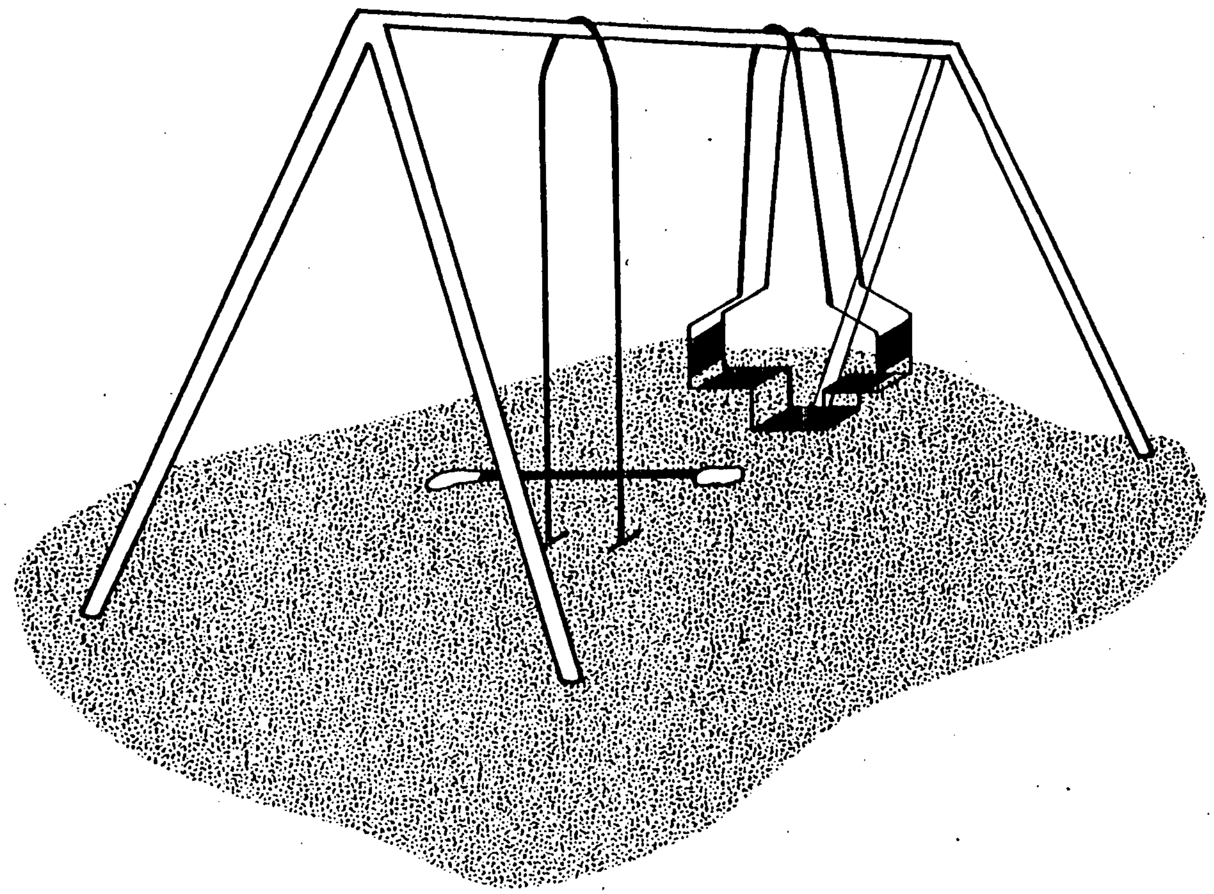
Tot Seats: Bucket, Half-Bucket with Chain, and Chair

FIGURE 5.7.2 – 1B: TYPICAL SWINGS



Multi-Axis Tire Swing

FIGURE 5.7.2 – 1C: TYPICAL SWINGS



Pendulum and Gondola Designs

FIGURE 5.7.2 – 1D: GLIDERS ARE NOT RECOMMENDED FOR USE ON PUBLIC PLAYGROUNDS

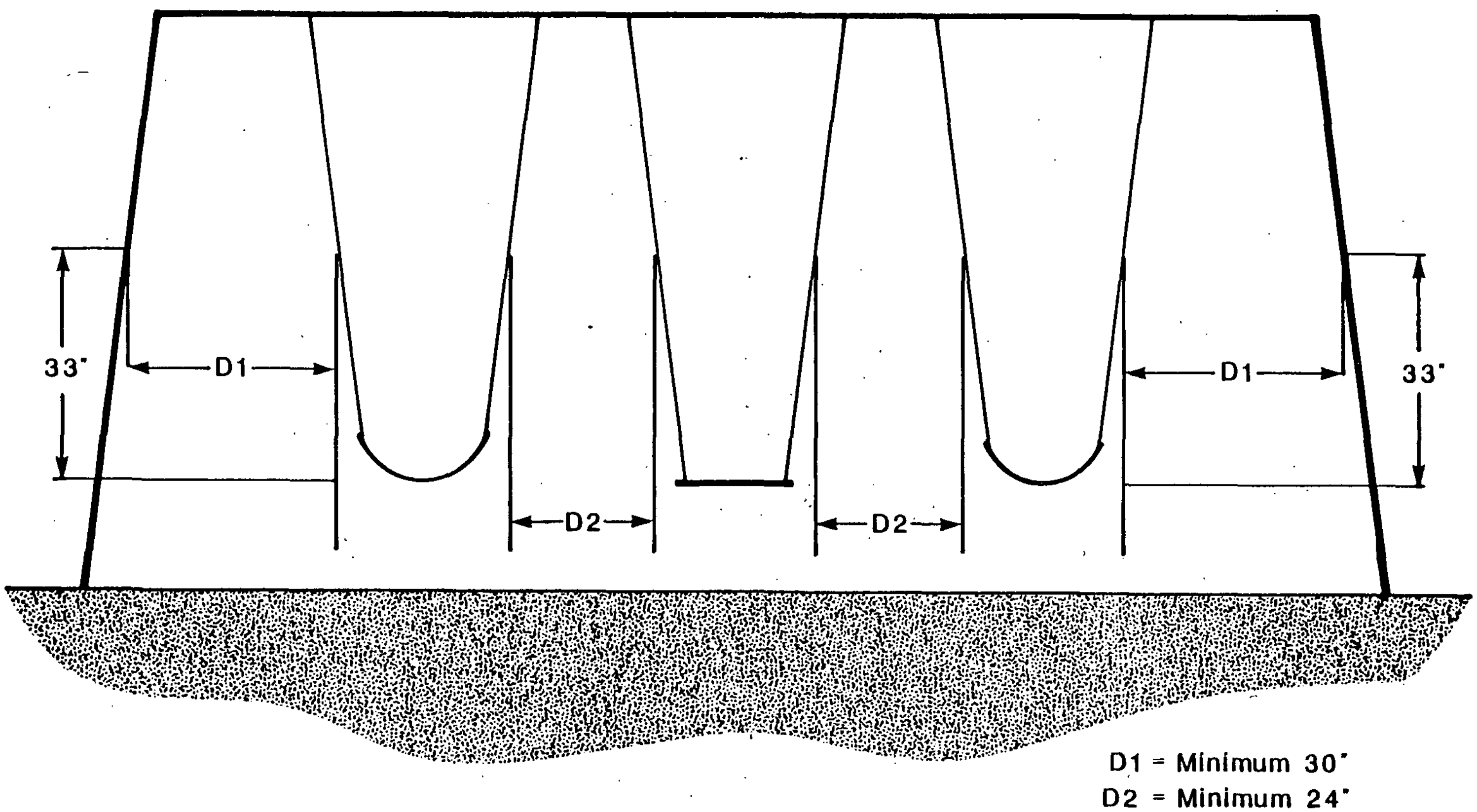
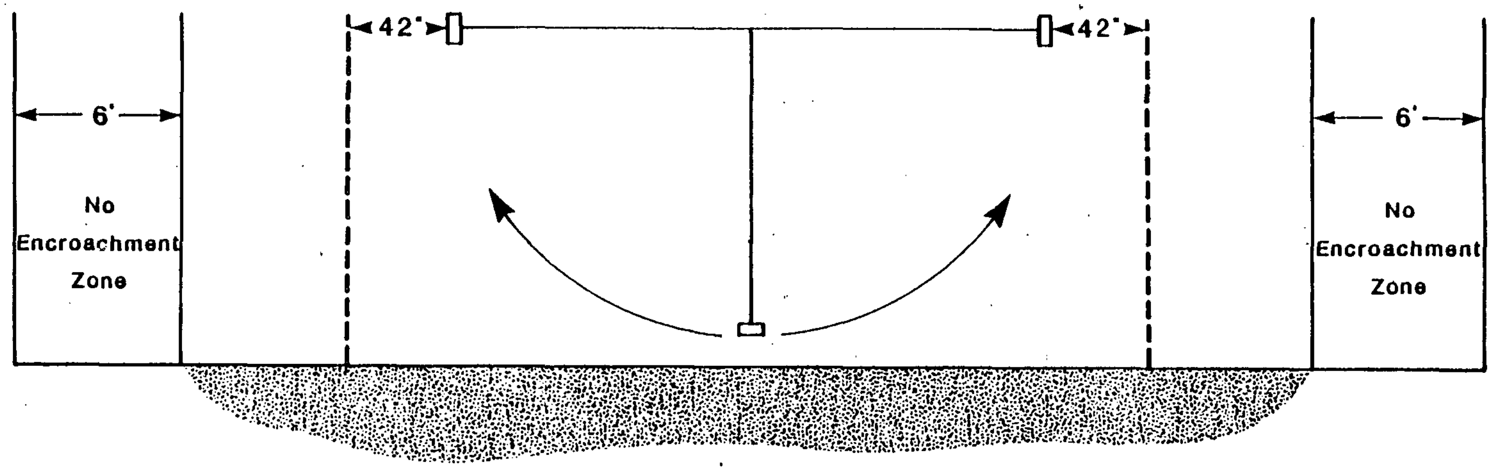


FIGURE 5.7.2 – 2: MINIMUM CLEARANCES FOR SWINGS



Denotes Fall Zone with Protective Surfacing

The dimensions of the fall zone depend on the height of the equipment (see Section 5.3.2.2).

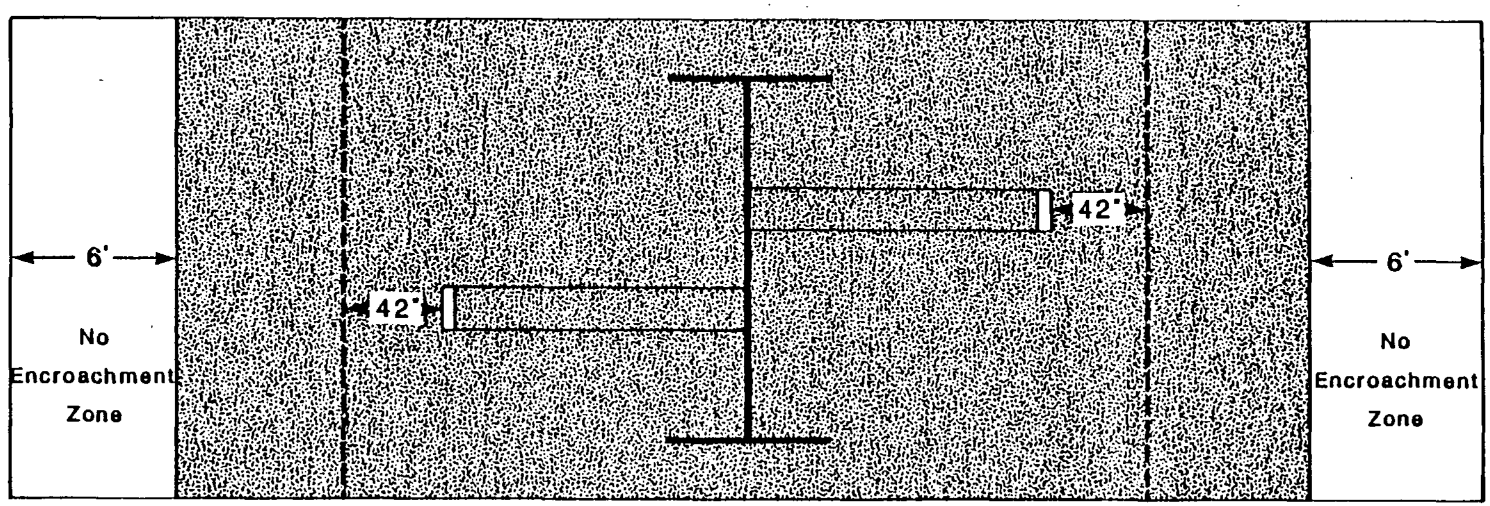
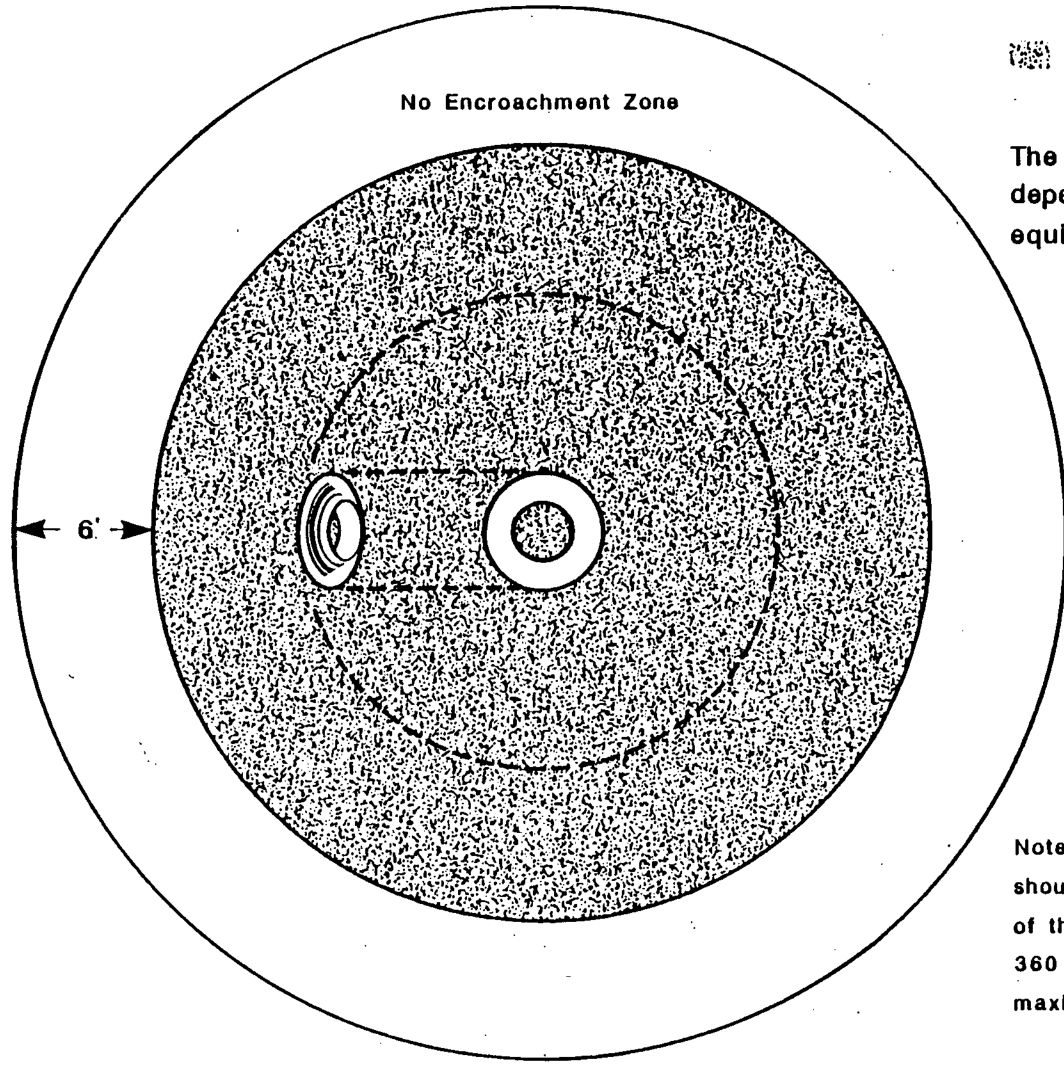


FIGURE 5.7.2 – 3: USE AND FALL ZONES FOR SWINGS



Denotes Fall Zone with Protective Surfacing

The dimensions of the fall zone depend on the height of the equipment (see Section 5.3.2.2).

Note: Use and fall zone measurements should be made from the outer edge of the tire as it completes a full 360 degree rotation while at its maximum attainable angle.

FIGURE 5.7.2 – 4: USE AND FALL ZONES FOR MULTI-AXIS TIRE SWINGS

5.7.3 CLIMBING EQUIPMENT

5.7.3 CLIMBING EQUIPMENT

5.7.3.1 PATTERNS OF CLIMBER USE

5.7.3.2 REVIEW OF CLIMBER INJURY DATA

5.7.3.3 DESIGN CONSIDERATIONS

5.7.3.3.1 Falls onto structural components

5.7.3.3.2 Easy descent; alternate means of descent

5.7.3.4 HORIZONTAL LADDERS, OVERHEAD RINGS

5.7.3.4.1 Spacing of rungs and overhead rings

5.7.3.4.2 Mount/dismount from horizontal ladder, overhead rings

5.7.3.5 SLIDING POLES

5.7.3.6 MAXIMUM HEIGHT OF CLIMBING EQUIPMENT

5.7.3.7 LAYOUT AND SPACING OF CLIMBING EQUIPMENT; USE, FALL ZONES

5.7.3.8 PROTECTIVE SURFACING

5.7.3.1 PATTERNS OF CLIMBER USE

In the literature, climbing equipment has been broadly defined to include arch ladders, sliding poles, balance beams, parallel bars, geodesic dome climbers, tunnels, chain net climbers, spiral climbers, multi-use structures, cable walks, and suspension bridges, such upper body devices as chinning bars, overhead horizontal ladders, turning bars, and overhead rings, and numerous other configurations of climbing bars (Brown, 1978; Bruya and Langendorfer, 1988; Moore et al. 1987). Some of these designs are depicted in Figure 5.7.3 - 1. A recent survey of elementary school playgrounds showed that chinning bars, overhead ladders, and sliding poles were the most common types of climbers in the sample, accounting for 17%, 11%, and 9% of all playground equipment, respectively (Bruya and Langendorfer, 1988).

Developmental data indicate that children between the ages of 2 and 2 1/2 years have the basic ability to walk up and down stairways without handrail support, and are beginning to climb up ladders using their arms and legs alternately (Esbensen, 1987). Thus, children at this age are capable of gaining access to climbing devices that have stair- or ladder-like components, but probably do not have the body control and balance required to negotiate most types of climbing apparatus. Consistent with this view, Aronson (1988) stated that most toddlers are not ready for independent access to climbing apparatus, and suggested that preschoolers meet three basic criteria before being allowed access to climbers: they should be proficient at climbing stairs, jumping from one-foot heights, and should be able to grip a handhold by wrapping their fingers and thumb around the component. Esbensen (1987) noted that a 2-year-old, if encouraged, can jump from a height of 8 to 10 inches and maintain balance on landing. A 3-year-old exhibits better balance, and, by the age of 4, a child can descend a long stairway by alternating the feet. A 5-year-old can climb up and down long ladders, in addition to stairways, by alternating feet on successive steps.

The ability to *descend* accesses at a given level of proficiency lags somewhat behind the comparable mode of ascent. Therefore, toddlers can more easily climb to the top of a structure than they can climb down, and care must be taken to provide an easy means of descent, such as a stairway. Brown (1978) recommended that climbers be designed to make descent as easy as ascent, to facilitate the transition from moving up to moving down, and to provide some alternate way out for descent, such as access to a platform or other piece of equipment. Traditional arch ladders were singled out as particularly hazardous, since they do not have a "way out option." Once users have begun to climb the arch ladder, they are forced to either complete the activity by climbing down the other side of the ladder, which may be beyond their physical abilities, or to climb back down the same side they climbed up (Brown, 1978).

Brown's point regarding the potential hazards of not having an alternate way out on arch ladders appears to be particularly true for younger users. The observational study showed that after climbing up one side of an arch climber, younger children (3- to 4-year-olds) either climbed back down the same side of the ladder, or had to be helped down by an adult. Moreover, arch ladders can become crowded at times, and if there is a line of users behind a child at the top of the climber, he or she is prevented from climbing back down the side used for ascent. Older children were able to turn themselves around 180 degrees in order to descend the other side of the ladder, but often chose to climb down through the opening between rungs near the top of the arch and drop down to the ground, sometimes after swinging from a rung by their hands. However, younger users appeared to have difficulty turning around at the top of the arch to position themselves for descent. One child began to climb down the other side of the ladder in a head-first position. When she stopped advancing, the user behind her grew impatient and tried to move her legs from the rung; the child had to be helped down from the arch ladder by an adult.

The developmental sequence of climbing and balance skills described above suggests that very young children may have difficulty using components of climbers designed to be more challenging, such as vertical ladders, curved ladders, and climbers with non-rigid components (e.g., net climbers, suspension bridges). The observational study supported this idea; for example, when 3- and 4-year-olds attempted to climb vertical ladders with three or four rungs, they often lacked the upper body strength and balance to ascend to the top, and sometimes required adult assistance to climb back down. On suspension bridges, which are lower in the middle than on either end, younger children had difficulty climbing up one end of the bridge to a platform; one child was observed to stumble while climbing up the inclined end of a bridge. According to Bruya and Langendorfer (1988), climbers are developmentally most suitable for children under 6 years of age, who tend to be younger than the users typically found on elementary school playgrounds. However, observational data indicated that children under 6 years of age had difficulty using some types of climbing equipment, such as arch ladders and horizontal ladders. Further, Bruya and Langendorfer did not specify the types of climbing devices that were considered more appropriate for younger children.

Brown (1978) noted that climbing activities contribute to neuromuscular development and eye-hand coordination. As with slides and swings, once children have become accustomed to the sensations associated with one mode of use, they explore new activities that may not represent intended uses of the equipment. The emergence of competitive play among 7- to 9-year-olds further encourages such activities as jumping from higher parts of the equipment, competing with a peer in games like follow the leader, and, in general, attempting difficult maneuvers. Based on her review of in-depth investigations from 1976-1978, Brown reported that the majority of climber-related injuries resulted from hazardous uses of horizontal ladders, such as being pushed from the top, falling from the top, or slipping while standing on the top. The detailed incident analysis of 1988 injury data showed that children were injured on a variety of climbing devices while trying difficult moves, such as balancing on the top beam of multi-use equipment (6-year-old, 8.5 feet above ground), going across a horizontal ladder by grasping every other rung (5-year-old), and doing somersaults and "backward flips" from climbing bars 6 feet or more above ground (6- and 7-year-olds). There was also evidence that competitive play contributed to several injuries among 6- to 9-year-olds; in one incident, a 7-year-old fell 5.7 feet from the roof of a climber during a game of "king of the mountain," described as one person attempting to push others off the structure. In 4 out of 60 incidents which involved a fall of victims 6 and 7 years of age, the initial cause of fall was attributed to jumping from a climbing structure. Three falls resulted from victims being pushed by other children.

In the observational study, 5- to 7-year-olds were not seen climbing across horizontal ladders from one end to the other; instead, they hung on an overhead rung at one end of the ladder, and then dropped to the ground. On a horizontal ladder that was within their standing reach, some of these users hooked their knees over the rungs and hung upside down. On higher equipment, older users were observed climbing on the top and sides of the horizontal ladder.

5.7.3.2 REVIEW OF CLIMBER INJURY DATA

The following characteristics of climber-related injuries emerge from the results of various studies, including the detailed incident analysis of 1988 data: 1) a relatively low percentage of all climber-related injuries are sustained by children under 5 years of age. 2) Falls from climbers have been the most common mode of injury, accounting for about three quarters or more of all climber-related injuries. 3) Relative to other equipment types, climbers have been associated with the highest rates of upper limb fractures, and with the highest hospital admission rates. 4) Younger children (0- to 4-year-olds) are more likely to sustain injuries to the head and face than older children (5- to 14-year olds), whereas older children are more likely to injure upper limbs. 5) Superficial facial injury is the predominant type of injury among younger children, and upper limb fracture is the most common type among older children (King and Ball, 1989).

The 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 for climber-related injuries is based on a review of 66 cases.

Climber-related injuries. In the NEISS-based Special Study of public playground equipment, climbing equipment accounted for 42% of all equipment-related injuries, a higher percentage than for any other equipment type (Rutherford, 1979). Most other estimates of the percentage of equipment-related injuries that involve climbers are greater than or equal to 30% (Canadian CAIRE data, 1982-86, NEISS data, 1987, and Pitt, 1988, reported in King and Ball; Helsing et al., 1988; Morbidity and Mortality Weekly Report, 1988; Royal Alexandra Hospital, 1981, cited in King and Ball, 1989) with some as high as 45% (Australian National Injury Surveillance and Prevention Project (NISPP), 1988, cited in King and Ball, 1989).

Proportions of injury reported in these studies reflect the relative use and availability of different equipment types. In comparison to other kinds of apparatus, some climber designs can accommodate more users at one time. Helsing et al. (1988) offered several explanations related to mode of use for the relatively high rates of injury associated with climbing apparatus: 1) climbers may require more advanced developmental skills than other equipment types; 2) parents may be less likely to supervise a child on climbing equipment than on swings or slides; 3) the multi-use nature of climbing equipment may increase the potential for horseplay and misuse of equipment, relative to other equipment types.

Based on survey data, Rutherford (1979) reported that climbers comprise 51% of all public playground equipment, and so, relative to the availability of climbers, the percentage of climber-related injuries shown in the 1978 Special Study is not disproportionately high. Bruya and Langendorfer (1988) obtained a higher estimate (65%) for the availability of climbers in their recent survey of elementary school playgrounds. However, climbers were broadly defined in their survey to include such equipment as sliding poles, balance beams, overhead rings, tunnels, and chain net climbers, whereas Rutherford's estimate may have been based on a narrower definition of climbing equipment.

Age of victims. The 1978 NEISS Special Study (Rutherford, 1979) showed that 9% of all climber-related injuries were sustained by 0- to 4-year-olds; with the exception of merry-go-rounds, this proportion of injuries attributed to the youngest age group is lower than for any other equipment type. The 5- to 7-year age group and the 8- to 10- year group each accounted for about one third of climber-related injuries. The 11- to 14-year-olds accounted for 23%, the highest percentage of injuries associated with this age group relative to other types of equipment. Other studies discussed by King and Ball (1989) corroborate the relatively low percentage of 0- to 4-year-olds involved in climber-related injuries (15%; NISPP, 1988; 15%, Royal Alexandra Hospital, 1981; 16%, 1982-86 NEISS data; 19%, 1982-86 CAIRE data; 21% 1987 NEISS data). The average age of children injured on climbers has been reported as 5 years (Illingworth et al., 1975, cited in King and Ball, 1989), and as 7 years for "monkey bars only" (Pitt, 1988, cited in King and Ball, 1989). The Royal Alexandra Hospital study (1981, cited in King and Ball, 1989) showed that 6-year-olds incurred the highest number of injuries on climbing frames compared to other ages, with climbers accounting for about half the injuries to this age group.

King and Ball (1989) concluded that, given the 1:2 ratio between the number of 0- to 4-year-olds and 5-to 14-year-olds in the total U.S. child population during the period covered by the 1982-86 NEISS data, climber injuries are disproportionately low among younger children. That is, children 5 years of age and older appear to be at greater risk of injuries associated with climbers. Age-related differences in frequency of use and the lower availability of climbing equipment on home play areas as compared to public and school playgrounds are factors likely to contribute to this finding.

The detailed incident analysis indicated that most (53 out of 66) of the injuries associated with climbers occurred among school-age children (5- to 14-year-olds). Further, the detailed incident analysis showed that when 1- to 5-year-olds were injured on climbers, the incident was more likely to occur at a public or school playground than in a private play area.

Mode of injury. The majority of climber-related injuries have been attributed to falls. In the 1978 NEISS Special Study (Rutherford, 1979), 73% of climber injuries on public equipment were attributed to falls to the surface (51%) or to falls in which the victim struck the same piece of equipment (22%). Falling against or running into equipment was more frequently associated with climbers (15% of all climber injuries) than with any other equipment type. In other studies discussed by King and Ball (1989), falls from height were reported as the predominant cause of climber injuries (1982-86 CAIRE data, Christensen et al., 1982).

In the detailed incident analysis, 58 out of 66 injuries were due to falls, 13 of which also involved impact with stationary equipment.

Falls from climbing equipment in the 1978 Special Study were caused by slipping, loss of grip, loss of balance, being pushed or bumped by another person, or missing a bar while swinging between bars (Rutherford, 1979). Based on her review of in-depth investigations collected from 1976 to 1978, Brown (1978) identified a number of additional factors implicated in falls from climbers: jumping, attempting a difficult move, misjudging the distance of a hand or foot support bar, partial grip on a bar, and fatigue. In some cases, wet shoes, perspiration on the hands, or moisture on the equipment contributed to injuries. Illingworth et al. (1975, cited in King and Ball, 1989) reported cases in which the victim was injured as a result of walking on top of or doing somersaults on top of a climbing frame. A questionnaire-based study conducted by the Royal Alexandra Hospital (1981, cited in King and Ball, 1989) indicated that 20% of 82 accidents on steel climbing frames were caused by the child's loss of grip.

In the detailed incident analysis, grip slipping was identified as the initial cause of fall in 36 out of the 60 cases in which a fall was involved. Other causes included jumping (4 cases), being pushed (3 cases), loss of balance (2 cases), foot slipping (1 case), rung beyond child's reach (1 case), and slipping while hanging on a bar by the knees (1 case). Several falls occurred in connection with another mode of injury, such as falling against climbing equipment, and impact with a rung or bar; in 9 cases, the initial cause of fall could not be determined from the in-depth investigations.

Falls from climbers may be particularly serious because of the heights involved. Survey data are available on the heights of climbers found on public and school playgrounds. Langley and Crosado (1982, 1984) found that 23% and 28% of climbers on school and public playgrounds (in Dunedin, New Zealand), respectively, exceeded 8.2 feet in height. In a U.S. survey of elementary school equipment, the mean climber height was 9.3 feet above the underlying surface; it was possible for children to climb 8 feet or higher on 40% of the climbers sampled, and 10% of climbers permitted children to climb more than 15 feet high (Bruya and Langendorfer, 1988). A safety inspection at elementary school playgrounds near Philadelphia conducted in 1984 and 1985 showed a lower mean height of climbing equipment, 6.7 feet (Ridenour, 1987).

Pinch points, protrusions, sharp edges, and sharp points were implicated in a small proportion (3%) of climber injuries on public equipment in the 1978 NEISS Special Study (Rutherford, 1979). Survey data indicated that 41% of climbers on elementary school playgrounds had sharp corners, edges, or projections, and 31% of climbing structures were judged to have open holes at the end of tubes or pipes that posed a finger entrapment hazard (Bruya and Langendorfer, 1988).

Other characteristics of incident. The detailed incident analysis showed that the majority (39 out of 66 cases) of climbing-related injuries in the sample occurred during primary use of the equipment. Ten victims were injured during initiation of the task sequence, 4 of whom fell while trying to begin swinging across an overhead horizontal ladder; and, 10 victims, 9 of whom were greater than 5 years of age, fell while trying to climb down, jump, or otherwise dismount from the equipment. Interaction with others was implicated in only 15 of the 66 cases.

Injury patterns. King and Ball (1989) concluded that in comparison to other equipment types, climbers were associated with low rates of facial injuries and high rates of upper limb injuries, based on their review of 1985-86 NEISS data, 1987 NEISS data, and 1982-86 CAIRE data. Most upper limb injuries sustained on climbers were fractures; the proportions of all fractures and of upper limb fractures on climbers were higher than those associated with any other equipment type. Moreover, upper limb fractures represented a higher proportion of all fractures sustained on climbers than they did for other types of equipment. In addition, the proportion of serious head injuries (concussion, internal injury, skull fracture) involving climbers was the second highest among all types of equipment, somewhat lower than the proportion of serious head injuries for slides. A number of studies discussed by King and Ball (1989) showed that climber-related injuries accounted for the highest proportions of hospital admissions relative to other equipment types (Illingworth et al., 1975; 1982-86 CAIRE data; Hansen and Kruse, 1985; Pitt, 1988). The higher likelihood of a climber-related injury to require hospital admission is not surprising, given the high percentage of fractures and serious head injuries relative to other equipment types.

King and Ball's (1989) presentation of 1985-86 NEISS data, 1987 NEISS data, and 1982-86 CAIRE data also showed that climber-related injuries have the following age-related patterns for body location and severity of injury. Consistent with the injury pattern for swings and slides, climbers were associated with higher percentages of head and facial injuries among 0- to 4-year-olds than among 5- to 14-year-olds, while upper limb injuries were more common among older children than among younger children. In terms of severity, superficial facial injury was the predominant type of climber-related injury for children under 5 years of age, and the next most frequent types were serious head injuries and upper limb fractures. Among 5- to 14-year-olds, upper limb fracture was the predominant type of climber-related injury and superficial facial injury was the second most frequent.

In the detailed incident analysis, the most common type of injury among 0- to 4-year-olds was a superficial facial injury (7 out of 13 cases); the two predominant types of injury among 5- to 14-year-olds were upper limb fracture (15 out of 53 cases) and superficial facial injury (13 out of 53 cases).

The CPSC's death certificate records indicate that nine climber-related fatalities occurred between 1973 and 1977 on public playgrounds (Rutherford, 1979), seven of which were due to falls. One death resulted when the climbing apparatus fell on the victim. King and Ball (1989) reported fatality data provided by the CPSC which indicated that of four climber-related deaths occurring between 1985 and 1987, two were caused by equipment falling on the victims and crushing them, and two were attributed to asphyxiation or strangulation. (King and Ball included in their analysis deaths that occurred in home play areas as well as on public playgrounds.) In a study of playground fatalities in Brisbane, Australia, Nixon, Pearn, and Wilkey (1981, cited in King and Ball, 1989) reported that one victim was crushed when a climbing frame fell over.

5.7.3.3 DESIGN CONSIDERATIONS

Climbers encompass a variety of equipment types, including multi-use structures with linked platforms. As discussed in the section on access (see Section 5.6.1), some accesses to platforms are designed to be more challenging than stairways and stepladders. For example, net and chain climbers with their non-rigid components require more advanced balance abilities, and on vertical rung ladders, users must have sufficient upper body strength to pull themselves up in the vertical direction. Since these more challenging accesses are intended to be used as climbing devices, some recommendations for rungs, non-rigid climbing components, handgripping components, and stepped platforms covered in the section on access and platforms are directly applicable to climbing equipment. Therefore, for the following design characteristics, the guideline content and probable rationale have already been discussed with regard to access or platforms, and the reader is referred to the appropriate sections.

Spacing between climbing bars. Although the guidelines specifically address the distance between climbing bars, their recommendation is the same as that for the spacing between steps and rungs on "slides and other equipment": the spacing must accommodate the arm and leg reaches of children (Volume 1). The discussion of vertical rise of rungs in Section 5.6.1.1.2.1 is appropriate for climbing bars that are used for hand and foot support during ascent and descent of climbing apparatus. However, the spacing of rungs that are intended to be gripped overhead on upper body devices, such as horizontal ladders, warrants a separate evaluation, and will be considered later in this section.

Diameter of climbing bars. The current guidelines do not address the diameter of climbing bars separately from other components intended to be grasped by the hands, such as ladder rungs and handrails. Moreover, the test condition used to develop the diameter recommendation for all hand gripping components was a hand gripping an overhead cylindrical component (NBS, 1978a). Handrail diameter is discussed in Section 5.6.1.1.3.2.

Non-rigid climbing components. Flexible climbing devices, such as net, chain, and tire climbers are discussed in Section 5.6.1.2.2. Whether flexible climbers are components of multi-use equipment (e.g., inclined accesses or suspended bridges) or stand-alone pieces of equipment, they share the critical features of not providing steady foot or hand support and of having connection points within the grid or between tires that require careful maintenance. Therefore, recommendations that apply to flexible climbing devices which provide access to or linkage between platforms also apply to non-rigid components on stand-alone climbing structures.

Other design considerations for climbing bars. Recommendations to ensure the structural security of rungs and ladders, and to discourage the use of rung ladders by toddlers are discussed in Section 5.6.1.1.2.6. These recommendations apply to climbing bars on all types of climbing apparatus.

Stepped platforms. Refer to Section 5.6.3.3 for a discussion of height differential between stepped platforms.

5.7.3.3.1 Falls onto structural components

Some climbers are designed so that users climbing on the inside or top of the equipment can fall onto climbing bars or other structural components in the interior of the equipment. On multi-use equipment, vertical posts that are unattached at the upper end and adjacent to platforms have also been identified as hazardous obstacles inherent in the design of the equipment.

Guideline content:

The current guidelines do not address the potential hazards of components on climbing structures that obstruct falls to the surface.

Probable rationale:

Not applicable.

Issues:

The Play For All Guidelines (Moore et al., 1987) and Beckwith (1988) pointed out that more traditional climbing structures, such as cube climbers or theme climbers with horizontal and vertical bars arranged in a three-dimensional grid pattern, may have interior climbing bars that would obstruct the fall of a user into the interior of the structure. Dome-shaped climbers, such as geodesic climbers, and arch climbers which present no structural obstructions in the fall area beneath or in the interior of the equipment are termed "free fall" climbers. The advantage is that the user will fall directly to the protective surfacing below rather than impacting rigid climbing bars. Current catalogs indicate that some theme climbers and other climbing structures with potential fall heights of 7 to 9.5 feet have climbing components in their interiors.

There is also some concern about protruding parts adjacent to platforms of multi-use equipment. For example, some platforms are adjacent to vertical posts, unattached at the upper end, that form part of the support structure for stairway access (J. Frost, personal communication, February 1989). The relatively small surface area of the top of a post presents a greater risk for impact injury than the surfaces of handrails, platforms, or steps. Surveys of climbing equipment found on school and public playgrounds (Langley and Crosado, 1982, 1984) indicated that about 2% of the climbers sampled had protrusions directly underneath them; protrusions were defined as objects such as vertically mounted logs. It is unclear whether obstructions to falls inherent in the design of climbers, such as vertical posts on multi-use equipment, were classified as protrusions.

Recommendations:

It is recommended that climbers do not have climbing components in the interior of the structure which obstruct falls to protective surfacing from the top or inside of the structure. On multi-use equipment, climbing components and platforms should not have vertical posts, unattached at the upper end, or other structural protrusions in the fall zone.

5.7.3.3.2 Easy descent; alternate means of descent

Guideline content:

The current guidelines state that "climbing equipment should not lure a child to make an easy climb to the top without providing a way for the child to descend as easily"; another platform or piece of equipment can serve as an alternate means of descent. Since a child climbing on a simple arch ladder may be forced to complete the activity, particularly if other users are waiting for a turn, simple arch ladders may not offer an easy "way out" option. (Volume 1)

Probable rationale:

Brown (1978) recommended that climbing equipment be designed so that users can descend as easily as they ascend, or have an alternate way out, such as access to a platform or other piece of equipment for descent. A "way out option" on arch ladders is particularly important, because of the potential conflict between two users ascending from opposite ends of the structure. In addition, users should not be forced to complete climbing the structure; an alternate means of descent is useful if the child is fatigued or afraid to continue.

Issues:

As discussed earlier, younger users may have difficulty descending a traditional arch climber once they have climbed to the top. Since there are no alternative means of descent, they must either climb back down the side they used for ascent or position themselves to climb down the other side of the arch, a maneuver not readily performed. Current catalogs show an alternate design for arch ladders, in which two additional curved ladders, perpendicular to a simple arch ladder, provide access to and exit from the top of the structure. In addition, the ladders are wide enough to accommodate more than one user at a time. Although this design provides additional ways to descend the structure, as the current guidelines recommend, two features of the structure should be noted: each side of the structure is equally difficult to descend; and, where the additional ladders are attached to the main arch ladder, there appears to be a larger space than that found between other rungs of the structure. Although observational data suggest that older children would climb down through this space to dismount the apparatus, the opening may pose a problem for younger children.

The benefits of multiple means of access have already been discussed in connection with slide platforms (see Section 5.7.1.3.1.3). Although few researchers or standards specifically address alternate means of access for climbing structures, some apply such recommendations to all types of equipment. The Canadian draft standards (CAN/CSA-Z614, 1988) state that on play equipment with elevations exceeding 6 feet more than one means of exit should be provided, in the event that children cannot negotiate one of the exit options. Single function equipment, such as a free-standing slide, is exempted from this requirement; it is unclear whether stand-alone climbing devices would be classified as single function equipment. For high climbing structures, the Canadian draft standards specify that there should be intermediate standing surfaces where users can decide to halt ascent and pursue an alternate way out. In addition to a general recommendation to provide an easy, alternate way out for most playground activities, the Seattle draft standards (1986) stipulate that multiple means of access and exit should be provided on all platform structures and for each event on a modular play structure. Since platforms are used as climbing surfaces, and climbing components such as net climbers and suspension bridges are commonly found on multi-use equipment, these standards are directly relevant to climbing equipment. The rationale for the Seattle draft standards is that children who are engaged in activities that are too challenging for them should have an immediate means of retreat. Simpson (1988) noted that a face-saving escape route for younger children should be one which is easier for them to negotiate than other means of descent. Esbensen (1987) pointed out that alternative accesses on climbing structures and other high pieces of play equipment help to vary the play experiences of older users. According to Frost (1980), multiple accesses help to reduce congestion on play equipment, and may thus decrease the likelihood of pushing or shoving.

On multi-use structures, where platforms are interconnected by climbing devices such as net climbers, horizontal ladders, and suspension bridges, it is relatively easy to ensure that children are not forced to use the more challenging climbing devices by installing alternative accesses. Manufacturers' catalogs show that multi-use equipment intended for younger children typically provide stairway access to platforms, in addition to more challenging modes of access like arch ladders and chain climbers, used primarily for ascent and not descent. On multi-use equipment intended for older users, flexible climbing devices and arch ladders can be attached to platforms as high as 6 feet above the underlying surface; in such cases, it may be preferable to provide a way out option at an intermediate height, particularly for 4- and 5-year-olds who may begin the climb but decide to halt their ascent. On some types of stand-alone climbers, such as geodesic domes, where there are no separable accesses, and in which lower components of the structure provide access to higher components, the method of climbing is uniform over the entire structure. Therefore, implementing an easier, alternate means of descent would involve modifying the basic design.

Recommendations:

Climbing equipment should be designed so that users are able to descend as easily as they ascend; one way of implementing this recommendation is to provide an easier, alternate means of descent, such as another mode of access, platform, or piece of equipment. For example, a stairway can be added to provide a less challenging mode of descent than a vertical rung ladder or flexible climbing device. (The levels of challenge that characterize different types of accesses are discussed in Section 5.6.1) Offering an easy way out is particularly important on climbing devices intended for preschoolers, since their ability to descend climbing components at a given level of proficiency emerges somewhat later than their ability to climb up the same components. The design of equipment should not force a child to complete a demanding activity, as when a line of users is likely to form behind the initial user. It is particularly important to provide an alternate means of descent when the activity involves a difficult transition such as from moving up to moving down, as in the case of a simple arch ladder.

5.7.3.4 HORIZONTAL LADDERS, OVERHEAD RINGS

5.7.3.4.1 Spacing of rungs and hanging rings

Guideline content:

Volume 1 makes the general recommendation that the spacing of support members and climbing bars should match the arm and leg reaches of children; no distinction is made between the spacing of rungs on vertical access ladders and the spacing of rungs on horizontal ladders. Both volumes specify that the distance between consecutive rungs on ladders should be between 7 and 11 inches. The spacing of overhead hanging rings is not addressed. (Volume 1; Volume 2, 11.3.2.3)

Probable rationale:

Since the recommended 7 to 11 inch spacing was based on the knee height of the minimum user (see Section 5.6.1.1.2.1), it is aimed at rungs intended to provide foot support during ascent. Because rungs on a horizontal ladder are intended to be grasped by the hands, as stated in Volume 2, their spacing requires a separate evaluation. Brown (1978) reported that data from the 1978 Special Study indicated that some climbing equipment-related injuries were caused by distances between support members for the hand that were too far for the reach envelope of the victim. (NBS, 1978a, 1978b; NRPA, 1976a; Volume 2, 11.2)

Issues:

The Seattle draft standards (1986) specify a maximum distance of 14 inches between rungs on horizontal ladders, which is also the maximum spacing recommended by Aronson (1988) for school-age children and by Werner (1982). Aronson suggested that the maximum distance between rungs be smaller for preschoolers, but did not indicate a specific value. The Canadian draft standards (CAN/CSA-Z614, 1988) require that the distance between rungs on overhead ladders, measured from center to center, should be a minimum of 12 inches and a maximum of 16 inches.

Estimating the reaching ability of minimum users on horizontal ladders is complicated by the fact that they must support their body weight with one hand as they move the other hand to grasp the next rung. The user's grip is subjected not only to the gravitational force acting on the body, but also to the forces generated by the momentum of the swinging movement. In the detailed incident analysis of 1988 injury data, 17 out of 20 injuries that resulted from falls from horizontal ladders were caused by the user's grip slipping, typically during the transition from one rung to the next.

A sample of current catalogs showed that at least one manufacturer features horizontal ladders on equipment intended for preschoolers. On some horizontal ladders intended for older children, the rungs are not perpendicular to the side supports, but instead are angled so that the distance between successive rungs depends on where the user grasps them. On other designs the side supports for the rungs are C- or S-shaped, which results in rungs that may be closer together on the inside edge of the curved support than on the outside edge.

Ridenour (1983) argued that although inter-rung distances on horizontal ladders typically range between 12 and 18 inches along designer-intended paths of movement, larger distances between rungs may be found on paths of movement that children actually take. For example, children may attempt to transfer from one piece of equipment to another by swinging between adjacent rungs. In a laboratory study, Ridenour had 6-year-old boys predict whether they would be able to successfully swing between two overhead rungs, and then recorded whether they were successful in using a hanging-swinging movement to get from the first rung to the target rung. Inter-rung distance ranged from 24 inches to 59 inches, at 5 inch intervals. During the self-prediction part of the study, each child was placed in a standing position holding onto an overhead rung and shown the actual inter-rung distance. Ridenour reported that the boys were very accurate in predicting whether or not the inter-rung distance would be too difficult to negotiate; rung spacing did not affect the accuracy of self-prediction. With regard to the actual attempts to swing from one rung to the next, as inter-rung distance increased, the percentage of successful trials decreased and the frequency of jumping movements increased. A movement was classified as jumping rather than hanging-swinging if a boy's body or limbs were not touching either the first or target rung, support bars, foot-rest, or ground in one 16-mm frame during the task. Jumping movements often resulted in landings before or below the target rung. Based on these results, Ridenour recommended that inter-rung distances along the movement paths that children actually take should be less than 24 inches, and that potential movement paths should be identified through field research with climbing equipment prior to marketing. It should be noted that, using 6-year-old boys, the 24 inch inter-rung distance was associated with an 80% success rate; therefore, the minimum inter-rung distance for 4-year-olds should be even more conservative.

Although neither the standards nor the literature addressed the spacing of overhead hanging rings, their mode of use involves the same hand-over-hand, swinging movements that characterize the intended use of horizontal ladders. One difference is that the smaller gripping surface provided by each ring gives the user a much smaller margin of error for grasping the next ring in comparison to bars on a horizontal ladder.

Recommendations:

On equipment intended for older children, the distance between rungs on overhead ladders, measured from center to center, should not exceed 14 inches. This maximum value is based on the frontal grip reach (14.9 inches) of the minimum user, a 5th percentile 4-year-old. Frontal grip reach gives some indication of the maximum distance that users can reach forward as they attempt to grasp the next rung, and therefore is a reasonable and somewhat conservative measure of reaching distance. The 14-inch maximum inter-rung distance is sufficiently conservative to be acceptable for younger users, given that typical users of overhead ladders are not likely to be younger than 4 years of age. Regardless of the age of the intended user, the distance between the opposing interior surfaces of adjacent rungs should be greater than 9 inches in order to satisfy the entrapment requirements (see Section 5.2.6).

It is not recommended that horizontal ladders intended for preschool-age children have unequal distances between rungs; two successive rungs should be equidistant regardless of where the user is grasping the rung, and all rungs on a horizontal ladder should be evenly spaced. These features help to minimize problems of perceptual judgment.

The recommendation for the maximum distance between rungs on horizontal ladders should also apply to the distance between overhead rings, because the pattern of use on these two types of upper body equipment is similar.

5.7.3.4.2 Mount/dismount from horizontal ladder, overhead rings

Guideline content:

The current guidelines do not make recommendations aimed at facilitating mount or dismount on horizontal ladders or overhead rings.

Probable rationale:

Not applicable.

Issues:

Some issues that arise in the design of horizontal ladders and overhead rings pertain to the type of access provided for mount or dismount, and the placement of the first rung or overhead ring at either end of the upper body equipment. The Play For All Guidelines (Moore et al., 1987) notes that two designs are currently used for access to horizontal ladders and overhead rings: decks, and horizontal rails or loops. Data are not available on the relative effectiveness of these alternatives.

Current catalogs showed that horizontal ladders and overhead rings are often attached to platforms on multi-use structures at one or both ends. Platforms used for access to these upper body devices ranged from 12 inches to 56 inches above ground; 36 and 42 inch heights for access platforms were not uncommon. Most catalogs did not specify the height of upper body devices attached to multi-use equipment; however, heights of horizontal ladders and support beams for hanging rings were estimated to range from 72 to 108 inches above ground.

Access platforms that are close in height to the overhead handholds on upper body devices can interfere with mounting or dismounting the equipment. According to the Canadian draft standards (CAN/CSA-Z614, 1988), overhead ladders should be designed so that users can grasp the first rung at either end from a standing position. It seems reasonable that younger users, who have less developed upper body strength, should be able to reach the first handhold easily, without having to adopt an awkward crouching position. However, as shown in Figure 5.7.3 - 2A, some access decks for upper body devices would not even permit a 5th percentile 4-year-old, with a stature of 37 inches, to assume a standing position if he or she were mounting the equipment from the platform.

Some access platforms have one or more climbing rungs beneath the level of the platform, presumably to facilitate dismount from the overhead device or to serve as access to the platform. These climbing rungs seem particularly useful for higher access platforms and for taller users: users would not be forced to pull themselves up directly to the level of the platform, since they would have the option of first moving from the upper body device to the climbing rungs. Figure 5.7.3 - 2B depicts the potential mismatch between the foot position of a taller user preparing to dismount an overhead horizontal ladder and the height of the access platform above ground. Considering that children are likely to approach the dismount in a fatigued state (Moore et al., 1987), providing climbing rungs for foot support beneath the platform level is a reasonable dismount feature.

Current catalogs also showed that vertical rung ladders and loop handles are used for access to upper body devices. Rungs are usually restricted to the lower half of the ladder, but it is difficult to ascertain the height of the highest rung intended for mount and dismount. Loop handles attached to the vertical support posts of upper body devices are similar to those used for hand support at the entrance to platforms and slides; however, when loop handles provide access to an upper body device, they appear to be intended primarily for foot support during climbing rather than for hand support. In the observational study, 6-and 7-year-olds who climbed loop handles to access a horizontal ladder did so only with great difficulty and did not successfully mount the apparatus. This design, which does not appear optimal for foot support, was seen in only one manufacturer's catalog.

Loop handles may also be attached to the vertical support posts at the entrance to a platform, presumably to aid in the transition between between the upper body device and the platform. In some designs, however, the handles extend far enough into the entrance area to potentially obstruct the movement of a user from the overhead handhold to the platform.

J. Frost (personal communication, February 1989), the Play For All Guidelines, and the Canadian draft standards address the potential for falls onto rungs or decks during dismount from upper body equipment. The Canadian draft standards specify that the user should be able to fall from the first rung of a horizontal ladder without striking anything directly below it; this requirement implies that the first rung on either end of a horizontal ladder should not be located directly above the climbing rung or deck used for mount or dismount. Moore et al. (1987) state that the last handhold on upper body equipment should not be located directly above the dismount rail or deck, and should be inset from either end of the overhead device by at least 8 inches to avoid falls onto the rail or deck. In current catalogs, the first overhead ring is typically inset from the end of the support beam; the first bar of a horizontal ladder may be inset or may be located directly above the access rung or platform. Frost recommended an alternative strategy to minimize the injury potential of a fall during dismount: access to a horizontal ladder should be provided by a tire buried halfway in the ground rather than by climbing rungs attached to the vertical support posts at either end of the ladder.

Some hanging rings consist of two series of rings suspended from parallel support beams which are attached to the vertical support posts of an access platform. This design is probably more difficult to dismount than a single row of hanging rings whose support beam is aligned with the center of the platform entrance.

Recommendations:

Horizontal distance between first handhold and access structure. Horizontal ladders and hanging rings should be designed to facilitate mount and dismount. On equipment intended for older children, the first handhold on either end of upper body equipment should not be placed directly above the platform or climbing rung used for mount or dismount. Rather, the horizontal distance between the first handhold and the access structure should be at least 8 inches and should not exceed 10 inches. This design feature should minimize the risk of a user impacting rigid access structures if he or she falls from the first handhold during mount or dismount. At the same time, the 10-inch maximum distance ensures that the first handhold is reachable by the minimum user, a 5th percentile 4-year-old. If the horizontal distance between the first handhold and access structure were greater than or equal to 11 inches, the height of the handhold above the access structure would be less than the recommended minimum height of 37 inches, as discussed below.

Given that typical users of upper body devices are not likely to be younger than 4 years of age, the 8 to 10 inch distance is also appropriate on upper body equipment intended for younger users.

The use of softer materials for access structures may help lower the risk of an impact injury, if a slip or fall occurs. For example, a tire buried in the ground can replace low access rungs, or wood can be used instead of metal.

Minimum and maximum height of first handhold above access. On upper body equipment intended for older children, the minimum user should be able to grasp the first handhold from a standing position on the access structure; older users in this age group can probably meet the challenge of mounting the device from a crouching position. Therefore, the height of the first handhold above the access structure should be at least 37 inches, which corresponds to the stature of the minimum user (37 inches), a 5th percentile 4-year-old. The maximum height of the first handhold above the access structure should be a function of the horizontal distance between the first handhold and the access structure. The greater the horizontal distance between the first handhold and access structure, the lower the handhold must be to accommodate the reaching distance of the minimum user (see Figure 5.7.3 - 3). If the first handhold is inset from the access structure by 8, 9, or 10 inches, the height of the handhold above the access structure should not exceed 40, 39, or 38 inches, respectively. These maximum heights are based on the reaching distance of the minimum user (13.75 inches), which was estimated by adding together successive arm length measurements between the acromion and the skin crease at the base of the middle finger.

On upper body equipment intended for younger children, the minimum user is presumed to be a 5th percentile 4-year-old, and the minimum and maximum heights of the first handhold above the access structure that were recommended for older users are also appropriate for younger users.

Other design features. In addition to dismount structures, such as an access platform or the uppermost rung of a ladder access, additional structures may be necessary to provide foot support during dismount to accommodate the foot position of a range of users (see Figure 5.7.3 - 2B). These additional structures may be climbing rungs beneath an access platform, or climbing rungs beneath the uppermost rung on an access ladder. The foot position of the minimum user, a 5th percentile 4-year-old, is approximately 42 inches below the handhold, and the foot position of the maximum user, a 95th percentile 12-year-old, is approximately 78 inches below the handhold. These values are based on the vertical grip reach of the respective users. While the placement of the highest climbing rung or other support surface should accommodate the smallest user, it is recommended that additional lower foot supports be provided to assist taller users.

5.7.3.5 SLIDING POLES

Guideline content:

The current guidelines do not contain recommendations for sliding poles.

Probable rationale:

Not applicable.

Issues:

Sliding poles. The Canadian draft standards (CAN/CSA-Z614, 1988) specify that sliding poles should be at least 18 inches and no more than 20 inches away from a platform, deck, or structural member. Access to the sliding pole should be from one point only. In addition, access should be provided by an opening in the guardrail; this opening should not exceed 15 inches in width unless there is free standing access to the sliding pole. Sliding poles are not recommended for preschool-age children. In current catalogs, sliding poles are typically attached to the open side of a platform on multi-use equipment; poles can be either vertical or inclined, so that they project farther out from the platform at the bottom than at the top. None of the catalogs reviewed indicated the distance between the sliding pole and its support structure. Sliding poles are attached to decks that range in height from 3 feet to almost 6 feet. In one design, a multi-use structure intended for children 2 years of age and older featured a sliding pole attached to a 64 inch high platform.

Recommendations:

On equipment intended for older children, the horizontal distance between a sliding pole and the edge of the platform or other structure used for access to the sliding pole should be at least 15 inches; this minimum distance applies to all points along the sliding pole. In addition, all points on the sliding pole at or above the level of the access structure, where the user is likely to reach for the pole, should not be more than 20 inches away from the edge of the access structure. These recommendations for the distance between sliding pole and access structure ensure sufficient clearance for the body of the maximum user to slide down unimpeded, and at the same time present a reasonable challenge for the reaching abilities of the minimum user.

Since sliding poles are designed to be more challenging than some other types of climbing equipment, they do not appear to be appropriate for preschool-age children, who may lack the requisite upper body strength and coordination to successfully slide down the pole. Moreover, once younger users have grasped the pole, they would be forced to complete the sliding activity since there is not a way-out option.

5.7.3.6 MAXIMUM HEIGHT OF CLIMBING EQUIPMENT

Guideline content:

The current guidelines do not address the maximum allowable height of climbing equipment, or of any playground equipment. For a general discussion of maximum height, refer to Section 5.1.3.6.

Probable rationale:

Not Applicable.

Issues:

As discussed in the injury data section, falls from climbers are the predominant cause of injury, accounting for about three quarters or more of all climber-related injuries. In their survey of elementary school playground equipment, Bruya and Langendorfer (1988) found that 60% of climbers in the sample ranged in maximum height from 9 feet to greater than 15 feet above the underlying surface, and that 10% of climbers exceeded 15 feet. Brown (1978) noted that climber-related fatalities attributed to falls sometimes involved fall heights of as little as 4 feet or as high as 8 feet, and that nonfatal injuries requiring emergency room treatment sometimes resulted from 3-foot falls from climbers.

D. Thompson (personal communication, February 1989), J. Frost (personal communication, February 1989; U. of Texas, 1989, unpublished manuscript), and Esbensen (1987) stated that maximum fall heights on climbing equipment should not exceed 8 feet. Esbensen's recommendation applies to children 5 years of age and under, while Frost's target group was school-age children. Moreover, Frost (1980; personal communication, February 1989) also proposed a more conservative criterion for determining maximum height of equipment, which is discussed below. Thompson specified a range of maximum heights between 6 and 8 feet. The 8-foot upper limit is consistent with the 8.2-foot maximum overall height for agility apparatus required in the Australian (AS 1924, Part 2, 1981) and British (BS 5696: Part 2, 1986) standards; these standards apply to agility equipment that is independent of, attached to, or integral with other playground equipment. The German standards (DIN 7926, Part 1, 1985) permit fall heights from climbing equipment up to 13.1 feet.

More conservative maximum heights have been advocated in the Play For All Guidelines (Moore et al., 1987), by Aronson (1988), and by Frost (1980; personal communication, February 1989; U. of Texas, 1989, unpublished manuscript). The Play For All Guidelines distinguishes between upper body devices (e.g., horizontal ladders, chinning bars, overhead rings) and other climbers in their recommendations for maximum height. An appropriate height for climbing equipment depends in part on whether the surfacing can protect the user from a severe injury caused by a fall as well as on the intended age group and ability to maintain the equipment and surfacing; in general, climbers do not need to exceed 56 inches to be challenging for users. To allow for effective use of upper body equipment which involves hanging from overhead components, the Play For all Guidelines specifies higher maximum heights than for other climbing devices. Horizontal ladders should not exceed 80 inches and the horizontal support bar for overhead rings and similar hanging components can be as high as 92 inches above ground, providing that the equipment is installed over 6 inches of chopped tire or 12 inches of uniform round sand. The 92-inch maximum height for overhead rings includes a 12-inch allowance for the hanging ring handles. Even with this allowance, children taller than 60 inches will have to bend their legs somewhat to avoid dragging their feet on the ground. However, since the mean stature of a 12-year-old is slightly less than 60 inches (58.6 inches), most intended users would not have to adopt this awkward strategy. Frost recommended that potential fall heights from climbing equipment not exceed the standing reach height of the taller expected users; for climbers, such as horizontal ladders, Frost permitted an additional few inches to allow for jumping from the apparatus. The vertical grip reach of a 95th percentile 12-year-old is 78.2 inches, which is comparable to the 80-inch maximum specified for horizontal ladders in the Play For All Guidelines. The corresponding measurement for a 95th percentile 5-year-old is 53.9 inches, slightly less than Moore et al.'s upper limit for climbers that are not primarily used for upper body activities.

Although Aronson (1988) recommended a maximum height of 72 inches for playground equipment in general, she stated that "fall distances from climbers should be minimized." One strategy is to provide intermediate platforms that limit potential fall heights to one-half the user's height. Frost (U. of Texas, 1989, unpublished manuscript) suggested installing alternating wooden platforms on existing metal climbing equipment so that fall heights never exceed 3 feet from any point on the equipment. Refer to Section 5.6.3.3 for a discussion of height differentials on stepped platform structures.

Recommendations:

A separate recommendation for the maximum height of most types of climbing equipment is not necessary. With the exception of upper body equipment and arch ladders, as discussed below, climbers should follow the age-specific maximum fall height recommendations given for all types of playground equipment (see Section 5.1.3.6).

Upper body devices such as horizontal ladders and overhead rings require special precautions because of their intended mode of use and level of challenge. Users are required to support their body weight with their hands, which can easily lead to fatigue and thereby increase the risk of falls, relative to climbers which provide foot support during usage. However, equipment should be high enough to keep most children in the intended age group from dragging their feet. Given these considerations, the height of handholds on upper body equipment intended for older children should not exceed 80 inches. This maximum height is based on the vertical grip reach (78.2 inches) of the maximum user in this age group, a 95th percentile 12-year-old, with an allowance added for ground clearance. It should be noted that there is a considerable difference (36 inches) between the vertical grip reach of the maximum user (78.2 inches) and that of the minimum user (42.1 inches), a 5th percentile 4-year-old. The potential 3-foot drop to the ground for the minimum user is probably not a serious safety problem, but may discourage younger children from using the upper body equipment. If the oldest intended user is less than 12 years of age, the maximum height of upper body devices should be estimated from the vertical grip reach of the corresponding 95th percentile user, plus 2 inches to allow for ground clearance.

On upper body devices intended for preschool-age children, height should not exceed 56 inches. This value corresponds to the vertical grip reach (53.9 inches) of the maximum user, a 95th percentile 5-year-old, plus an allowance for ground clearance. It should be noted that maneuvers required on upper body equipment are more difficult for younger children than for older children. Heights that are lower than the recommended maximum will facilitate use by smaller children, and will impede use by taller children; however, lower heights are not expected to present a safety problem for taller children.

Arch ladders are a special case of climbing equipment because, by design, they are easy to climb up but difficult to climb down, particularly for younger users. In addition, on arch ladders which require single file use, a line of users often forms behind the initial user, forcing him or her to complete the activity. Arch ladders should not exceed the vertical grip reach of the maximum user by more than a few inches, and should follow the recommendations for the maximum height of upper body devices.

5.7.3.7 LAYOUT AND SPACING OF CLIMBING EQUIPMENT; USE, FALL ZONES

Guideline content:

The guidelines do not specifically address the layout and spacing of climbing equipment on the playground.

Probable rationale:

Not applicable.

Issues:

Separation from other equipment. The Seattle draft standards (1986) recommend that climbing components be separated from other activities on a play structure to preclude jumping to, or falling from, one structure to another. Esbensen (1987) stated that horizontal ladders or bars should not be placed above or adjacent to slides, to remove the possibility of a child swinging on the overhead ladder and kicking into the body of someone descending the slide. In current catalogs, upper body devices on multi-use equipment do not appear to be close enough to slides to permit this type of conflict between users. In addition, Esbensen recommended that open platforms not be located next to swings. Frost U. of Texas, 1989, unpublished manuscript) addressed the layout of cable and chain balance devices, which typically consist of one cable suspended near the ground for foot support and a higher cable above for hand support. He suggested that barriers be installed to prevent children from running into the cables.

Linkage; traffic patterns. L. Bruya (personal communication, February 1989) noted that guidelines should be developed for traffic patterns on multi-use or linked equipment. According to Beckwith (1988), the Play For All Guidelines (Moore et al., 1987), and the Seattle draft standards (1986), when climbing components, including upper body devices, are attached to other play structures or used to interconnect structures, they are used more frequently than if they were separate units. The climbing devices become part of the traffic flow pattern from one play event to another. Similarly, static balance equipment (e.g., balance beams) receive heavier usage when they are used to link play structures with surrounding paths (Moore et al., 1987). Beckwith (1988) pointed out that integrating climbers with other structures helps to reduce the frequency of king-of-the-mountain games; however, play structure linkage should not offer easy access to the top of upper body equipment. Esbensen (1987) stated that activities on and around climbing structures should be compatible with each other. For example, L. Witt (personal communication, February 1989) cautioned against using climbing components that are too challenging, given the nature of the activities they link and their location relative to the flow of activity on the superstructure as a whole. In one case, the last activity connecting two platforms 6 feet apart consisted of three ladder rungs attached to a pair of chains. To negotiate this chain ladder, users had to slow down from a high speed and be very deliberate in their movements. Witt substituted a less challenging bridge made from tires for the chain ladder, making the linkage more compatible with the traffic flow.

The Canadian draft standards (CAN/CSA-Z614, 1988) address the location of sliding poles relative to the traffic flow: sliding poles should be designed to reduce the likelihood of traffic interfering with children as they descend the pole. This precaution is based on the fact that, during descent from a sliding pole, the line of sight of the user is limited. In the observational study, a sliding pole attached to a platform was positioned in front of a vertical rung ladder that provided access to the same platform. One child was observed using the rungs of the ladder to assist in shimmying up the sliding pole. This was indicative of the potential for conflict between children using the vertical ladder and children sliding down the pole.

Use, fall zones. Esbensen (1987) stated that protective surfacing should be placed directly below climbing equipment and extend 6 feet beyond their perimeter in all directions. Some researchers and standards address use and fall zones for climbers indirectly through their recommendations for stationary or fixed equipment. The Canadian draft standards specify that protective surfacing should extend 6 feet from the perimeter of stationary equipment; a no-encroachment zone is not required. When two pieces of stationary equipment are adjacent to one another, their fall zones are permitted to overlap completely, for a minimum extent of 6 feet of protective surfacing between their adjacent sides. When stationary equipment abuts moving equipment, they must have non-overlapping fall zones, and must be at least 12 feet apart. The NRPA (1976b) also recommended that the use zone for stationary devices provide 6 feet of protective surfacing in all directions from the perimeter of the equipment; the use zone did not include a no-encroachment zone. For stationary equipment less than 4 feet high, the use zone need only extend 4 feet from the perimeter. The Seattle draft standards are more conservative, requiring that protective surfacing extend at least 8 feet beyond the perimeter of fixed equipment in all directions. Burke (1980) stated that protective surfacing should extend 6 feet from the perimeter of stationary equipment, and that a no-encroachment zone should then extend another 6 feet.
Recommendations:

When climbing components are part of a multi-use structure, their level of challenge and mode of use should be compatible with the traffic flow from adjacent components. In addition, play structure linkage should be designed so that children cannot jump to, or fall from, one component to another. The swinging movements generated on upper body devices warrant special precautions to reduce the risk of impact with users on adjacent structures. Upper body devices should be placed so that swinging users cannot interfere with the movement of children on adjacent structures, particularly with their descent on slides. The design of adjacent play structures should not facilitate climbing to the top support bars of upper body equipment.

Sliding poles should not be in close proximity to other climbing devices or accesses. In addition, the foot of a sliding pole should be separate from other activities and from traffic so that a user can descend unimpeded by children directly below.

The fall zone requiring protective surfacing for climbing equipment should follow the general recommendations presented for all equipment (see Section 5.3.2.2). The use zone does not need to extend beyond the fall zone.

5.7.3.8 PROTECTIVE SURFACING

Guideline content:

The current guidelines do not address the surfacing required under climbing equipment separately from the general discussion of protective surfacing.

Probable rationale:

Not applicable.

Issues:

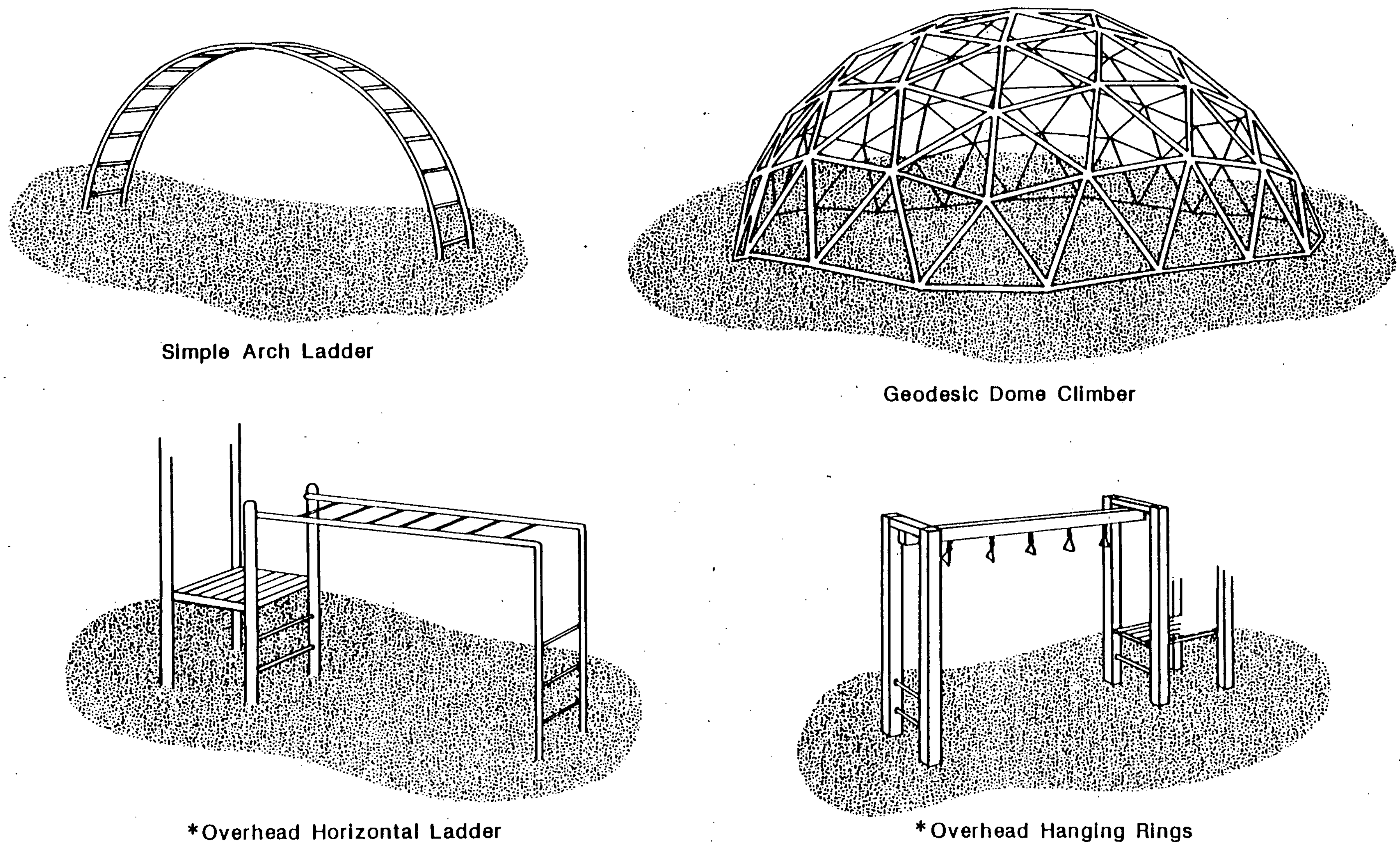
Few researchers made specific recommendations for the types of protective surfacing appropriate for climbing equipment. Esbensen (1987) simply suggested the use of a resilient surfacing material, such as sand. Aronson (1988) stated that surfaces under equipment that can be climbed should be covered with 8 to 10 inches of an impact absorbing material such as shredded tires, wood chips, loose sand, or pea gravel. Blacktop, concrete, grass, and earth were identified as unsafe surfaces.

Data are available from several surveys of playground equipment on the proportion of climbers observed to have different types of surfacing materials. The AALR Survey of elementary school playgrounds found the following surfaces under climbing equipment: sand, 24%; grass, 19%; clay, 18%; pea gravel, 16%; hard packed dirt, 10%; asphalt, 4%; mulch or tan bark, 3%; rubber matting, 3%; crushed rock, 2%; and concrete, 1% (Bruya and Langendorfer, 1988). Based on surveys of school and public playground climbing equipment in the Dunedin urban area, Langley and Crosado (1982; 1984) reported that grass and earth were the most common surfaces under climbers (44%-59%), followed by asphalt (17%-28%) and concrete (12%-14%). Asphalt surfaces were more common under climbers on public playgrounds than on school playgrounds. A 1984-85 safety inspection of elementary school playgrounds near Philadelphia revealed that 30% of climbers had asphalt or concrete surfaces, and 69% had dirt or turf (Ridenour, 1987). However, some caveats must be observed in interpreting the data from these surveys. None of the surveys measured the depth of the surfacing, which is necessary to evaluate the degree of protection these surfaces provided. Moreover, none of the surveys reported the criteria used to define each type of surfacing.

Recommendations:

All recommendations with regard to surfacing are made in a general section (see Section 5.1). Because falls must be anticipated from challenging climbing equipment, protective surfacing is especially important for climbing structures. While the minimum requirements of Section 5.1 apply, it is recommended that as much protective surfacing as possible be provided in the fall zone of climbing equipment.

FIGURES



*Note: This design shows how upper body equipment is typically integrated with multi-use equipment.

FIGURE 5.7.3 – 1: TYPICAL CLIMBING EQUIPMENT

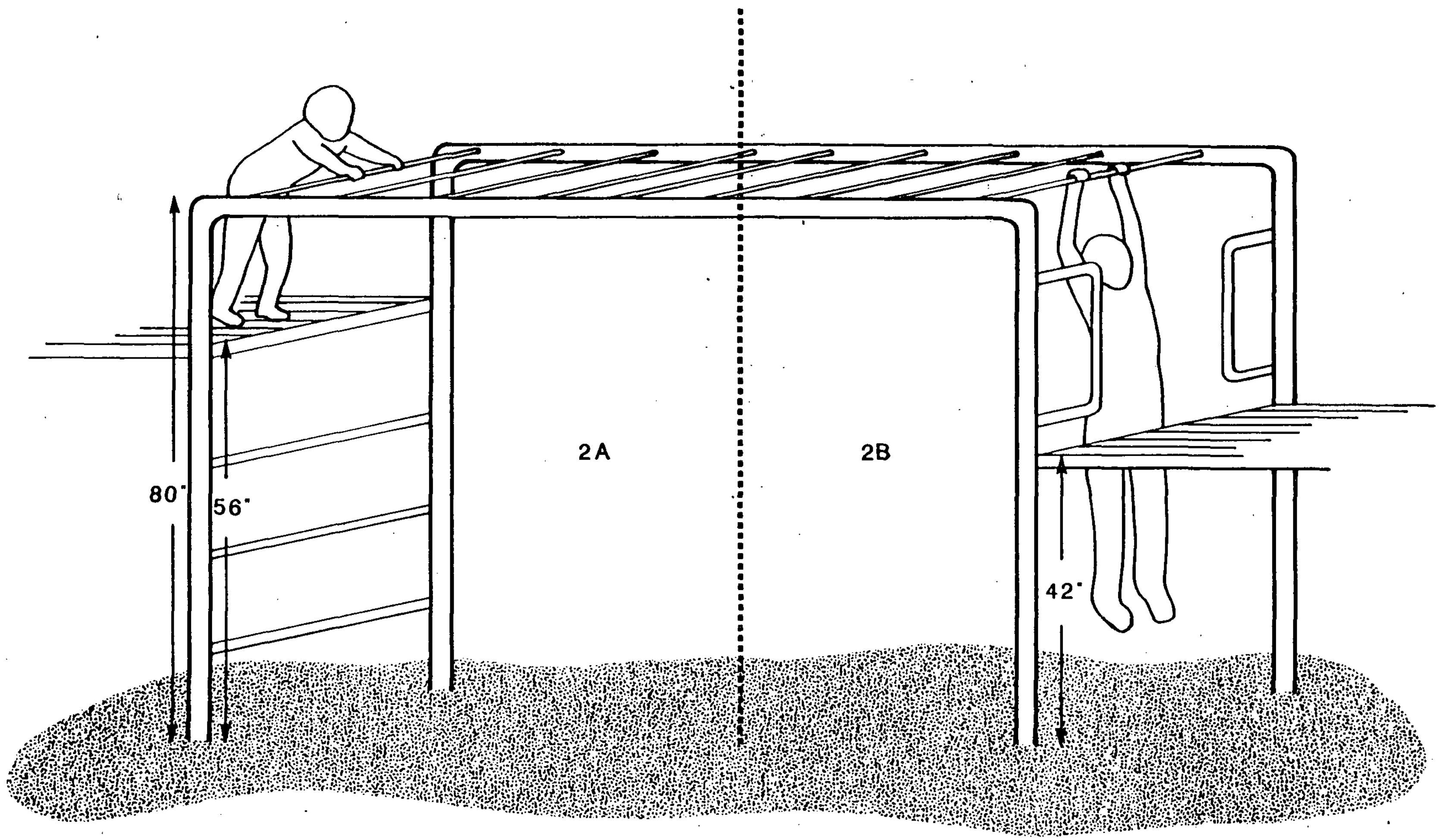


FIGURE 2A: Mount position of minimum user (5th percentile 4-year-old) on high access platform to overhead horizontal ladder. Note that minimum user cannot reach the first overhead rung from a standing position, and must adopt a crouching position.

FIGURE 2B: Dismount position of taller user on overhead horizontal ladder. Note the mismatch between the user's foot position and the height of the access platform. The addition of climbing rungs beneath the access platform would provide foot support during dismount for taller users.

FIGURE 5.7.3 – 2: EXAMPLES OF DESIGN FEATURES THAT INTERFERE WITH EASY MOUNT AND DISMOUNT ON AN OVERHEAD HORIZONTAL LADDER

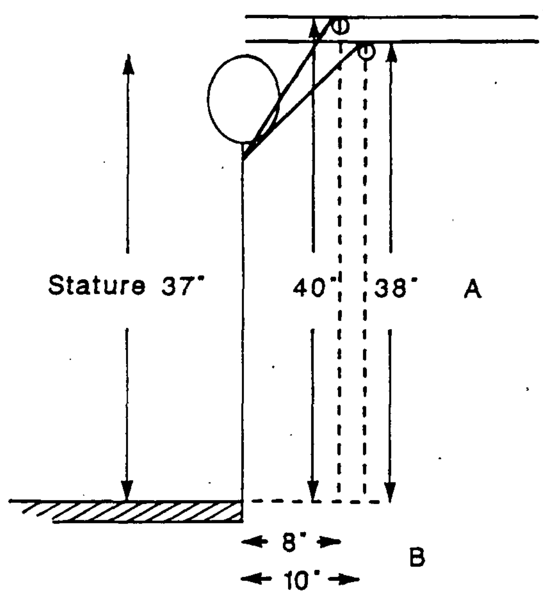


FIGURE 5.7.3 – 3: MAXIMUM HEIGHT OF FIRST OVERHEAD RUNG ABOVE ACCESS PLATFORM (A) AS A FUNCTION OF HORIZONTAL DISTANCE BETWEEN FIRST OVERHEAD RUNG AND ACCESS PLATFORM (B).

NOTE THAT THE GREATER THE HORIZONTAL DISTANCE BETWEEN FIRST OVERHEAD RUNG AND PLATFORM THE LOWER THE OVERHEAD RUNG SHOULD BE TO ACCOMMODATE REACHING DISTANCE OF MINIMUM USER (5TH PERCENTILE 4-YEAR-OLD).

5.7.4 MERRY-GO-ROUNDS

5.7.4 MERRY-GO-ROUNDS

5.7.4.1 PATTERNS OF MERRY-GO-ROUND USE

5.7.4.2 REVIEW OF MERRY-GO-ROUND INJURY DATA

5.7.4.3 ROTATING PLATFORM

5.7.4.3.1 Size and shape

5.7.4.3.2 Handgrips

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5.7.4.3.4 Height above ground

5.7.4.3.5 Speed of rotation

5.7.4.3.6 Oscillation

5.7.4.4 USE, FALL ZONES

5.7.4.5 SURFACING

5.7.4.1 PATTERNS OF MERRY-GO-ROUND USE

Merry-go-rounds are the most common type of rotating equipment found on playgrounds (see Figure 5.7.4 - 1). Generally, they consist of a circular base or platform close to the ground which spins in a horizontal plane. They are typically designed to accommodate a child either sitting or standing on the platform, with handrails to aid the child in maintaining balance while in rotation; however, some have actual seats attached to the base. Frost (1986b; U. of Texas, 1989, unpublished manuscript) noted that conventional playgrounds usually include a merry-go-round.

A study on play and equipment choices indicated that children preferred action-oriented equipment, such as merry-go-rounds or swings, over static equipment (Frost and Campbell, 1978). In fact, popularity rankings from this study showed merry-go-rounds to be the second most popular type of equipment, behind swings. Results of the SCIPP Survey in Massachusetts listed merry-go-rounds fifth for popularity and availability, falling quite far below swings, climbers, and slides but close to see-saws (Helsing et al., 1988).

Like other moving equipment, merry-go-rounds can "provide important sources of movement and perceptual challenge to children as they develop" (Bruya and Langendorfer, 1988). Merry-go-rounds can create a constantly changing environment in which both older and younger children practice movement skills at their own level. For young children especially, moving equipment enhances sensory-perceptual, cognitive, and motor development. Several sources agree that vestibular stimulation, which helps to develop good balance, is a valuable aspect of merry-go-round use (Bruya and Langendorfer, 1988; Frost, U. of Texas, 1989, unpublished manuscript; Seattle draft standards, 1986). Bruya and Langendorfer pointed out that "rapidly revolving merry-go-rounds appear to provide high degrees of angular acceleration which children seem to find especially stimulating and exhilarating." In addition, they explain how important it is for young children to develop proprioceptive perception. Merry-go-rounds provide an opportunity to encourage these skills.

Frost (U. of Texas, 1989, unpublished manuscript) noted that dramatic play is supported by merry-go-round use. Similarly, Bruya and Langendorfer (1988) suggested that the turn-taking and cooperation practiced while children play on merry-go-rounds aids in their "accommodation of more advanced levels of psychosocial development."

The observational study provided insight into the ways in which children use a conventional merry-go-round with handrails extending in toward the center of the platform base. Typically, several children rode on the merry-go-round while another child or an adult pushed it. When children were pushing, they usually either kept running alongside the merry-go-round, holding onto one of handrails to push or pull in order to keep the base rotating, or tried, at some point, to jump on while it was moving. Those riding either sat or lay down on the base itself, or stood leaning against the handrails. A few children were seen climbing up and sitting on top of the handrails, which was probably not a very stable position given the rotation of the equipment, and therefore, not very safe. Other hazardous behaviors observed include children sitting with their legs dangling over the edge, or leaning back over the edge while sitting or lying down and holding onto the handrails. These positions put them at risk of impact injuries, caused by either contact with the ground or other children.

It was clear from the observational study that younger children sometimes find themselves unable to get off the merry-go-rounds because they are being pushed by older children who take control of the equipment. Generally, an adult had to intervene and stop the equipment so that children could get off safely. One very young child, who was lying on his stomach, deliberately slid off a merry-go-round while it was rotating.

Frost (U. of Texas, 1989, unpublished manuscript) noted that many experts have serious reservations about placing merry-go-rounds on playgrounds. However, while they may be more limited in play function than other pieces of equipment, accident data have not shown that merry-go-rounds are among the most hazardous. Frost concluded that "with serious attention to design, installation, maintenance and supervision, reasonably safe yet challenging rotating equipment can be provided for children's play." He further noted that "the acceptable types have solid, circular bases, with strong, rigid handholds and are free from shearing mechanisms underneath the circular base." Available injury data and these design considerations, among others, are discussed in the following sections.

5.7.4.2 REVIEW OF MERRY-GO-ROUND INJURY DATA

Injury data for merry-go-rounds are very limited. This is due, in part, to a low incidence of related cases. For example, King and Ball (1989) did not include merry-go-rounds in their review of the Canadian CAIRE system's study of playground equipment-related injuries for this reason. Those studies which do address rotating equipment either classify merry-go-rounds as "other" or group them for unexplained reasons with other types of equipment such as see-saws. Such methods make it difficult to extract data which are specifically for merry-go-round injuries.

The 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 included only four cases in which injuries were caused by merry-go-rounds. Each of these illustrated an interesting design problem and will, therefore, be discussed in the relevant sections following.

Merry-go-round-related injuries. Rutherford's (1979) Hazard Analysis did include a separate discussion of merry-go-rounds. He concluded that merry-go-rounds are implicated in 8% of injuries. King and Ball (1989) reported comparable figures for the percentage of merry-go-round injuries from two other studies which recorded hospital-based injury data (Illingworth et al., 1975; Royal Alexandra Hospital, 1981). The SCIPP Survey in Massachusetts found that a slightly lower percentage of merry-go-rounds was implicated in playground injuries (Helsing et al., 1988).

Rutherford (1979) noted that merry-go-rounds account for 5% of all public playground equipment, which is roughly proportional to the percentage of injuries they cause. A New Zealand survey indicated that 6.4% of the pieces of equipment on public playgrounds were merry-go-rounds, while only 0.4% of the pieces of equipment on primary school playgrounds were merry-go-rounds (Langley and Crosado, 1982, 1984). The AALR Survey of elementary school playgrounds found that rotating equipment, including merry-go-rounds and swinging gates which rotate around a center fulcrum, comprised 1.4% of all equipment.

Age of victims. NEISS data in the 1978 Special Study showed that children 5 to 7 years of age were injured most frequently (63%), followed by those 8 to 10 years (23%), those 11 to 14 years (10%), and those 0 to 4 years (4%) (Rutherford, 1979). The Royal Alexandra Hospital study (1981, cited in King and Ball, 1989) found that children over 5 years old were injured more often using merry-go-rounds than younger children.

Mode of injury. The 1978 Special Study data, as reported by Rutherford (1979), indicated that falls were the most common cause of injury for merry-go-rounds. These included falls to the surface (73%), and falls striking the same piece of equipment (4%). Other injury patterns were pinch points, protrusions, sharp edges and sharp points (16%), and impact with moving equipment (5%).

As stated above, most falls from merry-go-rounds are to the ground. Moore et al. (1987) recognized that injuries on spinning equipment (merry-go-rounds or whirls) are often falls against or under moving equipment, and that these injuries tend to be more serious because of the size and mass of such equipment.

Rutherford (1979) gave the following scenarios for typical falls:

> Investigated cases indicated that children either lost their grip and were thrown from the apparatus, fell down while pushing it or fell while on the equipment. Those who fell while pushing were in some instances then struck by the device. Those who fell while on the merry-go-round struck or were struck by the gripping bars or struck the base itself.

In addition, Rutherford stated that between 1973 and 1977, merry-go-rounds were implicated in two fatalities, both of which were caused by falls.

Merry-go-round injuries caused by pinch points commonly involved damaged equipment (Rutherford, 1979). The AALR Survey results showed that 47% of the merry-go-rounds on the elementary school playgrounds studied had sharp edges, corners, or projections (Bruya and Langendorfer, 1988). In addition, 53% "had open areas near or around the rotation post in which a child's limb could be trapped and injured during equipment operation."

The CPSC provided nine additional in-depth investigations to study injuries caused by pinch, crush, and shearing points. These injuries occurred between 1979 and 1988. Five of the nine incidents involved merry-go-rounds; all of them resulted in either partial or full amputation of the child's finger. In each case, the child put his or her finger into a hole either on the base of the merry-go-round or on the central shaft. The injuries were then caused by contact with shearing components in the equipment's axle or undercarriage. Pinch, crush, and shearing injuries are discussed more fully in the review of injury data for general hazards.

One scenario documented in Rutherford's (1979) Hazard Analysis is that of a child riding on a merry-go-round with one leg extended beyond the perimeter of the base who consequently strikes a victim standing next to the merry-go-round with the force of the equipment's rotation. Rutherford noted that moving impact injuries involving merry-go-rounds were more common among children over 5 years old who are "indulging in some form of horseplay," in contrast to swing-related moving impact injuries which are generally sustained by younger users due to their less-developed perceptual and motor skills.

5.7.4.3 ROTATING PLATFORM

5.7.4.3.1 Size and Shape

Guideline content:

The current guidelines recommend that the rotating portions of merry-go-rounds (the platform or base on which children stand or sit), should be continuous and have an approximately circular shape. More specifically, Volume 2 states that "the difference between the minimum radius and the maximum radius of a non-circular base should not exceed 2 inches." (Volume 1; Volume 2, 8)

Both volumes suggest that the apparatus not have any components which extend beyond the perimeter of the base; and, Volume 1 notes that this will help reduce injuries caused by children walking into the path of moving equipment. Further, Volume 1 makes a specific reference to handrails not protruding beyond the edge of the base. (Volume 1; Volume 2, 8)

In addition, the surface of the base should not have any spaces or openings between the axis and the periphery which would permit penetration by a rod with a diameter of 0.3 inches. Volume 1 explains that "this will prevent a child's body part from passing through an opening and contacting a stationary object beneath the apparatus." (Volume 1; Volume 2, 8)

Probable rationale:

The intent of the above recommendations is to restrict access into the region circumscribed by the outermost point on the periphery of a horizontally rotating apparatus, because children who walk or fall into this area can be impacted by moving equipment. Parallel to statements made in the guidelines, the NBS rationale documents explain that a continuous and approximately circular base will:

1) prevent falls from the equipment onto the ground and into the path of the apparatus,

2) prevent any part of the user's body from contacting stationary objects beneath the apparatus, and

3) act as a barrier at the periphery of the apparatus, thus preventing a child from walking into the equipment's path.

The maximum 2-inch difference between minimum and maximum radii ensures an approximately circular base, while also providing for a reasonable manufacturing tolerance.

An opening with 0.3-inch diameter would allow a child's finger to penetrate it, which could result in fracture or amputation. To prevent such injuries, any space greater than or equal to 0.3 inches should not be allowed on the base or shaft of rotating equipment.

Issues:

Review of current catalogs revealed that there are three basic types of merry-go-rounds available in today's playground market. As previously mentioned, the most common is the traditional metal merry-go-round which consists of a circular component rotating in a horizontal plane intended for children to sit or stand on, with handrails extending in toward the center. These range from 5.5 feet to 10 feet in diameter, and usually have four, five, or eight handrails, depending on their diameter. Some manufacturers suggest that the smaller merry-go-rounds are more manageable for younger children. A slight deviation from that design which is often also marketed for younger users incorporates a metal platform, typically 6 feet in diameter, with four animal seats around the outside edge; some have handgrips to accommodate extra users who may be standing near the center of the apparatus. The animal seats are constructed of either polyethylene or cast aluminum. A number of manufacturers offer one other design geared toward preschool-age children, which replaces a flat base with a slightly concave dish in which children sit, and has a small guard rail around the perimeter. The diameter of these designs is 4 feet, except for one which is 6 feet. One of these is actually a tub-like apparatus with a bench around the inside for the users to sit on and a handgrip in the center. In addition, one manufacturer produces a slightly convex component, four feet in diameter, with a handgrip in the center, also intended for younger users.

The catalogs revealed that all merry-go-rounds currently manufactured are approximately circular. None of the designs depicted showed any protruding components or handgrips. They therefore appear to be in accordance with the CPSC recommendations.

Frost (U. of Texas, 1989, unpublished manuscript) and Ridenour (1986) both repeated the CPSC suggestions for approximately circular rotating components with no protruding components; and, the Seattle draft standards (1986) also made comparable recommendations. In addition, Beckwith (1988) and the Canadian draft standards (CAN/CSA-Z614, 1988) each stated that rotating equipment should not have any protrusions or projections beyond the perimeter of the rotating component.

The Play For All Guidelines (Moore et al., 1987), concludes that an effective means of reducing merry-go-round injuries is limiting the size of the equipment. It suggests that "a four foot diameter will hold four children and is much less likely to cause serious injury." Similarly, Beckwith (1988) stated that merry-go-rounds with diameters greater than 4 feet are not recommended for school settings.

The German standards (DIN 7926, Part 5, 1984) include a regulation which is comparable to the CPSC guideline that no openings or spaces on the surface of the base should allow penetration of a rod 0.3 inches in diameter. The only other support, however, for this recommendation came from Ridenour (1986). Others are more stringent. For example, the Seattle draft standards give the following specification: "delete spaces or openings in the rotating base of equipment that permit inserting a rod or stick of any diameter." Bowers (1988b) concluded that merry-go-rounds would be safer if "all openings through which children can fall or in which limbs and fingers can be injured" were covered. Frost (U. of Texas, 1989, unpublished manuscript) also recognized the danger not only of finger entrapment but that of children falling through larger openings, and therefore recommended solid bases for rotating equipment. He observed the extreme hazards of older merry-go-rounds which allow children to stand or run inside the rotating base. J. Frost (personal communication, February 1989) further stated that there are still thousands of open-base merry-go-rounds; these outmoded devices should be removed from playgrounds.

The equipment catalogs show that all of the merry-go-rounds currently offered have platforms without any openings or spaces, this is because they are either solid or have a cover in the middle to protect the rotating mechanism. Thus open-base designs may no longer be available for purchase; however, that does not mean they are not still on playgrounds. In fact, two of the four cases of merry-go-round injuries from the detailed incident analysis involved an open-base design, which incorporated a circular bench around the central structure with an opening between the bench and the center so that children could sit facing the middle. One victim sustained a laceration on the back of the head after falling to the ground and subsequently hitting the rotating base; the other sprained an ankle, but the details of the incident were unclear.

Recommendations:

The current CPSC recommendations regarding the configuration of rotating components are warranted and should be repeated. The rotating platforms of merry-go-rounds should be continuous and approximately circular; the difference between the minimum and maximum radii should not exceed 2 inches (see Figure 5.7.4 - 2). There should not be any components, including handgrips, which protrude beyond the perimeter of the base. The surface of the platform, from the axis of rotation to the periphery, should not have any openings or spaces which would permit penetration by a rod 0.3 inches in diameter. This corresponds to the diameter of the minimum user's index finger, a 5th percentile 2-year-old.

5.7.4.3.2 Handgrips

Guideline content:

Handgrips for merry-go-rounds are not addressed in the current Handbooks, except in regard to protruding components, as discussed above.

Probable rationale:

Not applicable.

Issues:

Frost (U. of Texas, 1989, unpublished manuscript) observed that "the manufacture of some is so shoddy that railings break off after limited use, exposing jagged edges and eliminating the protection of hand-holds." He concluded that strong, rigid handgrips are a necessary component of safe merry-go-rounds. The Canadian draft standards suggest that children be provided with a "secure means of holding on," and state that such handgrips must meet the criteria for hand gripping components. The British standards (BS 5696: Part 2, 1986) specifically require that each seat or user position have a handgrip with a diameter between 0.7 and 1.6 inches; and, when there are seats, the handgrips must not be less than 4 inches above the seat surface.

The only other discussion of handgrips is a statement by Beckwith (1988) that "spinners must have rails which fully enclose the platform." However, it seems that this design would prevent easy entrance to as well as exit from the rotating component and, therefore, pose an additional hazard.

Recommendations:

A means for holding on should be provided for each intended user. All handgrips should be secure against detachment. Given the observed play patterns of older children, merry-go-rounds intended for this age group should have handgrips designed so as not to interfere with safe access to and exit from the platform while it is rotating. The diameter of handgrips should follow the recommendations given for the diameter of handgripping components (see Section 5.6.1.1.3.2).

5.7.4.3.3 Pinch, crush, and shearing points; sharp edges

Guideline content:

In discussion of general hazards, the current guidelines warn that unprotected moving parts, such as those on merry-go-rounds, can crush or pinch a child's finger. (Volume 1)

Probable rationale:

The only rationale given is that which is implied in the handbook itself: to prevent injuries caused by exposed moving parts.

Issues:

Frost (U. of Texas, 1989, unpublished manuscript) noted that "poorly designed and badly worn merry-go-rounds frequently have exposed gear boxes or axles that can crush or amputate fingers," and that any such equipment should be removed from playgrounds. He reported an incident in which a 9-year-old girl's finger was amputated by exposed moving parts on a merry-go-round. The Play For All Guidelines (Moore et al., 1987) also recognizes that negligent maintenance often leaves a gap between the central support post and the rotating platform which can then result in finger entrapment. It further explains that merry-go-rounds used to be constructed from pipe and did have open centers; because these designs with open frameworks have proven so hazardous, they should all be eliminated. All merry-go-rounds should be carefully inspected and properly maintained to ensure that the bearings do not present possible finger entrapment areas.

As previously noted, merry-go-rounds with solid bases as well as those which cover the connection area between the platform and the rotating mechanism are offered in current catalogs. Consistent with the review of catalogs, Frost observed that many new merry-go-rounds have solid platforms, while Moore et al. (1987) observe that newer designs "shroud this connection" between the central support pole and the platform.

In addition to addressing finger entrapment areas, Frost (U. of Texas, 1989, unpublished manuscript) recognized that "the user must also be aware that children can and do crawl under merry-go-rounds and the undercarriage should be free of shearing and crushing mechanisms." He stated that serious injuries caused by these mechanisms have been documented.

Both the Canadian draft standards (CAN/CSA-Z614, 1988) and the British standards (BS 5696: Part 2, 1986) regulate the distances which would expose moving parts to a child on a merry-go-round; however, their requirements are quite different. The Canadian draft standards state that "no space greater than 0.2 inches should be exposed between moving part(s) within the rotating device where it would be accessible to a child." The British standards stipulate that moving parts adjacent to the position normally occupied by the child must not be closer than 19.7 inches to any stationary part, unless the stationary part is totally enclosed by the moving part; ground clearance is an exception to this rule. Further, they require that any enclosure prevent "unauthorized access to all parts where movement of one part relative to another occurs."

Bowers (1988b) recognized the danger of sharp edges on moving equipment and suggested that eliminating any such edges would add greatly to the safety of merry-go-rounds. Several of the manufacturers specify in their catalogs that the merry-go-rounds have special rolled edges to prevent children from receiving lacerations if they reach underneath the base.

Recommendations:

A specific recommendation with regard to pinch, crush and shearing points on merry-go-rounds is warranted. There should not be any exposed moving parts: rotating bases should either be solid or have secure covers which prevent access to the rotating mechanisms. Further, there should not be any accessible shearing or crushing mechanisms in the undercarriage of the equipment. Good maintenance is especially critical for merry-go-rounds. The need for continuous attention to potential pinch and crush points should be considered in the purchasing phase and throughout the life of the merry-go-round.

The rotating bases of merry-go-rounds should not have any sharp edges.

5.7.4.3.4 Ground clearance

Guideline content:

The current guidelines do not address the height of a merry-go-round's base above ground.

Probable rationale:

Not applicable.

Issues:

Preston (1988) suggested that "consideration should be given to specifying the maximum clearance between the rotating platform and its fixed (non-rotating) base," which is usually the ground. Most manufacturers do not list the ground clearance for traditional merry-go-rounds in their current catalogs; only two of them include this information, indicating that the platforms of these particular merry-go-rounds are either 10 or 12 inches above ground. Photographs in the catalogs show children using merry-go-rounds, and it appears that the platforms are either only slightly above ground or are approximately at the user's knee height. The merry-go-rounds intended for younger children which incorporate a convex dish-like platform range from 18 to 30 inches above ground, according to the catalogs.

Because children do tend to drag their feet and otherwise hang over the edges of merry-go-rounds, it is important that the design prevents the possibility of entrapping and causing injury to children's limbs. As previously noted, Frost (U. of Texas, 1989, unpublished manuscript) recognized that children are also known to climb under merry-go-rounds, which in addition to the hazards of pinch and crush points, presents another problem if the ground clearance can cause entrapment of either limbs or bodies. Both the Seattle draft standards (1986) and the Play For All Guidelines (Moore et al., 1987) recommend that merry-go-rounds be installed so that children cannot become entrapped underneath.

There is a range of recommendations for the ground clearance of merry-go-rounds. The Seattle guidelines state that the platform should be "close to the ground." The British standards (BS 5696: Part 2, 1986) stipulate that the rotating platform must have a ground clearance of not less than 4.5 inches nor more than 4.9 inches at the perimeter which is maintained for at least 11.8 inches toward the center, or there must be a minimum ground clearance of 19.7 inches throughout. The Canadian draft standards (CAN/CSA-Z614, 1988) require that the clearance between the underside of the platform and the protective surface be either less than 4 inches or greater than 10 inches. Beckwith (1988) suggested that "the distance from the bottom edge of the platform and the fall surface should not exceed 6 inches." The German standards (DIN 7926, Part 5, 1984) specify a ground clearance of 15.75 inches for carousels. Thus, there appear to be three theories behind ground clearance for merry-go-rounds: the platform should either be 1) low enough that children's limbs cannot reach under it, 2) low enough that children cannot crawl under it, or 3) high enough that if children do crawl under the platform, entrapment cannot occur.

Recommendations:

For maximum protection, it is recommended that the ground clearance of the rotating platform on merry-go-rounds be less than 3.5 inches. When merry-go-rounds are installed over loose surfacing materials, measurement of this distance should take into account the pitting effects around the perimeter of the equipment which can be expected with normal use.

If the ground clearance is greater than 3.5 inches, children can crawl under the merry-go-round and become entrapped. To eliminate the risk of children getting trapped, the ground clearance would have to be greater than 16 inches, which is the shoulder breadth of a 95th percentile 12-year-old. However, ground clearances this high would make it difficult for smaller children to get on and off the merry-go-round safely, given that the step height of a 5th percentile 4-year-old is 12 inches.

5.7.4.3.5 Speed of rotation

Guideline content:

The speed at which merry-go-rounds rotate is not addressed in the current guidelines.

Probable rationale:

Not applicable.

Issues:

Both the Australian (AS 1924, Part 2, 1981) and Canadian (CAN/CSA-Z614, 1988) draft standards address the fact that children basically have no control over a merry-go-round's movement once it is in motion. Because children are then at risk of physical and psychological injury, the standards each recommend that merry-go-rounds not be used unless their designs overcome these operational problems. King and Ball (1989) discussed these concerns, further explaining that several children usually play on a merry-go-round together, and, therefore, each individual has even less control. They point out that "very young children in particular do not have the adequate balance and strength to hold on securely if the speed is too fast." Further, King and Ball observed that the Illingworth et al. (1975) study included accident scenarios which illustrate the tendency for older children to bully younger children on merry-go-rounds. One of the injuries from the detailed incident analysis involved a 5-year-old who fractured her clavicle after falling from a conventional merry-go-round: an older child, described as a bully, was reportedly pushing the merry-go-round too fast. It is important to weight the potential negative psychological effects younger children may experience against the momentary thrill of use.

The Play For All Guidelines (Moore et. al., 1987) observes that speed limiters are now available for some of the larger merry-go-rounds, and that although they are not as effective as limiting the size of the equipment, they may help reduce injuries. Esbensen (1987) stated that unless a merry-go-round has "built-in mechanisms to control the speed of rotation, it is not appropriate for a preschool program." In addition to the concerns discussed above, the Canadian draft standards suggest that merry-go-rounds be used only in supervised areas. Frost (U. of Texas, 1989, unpublished manuscript) mentioned speed governing devices, but concluded that they may not be necessary in applications where supervision is available.

The Seattle draft standards (1986) as well as the British standards (BS 5696: Part 2, 1986) require a speed limiting device for merry-go-rounds. Further, M. Ridenour (personal communication, February 1989) noted that the original standards issued by NRPA included a recommendation for speed governors. She stated that this specification should be reconsidered for the CPSC guidelines. Preston (1988) reported the British standards and also questioned whether speed governing mechanisms should be required. However, as F. Wallach (personal communication, February 1989) recognized, the effectiveness of these devices needs to be evaluated.

Review of current catalogs confirmed that devices to control rotational speed are offered for some merry-go-rounds. One manufacturer described the devices provided: a mechanical brake has speed limiting power; whereas, a hydraulic brake will prevent a merry-go-round from going around and around perpetually.

Although the CPSC handbooks do not contain any discussion of the speed of rotating equipment, the NBS proposed standards and supporting rationale do address this issue (NBS, 1978a). A test method was developed to determine whether or not a merry-go-round was acceptable with regard to its maximum permissible rotational speed (revolutions per minute), which can also be evaluated in terms of peripheral speed (feet/second). This test and the rationale provided are presented below, as they are seen in the above referenced document.

(1) Requirement:

When measured in accordance with paragraph (2) of this section, the measured speed, S_c, of the equipment shall meet the following requirement:

S_c (revolutions per minute) $\leq 66.4/\sqrt{R}$

where R is the maximum radius of the equipment in feet.

(2) Test Method:

(i) Have a male adult, while standing in one location relative to the equipment, manually rotate the equipment to the maximum speed he can achieve.

NOTE: The adult shall be between 18 and 34 years of age, weigh between 150 and 190 pounds, and have a height between 68 and 73 inches.

(ii) Repeat the above procedure three times, using different subjects to rotate the equipment. Compute the average of these 3 trials (S_c).

(iii) Measure the maximum radius, R, of the equipment. If S_c meets the requirement of paragraph (1), the equipment is acceptable.

(3) Supporting rationale:

The intent of this requirement is to reduce the risk of falls and subsequent injuries resulting from excessive speed of rotating equipment.

Based on limited injury data, it appears that falls associated with the speed of rotating equipment occur as follows: 1) a user may lose his/her balance when getting on or off the equipment; or 2) a user may be thrown off the moving equipment by the action of centrifugal force.

Ideally, for a user to maintain balance when getting on or off the equipment, the speed of the equipment should be zero. However, a user who is getting on or off moving equipment can maintain a reasonable balance if he/she moves (runs or walks) with a velocity (speed as well as direction) equivalent to that of the rotating equipment just before getting on or immediately after getting off the equipment. In actual play conditions, children generally get on or off the equipment while it is moving, hence the maximum attainable speed of rotation should be limited. This limiting value of the speed should be within the running capabilities of the users of the equipment.

A study by John A. DeBenedictis indicates that an eight-year old is capable of running 100 yards in 13 seconds. However, this speed (23 ft/sec) is probably beyond the capability of most eight-year olds. Data on the running capabilities of children in general are not available. Also, the running capability varies among children of the same age group. Therefore, the speed at which users can get on or off the moving equipment without losing their balance can only be arrived at subjectively.

The second way in which falls occur from rotating equipment is through the action of the centrifugal force. The magnitude of centrifugal force acting on a user who is occupying a rotating apparatus is given by:

$$F = \frac{W}{g}\left(\frac{\pi^2 N^2 r}{900}\right) \qquad (1).$$

where:

F = centrifugal force (pounds)
W = weight of the user (pounds)
g = acceleration due to gravity (ft/sec^2)
r = radius of the circle described by the user's center of gravity (ft)
N = rotational speed of the equipment or of the user occupying the equipment (rpm)

This force is maximum when r is equal to the maximum radius, R, of the rotating equipment, or

$$F_{max} = \frac{W}{g}\left(\frac{\pi^2 N^2 R}{900}\right) \qquad (2).$$

The force, F, acts along the radius, r, passing through the user's center of gravity and is directed away from the axis of rotation. This force tends to pull the user off the equipment. This action of centrifugal force is resisted by: 1) the user's act of gripping the handholds provided for this purpose, and 2) the force of friction between the user and equipment. The magnitude of the force of friction in some situations may be negligible. In these situations, the pull of centrifugal force is primarily resisted by the user's act of gripping the handholds. Hence, the maximum allowable magnitude of centrifugal force must be less than or equal to the magnitude of the force that the user is capable of supporting with his/her arms while gripping the handholds. Data concerning this capability for users of the equipment are not available. However, children have often been observed doing chinups or swinging through large arcs while holding onto the overhead components, thus supporting, for a short while, a force equivalent to twice their weight. For longer durations, it is assumed that most children are capable of supporting a force equivalent to one and one-half times their weight while holding onto handholds. Hence, the maximum magnitude of centrifugal force should be less than or equal to one and one-half times the user's weight (W), that is,

$$F_{max} = \frac{W}{g} \left(\frac{\pi^2 N^2 R}{900} \right) \leq 1.5\ W \qquad (3).$$

Equation (3) may be solved to obtain the maximum permissible rotational speed, N_c, of the moving equipment as,

$$N_c = \frac{30}{\pi} \sqrt{\frac{1.5g}{R}} = \frac{66.4}{\sqrt{R}} \qquad (4).$$

The peripheral speed, V, of the rotating equipment corresponding the N_c, may be obtained as,

$$V(\text{ft/sec}) = \frac{\pi}{30} R N_c = 6.94\sqrt{R} \qquad (5).$$

Equations (4) and (5) are utilized to calculate the values of N_c and V for nominal values of R. These values of N_c and V are given below:

R (ft)	N_c	V (fps)
2	46.9	9.8
3	38.3	12.0
4	33.2	13.1
5	29.7	15.5
6	27.1	17.0
7	25.1	18.4

The maximum radius of most rotating equipment is between 2 and 7 feet. The peripheral speed, V, corresponding to the permissible rotational speed, N_c, for rotating equipment with maximum radii in this range, are well within the running speed of 23 feet/second quoted earlier. Limiting the maximum speed attainable during actual play conditions to the values of N_c should reduce the frequency of falls associated with the speed of rotating equipment.

The rotational speed attained by any given piece of equipment depends on the magnitude of the angular impulse applied to accelerate it; the larger the applied impulse the greater the attained speed. Therefore, it is essential to specify the magnitude of angular impulse that should be applied during a test. This impulse should approximate that experienced by equipment during actual play conditions.

The data regarding the magnitude of impulse experienced by rotating equipment during actual play conditions are not available. Therefore, it is impossible to objectively develop a mechanical device for accelerating the equipment during testing. Also, since rotating equipment is manufactured in many styles, it would be difficult, if not impossible to develop a single device for this purpose. For these reasons, the basic procedure for testing recommended by NRPA, although subjective, is adopted, particularly, in view of the fact that such equipment during actual use is often spun by adults (parents or older siblings of users). To ensure some element of uniformity, it is recommended that the adult spinning the equipment for the test should have the following characteristics.

Age: 18 years to 34 years
Weight: 150 to 190 pounds
Height: 68 to 73 inches

Several aspects of the above test method and rationale warrant discussion. The two injury scenarios stated above which were used as a basis to develop the criteria seem reasonable; however, the actual determination of the criteria is adversely effected by reliance on subjective judgments and lack of data in both cases.

In the first case, it does seem reasonable to assume that if a child can move with the same velocity (speed and direction) as the merry-go-round when trying to get on or off, he or she will be able to maintain relatively good balance, and thereby reduce the risk of falling. Further, it is also then reasonable to limit the speed of the rotating equipment to stay within the running capabilities of the children using it. The problem comes, however, in determining what the running speed criterion should be. NBS reported that the maximum running speed of an 8-year-old is 23 feet/second. Not only does NBS acknowledge a lack of data for the running capabilities of children, but they also recognize the great potential for individual differences within age groups for such skills, noting that 23 feet/second is beyond the ability of most 8-year-olds. It did not initially appear that NBS intended to use 23 feet/second as a criterion for rotating speed, given these caveats. However, 23 feet/second was in fact used later in the discussion as the criterion to assess the safety of the peripheral velocities which were calculated for merry-go-rounds with various base sizes. Uncertainty regarding the running speed criterion for an older user becomes further compounded when this measure is applied to users from the younger age group, 2 to 5 years. A 4-year-old, for example, certainly cannot run with the same facility as an 8-year-old, much less at the same speed.

The Canadian draft standards follow the same argument that the maximum attainable peripheral speed of a merry-go-round should not exceed a child's running speed; and like the NBS test, this speed is measured at the base's maximum radius to yield the maximum value. In contrast, the speed stated is only 13 feet/second, which is much less than the upper limit allowed by the NBS criterion. Further, the Canadian draft standards give an even lower permissible speed for preschool equipment, 6.5 feet/second, to compensate for the less developed motor skills of these younger users.

As noted earlier, the British standards require the use of a speed governing device. They also specify a test method to assess "whether the speed of the equipment is limited to that which will not form a hazard to children using it." The criterion set is that the peripheral speed must not exceed 30 revolutions per minute or 16.4 feet/second, whichever is less. Again, this value is well below the velocities allowed by the NBS test. It is important to recognize, however, that the British test method is significantly different. They use a tyred wheel driven through a reduction gear by a variable speed motor to apply a tangential load of 60 kg, as measured with a spring balance mechanism, and then measure the revolutions per minute or the peripheral speed. In a relevant section of the British standards, the speed governing device is described as follows:

> The means of limiting the speed should be designed so as not to impede rotation of the equipment during its normal use by children at peripheral speeds up to about 10 feet/second. Thereafter, the means of limiting the speed should operate smoothly and progressively up to the specific requirements which are based on the force exerted by two strong adults purposely endeavoring to overspeed the equipment to an unsafe condition.

Given this, it can be inferred that the tangential force applied during the British test is intended to simulate the force with which "two strong adults" could push a merry-go-round. It can also be assumed that what they consider a safe speed under normal use by children is well below the 23 feet/second criterion of the NBS test, like the Canadian draft standards. Another interesting contrast this illustrates is that the British method is much more stringent than the NBS method in using a force comparable to two adults pushing the equipment rather than only one.

The second injury pattern implicated involves the centrifugal forces generated by a rotating merry-go-round, which acts on the children riding on the equipment. Arguing that "the maximum allowable magnitude of centrifugal force must be less than or equal to the magnitude of force that the user is capable of supporting with his/her arms while gripping the handholds" seems reasonable. However, as with the previous case, subjective judgments are used to determine the criterion for this aspect of the test: a maximum centrifugal force of one and one-half times the user's weight. NBS again acknowledged that "data concerning this capability for users of the equipment are not available." Further, even if an 8-year-old can support this level of force (one and one-half times his or her weight), it is doubtful that younger children can support a proportional amount given their less developed muscle tone and general physical stature.

Recommendations:

It is clear that the speed of rotating equipment is an important issue. Excessive speeds could conceivably cause injury to children using the equipment, especially younger users. Therefore, the maximum attainable speed of merry-go-rounds should be limited. Depending on the design, this may be achieved by a mechanical device or it may be inherent in other characteristics of the equipment. Speed limiting devices currently on the market need to be thoroughly evaluated with regard to their effectiveness.

Although it is not clear what an appropriate maximum rotational speed would be, the criterion used by NBS, 23 feet/second, is certainly too high because it was based on the maximum running speed of an 8-year-old and such abilities cannot realistically be assumed for all 8-year-olds much less all 4-year-olds. In the absence of sufficient data it is recommended that a target value around 15 feet/second be used as a criterion for safe peripheral speeds of merry-go-rounds, which is much more consistent with foreign standards. When data become available to develop a more appropriate criterion and test method to determine which merry-go-rounds are unsafe due to their speed of rotation, this recommendation should be modified accordingly.

Because young children are at the greatest risk when older children are in control of the merry-go-round and pushing it with forces large enough to attain high speeds, active adult supervision could be helpful in preventing injuries resulting from these situations.

5.7.4.3.6 Oscillation

Guideline content:

Merry-go-rounds which oscillate are not addressed in the current handbooks.

Probable rationale:

Not applicable.

Issues:

The British standards (BS 5696: Part 2, 1986) state that "if oscillatory motion is provided in addition to rotary motion, the extremity of oscillation of the equipment shall not exceed 12 degrees on either side of the equilibrium position." They also recommend that any oscillation should be "restrained progressively towards the extremities of movement so that no sudden stops or reversal of motion can occur." The Canadian draft standards (CAN/CSA-Z614, 1988) make a recommendation comparable to the latter British specification.

Recommendations:

Certain merry-go-rounds provide oscillatory motion in addition to their rotation. Merry-go-rounds which oscillate are not recommended for public playgrounds.

5.7.4.4 USE, FALL ZONES

Guideline content:

Volume 1 contains a general discussion of use zones which includes reference to the fact that adequate room must be provided for children to "spin-off" from merry-go-rounds.

Probable rationale:

No specific rationale is stated for the above recommendation. However, the intent is presumably to help prevent children from running into the path of moving merry-go-rounds or other children who are using the equipment.

Issues:

Werner (1982) suggested that moving equipment, such as merry-go-rounds, should be located in a corner or near an edge of the playground, to protect children from injuries as they run from one piece of equipment to another. The Canadian draft standards (CAN/CSA-Z614) also recommend that merry-go-rounds be placed in non-traffic areas.

Providing merry-go-rounds with ample perimeter space so that children can get on and off the equipment safely is important and may help to eliminate some of the injury patterns associated with this type of equipment (Bowers, 1988b). The Canadian draft standards specify that the fall zone should extend 6 feet beyond the perimeter of the rotating base in all directions. The use zone should also include a no-encroachment zone for an additional 6 feet in all directions. Preston (1988) reported the NRPA recommendations for use and fall zones: protective surfacing should extend 7 feet from the perimeter of merry-go-rounds in all directions, and the no-encroachment zone should extend 6 feet further. The German standards only address the area which requires resilient surfacing for merry-go-rounds rather than the entire use zone, stating that this area must extend 6.5 feet in all directions from the perimeter of the equipment.

The German standards also give a recommendation for a head clearance of 6.5 feet above merry-go-rounds.

Recommendations:

The fall zone for merry-go-rounds should provide 6 feet of protective surfacing in all directions from the perimeter of the rotating base. To complete the use zone, a no-encroachment zone should extend an additional 6 feet in all directions beyond the fall zone (see Figure 5.7.4 - 3).

5.7.4.5 PROTECTIVE SURFACING

Guideline content:

The current guidelines do not make any recommendations with regard to surfacing under merry-go-rounds in particular.

Probable rationale:

Not applicable.

Issues:

Due to excessive wear in the area around merry-go-rounds caused by children running along side of the rotating base, extra attention is needed to maintain proper surfacing and ground clearances (Beckwith, 1988; Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987; Seattle draft standards, 1986, British standards, BS 5696: Part 3, 1979). This problem is especially true in the case of loose surfacing materials: Frost recommended using up to 2 feet of loose surfacing materials to provide extra depth and protect against pitting effects; Beckwith recommended double deep surfacing materials and positive drainage. The Play For All Guidelines recognizes that "some installers attempt to solve this problem by mounting the units over rubber matting." It concludes that this may be acceptable, if the matting is sufficiently resilient and properly maintained. Frost suggested using manufactured impact surfaces which are compact and secured. Similarly, the British standards state that "provision of a firm surface is essential."

The AALR Survey of elementary school playgrounds found the following surfaces under rotating equipment: asphalt or concrete, 21%; pea gravel, 16%; tan bark or mulch, 15%; grass, 14%; hard packed dirt, 9%; clay, 9%; sand, 7%; rubber matting, 6%; large gravel, 3% (Bruya and Langendorfer, 1988).

Recommendations:

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

FIGURES

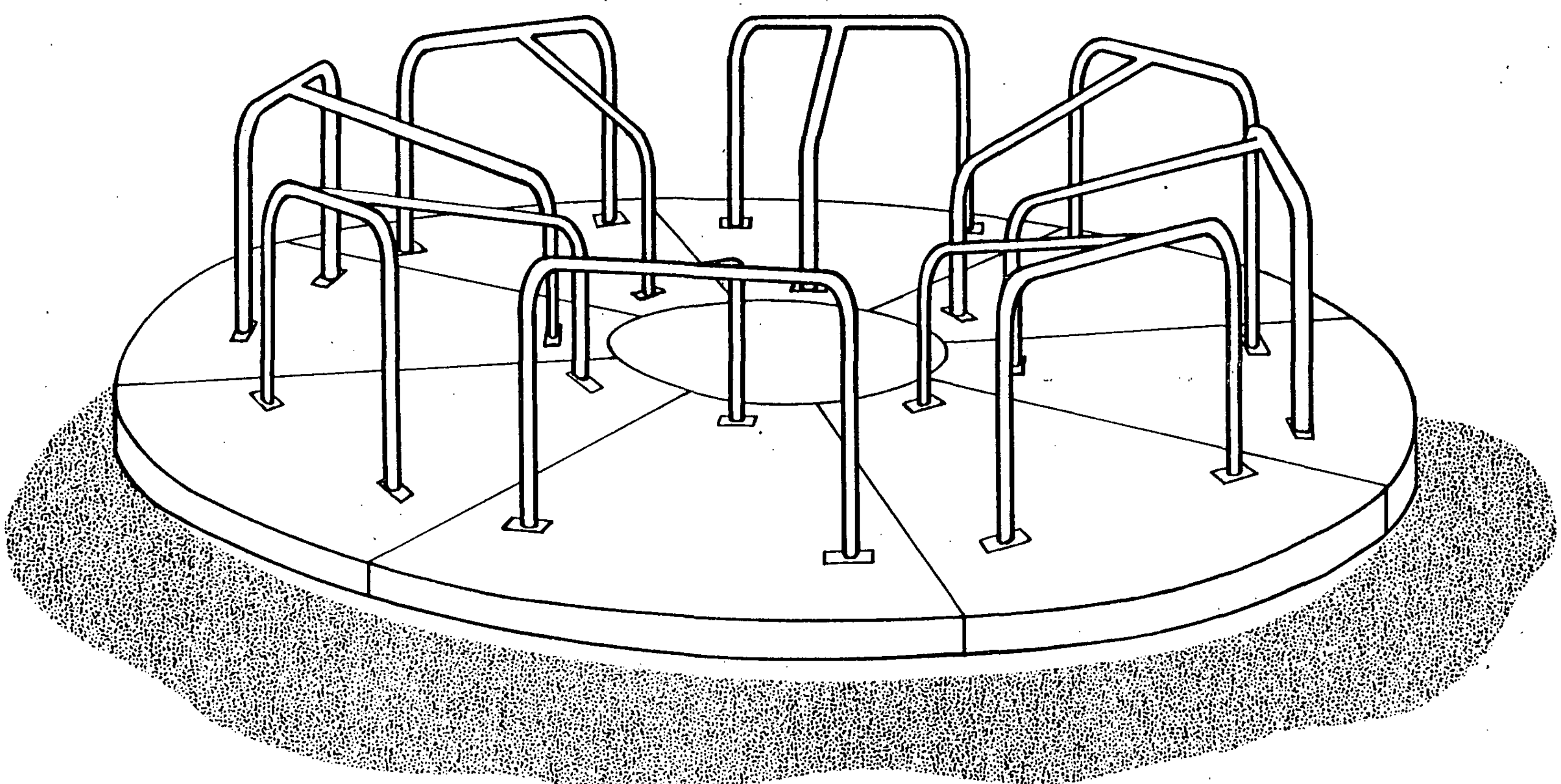
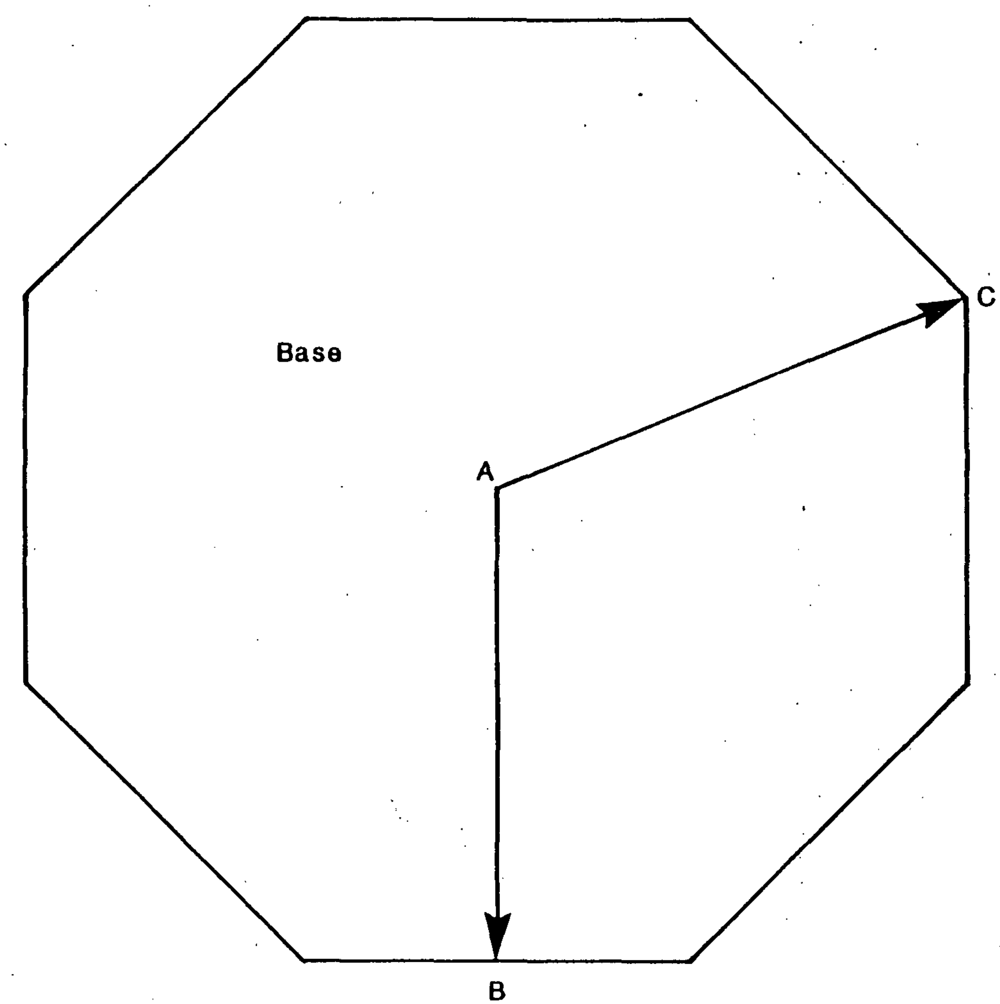


FIGURE 5.7.4 – 1: TYPICAL MERRY-GO-ROUND



A = Axis of Rotation

AB = Minimum Radius

AC = Maximum Radius

The difference between dimension AC and AB should not exceed 2.0 inches.

FIGURE 5.7.4 – 2: MINIMUM AND MAXIMUM RADII OF NON-CIRCULAR PLATFORM

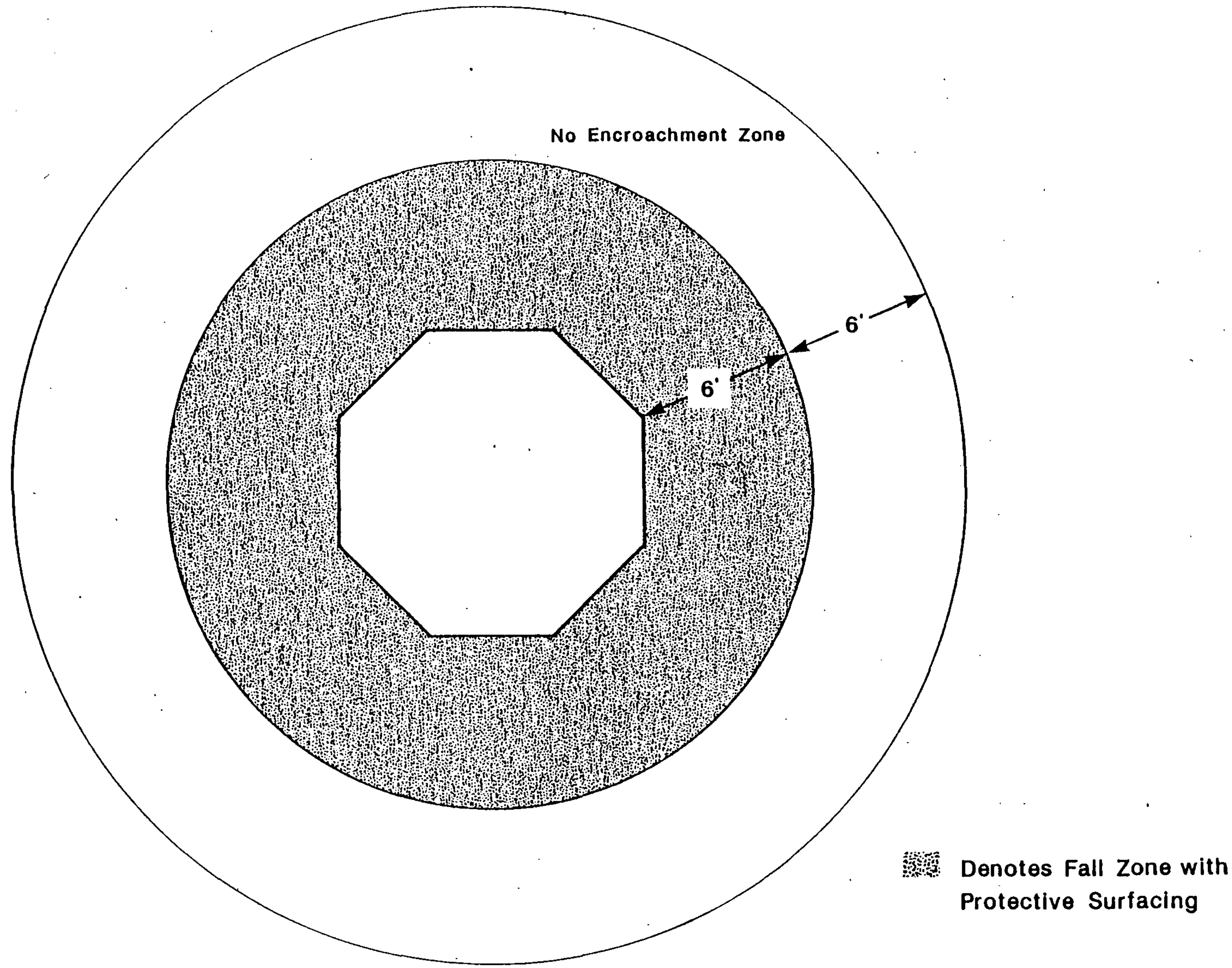


FIGURE 5.7.4 – 3: USE AND FALL ZONES FOR MERRY-GO-ROUNDS

5.7.5 SEESAWS

5.7.5 SEESAWS

5.7.5.1 PATTERNS OF SEESAW USE

5.7.5.2 REVIEW OF SEESAW INJURY DATA

5.7.5.3 DESIGN CONSIDERATIONS

5.7.5.3.1 Pinch, crush points

5.7.5.3.2 Height above ground

5.7.5.3.3 Handgrips

5.7.5.4 USE, FALL ZONES

5.7.5.5 PROTECTIVE SURFACING

5.7.5.1 PATTERNS OF SEESAW USE

The typical seesaw incorporates two seats on either end of a board or pole and is supported by a fulcrum (see Figure 5.7.5 - 1). Children ride up and down as the seesaw pivots on the fulcrum. Older seesaws are generally wooden with a metal fulcrum; the current trend, as indicated by the review of catalogs, is all-metal seesaws. However, it appears that seesaws are not as readily available in the playground equipment market as they once were: only two of the catalogs reviewed offered fulcrum seesaws.

A study of children's play and equipment choices revealed that seesaws were ranked third in popularity; the authors concluded that children simply prefer action-oriented equipment over static equipment (Frost and Campbell, 1978). The SCIPP survey reported that seesaws were fourth on a list which indicated how frequently children use various pieces of equipment (Helsing et al., 1988).

Bruya and Langendorfer (1988) noted that seesaws are "perhaps the most complex piece of moving equipment on the playground," because two children must cooperate and integrate their actions for normal use. They recognized that young children are generally characterized by their egocentrism and that their social and motor skills are rudimentary. Therefore, even advanced young children would be challenged by the cooperative demands of a seesaw. Bruya and Langendorfer explained that:

> It is difficult for the young child to recognize the potential plunge to the ground if, suddenly "captured" by another interesting event, they abruptly get off when their end is on the ground. They often will not appreciate in advance the potential head, neck, back, and other injuries that can occur from a body dropping almost four feet onto any surface, regardless of its texture and composition.

In addition to the opportunity to practice complex cooperation, Bruya and Langendorfer noted that seesaws provide vestibular and postural stimulation. Motor development of "climbing, rocking, jumping, and bouncing activities" is also supported by seesaw use.

Frost (U. of Texas, 1989, unpublished manuscript) expressed a different view of seesaws. He stated that "the seesaw is functionally narrow as a vehicle for play," arguing that children can only go up and down or fall off. Further, "limited dramatic play is involved, no constructive play is involved, the child's thinking is minimally enhanced, no impact on the equipment is made--nothing is created."

Observational data for seesaws was limited. In one situation with two very young children, one on each end of the seesaw, the accompanying adults had to support each of them to help them maintain their balance and sit upright. Further, the adults had to push the seesaw up and down to creating the pivoting motion, since the children could not operate the equipment themselves. This was partially due to their size--their legs could not reach the ground--and their weight was not substantial enough to initiate the movement. On another seesaw, there was a young child sitting passively on one end and an adult standing next to the seesaw at the other end pushing it up and down.

5.7.5.2 REVIEW OF SEESAW INJURY DATA

Results of various studies, including the detailed incident analysis of 1988 data, have indicated that the following characteristics are typical of seesaw injuries. 1) Older children (5- to 14-year-olds) may have a proportionally higher frequency of seesaw injuries than younger children (0- to 4-year-olds). 2) In most studies, the predominant mode of injury for seesaws was falls, representing from 57 to 63 percent of cases. 3) Relative to other types of equipment, seesaws generally account for a high rate of superficial injuries, which are mainly to the face. Lower limb and trunk fractures are also more common. 4) The predominant type of seesaw-related injuries for victims of all ages is superficial facial injuries. For younger children, the next most frequent types are lower limb injuries and superficial head injuries; for older children, the next most frequent types are upper limb injuries and superficial head injuries (King and Ball, 1989).

The 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 seesaw-related injuries is based on a review of ten cases.

Seesaw-related injuries. Rutherford (1979) concluded from the 1978 Special Study data that seesaws are involved in 5% of all equipment-related injuries on public playgrounds. The majority of studies discussed by King and Ball (1989) which reported hospital-based data indicated that seesaws account for 4-5% of injuries (Avery and Probert, 1984; Christensen et al., 1982; Royal Alexandra Hospital Study, 1981; Oliver et al., 1981; Canadian CAIRE data, 1982-86; NEISS data, 1982-86). In addition, NEISS data from 1983-87 for preschool-age children indicated that 5% of equipment-related injuries on home and public playgrounds involve seesaws (Morbidity and Mortality Weekly Report, 1988). Results of the SCIPP survey of Massachusetts playgrounds showed a comparable percentage of seesaw injuries as well, 4% (Helsing et al., 1988).

It is important to determine the availability of seesaws in order to evaluate the frequency of seesaw injuries; however, such data are quite limited. Rutherford (1979) found that seesaws account for 6% of the equipment on public playgrounds. The percentage of injuries is, therefore, roughly proportional to the percentage of available equipment. Several surveys have reported comparable figures for seesaw availability, ranging from 5 to 7%: Langley and Crosado's survey of school and public equipment in New Zealand (1982, 1984); the AALR survey of elementary school playgrounds (Bruya and Langendorfer, 1988); and the PORS study conducted in the Netherlands (1987, cited in King and Ball, 1989).

Age of victims. The proportion of younger children involved in seesaw injuries was much lower than that for older children, according to the 1978 Special Study data: 0-to 4-year-olds, 11%; and 5- to 14-year-olds, 89% (Rutherford, 1979). Other hospital-based data indicated that older children more frequently incur seesaw injuries than younger children, as discussed by King and Ball (1989). King and Ball cited involvement of 0- to 4-year-olds ranging from 25 to 37 percent, and involvement of 5- to 14-year-olds ranging from 60 to 75 percent (Hansen and Kruse, 1985; Royal Alexandra Hospital, 1981; Canadian CAIRE data, 1982-86; NEISS data, 1982-86). Because it is unclear whether older children tend to use seesaws more often than younger children, it is difficult to assess the differences in the proportion of injuries sustained by these age groups.

Mode of injury. The majority of seesaw injuries have been attributed to falls. Data from the 1978 Special Study indicated that falls to the surface account for 51% of seesaw injuries, and falls striking the same piece of equipment account for an additional 12% (Rutherford, 1979). The nature of seesaw use places children on the high end of the board at risk for falls from potentially dangerous heights.

Several studies discussed by King and Ball (1989) showed a predominance of falls: Canadian CAIRE data indicated that 58% of seesaw injuries between 1982 and 1986 involved falls from height; Christensen et al. (1982) reported that falls were involved in 57% of seesaw cases; and Hansen and Kruse (1985) found that 59% of seesaw injuries were caused by falls.

Of the ten seesaw injuries in the detailed incident analysis, six were attributed to falls to the surface. Three of these occurred when another child got off of the opposite end of the seesaw during primary use of the equipment, which caused the victim to fall; one child was pushed off the seesaw by another child, also during primary use; one child fell while dismounting; and one child fell while walking on the board of the seesaw.

Seesaw-related injuries can also be caused by impact with moving equipment (Rutherford, 1979). CAIRE data for 1982-1986 (reported in King and Ball, 1989) indicated that being "struck by or against objects" caused 28% of seesaw injuries. King and Ball recognized that this mode represented a high proportion of injuries, as it had for other moving equipment, such as swings.

In the detailed incident analysis, three of the ten cases involved impact with moving equipment. Two injuries occurred when a child pushed down the seesaw and it hit the victim in the face: one victim was standing too close to the equipment, and one was walking by it. Both of these cases were situations in which the victim was not actually using the equipment. The other incident resulted from the victim himself pushing down one end of the seesaw and then getting hit in the face.

Pinch points, protrusions, sharp edges, and sharp points were also implicated in 3% of seesaw injuries in the 1978 Special Study (Rutherford, 1979). Being "caught in or between objects" accounted for 9% of seesaw injuries in the 1982-86 CAIRE data (reported in King and Ball, 1989). However, it is unclear whether this category includes injuries due to pinch points. King and Ball explained that seesaws account for higher a proportion of trapped limbs than any other type of equipment.

Rutherford (1979) explained that punctures caused by "large splinters from worn, poorly maintained, or damaged wooden seesaws" were also implicated in investigated cases. The detailed incident analysis included one laceration sustained while the victim was dismounting a wooden seesaw, which reportedly had rough edges due to wear. Eight of the ten seesaws included in the detailed incident analysis had wood seats.

Injury patterns. As reported by King and Ball (1989), a comparison of seesaw injuries by age and body part in the 1982-86 CAIRE, 1985-86 NEISS, and 1987 NEISS datasets indicated that facial injuries dominate for all ages, representing approximately one-third of all seesaw cases. This pattern was even more pronounced for 0- to 4-year-olds than for 5- to 14-year-olds. For younger children, lower limb injuries were the second most frequent type of seesaw-related injury, followed by upper limb injuries; whereas for older children, upper limb injuries were the second most frequent type, followed by lower limb injuries.

Severity is an important factor in assessing patterns of injuries. As reported by King and Ball (1989), both the 1987 NEISS and the 1982-86 CAIRE datasets indicated that relative to other pieces of equipment, seesaws account for a higher proportion of superficial injuries (e.g., lacerations and contusions), which are predominantly injuries to the face. Also, lower limb fractures were more common for seesaws than for other equipment types, while the proportion of upper limb fractures was lower. A lower percentage of seesaw injuries consisted of serious head injuries, including concussion, internal head injury, and skull fracture, than was the case for any other major equipment type. The 1987 NEISS data showed that seesaws were associated with the highest proportion of trunk fractures.

When separated into age groups, the above referenced data showed that superficial facial injuries dominate in both groups. While lower limb fractures and superficial head injuries were the next most common for younger children, upper limb fractures and superficial head injuries were the next most common for older children. The proportions of superficial injuries to both the upper and lower limbs were comparable for the two age groups. Head injuries tended to be more serious for older children.

The seesaw injuries in the detailed incident analysis followed these same general patterns. Four of the ten were superficial facial injuries; three were upper limb fractures; one was a superficial injury to the lower limb; and two were trunk injuries, one which indicated possible soft tissue damage to the spinal cord.

Rutherford (1979) noted that no fatalities involving seesaws were reported to the CPSC between 1973 and 1977.

5.7.5.3 DESIGN CONSIDERATIONS

Guideline content:

The current handbooks do include seesaws in the general review of injury data; however, in treatment of each type of equipment for safety recommendations, seesaws are not addressed. (Volume 1)

Probable rationale:

Not applicable.

Issues:

Several designers have serious reservations about fulcrum seesaws, because the hazards of use are considered greater than the developmental gains. For example, Bruya and Langendorfer (1988) included the following discussion in reporting the results of the AALR survey:

> When the complexity for cooperation and movement is coupled with the incredibly poor safety features observed with teeter totters, the situation is ripe for disaster. Because of the average height of seesaw travel, the lack of cushioning, and the hard surfaces underneath them, injuries of varying severity are almost guaranteed. In addition, poor maintenance and design enhance the chances for blows, lacerations, and punctures coming from the moving seesaw.

Esbensen (1987) noted that old-fashioned seesaws had virtually disappeared from day care centers and public playgrounds. His view of seesaws is perhaps even more negative: recognizing the potential for serious injuries to the back and head, he referred to fulcrum seesaws as "lethal." Werner (1980), the Play For All Guidelines (Moore et al., 1987), and the Seattle draft standards (1986) also commented on these hazards of seesaw use. Werner pointed out that this equipment is responsible for many spine jarring incidents which can cause serious injury.

Esbensen's (1987) recommendation was the following: "any existing seesaws with potential for causing brutal falls and for children being pinched by their central fulcrums should either be eliminated or be supervised by two adults when in use." He further suggested that spring-loaded seesaws were a safer alternative. This is a relatively new design which incorporates multiple seats on a spring rocking apparatus and also allows for the cooperative play of seesaw use; a more detailed discussion of spring-loaded seesaws is in the spring rocking equipment section (see Section 5.7.6.4). Moore et al. (1987) and Oliver et al. (1981) also supported the use of spring-loaded over fulcrum seesaws. Oliver et al., recognized that if one of the two children on a traditional seesaw suddenly dismounts, both children are at risk of injury: "the child still on the board hits the ground very hard (and can crush both feet under the seat) and the other child may be hit on the body or face by the rapidly-rising end that has just been vacated." Similarly, the Seattle draft standards suggest that seesaw equipment be designed "with hydraulic limitations or springs to prevent the possibility of one child being dropped too hard against the ground or being held unwillingly up in the air." The potential for injury is even greater for inexperienced, younger children using seesaws. Observational data suggest that seesaws are typically not usable by children under 4 years of age without adult assistance.

Recommendations:

Improvements can be made to minimize the risks of fulcrum seesaws. However, certain hazards are inherent in their design, such as the lack of control and predictability; safe use depends on the behavior of two children, because the actions of one child can adversely affect the other user. In addition, the developmental and play values associated with seesaws appear to be limited. Cooperative play, which is the main benefit of seesaw use, can be stimulated through other activities on the playground which are less hazardous. Therefore, serious consideration should be given to the hazards associated with seesaw use before this equipment is installed on public playgrounds intended for older children.

Fulcrum seesaws are not recommended for use on playgrounds designed for preschool-age children.

5.7.5.3.1 Pinch, crush points

Guideline content:

See-saws are mentioned as one type of equipment which needs special attention to exposed moving parts in order to avoid pinch and crush hazards. This is the only recommendation in the current guidelines pertaining to seesaws. (Volume 1)

Probable rationale:

No rationale is explicitly stated for the general warning regarding exposed moving parts. Presumably, it is simply intended to reduce pinch and crush injuries.

Issues:

Most sources agree that fulcrum seesaws present dangerous pinch hazards at their pivot point. In fact, the AALR survey reported that 51% of the seesaws observed "were constructed such that fingers could be pinched or crushed during operation" (Bruya and Langendorfer, 1988).

Frost (U. of Texas, 1989, unpublished manuscript) noted that equipment should be inspected to ensure that the axle of a seesaw "cannot crush fingers or other body parts." Similarly, the Canadian draft standards (CAN/CSA-Z614, 1988) recommend that all risk of pinching body parts be eliminated at the pivot point. The Australian (AS 1924, Part 2, 1981) and British (BS 5696: Part 2, 1986) standards are more precise, both requiring that the suspension mechanism be enclosed to prevent unauthorized access. The Seattle draft standards (1986) are basically the same, also stating that the fulcrum should be enclosed, except they specify "to avoid catching clothes or fingers."

There is also concern that the seesaw itself could pose crushing or trapping problems when contacting the ground. The Seattle draft standards contain the following provision: "provide a method to prevent feet and legs from being pinched at the ground, such as blocks or part of a rubber tire secured below the seats." With the same reasoning, Frost (U. of Texas, 1989, unpublished manuscript) also recommended the use of partial automobile tires to act as a rubber bumper.

A related issue is the impact with which the seesaw seats hit the ground, because this force is transferred to the user. Both the Australian and Canadian standards address this with recommendations identical to those stated above: tires, or some other cushioning material, should be embedded in the ground below the seats of seesaws to absorb sudden impact by preventing them from hitting the ground directly. The Australian standards add an important point, noting that steel-belted radials should not be used.

Recommendations:

The fulcrum of seesaws should be enclosed to ensure that pinch and crush hazards are eliminated.

Partial car tires, or some other shock-absorbing material, should be embedded in the ground underneath the seats of seesaws, or secured on the underside of the seats. This will help prevent limbs from being crushed or trapped between the seat and the ground, as well as cushioning the impact.

5.7.5.3.2 Height above ground

Guideline content:

The current guidelines do not address the height of seesaws above ground, either while stationary or while in motion.

Probable rationale:

Not applicable.

Issues:

Another way to address the potential for crushing or trapping limbs under the seesaw itself is with ground clearance specifications. The Australian standards (AS 1924, Part 2, 1981) simply state the "when ground clearance is being considered, the designer should take into account the possibility of injury to the user and reduce this risk by eliminating foot, leg, and knee entrapment or crush points under the apparatus." The British standards (BS 5696: Part 2, 1986) are more specific, stipulating that the seat assembly must have a minimum ground clearance of 8.1 inches throughout the range of motion. It is important to recognize that this British standard is one of the general recommendations which pertain to fulcrum seesaws as well as spring rocking equipment. Further, no suggestions are made as to how this ground clearance should be achieved. One possibility would be the design recommended by other standards which incorporates an impact-absorbing cushion below the seat, such as a piece of tire embedded in the ground, so that the seat never actually hits the ground.

Both the Australian and British standards also give height specifications for the seesaw when it is unladen and at rest in the equilibrium position, with the seats horizontal: the upper surface of the seats should not be more than 39.4 inches above adjacent ground level. The Canadian draft standards (CAN/CSA-Z614, 1988) recommend that the pivot height not exceed 30 inches.

L. Witt (personal communication, March 1989) explained that Montgomery County, Maryland, is no longer installing seesaws because they are viewed as inherently dangerous, especially since children have the tendency to jump off them. He noted that seesaws are generally installed too high; when one seat is on the ground, the other can be as much as 6 feet above the surface. To improve the safety of existing seesaws, the County is trying to lower the height.

Height can also be limited by restricting the motion of seesaws. The Australian standards state the "surfaces which are horizontal in the rest or equilibrium position should have a maximum angle of elevation of 30 degrees from the horizontal at the extremity of motion." The British standards have a similar requirement, except that the maximum elevation allowed is only 20 degrees. In addition to the above recommendation, the Australian standards stipulate that no moving part of the apparatus, including the seats, should be able to attain a height greater than 6 feet above ground. Further, both the Australian and British standards suggest that toward the extremity of movement, motion should be restrained in order to minimize the possibility of a sudden stop or reversal of motion.

Recommendations:

One hazard unique to seesaws is the potential for the child on the high end of the apparatus to experience an uncontrollable drop to the ground. It is clearly important that the height of this drop be limited. In the absence of any firm empirical data, it is recommended that the maximum attainable height of the seat positions on seesaws be limited to 5 feet.

5.7.5.3.3 Handgrips

Guideline content:

The current guidelines do not address the design of handgrips for seesaws.

Probable rationale:

Not applicable.

Issues:

The Australian standards (AS 1924, Part 2, 1981) suggest that grip handles have a diameter between 0.51 inches and 1.50 inches. The British standards (BS 5696: Part 2, 1986) require grips that are between 0.71 inches and 1.57 inches in diameter. Both of these standards recommend that handles have a clearance of not less than 3.93 inches above the upper surface of the seat.

The Canadian draft standards (CAN/CSA-Z614, 1988) address different characteristics of handgrips. They note that handgrips should be fixed and designed so that rungs and bars, or any part thereof, do not turn when grasped. In addition, they recommend that handgrips be blunt-edged with a minimum radius of 3/8 inch and no sharp points. Further, "handgrips that protrude beyond the side(s) of the seat beam should be designed in such a manner that it cannot entrap the knee between the handgrip and the ground."

Results of the AALR survey indicated that 55% of the seesaws observed on elementary school playground had a pair of 3-inch handgrips (Bruya and Langendorfer, 1988).

Recommendations:

Handgrips should be provided for gripping with both hands and should not turn when grasped. The diameter of the handgrips should follow the general recommendations for handgripping components (see Section 5.6.1.1.3.2). If handgrips protrude beyond the sides of the seat, they should be designed so that the user's knees cannot be trapped between the handgrip and the ground.

5.7.5.4 USE, FALL ZONES

Guideline content:

No mention is made of seesaws in the general discussion of use zones in Volume 1.

Probable rationale:

Not applicable.

Issues:

As with all other types of equipment, it is important to provide protective surfacing in the fall zone of seesaws, as well as to allow for an adequate overall use zone. However, none of the sources have addressed the details of such zones for seesaws.

Recommendations:

The fall zone for an individual seesaw should extend 6 feet beyond the seats at each end as well as 6 feet to each side of the apparatus. Where several seesaws are attached to a single unit, the fall zone should extend 6 feet from the seats at both ends of the seesaws and also 6 feet from the side of the outermost seesaw at either end of the entire unit (see Figure 5.7.5 - 2).

The distance between adjacent seesaws on the same unit should be a minimum of 42 inches, to prevent hazardous interaction of the users (see Figure 5.7.5 - 2). Twice the arm length of a maximum user was used to estimate the distance spanned by two children reaching out to the side, and then a slight tolerance was added for extra protection. Approximate arm length was determined by the difference between lateral grip reach and shoulder breadth, which is 20 inches for a 95th percentile 12-year-old.

The no-encroachment zone needed to complete the use zone should extend from the protective surfacing an additional 3 feet behind and to each side of the seat positions (see Figure 5.7.5 - 2). This provides extra protection from impact injuries caused by children walking into or playing in the area of a moving seesaw.

5.7.5.5 PROTECTIVE SURFACING

Guideline content:

The handbooks do not currently make any recommendations pertaining to protective surfacing for seesaws in particular.

Probable rationale:

Not applicable.

Issues:

The AALR survey of elementary school playgrounds found the following surfaces under seesaws: grass, 21%; pea gravel, 18%; hard packed rocks, 18%; sand, 14%; clay, 14%; concrete or asphalt, 11%; mulch, 2%; rubber matting, 2% (Bruya and Langendorfer, 1988).

The Canadian draft standards (CAN/CSA-Z614, 1988) state that seesaws should be set on a protective surface. The Seattle draft standards (1986) note that the ground under seesaws should be checked for wear patterns and any holes should be filled in.

Recommendations:

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

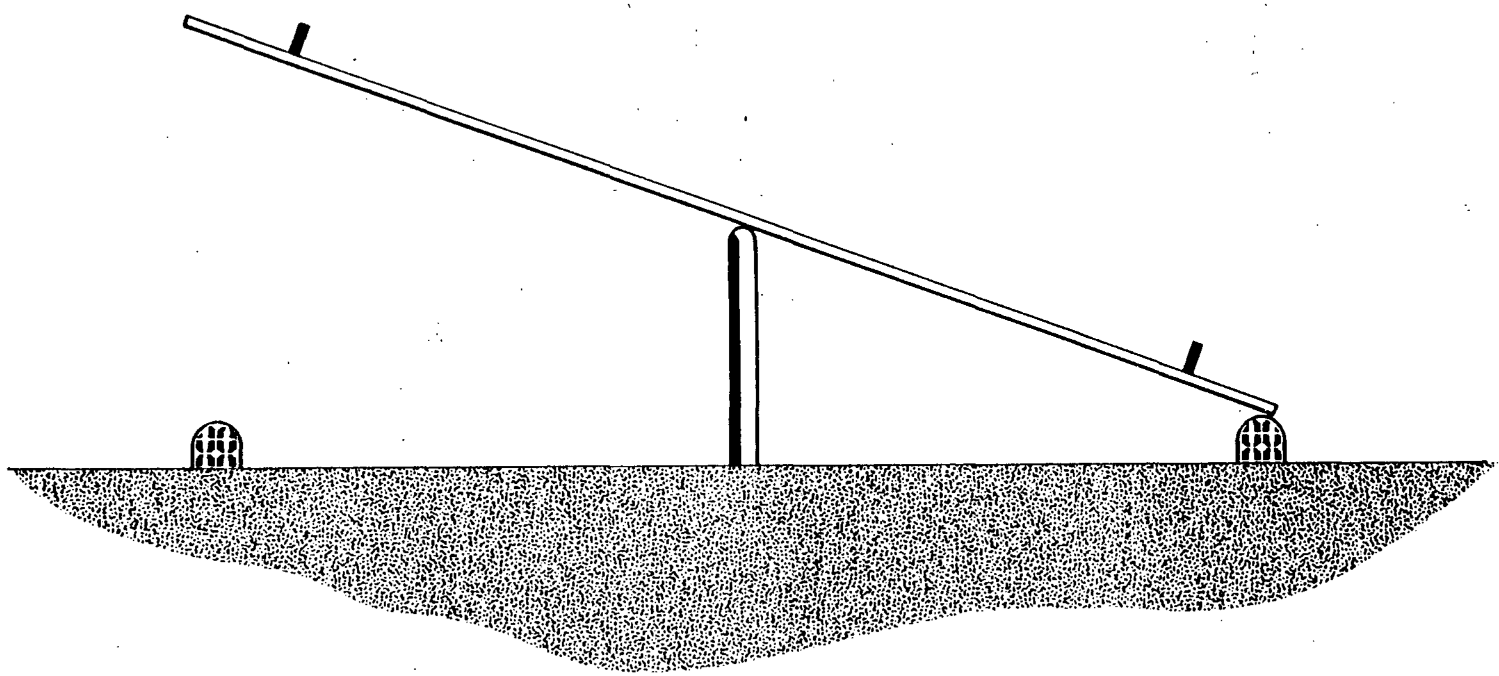


FIGURE 5.7.5 – 1: TYPICAL FULCRUM SEESAW

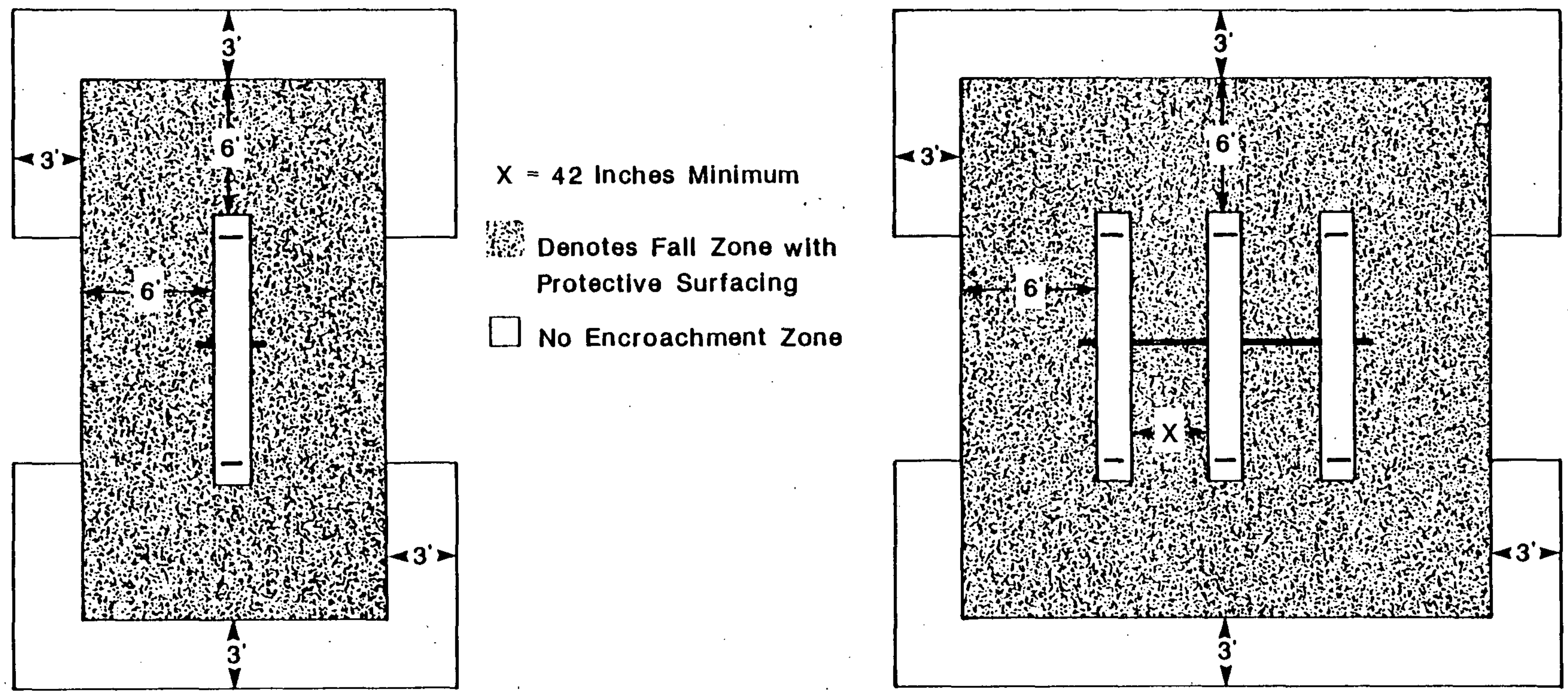


FIGURE 5.7.5 – 2: USE AND FALL ZONES FOR FULCRUM SEESAWS

5.7.6 SPRING ROCKING EQUIPMENT

5.7.6 SPRING ROCKING EQUIPMENT

5.7.6.1 PATTERNS OF SPRING ROCKING EQUIPMENT USE

5.7.6.2 REVIEW OF SPRING ROCKING EQUIPMENT INJURY DATA

5.7.6.3 SPRING ROCKERS

5.7.6.3.1 Seat design

5.7.6.3.2 Handgrips and footrests

5.7.6.3.3 Springs

5.7.6.3.4 Height of seat assemblies

5.7.6.4 SPRING-LOADED SEESAWS

5.7.6.5 USE, FALL ZONES

5.7.6.6 PROTECTIVE SURFACING

5.7.6.1 PATTERNS OF SPRING ROCKING EQUIPMENT USE

Many playground equipment manufacturers offer a variety of spring rocking equipment for children. The typical design is an animal seat on a coil or c-shaped spring (see Figure 5.7.6-1), which children sit on and rock back and forth, as fast as their body weight and strength can achieve (Esbensen, 1987). Review of current catalogs showed that animals ranging from horses to elephants, ducks, porpoises, and rabbits have been made into rocking toys intended for use by one child at a time. In addition, there are cars, planes, bicycles, and motorcycles available, some of which are designed with two seats. A common variation of the single spring rocker has two to six seats attached to the ends of poles which extend out from a center piece supported by a spring mechanism; this is often referred to as a spring-loaded seesaw (see Figure 5.7.6 - 1). Another spring-based seesaw design has springs underneath some or all of the seats, rather than in the middle of the apparatus. Tires and small platforms mounted on springs are also available as alternatives to spring toys with seats. Esbensen (1987) noted that "whatever their design value, the spring-based items should provide children with some play value as well as some positive developmental experience."

The Play For All Guidelines (Moore et al., 1987) states that "children respond dramatically to opportunities for bouncing and rocking." Further, it recommends that play equipment support those activities. It observed that young children, those 5 and under, love riding spring animals; therefore, this equipment should be included in areas for tot play. Similarly, Frost (U. of Texas, 1989, unpublished manuscript) noted that if used, spring rocking equipment was "best placed on playgrounds for toddlers." He further stated that spring equipment usually sat relatively idle where playgrounds were well-equipped with interesting choices.

Bruya and Langendorfer (1988) concluded that for spring rocking equipment on elementary school playgrounds, the potential for a developmental role is minimal. They observed that because the motion of spring equipment is usually quite limited, it does not present much of a challenge to anyone except the smallest children. The actions associated with this equipment are limited to climbing and bouncing, but there is also some opportunity for imaginary play. Frost (U. of Texas, 1989, unpublished manuscript) agreed that "the primary play function is jumping up and down." In addition to bouncing movements, Bruya and Langendorfer noted that there is some enhancement of sensory-perceptual skills because young children "must concentrate on integrating postural and visual cues while riding atop a wildly swaying rocking toy." The Seattle draft standards (1986) also note that this equipment can help in developing balance.

The observational study contained several examples of young children playing on spring rockers. Children on single animal seats, a duck and a zebra, generally rocked back and forth as intended, sometimes using quite a bit of body strength and movement to get the spring swaying rapidly. Other children who were interested in the equipment sometimes stood rather close to the moving apparatus, putting themselves at risk of an impact injury. A two-seat car and a two-seat plane were also observed. Again, the equipment was mostly used as intended, with children in both seats working together to create the rocking motions. However, in one instance, a third child sat on the wing of the plane while two others were in the proper seats. A third child also involved himself in the action of the car at one point, pushing the front of it up and down. Both of these third-person interactions appeared to increase the hazards of use for all three children.

5.7.6.2 REVIEW OF SPRING ROCKING EQUIPMENT INJURY DATA

There is little injury data available to help characterize incidents which involve spring rocking equipment. Brown's (1978) Human Factors Analysis did not address it at all; Rutherford's (1979) Hazard Analysis reported injuries for spring-action equipment only in the category of "other," without any discussion of common injury scenarios. The detailed incident analysis of 1988 data included only one case, which is discussed in the relevant section.

Two surveys of playground equipment each contained limited information regarding spring rocking equipment. The SCIPP survey (Helsing et al., 1988) found that rockers were involved in 3% of all injuries. When composite hazard scores were calculated to assess the overall risk of injury associated with each equipment type, spring rockers were ranked as the sixth most hazardous type. The AALR survey (Bruya and Langendorfer, 1988) reported that 84 individual pieces of spring rocking equipment were found on 206 elementary school playgrounds. Bruya and Langendorfer concluded that 41% of the playgrounds had a rocking apparatus; however, this equipment only accounted for about 3% of all equipment in the survey. It is interesting that the percentage of spring rocker injuries, as reported by the SCIPP survey, is roughly proportional to the percentage of equipment available, as reported by the AALR survey.

5.7.6.3 SPRING ROCKERS

Guideline content:

The current guidelines do not address any of the design considerations for spring rocking equipment which are discussed in the following sections: seat design, handgrips and footrests, springs, and height above ground.

Presumably, this equipment was not considered because it is generally used by younger children, while the handbooks were intended to address only children 5 years of age or older.

Probable rationale:

Not applicable.

5.7.6.3.1 Seat design

Issues:

As discussed above, current catalogs indicated that the most common design for spring rockers is animal seats. Most of these are designed for one user; however, several designs are now available which have two seats, including cars, planes, bikes, and motorcycles. Seat designs which encourage fantasy or imaginary play can add to a positive developmental role for spring rocking equipment. According to current catalogs, the seats are generally constructed of high density plastic such as polyethylene or cast aluminum.

The Play For All Guidelines (Moore et al., 1987) notes that "designs which contain, and correctly position and support the child are preferred so long as they are not too heavy for the small children to activate." It recognizes that this weight problem was apparent in some of the vehicle designs. Esbensen (1987) suggested that the seat design should be comfortable while also providing "a sure grasp of the equipment."

Recommendations:

Seats for spring rocking equipment should be designed for children 5 years of age and under, because they are the primary users of this equipment. Proper positioning and support for the child at all attainable angles, as well as comfort, should be considered. Further, seats should promote good balance. Seat design should minimize the likelihood of the rocker being used by more than the intended number of users.

5.7.6.3.2 Handgrips and footrests

Issues:

In addition to a seat which provides a secure ride, spring rocking equipment usually has both handgrips and footrests for the user. As seen in current catalogs, there are usually either two small handgrips, one on each side of the animal's head for example, or one larger handgrip in the center. Rather than one undivided bar, footrests are generally separated to provide a place for each foot. Some designs attach the footrests to the seat itself, while others incorporate them in the structure of the spring mechanism. In the case of coil springs, it would seem prudent to locate the footrests on the seat itself to encourage children to keep their feet farther away from the spring and thereby lessen the risk of pinching or entrapping a foot in the coils.

Esbensen (1987) and the Play For All Guidelines (Moore et al., 1987) recognized that it is very important for the young users of spring rockers to be able to hold on securely. Moore et al. recommend a 0.75-inch grip size and ample foot rests.

The Australian (AS 1924, Part 2, 1981) and the British (BS 5696: Part 2, 1986) standards have similar recommendations for handgrips on this kind of rocking equipment. Both state that each seating position should have a grip handle, and that the clearance of the handle should not be less than 3.93 inches above the upper surface of the horizontal seat. However, the Australian standards recommend a grip diameter between 0.51 inches and 1.50 inches, while the British recommend a grip diameter between 0.71 inches and 1.57 inches.

For footrests, the Australian and British standards are identical and include the following specifications:

> If footboards are required, they should be fitted on to each side of the seat assembly for its full length, and the footboards should not project less than 3.54 inches nor more than 7.87 inches from the sides of the seat assembly.
>
> If individual footrests are required, they should be fitted on to each side of the seat assembly and should not project less than 3.54 inches nor more than 4.94 inches from the sides of the seat assembly.
>
> The underside and ends of the footboards should be curved and/or angled to deflect away from the apparatus any article or part of a user's body underneath.

The Canadian draft standards (CAN/CSA-Z614, 1988) also address hand and foot grips: where required, they should be fixed, and any rungs, bars, or parts thereof should not turn when grasped. Further, the grips "should not project beyond a maximum of five inches." It is also suggested that all projections be blunt-edged with a 3/8-inch minimum radius and no sharp points.

Results of the AALR survey indicated that 74% of the spring rockers found on elementary school playgrounds had a pair of 3-inch handholds, and 78% had sufficient footrests, defined as 4 by 6 inches (Bruya and Langendorfer, 1988).

Recommendations:

The relative positions of the seat assembly, handgrips, and footrests vary considerably among the different spring rockers. Therefore, specific recommendations for these positions are not given.

The size of handgrips and footrests should be proportioned to preschool-age children, because they are the primary users of this equipment. Handgrips should be at least 3.0 inches long, which accommodates the maximum fist breadth of a 95th percentile 5-year-old (2.8 inches). The diameter of handgrips should follow the general recommendations for hand gripping components (see Section 5.6.1.1.3.2). Footrests should be at least 3.5 inches long, which accommodates the foot breadth of a 95th percentile 5-year-old (3.0 inches). Neither the handgrips nor the footrests should project more than 5 inches beyond any point along the perimeter of the seat assembly, to help prevent injuries caused by large protrusions. Excessive protuding components have been identified as a hazard; however, there is no empirical data on which to base a recommendation. Consensus in foreign standards indicates that 5 inches is a reasonable distance for handgrips or footrests on spring rocking equipment to project.

Issues:

Three different spring mechanisms were seen in the catalogs for rocking equipment: a coil spring, a c-shape spring, and a rubber spring. The coil spring is probably the most common and is generally associated with this equipment. However, the potential for pinching must be considered.

Many of the manufacturers describe the coil springs as "pinch-free" or "non-compression" in their catalogs. One manufacturer offers a safety clamp that "effectively locks the coils of the spring at the top and bottom," so that the risk of a child pinching either hands or feet has been removed from those areas, which the manufacturer identified as the critical points for pinching. The catalog further explains that the resistance of their springs is so great that "even the weight of an adult cannot compress the spring completely." When a load of 176 pounds is applied, the total height of the spring is reduced by only one inch, and therefore, the risk of pinching between coils is eliminated.

Esbensen (1987) stated that "the design should ensure that the child cannot get limbs pinched or trapped in the spring when the equipment is being used." Similarly, both the Canadian (CAN/CSA-Z614, 1988) and Seattle (1986) draft standards recommend that pinching of body parts be prevented. The German standards (DIN 7926, Part 2, 1984) state that "the design shall ensure that it is difficult for users to reach crushing and sharing points, e.g., flexible covers shall be fitted." The British standards (BS 5696: Part 2, 1986) require that the suspension mechanisms be enclosed to prevent unauthorized access.

Bruya and Langendorfer (1988) concluded from the results of the AALR survey that it appeared very likely that "fingers could be injured by being caught in the spring mechanism," given possible spring-action pinch points on 38% of the equipment.

Rocking motion: The three spring mechanisms offered in current catalogs would appear to each provide a different type of rocking motion. The traditional coil springs rock back and forth, and depending on the user's size and strength, they can sway quite far and quite rapidly, as seen in the observational study. Slight side-to-side movement may also be possible for some of the coil springs, although this is not intended to be the main motion. The c-shape springs also go back and forth; however, given the shape of this design, it would seem that this motion is more constrained than that produced by a spring which is free to go just as far back as forward. Therefore, the rocking motion for c-shape springs is probably less back and forth, and more up and down. The rubber spring mechanism appears to provide only up and down movement.

The Play For All Guidelines (Moore et al., 1987) brings up a good point: "springs designed for use on playgrounds must meet difficult criteria; they must be soft enough for small children to move yet strong enough to avoid damage when used inappropriately by large children." Esbensen (1987) also addressed the rocking motion of spring equipment, noting that designs should be such that young children can initiate and control the movement. Further, he recognized that "the rocking motion should be varied, not simply back and forth, to challenge the equilibrium and lateralization experience of the child."

The Australian (AS 1924, Part 2, 1981) and British standards each give specifications which address the range of motion allowed for rocking equipment, except that they characterize the movement differently. The Australian standards state that "surfaces which are horizontal in the rest or equilibrium position should have a maximum angle of elevation of 30 degrees to the horizontal at any position during motion." The British standards state that "throughout the range of motion no part should move a greater distance than 24.4 inches when measured horizontally." Both countries also include recommendations that the suspended points should be interdependent, and that motion should be progressively restrained toward the extremities of movement to prevent sudden stops or reversals of motion.

Also related to the limits of motion for rocking equipment, both the Australian and British standards suggest that no part of the apparatus should be able to move to a height greater than 6 feet above ground, when the equipment is in motion.

Recommendations:

The springs of rocking equipment should be designed to preclude the possibility of children pinching either their hands or their feet between the coils, under conditions of dynamic use by a 95th percentile 12-year-old. The weight of a 95th percentile 12-year-old is 120.6 pounds. Although spring rocking equipment is generally intended for use by younger children, this design aspect should accomodate the weights of older user's because they can be expected to use the equipment from time to time. For maximum safety, it is recommended that the distance between exposed coils not compress to less than 2.2 inches, given the above conditions of use. This measurement corresponds to the foot height of a 95th percentile 5-year-old, which was approximated by the sphyrion height.

5.7.6.3.4 Height of seat assemblies

Issues:

The Canadian draft standards (CAN/CSA-Z614, 1988) recommend that the height of the seat above ground should be between 18 and 24 inches for spring equipment intended for preschool children. The Australian (AS 1924, Part 2, 1981) and British (BS 5696: Part 2, 1986) standards each state that the vertical distance from the ground to the upper surface of the seat should not exceed 39.4 inches when the apparatus is stationary. Further, the British standards require that the ground clearance of the seat assembly not be less than 8.1 inches nor more than 16.7 inches throughout the range of motion, to minimize the risk of entrapment of children's limbs. Although the Australian standards do not give dimensions for this specification, they do state the following: "when considering ground clearance, the designer should take into account the possibility of injury to the user and reduce this risk by eliminating foot, leg, and knee entrapment or crush points under the apparatus." One additional ground clearance requirement in the British standards stipulates that footrests must have a minimum ground clearance of 17.7 inches throughout the range of motion.

Both the AALR survey (Bruya and Langendorfer, 1988) and the SCIPP checklist (1988) measured the height of seats above ground for the rocking equipment. The AALR survey recorded the rocker with a seat height less than 30 inches; and the SCIPP survey recorded those with a seat height less than 39 inches. Results of the AALR survey indicated that 82% of the seating surfaces on spring rockers were less than 30 inches above ground.

Recommendations:

Presumably, children 5 and under are the most likely to use and enjoy spring rocking equipment. Therefore, the height of seat assemblies above ground should be correlated to users of this age group. Seat assemblies of this equipment should be between 18 and 28 inches above ground level. The maximum corresponds to the waist height of a 95th percentile 5-year-old (26.3 inches), to allow for the climbing often involved in mounting such seats. The minimum height above ground takes into account the extended leg length of a 95th percentile 5-year-old, which was approximated by the gluteal furrow height (19.8 inches), so that the oldest users of spring rockers will not be at risk of jamming their feet into the ground while seated.

5.7.6.4 SPRING-LOADED SEESAWS

Guideline content:

The current handbooks do not address the type of spring rocking equipment which is commonly referred to as spring-loaded seesaws.

Probable rationale:

Not applicable.

Issues:

As previously described, many manufacturers offer spring-loaded seesaws as an alternative form of spring rocking equipment. It is common to find these discussed in conjunction with conventional fulcrum seesaws. In fact, one manufacturer explains that the users of spring-loaded seesaws can benefit from the interplay of a seesaw while also experiencing the bouncing of a spring-action rider.

The Play For All Guidelines (Moore et al., 1987) explains that although conventional seesaws are popular and support cooperative play, they present a great risk of back injuries as well as crush points. Therefore, they are not recommended, with an exception given to spring-loaded seesaws "which have solved some of these problems." Moore et al. acknowledge that more research is need to evaluate this equipment. Given the results of their study, Oliver et al. (1981) initiated a number of injury prevention programs, including the introduction of a 4-way rocker in place of traditional seesaws. They explained that because this equipment is spring-loaded, one child can ride alone. Further, there is considerably less risk of injury when two children are using it together if one suddenly dismounts, which is a common injury scenario for fulcrum seesaws.

Esbensen (1987) expressed a similar opinion, referring to the conventional fulcrum seesaws as "old-fashioned" and "lethal," but describing the new spring-based seesaw as "safe." His discussion makes an interesting point: "in the last five years a new generation of counter-balanced spring-based seesaws has appeared on the market, and once again it is possible for a pair of young children to experience the weight differences between them when they sit on opposite ends of the boards. The design of these new seesaws also enables teachers or parents to safely seesaw with the children."

The one injury caused by spring rocking equipment in the detailed incident analysis involved a spring-loaded seesaw, with four animal seats. A 4-year-old was standing too close to one of the seats while other children were bouncing on the equipment; he was struck in the face and suffered minor lacerations and a chipped tooth.

Recommendations:

Spring-loaded seesaws should follow all of the recommendations given above for other spring rocking equipment.

5.7.6.5 USE, FALL ZONES

Guideline content:

No mention of spring rocking equipment is made in the guidelines' general discussion of use zones.

Probable rationale:

Not applicable.

Issues:

Esbensen (1987) noted that rocking equipment should be placed where it will not interfere with other activities. However, he further stated that "in some instances, the equipment can complement another area. For example, if close by a social/dramatic zone, the rocking item might be a vehicle or creature on a spring, ready for departure." He also simply recommended that this equipment be placed on a resilient surface such as sand, without specifying dimensions for a fall zone.

The Canadian draft standards (CAN/CSA-Z614, 1988) do give dimensions for a fall zone, recommending that protective surfacing extend 6 feet on all sides of the equipment.

In the observational study, the spring rockers seen were in an area set off by retaining walls for the surfacing materials, which would denote the fall zone. However, this did not prevent other children from walking into the area and standing within such close proximity to the rocking apparatus that they were at risk of an impact injury.

Recommendations:

The fall zone around spring rocking equipment should include protective surfacing for 6 feet in all directions, measured from the perimeter of the seat assembly in its stationary rest position (see Figure 5.7.6 - 2). The use zone does not need to extend any further than the fall zone in the case of spring rocking equipment.

5.7.6.6 PROTECTIVE SURFACING

Guideline content:

The current guidelines do not make any recommendations specifically for surfacing under spring rocking equipment.

Probable rationale:

Not applicable.

Issues:

The AALR survey included surfacing information for each type of equipment (Bruya and Langendorfer, 1988). The results for spring rocking equipment were as follows: sand, 24%; pea gravel, 24%; grass, 17%; concrete or asphalt, 13%; hard packed dirt, 10%; large gravel, 6%; tan bark, 3%; rubber matting, 3%.

Recommendations:

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

FIGURES

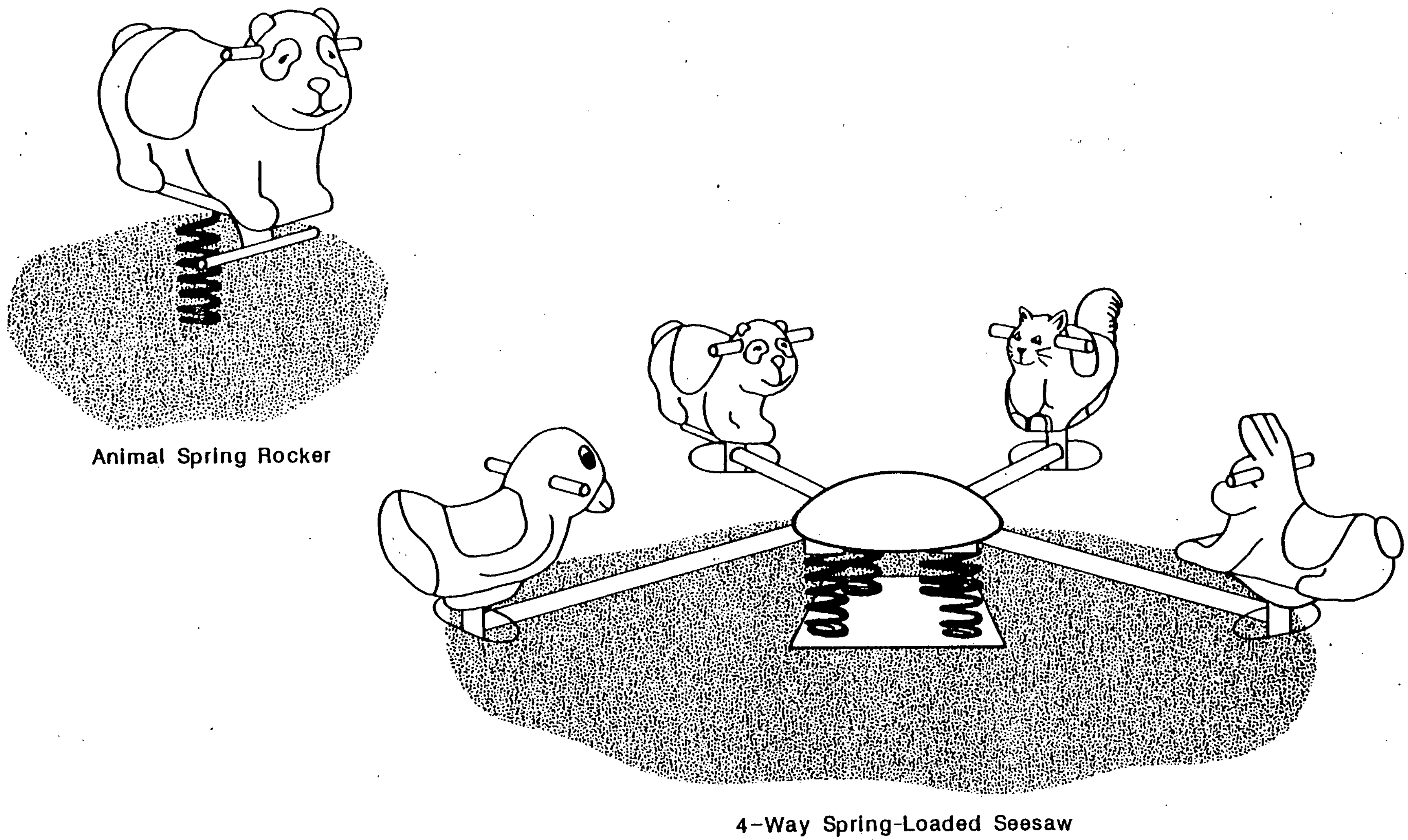
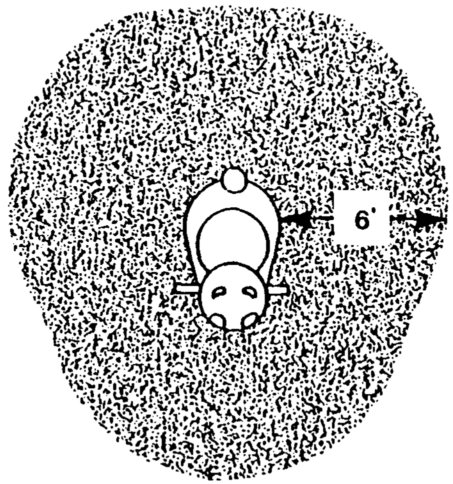
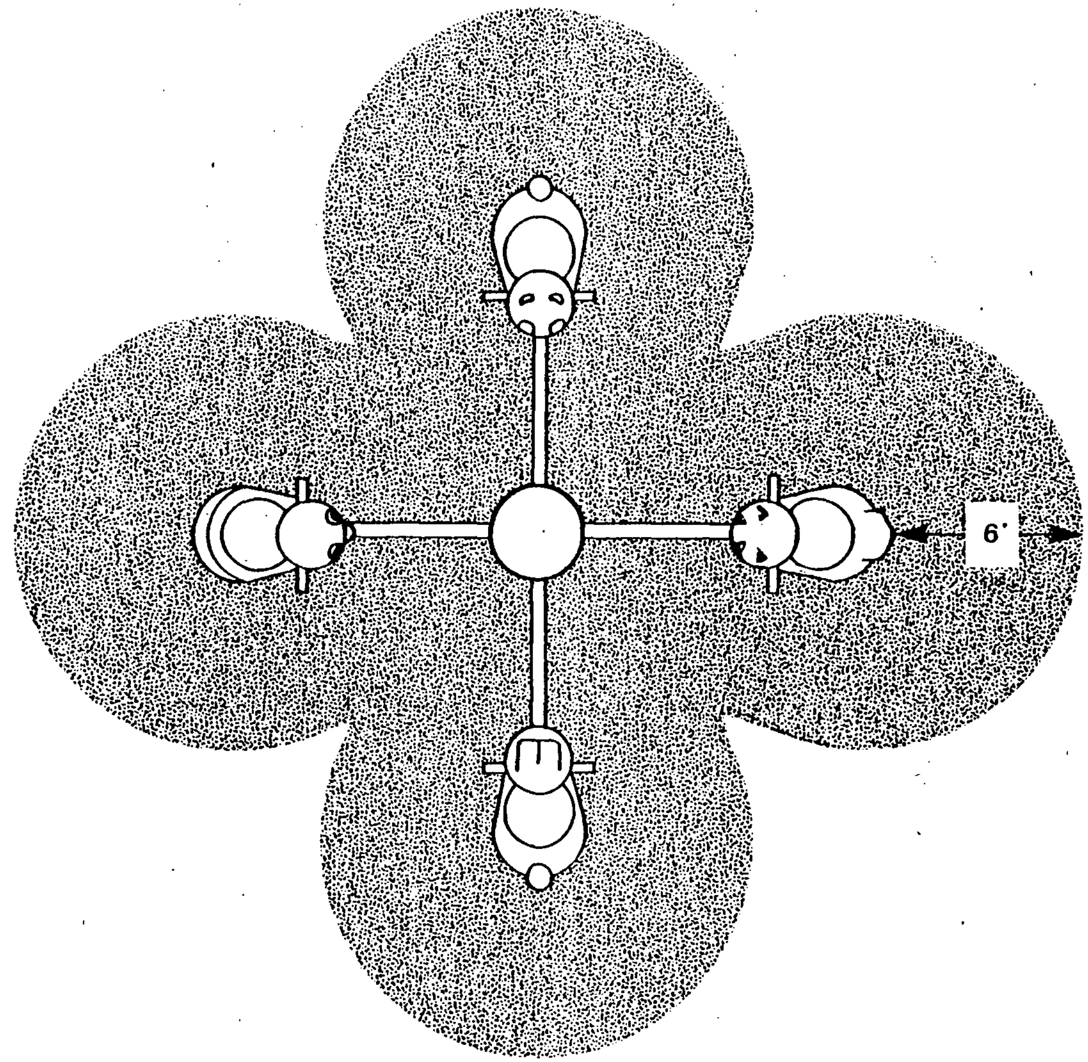


FIGURE 5.7.6 – 1: TYPICAL SPRING ROCKING EQUIPMENT





Denotes Fall Zone with Protective Surfacing

Note: The use zone does not need to extend beyond the fall zone for spring rocking equipment.

FIGURE 5.7.6 - 2: USE AND FALL ZONES FOR SPRING ROCKING EQUIPMENT

6. SUMMARY

Playgrounds are an important part of every child's world. However, if children are to enjoy playgrounds and play safely, greater attention needs to be given to our nation's public play areas. This report and the accompanying Handbook provide guidelines for evaluating and designing public playground equipment and equipment settings. The safety of each individual piece of playground equipment as well as the layout of the entire play area should be considered; and, installation of protective surfacing under all equipment is crucial.

Human factors design principles guided this research. The issues and recommendations discussed throughout this report are based on a review of available injury data, pertinent literature and standards, current expert opinion from a variety of disciplines, and the developmental needs and play patterns of children. The extensive rationale provided in the report should be useful to equipment designers, standards groups, school personnel, parks and recreation personnel, and any other persons interested in public playground safety. Moreover, it should prove helpful for future revisions of the Handbook.

Although each detailed specification is important, a few general points warrant summarization. These are briefly stated below.

Age Considerations. Preschool-age and school-age children differ dramatically not only in physical size and skill, but also in the development of their cognitive and social skills. These differences translate into different play patterns and typical injury scenarios. Therefore, age-appropriate playground designs must consider the type of equipment, the scale of equipment, and the layout of equipment, with regard to these differences. Recommendations throughout the report and Handbook address the different needs of preschool-age and school-age children.

Supervision: Although good equipment design and maintenance are essential for a safe playground, they do not obviate the critical need for adequate supervision. Compliance with safety guidelines does not allow less stringent adult supervision. No playground can be completely safe; hazards can be minimized, but it is not desirable to remove all challenge from playground equipment. Furthermore, children can be expected to use equipment in unintended and unanticipated ways. Attentive supervision is always imperative, although the supervision needs vary with the ages of the children and the size of the group involved.

Surfacing. Falls to the surface are the predominant mode of public playground injury and can be expected to occur from virtually any type of equipment. The surface under equipment is a major factor in determining the injury-causing potential of a fall. Therefore, all playground equipment must have protective surfacing. Certain surfacing materials (e.g., loose materials, such as sand and wood chips) can help absorb the impact of falls; however, there are many important variables, including environmental conditions, which affect the cushioning properties of different materials and must be considered. For example, it is essential that loose materials be installed at adequate depths and then be carefully maintained.

Specific recommendations for the impact performance of surfaces are intended to minimize the risk of serious head injuries resulting from falls. Unfortunately, current models for head injury do not adequately cover the circumstances of a fall from playground equipment, particularly for children. Moreover, little is known about the effectiveness of surfaces in reducing the risk of severe injury to the limbs, even though limb fracture is a more frequent outcome of falls than severe head injury.

Playground layout and design. Playgrounds typically include a number of different types of equipment and play areas, which support a variety of simultaneous activities. Although specific design guidelines address the safety of each type of equipment, a piece of playground equipment cannot be considered "safe" in itself, but only as it is integrated into the full playground equipment setting. Each product's potential for injury must be evaluated in the context of spatial relationships with other equipment and activities, surface treatments, pedestrian traffic patterns, separation of children of different ages, support of adult supervision, durability under conditions of use, maintenance, and various other environmental considerations. Recommendations regarding the overall layout of playgrounds have been incorporated throughout this report.

Safety vs. play value. Much can be done to insure that public playgrounds are safe for users of all ages. This report has attempted to contribute to the achievement of greater public playground safety through the discussion and analysis of safety problems, the clarification of safety needs, and the development of recommendations for playground equipment design and use. However, this emphasis on safety does not mean that other considerations are unimportant in the design, selection, and use of public playgrounds. Playgrounds certainly need to be safe, but "safe" design does not necessary imply "good" design. The equipment and activities on playgrounds should have positive play value, supporting the types of play engaged in by children of the intended age group. Further, playgrounds should enhance children's cognitive, social, and emotional development in addition to their physical development.