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5.2.1 REVIEW OF INJURY DATA FOR GENERAL HAZARDS

Sharp points, corners, and edges; protrusions and projections; pinch, crush, and shearing points: Rutherford's (1979) Hazard Analysis of injuries associated with public playground equipment addressed all of these hazards together. The 1978 Special Study data indicated that 5% of all equipment-related injuries were associated with pinch points, protrusions, sharp edges, or sharp points. Although these injuries occurred on all types of public playground equipment, they accounted for a higher proportion of merry-go-round and slide injuries than climber, seesaw, and swing injuries. As expected, injuries related to general hazards are usually superficial, such as lacerations and contusions; fractures and sprains are less common. Rutherford noted that rusty or broken equipment was often involved when injuries resulted from pinch points, protrusions, sharp edges or sharp points.

Other injury data for these three categories of hazards on playground equipment are limited. The AALR survey of elementary school playgrounds reported that there were sharp corners or projections at 41% of the playgrounds studied (Bruya and Langendorfer, 1988). Analysis by equipment type revealed that sharp corners or projections were found on the following pieces of equipment: 53% of seesaws; 46% of rotating equipment; 41% of climbing equipment; 35% of slides; 26% of swings; and 24% of spring rocking equipment. Data from the SCIPP survey indicated that 6% of all equipment-related injuries resulted from "being cut by the equipment" (Helsing, Rodgers, and Mirabassi, 1988). Similarly, a survey of primary schools in New Zealand showed that 6% of equipment-related injuries were cutting/piercing accidents (Langley et al., 1981). The PORS Study (1987, cited in King and Ball, 1989) of hospital data in Holland implicated "being cut by an object" in only 2% of all playground injuries, but an additional 2% were attributed to "crushing" incidents.

The detailed incident analysis of 1988 injury data included eleven cases in which the injury was a cut or puncture incident. Of these cases, seven were swing-related (five of which involved gliders), two were slide-related, one was seesaw-related, and one involved a concrete tunnel. The direct cause of the cut/puncture injuries was most often a protruding or uncapped bolt on the equipment (6 cases). Sharp edges (2 cases), rough textured material (1 case), and broken glass (1 case) were also involved. (The cause of the eleventh case is unclear.) All of the injuries were lacerations: two to the head, four to the face, two to the upper limb, one to the lower limb, and one to the trunk. This finding supports Rutherford's (1979) conclusion that majority of injuries related to these general hazards are lacerations or contusions/abrasions, and also that all body parts are involved.

All five of the glider-related cut/puncture injuries were caused by protruding or uncapped bolts, two on the glider itself and three on the adjacent support structure. Each of these injuries was a laceration; four were to the head or face and serious enough to require stitches. These five incidents accounted for half of all the glider-related injuries in the detailed incident analysis.

The bolt which connects the suspending chains to the seat can be a problem on conventional swings. One of the cases in the detailed incident analysis involved a 5-year-old who lacerated his face while swinging on his stomach because he contacted the connecting bolt on an adjacent swing. It is very common for young children to swing on their stomachs, and eliminating this hazard could prevent injuries such as this one. In general, the frequency of injuries caused by protruding or uncapped bolts could be reduced through increased attention to good design in conjunction with good inspection and maintenance procedures.

The slide-related cut/puncture injuries in the detailed incident analysis also help illustrate the importance of good maintenance. One child suffered from a laceration caused by a sharp edge along the side of the slide chute, which he was properly using as a hand guide while descending. It is common for stainless steel to fail with age and expose sharp edges; however, this problem can be repaired if noticed by inspection crews. The second slide-related injury was caused by broken glass in the sand below the exit region of the slide: a 4-year-old lacerated her foot exiting the slide in the normal manner. To prevent such incidents, any broken glass or other debris need to be removed from all protective surfacing on a regular basis.

A sharp edge on a wooden seesaw caused the seesaw cut/puncture injury in the detailed incident analysis. Again, good inspection and follow-up maintenance could prevent this type of injury. Rutherford (1979) had also noted that worn or damaged seesaws are a problem.

The detailed incident analysis also included two cases of pinch/crush injuries. Both were lacerations/contusions to the child's finger. In one case, a 6-year-old pushing other children on a tire swing pinched her finger at the connection between the suspending chain and the metal support inside the tire. The other injury was sustained by an 8-year-old who was standing on a glider holding the rigid suspension bar near the hinge and pinched his thumb as the glider was swinging. Poor design appears to have been a factor in both of these injuries because adjacent moving components of the equipment were accessible to the user.

Nine additional in-depth investigations were provided by the CPSC to further study pinch, crush, or shearing injuries. These incidents occurred between 1979 and 1988. Interesting patterns of injury were evident for incidents which involved merry-go-rounds and gliders.

Five cases of merry-go-round injuries left children with partial or full amputation of fingers. Poor maintenance was clearly a factor in four of the five incidents with details of the fifth unclear. Three of the injuries occurred when the child put his or her finger in an accessible hole in the central shaft, causing contact with shearing components of the equipment's axle; one injury occurred when a child put his or her finger in an accessible hole on the base causing contact with shearing components of the equipment's undercarriage. If properly maintained, these merry-go-rounds would not have had the accessible openings. Observational data also included an example of a young child putting his finger into a small hole on the base of a merry-go-round; he was able to pull his finger out before incurring any injuries.

Four cases of glider-related injuries reported lacerations or contusions to children's fingers, two of which were serious (stitches required). Similar to the glider-related pinch/crush case in the detailed incident analysis, three of the injuries were attributed to exposed moving parts in the suspension mechanism of the glider. The children were climbing on the support frame, other components of the swing set, or the glider itself to gain access to the top cross bar and suffered pinch injuries caused by the suspension mechanism when the glider was in motion. Injuries such as these could be prevented if the design of gliders included a cover fully enclosing the suspension mechanism and eliminating access to moving parts. The fourth injury resulted when one of the suspension bars broke at the connection to the handhold, causing the equipment to collapse. The victim fell backward and pinched his thumb.

Clothing entanglement: Rutherford's (1979) Hazard Analysis included discussion of deaths which occurred on public playground equipment from 1973 to 1977. He noted that clothing entanglement was an important cause of slide-related deaths. Children were strangled while sliding because their clothing somehow got caught at the top of the slide. In some cases, ropes were involved.

Accidental strangulations from strings of children less than 5 years old were studied by Rutherford and Kelly (1981) for the period from 1973 to 1980. A strangulation occurs when something around the neck tightens and strangles the victim. Play equipment was implicated in 29 cases, and all but two of them were fatalities. Rutherford and Kelly pointed out that slides accounted for the majority of these accidents, and that often a handrail or some other component at the top of the slide was involved.

Feldman and Simms (1980) reviewed 233 cases of childhood strangulations, which included data from Seattle hospitals (1966-1978), the Seattle coroner (1975-1978), and 1977 NEISS data. Three of the four cases occurring on playground equipment in Seattle involved the child's jacket or poncho hood getting "caught on the upright rail of a home playground slide." The fourth death resulted from a scarf getting caught on a merry-go-round pole.

King and Ball (1989) acknowledged that "the role of clothing is seldom mentioned in studies of playground equipment accidents." They obtained information from the CPSC on deaths from 1985 to 1987, four of which were attributed to clothing entanglement. Like Rutherford and Kelly (1981), King and Ball explained that slide-related deaths and climber-related deaths resulted from children's clothing or ropes they were carrying getting caught on the equipment and causing asphyxiation/strangulation.

The CPSC provided ten additional in-depth investigations regarding clothing entanglement deaths, which occurred from 1980 to 1988. Nine of these were due to asphyxiation/ strangulation, while one death resulted from a severed spinal cord. It is unclear whether any of these cases were included in the sample of fatalities discussed by King and Ball (1989) or by Rutherford and Kelly (1981).

Slides were involved in seven of the ten CPSC clothing entanglement deaths. Five of the slide-related deaths were suffered by children in the 0- to 4-years age group. In three cases, the hood of the child's jacket got caught at the top of the slide and the child continued to slide down unknowingly; one child who had mittens on a string through her coat sleeves started descent down the chute not realizing that her mittens were caught at the top; the remaining case involved a slide ladder, but details of the entangled clothing were unknown. Both deaths to children in the 5- to 14-years age group were caused by something the child was carrying around his or her neck; a jump rope in one case and a toy canteen in the other. These incidents were similar to those involving the children's clothing, in that the objects were caught at the top of the slide when the victims slid down and were stranguled. Protruding bolts were involved in four of the seven slide-related clothing entanglement cases; three were at the top of the slide and one was at the top of the ladder.

Climbing equipment was involved in two of the remaining CPSC clothing entanglement asphyxiation/strangulation cases. Both were caused by a component which was attached to the structure on only one end and presented a potential "hook" on which children's clothing could get caught. Because the victims were so high that their feet could not reach the ground, their weight was supported only by the clothes around their neck. In one case, a 21-month-old's bib was caught on a vertical post of a small jungle gym apparatus. The other case involved a climbing structure with horizontal rungs which served as steps radiating off a center post; it was possible to climb as high as 9 feet on this equipment, installed over an asphalt surface. A 6-year-old fell while climbing and her jacket got caught on one of the horizontal components which was 6 feet above ground.

One death in the group of additional clothing entanglement in-depth investigations provided by the CPSC involved a trapeze swing. A 6-year-old fell and the hood of her jacket caught on an open hook connecting the suspending chains and the trapeze bar. Open "S" hooks are a serious hazard on swing sets, because they can easily catch children's clothing or cause lacerations. The current guidelines recommend that all open hooks be closed tightly to eliminate this problem. Both Gilje (1989) and Kane (1989) reported a recent death which was the result of clothing entanglement on an open S hook on a home swing set.

Two other clothing entanglement deaths involving climbing equipment were uncovered in a search of the CPSC death certificate file from 1973 to 1988. An 8-year-old was strangled in 1980 when his or her clothing became caught on a protruding bolt during a fall; and, a 5-year-old died of asphyxiation in 1986 after slipping while playing on a jungle gym. The 1986 case may overlap with those considered by King and Ball (1989).

Entrapment: Section 5.2.6.2 contains a broad overview of entrapment and definitions which explain various scenarios. Because entrapment scenarios are generally complex, it is recommended that Section 5.2.6.2 is read prior to this discussion of injury data.

Miles, Rutherford, and Coonley (1983) conducted a hazard analysis on structural entrapment for infants and children. Over 472 head entrapment incidents involving forty different types of products, including playground equipment, occurred between 1973 and 1983. This report was later updated to include data through January, 1986 (Tinsworth, 1986). One important finding for present purposes was that children over the age of 5 were not involved in playground equipment entrapments.

Playground equipment (home and public) was involved in a total of twenty-four incidents, eight of which were fatal. The ages of the victims were as follows: one less than one year, seven 1-year-olds, five 2-year-olds, six 3-year-olds, two 4-year-olds, one 5-year-old, and two victims of unknown age. Generally, in the non-fatal incidents, the children were being supervised by nearby adults who were able to rescue the victims quickly. On public equipment, entrapments were usually between rungs or steps of a ladder or in the opening between ladder and platform. On home equipment, entrapments occurred most often on swing sets, where children became trapped in the seats of glider swings or between support bars on the "A" frame. (Miles et al., 1983; Tinsworth, 1986)

Another product addressed in these hazard analyses was indoor toddler gym houses. These generally have a short ladder with open risers leading to a platform with a small slide, and the area underneath the platform serves as a partially-enclosed play space. Young children enjoy climbing, sliding, and playing both in and on such toddler gym houses. Although this equipment is not intended to be installed outdoors, the entrapment scenarios are similar to incidents involving playground equipment and therefore relevant. Indoor toddler gym houses were involved in fourteen entrapments, four of which were fatal. The ages of the victims were as follows: four 1-year-olds, four 2-year-olds, one 3-year-old, four 4-year-olds, and one 5-year-old. Incidents usually occurred when a child stuck his or her head through the ladder steps and was then unable to pull it back out after rotating it to a larger dimension. Several manufacturers have issued recalls for these products since this hazard was discovered. (Miles et al., 1983; Tinsworth, 1986)

Deppa's (1989) study of structural entrapment included a comprehensive accident analysis of head entrapment incidents on all types of playground equipment. The reader is referred to Deppa's complete report for the details of her analysis, which is also discussed in conjunction with the entrapment recommendations (see Section 5.2.6.2).

Deppa (1989) concluded that "the oldest user at risk for head entrapment appears to be five years of age." All openings in playground equipment are potential entrapment hazards, regardless of their height above ground. Young children can suffer strangulation from entrapment even in an opening which is so low that their feet can touch the ground because they may not have all of the cognitive and motor skills necessary to support and then extricate themselves. The only exception is an opening in which the ground serves as the lower boundary. Deppa's review indicated three other very important factors regarding playground equipment entrapments: all incidents involved completely-bounded openings; the openings were in both the horizontal and vertical planes; and, children can be entrapped through either head first or feet first entry.

In-depth investigations originally reviewed by Deppa (1989) were further examined for this project. The thirty-eight cases studied occurred between 1979 and 1987. Discussion here will separate the incidents into three categories: those involving public playground equipment (15 cases), those involving home playground equipment (11 cases), and those involving indoor toddler gym houses (12 cases). Although the scope of this report is limited to public playground equipment, in the case of entrapment, it is especially important to also analyze incidents which occurred on home equipment and indoor toddler gym houses to better understand and characterize the injury scenarios.

Guard rails or protective barriers were involved in almost half (6 of 15) of the entrapment incidents on public playground equipment. Three cases involved openings in the vertical plane within the guard rails or protective barriers themselves. In one case, a 2-year-old was fatally injured as a result of head entrapment between horizontal bars around a platform of preschool equipment. The distance between the two bars was 5.31 inches. It is unclear exactly how the entrapment transpired. In the second case, a 5-year-old was entrapped between vertical bars on a platform, most likely following feet first entry, but he was pulled to safety by an adult witness without incurring any injuries. The distance between the two bars was 4.6 inches. The third case involved a 4-year-old and an opening formed by bars protecting an elevated playhouse. She entered head first from the inside and both force and lubricating liquid were required to remove her head. The size of the opening was 5.25 by 4.4 inches.

Four entrapments occurred between a guard rail or protective barrier and the equipment platform, all of them feet first entry into an opening in the vertical plane. Three cases were fatal: one 2 1/2-year-old and two 4-year-olds died after head entrapments in openings which ranged from 6.7 inches to 7.1 inches. The fourth, non-fatal, case involved a 3-year-old and a 5.75-inch opening. The following scenarios appeared common for this particular type of entrapment: the victim was either sitting on the platform with his or her legs dangling over the edge or lying face down on the platform. The victim then became entrapped when sliding off the platform under the guard rail or protective barrier, either intentionally or unintentionally. Observational data revealed that the opening between a guard rail or protective barrier and the platform is often an entrapment hazard. Further, Esbensen (1987) also noted two deaths occurring in this type of opening; it is unclear whether these cases overlap with those discussed above.

Two cases similar to the entrapments between a guard rail or protective barrier and the equipment platform occurred between a horizontal climbing rung which was above platform level and the platform. As seen in the report photographs, the design of this particular type of multi-use equipment incorporated a rung ladder where the last two rungs were above platform level, presumably so that children could climb higher than the platform to use an attached sliding pole. Although the distance between these two top rungs (10.6 inches) would not present an entrapment hazard, the distance between the lower of the two top rungs and the platform was only 4.5 inches, creating a dangerous opening in the vertical plane. A 3-year-old entered this opening feet first and slid through, becoming entrapped at his chest; he was rescued without any injuries. Staff members of the daycare center where the incident occurred did some checking and found that many of the 3-year-olds in the group could become entrapped either head or feet first in the same opening. Another in-depth investigation indicated that other equipment from the same manufacturer also incorporated this hazardous design. Parents had reported two separate incidents to a local Parks Department stating that their children had slipped feet first off the platform under the horizontal climbing rung, and were entrapped by the head. This opening was reported as approximately 4.5-5 inches.

In addition to the above examples of openings in the vertical plane, the group of in-depth investigations for public playground equipment included examples of openings in the horizontal plane. The first case covered two incidents on the same piece of equipment. Both children fell feet first into a gap between an access ladder (which has steps consisting of large wood logs) and the platform it served. The last step was at the same height as the platform, but there was a 7-inch space between them that children had to step or crawl over during the transition from ladder to platform. A 3-year-old was entrapped in this opening by his head, and a 5-year-old was entrapped by his chest. Neither child incurred injuries other than minor abrasions. Two other investigations identified similar openings in design which incorporated an arch ladder connected directly to a slide chute without a platform. Both incidents involved 3-year-olds who fell feet first through the opening during the transition from climbing to sliding. The openings were 4.25 and 5.75 inches. In one of the two cases, it took two adults approximately five minutes and the use of petroleum jelly to forcibly remove the child's head. In another case where the opening was in the horizontal plane, a 3-year-old put her head between two rungs on an overhead ladder. The distance between rungs was 4.2 inches.

Details of the two remaining cases on public playground equipment are unclear. In one case, a 3-year-old playing on a dome climber did some sort of backward flip and ended up with his neck trapped in one of the triangular sections of the climber, apparently after head first entry. The dimensions and orientation of the opening were unknown. This neck entrapment in a completely-bounded opening following head first entry appears to be unique; neck entrapment is generally an issue only for partially-bounded openings or angles. The only information known for the final case is that a 14-month-old was trapped between bars of a climber apparatus. Note that this is the youngest of the victims for public playground equipment. In fact, the victims of the other thirteen incidents ranged from 2 to 5 years.

For home playground equipment, seven of the eleven entrapment incidents involved gliders. A pendulum-type glider was implicated in one non-fatal case: a 2-year-old entered head first into 5.6-inch opening between the two vertical suspension bars of the swing. The gondola-type gliders were implicated in six separate entrapment cases, all non-fatal. In each case, the child was trapped in the space between the seat and the backrest after feet first entry. Four of the victims ranged in age from 11 months to 18 months old; they were trapped in openings from 2.5 to 4 inches. The other two victims were 2 1/2 and 3 years old; they were trapped in 5- and 10-inch openings, respectively.

Two of the home playground equipment entrapments involved the support frame. In one case, a 4-year-old put his head into an opening between two support bars, one for the frame and one for the slide platform. The distance between the bars was approximately 6-8 inches. The second incident involved a 2-year-old whose head became entrapped in a 68-degree vertex formed by two support bars on an "A" frame. This appears to be a unique case; it is the only investigation which implicated equipment components that form a vertex, and further, the problem was head entrapment rather than neck entrapment, generally associated with partially-bounded openings or angles.

There are two last entrapment cases for home equipment. An 18-month-old entered an opening between the top rung of a ladder and the slide platform. This was a fatal, head first entrapment into a 5.75-inch space. The other incident occurred between the seat and arm of a tot swing seat: a 2-year-old child entered the 5-inch opening feet first but was pulled to safety by a nearby adult.

The final category of entrapment incidents in the group of in-depth investigations reviewed by Deppa (1989) are those involving indoor toddler gym houses. Eight of the twelve cases occurred between the top rung of the ladder and the platform. Three of these eight cases involved children under two years of age, one of which was fatal. In this age group, two victims entered head first and one entered feet first; the openings ranged from 5 to 6.25 inches. The remaining five of these eight cases involved children between 2 and 3 1/2 years old, one of which was fatal. In this age group, two victims entered head first and three entered feet first; the openings ranged from 4 to 6.9 inches. Two additional cases, one fatal and one nonfatal, occurred between rungs on the ladder. The fatal case involved an 18-month-old and a 6.25-inch space; the non-fatal case involved a 5-year-old and a 5-inch space.

The design of these toddler gym houses incorporated a play space underneath the platform. A common scenario for the head first incidents was that children put their heads through openings in the ladder "either to explore or to see toys or other children inside the play enclosure" (Deppa, 1989). They then became entrapped after turning their head to a larger dimension. For the feet first incidents, it is conceivable that the children were either intentionally climbing through the opening to explore, or fell while ascending the ladder and slipped unintentionally through the opening. Current catalogs show some designs for outdoor slides with partially-enclosed play spaces underneath them; however, unlike the indoor toddler gym houses, these oudoor slides have access ladders with closed risers, thus precluding the common scenarios for entrapment found on the indoor gym houses.

Just as the above scenarios are similar to the entrapment incidents on outdoor playground equipment, the other two cases for indoor toddler gym houses are also comparable. A 2-year-old was trapped after feet first entry into an opening (6.1 inches) between a horizontal guard rail and the platform; there were four entrapments between a guard rail or protective barrier and the platform on public equipment, and also three related incidents between climbing rungs above platform level and the platform. A 22-month-old was fatally injured following head first entrapment in an opening (6.75 inches) between the underside of the slide and a horizontal support brace; there was a similar, but fatal, case on home equipment.

Trip hazards: King and Ball (1989) recognized the importance of distinguishing between falls from height and falls on the same level, which include tripping incidents. In summarizing findings from British studies (relying heavily on data from the Inner-London Education Authority), they concluded that "the majority of playground accidents involve falls on the same level," such as collisions, stumbling and tripping.

There is only one source which directly addresses falls caused by tripping over equipment. Helsing et al. (1988) reported that 9% of equipment-related injuries were falls resulting from tripping over equipment, based on data collected during the SCIPP survey.

Other studies group tripping or stumbling accidents with other data, sometimes only referring to falls on the same level without specifying those due to tripping. Data collected by Langley, Cecchi, and Silva (1987, cited in King and Ball, 1989) in New Zealand included falls from playground equipment, bicycles, and slipping and stumbling. In a group of 818 children 8 and 9 years old, 8% of 256 incidents were attributed to slipping and stumbling. In a similar study of 803 children 10 and 11 years old, data included falls from height (bicycles, sporting equipment, and playground equipment) and falls on the same level. Langley et al. found that of the 413 incidents, 15% were falls on the same level. It is unclear exactly what proportion of these involved slipping and stumbling. Langley et al. (1981) also observed that 22% of 518 injuries reported in 83 primary schools to children 5 years of age and older involved falls on the same level due to tripping, slipping, or stumbling. A study in France conducted by Fortin (1984, cited in King and Ball, 1989) recorded 151 injuries among nursery school children from December 1979 to May 1980; 55% were caused by collisions, tripping, being pushed, or slipping. The PORS study of hospital data in Holland (1987, cited in King and Ball, 1989) found that falls on the same level accounted for 15% of all playground injuries, and collision/pushing was implicated in another 14%.

5.2.2 SHARP POINTS, CORNERS, AND EDGES

Guideline content:

The Handbook recommends that there be no accessible sharp edges or points that can cut or puncture children's skin or catch clothing when the equipment is assembled in accordance with the manufacturer's instructions. It is also noted that "if the edge or point is questionable in terms of its injury potential, it should be considered as being sharp." (Volume 1; Volume 2, 7.1)

Probable rationale:

"This requirement is intended to preclude accessible points and edges that may lacerate or puncture human tissue." Since an objective test procedure has not been developed, the injury causing potential of points and edges has to be based on judgment alone. Research relative to other products is continuing on potential procedures which may eventually be applicable to playground equipment. (NBS, 1978a)

The NRPA noted that "there is no reason why all accessible exposed edges of public playground equipment cannot be hemmed, rolled, tempered, curled, or otherwise treated so as not to even raise a question about it being a sharp edge." Further, they decided not to recommend an extensive, expensive testing procedure for what was felt to be a "rather obvious common-sense type of judgment." (NRPA, 1976a)

Issues:

It is clear that sharp points, corners and edges present a hazard to children on playgrounds. Frost and Henniger (1979) pointed out that sharp or rough edges "are a common source of injuries. Cuts and scrapes, many of which require more than just a bandage to repair, are a frequent result." Further, Frost (U. of Texas, 1989, unpublished manuscript) noted that sharp jagged edges can catch children's clothing. Two other articles by Frost (1986b, 1986c) also mentioned the hazards of accessible sharp edges. Ward (1987) recognized that "poor maintenance or accumulated wear and tear can lead to the exposure of sharp edges."
In order to prevent injuries caused by sharp points, corners, and edges, most experts agree that they should simply be eliminated and equipment should be free of all such hazards (Aronson, 1988; Beckwith, 1988; Frost and Henniger, 1979; Frost and Wortham, 1988; Geiger, 1988; Kane, 1989; Stoops, 1985; Sweeney, 1982, 1985, 1987; Werner, 1982). Beckwith and Werner further recommended that all corners and edges be rounded.

Foreign standards also address this hazard. Both the Australian (AS 1924, Part 2, 1981) and the British (BS 5696: Part 2, 1986) standards state that equipment must not have any sharp or rough edges in any position which may present a hazard to the child. The German standards (DIN 7926, Part 1, 1985) do not permit pointed or sharp edges. The Canadian draft standards (CAN/CSA-Z614, 1988) and the Seattle draft standards (1986) are both quite similar to the current CPSC recommendations: there should not be any accessible sharp edges or points which could cut or puncture a child's skin or catch a child's clothing.

The Australian standards stipulate that the edges of timber and metal must be slightly rounded. The Canadian draft standards are more detailed: woodwork should be chamfered or rounded with a minimum radius of curvature of 0.35 inch. Similarly, the Seattle draft standards require that all concrete and wood edges have a minimum chamfered radius of 0.25 to 0.50 inch. The German standard for this allows a smaller minimum radius of chamfer: 0.12 inch.

The Australian standards also regulate edges for sheet materials. If sheet materials are less than 0.08 inch thick, they must be "finished on exposed edges with a neat roll or rounded capping." Requirements for the treatment of metal edges are more detailed in the Canadian draft standards. They give a general recommendation similar to Australia's for sheet materials; however, they also specify that the radius of the rolled edge should be at least 0.25 inch. Further, if the thickness of the material will not allow this, then the edges should be curled in or have rounded permanent capping so that the openings are enclosed. The Seattle draft standards state that "all metal edges shall be hemmed, eased, rolled, curled, or capped." It is also recommended that maintenance procedures include regular inspections of metal seams to ensure that no sharp edges have been exposed.

In addition to the requirements pertaining to sharp points, corners, and edges, the German standards stipulate that rough surfaces must not "carry any risk," without elaborating on exactly what constitute such surfaces. The Seattle draft standards require that finishes and surfaces not abrade children's skin or be able to catch their clothing.

Esbensen (1987) noted that playground equipment in general should be well finished and eliminate potential splinters. Several standards also give attention to the potential for wood materials to cause splinters. The Australian standards simply require woodwork to be smooth, while the Canadian standards recommend that woodwork and all gripping surfaces be splinter-free. The German standards state that "wooden playground equipment for children shall have low susceptibility to splintering," and "equipment made of other materials shall be non-splintering." The problem of splinters requires attentive maintenance, as recognized by the Seattle draft standards: wood parts must be inspected frequently for potential slivers and splinters; they should be sanded or refinished as necessary.

Recommendations:

The current guidelines regarding the hazards of sharp points, corners, and edges are certainly warranted. There should be no such hazards on any components of playground equipment which could cut or puncture children's skin. Frequent inspections are important in order to prevent injuries caused by the exposure of sharp points, corners, or edges due to wear and tear on the equipment.

Woodwork should be smooth and well finished to protect against splinters. All corners, metal and wood, should be rounded; all edges should be rolled or have rounded capping. Because there are no data regarding the feasibility and safety of different radii of curvature or chamfer, performance criteria are difficult to specify.

Special attention to sharp edges on slides, especially metal ones, is warranted: both the sides along the slide chute and the exit end can be particularly dangerous if protective measures are not taken (see Sections 5.7.1.3.3.3 and 5.7.1.3.4.5).

5.2.3 PROTRUSIONS AND PROJECTIONS

Guideline content:

Similar to the recommendations for sharp edges, corners, and points, the guidelines state that there should be no accessible protruding points or ends which could cut or puncture children's skin or catch their clothing. (Volume 1)

Volume 1 recognizes that "manufacturers usually provide self-locking nuts or other devices to prevent nut and bolt assemblies from coming apart." Both volumes further note that all such fasteners as well as any exposed ends of bolts should be covered with smooth finished protective caps, covers, or the equivalent; these should not be removable without the use of tools. As explained in Volume 2, "when properly torqued, the recommended length of the protruding bolt end should be such that the cap or covering fits against the nut or surrounding surface." In addition, the exposed ends of tubing which are not resting on the ground or otherwise covered, should also have protective caps or plugs which cannot be removed by hand. (Volume 1; Volume 2, 7.1)

Recommendations and a suggested test procedure to measure protrusions are also included in Volume 2. When tested in accordance with the procedures below, no protrusions should extend beyond the face of any one of the three test gauges. The dimensions of these gauges are: 1) inner diameter of 0.50 inch, outer diameter of 1.0 inch, thickness of 0.25 inch; 2) inner diameter of 1.50 inches, outer diameter of 2.0 inches, thickness of 0.75 inch; 3) inner diameter of 3.0 inches, outer diameter of 3.5 inches, thickness of 1.5 inches. The suggested test method is as follows: "successively place each gauge over each protrusion to determine if the protrusion extends beyond the face of the gauge." This test method does not apply to inaccessible protrusions, except those that may be contacted by a child falling from the equipment. (Volume 2, 7.3)

Protrusions on the front and rear surfaces of suspended members of swing assemblies are also excluded from the above test. However, separate procedures are given for this application. No surface in the potential impact region on a suspended member should protrude through the hole beyond the face of the specified gauge: minimum inner diameter of 1.25 inches, maximum outer diameter of 2 inches, maximum thickness of 0.125 inch. The gauge can be made of any rigid material. The suggested test procedure is as follows: "place the gauge over any protrusions on the front and rear surface of the suspended member such that the axis of the hole is parallel to both the intended path of the suspended member and a horizontal plane." (Volume 2, 7.3.3.2)

Probable rationale:

Exposed ends of bolts generally have a diameter that could cause a serious puncture or eye injury. In addition, the threaded ends of bolts have a textured surface with a greater potential for causing lacerations than a smooth surface would have. Therefore, the intent of these requirements is to ensure that bolts do not present such hazards. The risk of injury should be reduced if bolts which protrude beyond the nuts or surrounding surfaces are covered with protective caps. It is important to recognize that the bolt end and its covering are still subject to the requirements of the general protrusion test. (NBS, 1978a; NRPA, 1976a)

Bolts which are completely countersunk or recessed below the surface are exempt from the protrusion requirements. Although such treatment of bolts will preclude impact by the user, if the countersunk opening is still accessible a child could reach in and contact a sharp edge. Therefore, countersunk bolts must meet the requirement for sharp edges. (NRPA, 1976a)

Exposed ends of tubing could also puncture or lacerate human tissue on impact. Protective caps or plugs to cover all exposed ends are, therefore, required to prevent such injuries. (NBS, 1978a)

The suggested test methods and related recommendations are intended to prevent protrusions which could puncture, impale, or cause eye or ear injuries upon contact, or which could catch clothing and result in falls or other injury scenarios. Protrusions addressed here are the individual, narrow, and generally pointed or thin-edge type with limited contact area. Any such protrusions can be identified if they protrude beyond the back surface of any one of the three test gauges. (NBS, 1978a; NRPA, 1976a)

The following explanation of the dimensions chosen for the three test gauges was given (NBS, 1978a):

> A small diameter protrusion, because of its small surface area, generally presents a greater risk of penetration than does a larger protrusion. The gauges, therefore, have been dimensioned accordingly. The specific dimensions are based on judgments; the thickness and inside diameter dimensions were proposed by the NRPA. The gauge with the smallest opening ensures that no protrusion smaller than 0.5 inch diameter extends more than 0.25 inch from the surrounding surface. The gauge with the 1.5 inch opening ensures that no protrusion with a diameter between 0.5 inch and 1.5 inches extends beyond 0.75 inch. This is especially critical because a protrusion not meeting this requirement could project into the eye socket to depth that could result in serious injury. The third gauge has an inside diameter of 3.0 inches and is 1.5 inches thick. Thus, protrusions having a diameter between 1.5 and 3.0 inches cannot extend more than 1.5 inches beyond the surrounding surface.
>
> The width of each gauge, that is, the difference between the outside radius and inside radius is substantially smaller than that proposed by the NRPA. The argument for a larger width is based on a premise that several protrusions clustered together act as a surface and consequently do not present the hazard that a single protrusion does. This premise may be valid for protrusions on the interior of such an arrangement but not necessarily for those on the exterior....The gauge width specified in this requirement is 0.25 inch for each gauge. This width will treat all but closely clustered protrusions as individual protrusions.

No distinction is made between horizontal and vertical protrusions. Since a child can attain many different positions while playing on most equipment, it is improbable that the injuring potential of a protrusion is significantly dependent upon its orientation. For this reason, the requirements in this section do not differentiate between horizontal and vertical protrusions.

Protrusions on the front and rear surfaces of suspended members of swing assemblies are treated separately because of the potential for moving impact incidents. The rationale for impact performance requirements includes data relevant to protrusions on suspended members (see Section 5.7.2.3.1.2). The general intent of this test is to ensure that suspended members do not have protrusions which are capable of impacting the zygoma directly without bearing on other parts of the head at the same time.

Issues:

Frost (U. of Texas, 1989, unpublished manuscript) noted that "exposed, protruding bolts were common on almost all commercial metal equipment until recently." Exposed bolts and other protruding elements such as exposed tubing clearly present a hazard to children using playground equipment (Frost, 1986b, U. of Texas, 1989, unpublished manuscript; Frost and Henniger, 1979; Goldberger, 1987). In addition to causing cut or puncture injuries, protrusions are often involved in clothing entanglement incidents (Frost, U. of Texas, 1989, unpublished manuscript). In related comments, M. Ridenour (personal communication, February 1989) pointed out that vertical protrusions are a special problem because they can hook straps or ties on children's clothing as well as presenting impact hazards. As discussed previously, many of the cut/puncture injuries in the detailed incident analysis were caused by protruding bolts. Further, the additional in-depth investigations provided by the CPSC implicated protruding bolts in several slide-related clothing entanglement deaths as well as vertical and horizontal components on climbing equipment.

General recommendations that equipment should be free of dangerous protruding parts are common (Frost and Henniger, 1979; Frost and Wortham, 1988; Moore et al., 1987; Werner, 1982). Others have specifically suggested the elimination of exposed bolts and/or exposed ends of tubing (Aronson, 1988; Bowers, 1988a; Burke, 1980; Esbensen, 1987; Frost and Henniger, 1979; Geiger, 1988). In addition, Frost (U. of Texas, 1989, unpublished manuscript), Kane (1989), Stoops (1985), and Sweeney (1982, 1985, 1987) all reported the CPSC recommendations to avoid hazardous protrusions.

Each of the foreign standards reviewed addresses protrusions and projections. The Australian (AS 1924, Part 2, 1981), British (BS 5696: Part 2, 1986), Canadian draft (CAN/CSA-Z614), and German (DIN 7296, Part 1, 1985) standards all stipulate that no protrusions or projections are allowed in any positions on play equipment which may present hazards to the children. The Seattle draft (1986) standards also contain a comparable recommendation.

<u>Protective caps or plugs, and other treatments of connecting hardware</u>: Beckwith (1988) stated that "all protrusions from connecting hardware must have a permanently affixed protective covering." Both Beckwith and Frost (1986c) recommended that exposed ends of pipes be covered by caps or plugs. Kane (1989), Stoops (1985), and Sweeney (1982, 1985,

1987) all reported the CPSC recommendations regarding protective caps or plugs for bolts and exposed ends of tubing.

The German standards require protruding bolt threads to be permanently covered. The Canadian draft standards suggest that "open ends of all tubing should be provided with permanent caps or plugs which have a smooth finish, and are tight fitting." The Seattle draft standards mandate the shielding of threaded bolts, exposed ends of tubing, and rods with fixed protective caps; they further comment that the caps must not extend more than one-half their diameter and that special tools must be utilized for removal of the caps. In addition, recognition is given to the importance of inspecting equipment to ensure that all protective caps are in place and replacing any missing ones. Similarly, Ward (1987) noted that "poor maintenance or accumulated wear and tear" can lead to the loss of protective caps.

Frost (U. of Texas, 1989, unpublished manuscript) was critical of protective caps as well:

> Some efforts have been made to install smooth protective caps over bolts, but these are generally poorly secured and falls have resulted from the caps pulling loose in the grasp of children. Another more promising approach is to countersink or indent protruding bolts.

Helsing et al. (1988) and Werner (1982) each supported the idea of nuts and bolts being recessed or countersunk. In addition, the Play For All Guidelines (Moore et al., 1987) recommends that "as a general rule, all nuts and bolts should be recessed, fitted with tamper proof locks and hole plugs."

The British standards as well as the Canadian draft standards address this option in the context of other allowable treatments of connecting hardware. The British standards state that if fasteners used on any accessible part of the equipment are not countersunk or counterbored, they must be either the rounded head or hexagon types with chamfered corners. The Canadian standards suggest that all bolt ends be countersunk, and that all screws or set screws have dome heads unless they are countersunk. Both of these standards stipulate that accessible nuts must have the protruding thread cut off and the remainder peened so that no sharp edges remain.

Moore et al. (1987) noted that the CPSC guidelines allow protrusions if they are of a minimum size and length, based on the recommended test method. However, Moore et al. recognized that "most manufacturers now exceed those guidelines and have removed nearly all protrusions." The Play For All Guidelines specifies a preference for such play equipment. However, if there are protruding objects, they should never project more than their diameter; that is, a one-half inch bolt should not project more than one-half inch from the surrounding surface. Similarly, Beckwith (1988) stated that "all protrusions, even if covered, must not extend greater than the diameter of the object." The suggested test in the current guidelines allows objects to protrude slightly more than their diameter in some cases; however, others are allowed to protrude only half their diameter. If the diameter is less than 0.5 inch, the object is allowed to protrude only 0.25 inch; if the diameter is between 0.5 and 1.50 inches, the object is allowed to protrude 0.75 inch; if the diameter is between 1.50 and 3.0 inches, the object is allowed to protrude 1.50 inches.

Recommendations:

Playground equipment should not have any protrusions or projections which present hazards to the children, either of potential cut or puncture injuries or of clothing entanglement incidents.

The best approach is to eliminate protrusions and projections altogether through the design of the equipment or by countersinking or recessing all potential hazards such as connecting hardware. When this treatment is not feasible, all protruding exposed bolts and ends of tubing should be covered with permanently affixed caps or plugs which are removable only with the use of tools. These covered bolts are then subject to the protrusion criterion described below. Even when connecting hardware is countersunk, it is important to ensure that the bolt ends do not have sharp edges, so caps or plugs are still warranted.

No protrusion should extend more than one-half its diameter beyond the surrounding surface. If a protrusion extends more than one-half its diameter, it is considered hazardous. This requirement is comparable to the current protrusion tests specified in the guidelines in some cases, while it is more conservative in others. Further, it eliminates the need to use three test gauges, as required in the current procedure.

Protrusions should not increase in diameter from the surface to the exposed end. This would create a hazard for clothing entanglement since the protrusion could act as a hook.

Protrusions on suspended members of swing assemblies are a special case. As discussed with regard to impact testing (see Section 5.7.2.3.1.2), head injury data suggest that small area impacts can cause skull fracture to the zygoma (the most sensitive part of the head). Therefore, protrusions on suspended members of swing assemblies can be especially hazardous. The test specified in the current guidelines for this case is reasonable, given the potential for impact incidents.

5.2.4 PINCH, CRUSH, AND SHEARING POINTS

Guideline content:

It is recommended that playground equipment not have any accessible pinch, crush, or shearing points. Such points can be caused by components moving relative to each other or to a fixed component when the equipment is moved through its anticipated cycle of use. Further, children's clothing can become entangled in accessible parts of moving equipment. Volume 1 notes that unprotected moving parts on gliders, merry-go-rounds, or seesaws could present such hazards and crush or pinch a child's fingers. Volume 2 explains that "to determine if there is a possible pinch or crush point, consider the likelihood of entrapping a body appendage and the configuration and closing force of the components." (Volume 1; Volume 2, 7.2)

Probable rationale:

The intent of this recommendation is to prevent serious injuries such as amputations, fractures, and contusions which can result from contact with pinch, crush, or shearing points on playground equipment. "No test method is provided because the configuration and location of such points varies considerably as does the potential for injury in terms of the body part that may be entrapped and the forces which may be exerted." (NBS, 1978a)

Issues:

Several sources reported the CPSC recommendations to avoid pinch, crush, or shearing points (Frost, U. of Texas, 1989, unpublished manuscript; Kane, 1989; Stoops, 1985; Sweeney, 1982, 1985, 1987). Many others also stated that there should be no pinch, crush, or shearing points and that playground equipment should be checked for exposed mechanisms and junctures in moving components (Aronson, 1988; Frost, 1986b, 1986c; Frost and Henniger, 1979; Frost and Wortham, 1988; Goldberger, 1987; Werner, 1982).

The German standards (DIN 7296, Part 1, 1985) stipulate that there must not be any crushing or shearing points between moving and stationary parts of equipment; they make no mention of adjacent moving parts. Both the Australian (AS 1924, Part 2, 1981) and the Canadian draft (CAN/CSA-Z614, 1988) standards recommend that wherever possible, equipment be designed to eliminate possible pinch, crush, or shearing points; however, if such points are unavoidable, they should be inaccessible to the user. The Australian standards note that the specification does not apply to chains and ropes used to suspend swing assemblies. The Canadian draft standards explain that such points can be caused by "the junctures of two components moving relative to one another," which is similar to the CPSC's explanation. The Seattle draft standards (1986) are comparable to the others. They do not allow any accessible pinch, crush or scissor-like areas caused by adjacent moving parts. Further, "shield or enclose moving parts of equipment so body parts cannot be pinched, crushed or caught during normal use or reasonably foreseeable misuse." Such shields should be checked regularly to ensure that they are in place.

Certain types of playground equipment often present pinch, crush, and shearing points by nature of their design. Merry-go-rounds, seesaws, and gliders are most frequently implicated in discussion of these hazards. However, attention to good design can reduce the risks of each type of equipment by enclosing moving parts to eliminate access to the dangerous areas. Detailed discussion of these issues for each type of equipment is included in the relevant sections of this report.

Frost (U. of Texas, 1989, unpublished manuscript) made an excellent point regarding pinch, crush, and shearing areas and consideration of children's play behavior during the design process. In support of equipment designs which do not eliminate all pinch and crush points, a common argument is that these hazards are not accessible when the equipment is "used as intended."

> Such claims reflect profound ignorance of child behavior. In their normal play children will use any play equipment in a wide range of ways not "intended." If a potential hazard is present, they will be at risk. Consequently, designers must expect wide variation in play and plan for unusual and bizarre activity.

Recommendations:

The current recommendations regarding pinch, crush, and shearing points are acceptable; however, additional specifications are also warranted to alert readers to the dangers on certain types of equipment since such hazards are known to cause serious injuries.

There should be no accessible pinch, crush, or shearing points on playground equipment which can injure children or catch their clothing. Such points can be caused by the juncture of adjacent moving components or of a moving component adjacent to a stationary component. All moving parts should be enclosed to prevent access.

Merry-go-rounds should not have any openings or holes on the base which allow children to contact shearing components in the equipment's axle or undercarriage (see Sections 5.7.4.3.1 and 5.7.4.3.3). Springs on rocking equipment should be designed to eliminate the possibility of children pinching or trapping appendages or limbs between the coils (see Section 5.7.6.3.3). The fulcrums of seesaws should be totally enclosed (see Section 5.7.5.3.1). More detailed recommendations are included individual discussions of these types of equipment.

5.2.5 CLOTHING ENTANGLEMENT

Guideline content:

Volume 1 addresses clothing entanglement as a general hazard; however, Volume 2 does not contain any recommendations pertaining to this hazard. Accessible parts of moving equipment should be designed so that they cannot catch clothing. In addition, components next to sliding surfaces such as ladders and uprights, protective barriers, and handrails, should also be designed to protect against clothing entanglement. "If clothing is entangled, the equipment's or the child's momentum is often great enough to cause loss of balance or an injury." (Volume 1)

Open S hooks can catch clothing and should, therefore, be avoided. The ends of any open hooks on equipment should be pinched tightly closed. The guidelines also mention that in addition to causing cut and puncture injuries, sharp points, corners and edges as well as protrusions and projections can catch children's clothing. (Volume 1)

Probable rationale:

No technical rationale for the above recommendations is directly stated. Presumably, such efforts are intended to reduce injuries, many of which are very serious, that often result from children's clothing becoming entangled with playground equipment. The NRPA documents simply state that "open hooks or other devices do represent a potential problem and should not exist on the equipment" (NRPA, 1976a)

Issues:

As discussed in the injury review for general hazards, clothing entanglement can be a serious problem. It is common for such incidents to cause death due to asphyxiation and strangulation, because the clothing can tighten around the child's neck as either the equipment or the child is in motion. Slides are frequently involved in clothing entanglement injuries and fatalities: protruding bolts or components at the top of the slide can catch children's clothing before they slide down the chute. Open S hooks on swings have also been implicated in a few cases.

Documented cases of clothing entanglement have shown that often children's jackets and hoods of jackets were involved in the incidents. Frost (1986b) noted that ponchos can also contribute to these injuries. Other problems have been ropes or different things that children carry around their necks while playing on equipment.

Goldfarb (1987) stated the issue quite simply: "avoid play equipment which may entangle a child's clothing." Several sources reported the CPSC recommendations regarding clothing entanglement, including the warning about open S hooks (Kane, 1989; Stoops, 1985; Sweeney, 1982, 1985, 1987). Both Frost (U. of Texas, 1989, unpublished manuscript) and Goldberger (1987) recognized the potential for sharp edges and protrusions to catch clothing. Frost pointed out that protruding components on the upper portions of equipment are especially dangerous, because they can cause suspension and strangulation. Similarly, M. Ridenour (personal communications, February 1989) noted that vertical protrusions can hook straps or ties on children's clothing, as previously discussed. Beckwith (1988) stated that "all parts of the playground including connecting hardware and handholds must not be capable of entangling clothing."

S hooks are most often used on swing assemblies, both to connect the seat to the suspending chains and in the hanger mechanism. If such hooks are open, they can easily catch clothing or cause lacerations. Many experts, in addition to those mentioned above who reported the CPSC guidelines, warn against the use of open S hooks and recommend that all such hooks be tightly closed by pinching the ends together (Aronson, 1988; Beckwith, 1988; Gilje, 1989; Goldberger, 1987; Werner, 1982). The use of S hooks is more fully discussed in the swing section of this report (see Section 5.7.2.3.2).

The Seattle draft standards (1986) addressed potential clothing entanglement with recommendations similar to those of the CPSC. "In general, accessible parts of moving apparatus and components next to moving children should be designed so they cannot catch a child's clothing." They also noted that sharp points or protrusions which could catch clothing should be avoided. Further, all S hooks are required to be closed. King and Ball (1989) discussed Canadian guidelines published by the Canadian Institute of Child Health (1985). These guidelines focus on inspection of equipment: "children can get caught on protruding surfaces or entangled among bars and ropes. Check slides, ladders, guardrails, protective barriers, climbing bars and balance boards for protrusions that can catch clothing or limbs."

Frost (1986b) discussed clothing entanglement as a major problem for home equipment:

> Hangings are a common cause of fatalities on back-yard playgrounds. These appear to be caused by faulty design, protruding parts and exposed bolts that entrap clothing.
>
> Children may also be unsupervised for long periods of time in back-yard playgrounds so the child who is accidentally suspended by the head or neck does not have the immediate adult assistance usually available at school playgrounds.

Recommendations:

The current guidelines for clothing entanglement are warranted; however, the recommendations regarding S hooks should include specific reference to swing assemblies.

Playground equipment should not be capable of entangling children's clothing. Protrusions and projections should be avoided since they can catch clothing; this can be especially hazardous at the top of equipment. All accessible moving parts also have the potential to entangle clothing and should be designed to prevent such incidents. Components next to sliding surfaces, including ladders, handrails, and protective barriers, should be designed so they cannot catch clothing. Horizontal and vertical members of climbers or multi-use equipment which are attached to structures on only one end, such as vertical posts, also present entanglement hazards since they can hook children's clothing.

Open S hooks on swings are a clothing entanglement hazard and should be avoided (see Section 5.7.2.3.2). Any open hooks on equipment should be closed by pinching the ends tightly together.

5.2.6 ENTRAPMENT

Guideline content:

Volume 1 discusses entrapment in its section on general hazards. "No component or group of components should form angles or openings that could trap any part of a child's body or a child's head." It is further explained that "if part of an accessible opening is too small to allow children to withdraw their heads easily and the children are unable to support their weight by means other than their heads or necks, strangulation may result." Swinging exercise rings which have diameters between five and ten inches are given as an example of an entrapment hazard, and it is recommended that all such rings be removed from playgrounds. In addition, narrowly spaced horizontal bars are recognized as a potential entrapment hazard, but specific dimensions are not stated: "if the distance between the bars is less than the height of a child's head, children will have difficulty rotating their heads backward to free them." (Volume 1)

Volume 2 contains a separate section for entrapment, which includes both general comments and suggested test procedures. In general,

> to ensure that a child's arms, hands, or other body parts cannot become lodged in the equipment when the momentum of the child or the equipment is sufficient to cause injury or a loss of balance, accessible components of moving apparatus and components adjacent to sliding surfaces (protective barriers, sides, handrails, etc.) should not be of a configuration that can entrap any part of a user's body. (Volume 2, 10.1)

With regard to head entrapment, guidelines are recommended for angles and openings which are accessible according to the suggested test method, "to prevent a component or group of components from forming an angle or opening that can trap a user's head." Note that this is similar to the general statements made in Volume 1; however, the specific guidelines for angles and openings are only in Volume 2. (Volume 1; Volume 2, 10.2)

The suggested test method uses a three-dimensional probe to determine whether an opening is accessible. The probe is a rectangle with radiused corners with a third dimension added for depth: the length is 6.0 inches, the width is 5.0 inches, the radius of the corners is 2.5 inches, and the depth is not specified. "If the probe penetrates an opening to a depth of at least 4 inches, or if the unbounded part of a partially bounded opening is at least 1.75 inches wide, the opening can be considered accessible." If it is accessible, the opening is subject to the specifications below to determine whether it agrees with the guidelines. (Volume 2, 10.2.2)

The recommendations are as follows:

> Angles - Angles formed by adjacent surfaces on the boundary of an accessible opening should exceed 55 degrees.

Distance - The distance between two opposing interior surfaces forming the boundary of an accessible opening should not be less than 7 inches when measured perpendicular to each surface.

Projected Lines of Intersection - For components that do not form a vertex, the angle is determined from the projected lines of intersection. This angle should agree with the recommendations stated above for angles. Parallel surfaces should agree with the recommendations stated above for distance. (Volume 2, 10.2.1)

There are four exceptions to these guidelines.

Exception 1 - Angles less than 55 degrees with a lower leg projecting more than 10 degrees below horizontal.

Exception 2 - Angles and portions of accessible openings less than 24 inches above the ground or similar surface which provides the same opportunity as the ground for supporting the body.

Exception 3 - Accessible openings that are completely unbounded by a lower surface.

Exception 4 - Angles less than 55 degrees that have been filled or similarly covered such that the recommendations for distance between interior opposing surfaces is met. (Volume 2, 10.2.3)

Probable rationale:

For the general entrapment recommendations, the rationale is stated in the guidelines. The concern is that a child's body parts may become entrapped by certain parts of equipment and the momentum of either the child or the equipment could cause injury. "Should entrapment occur, a child could fall or be thrown from the equipment, dragged by a moving apparatus, or injured in some manner." For example, if a slide has guard rails or handholds at the top of chute which form a vertex with the sides, the hand or arm of a sliding child could get trapped in this vertex. "The determination that an entrapment hazard exists should be guided by the location, orientation, and accessibility of the components, and the user's anticipated activity." (NBS, 1978a)

The guidelines also state part of the rationale for the recommendations to guard against head entrapment in particular. If part of an accessible opening, partially or completely enclosed, is too small to allow withdrawal of the head, entrapment may occur; further, if the entrapped child cannot support his or her weight by means other than the head and neck, this may result in strangulation. Any enclosed opening that allows insertion of the head or any partially enclosed opening that allows insertion of the neck may present very hazardous situations. (NBS, 1978a)

A single, approximately horizontal edge, say a one-inch diameter bar, will not entrap the head of an otherwise unsupported individual because the neck will permit the head to rotate backward, thereby releasing the individual. However, a second bar, placed essentially parallel and above the first at a distance less than the head height of the individual will prevent this rotation and consequently trap the individual's head. Similarly, if the upper bar is replaced by two bars perpendicular to the first and approximately parallel at a distance less than head width apart, the head will be prevented from rotating back and releasing the individual. Preventing this form of entrapment is the underlying motivation for the requirements of this section. (NBS, 1978a)

The probe specified in the guidelines to determine which openings are accessible represents the head height and head width of the minimum user (NBS, 1978a). Head height for the 5th percentile 5-year-old is 6.5 inches; the probe has a length of 6 inches. Head breadth for a 5th percentile 5-year-old is 5.2 inches; the probe has a width of 5 inches. Note that the dimensions chosen by the CPSC are conservative with respect to the anthropometric data for these head measurements of a 5th percentile 5-year-old.

"Openings that do not permit the insertion of the probe but are not completely enclosed are accessible if the unbounded part of the opening is greater than the neck diameter of the minimum user." The corresponding anthropometric measure is neck breadth, which is 2.6 inches for the minimum user (5th percentile 5-year-old). In the guidelines, 2.6 inches was reduced to 1.75 inches for this requirement to account for compression of the neck tissues. (NBS, 1978a)

The minimum distance allowed between two opposing interior surfaces (7 inches) "is based on the head height of the maximum user," (95th percentile 12-year-old), which is 8.5 inches. The 7 inch specification allows for "compression and a slightly smaller distance between the top of the head and a point in front of the neck." It would not be appropriate to apply this recommendation to adjacent surfaces which form an angle, and, therefore, a minimum angle is also specified. The 55 degree angle was proposed by the NRPA and is specified in the NBS voluntary standards for home playground equipment. "The choice of this angle is based on best engineering judgment of a potentially hazardous angle for entrapment." (NBS, 1978a)

There are several exclusions from the requirements for head entrapment. When an angle has a lower leg which projects more than 10 degrees below the horizontal, a child would tend to "roll out" or "slide out" rather than becoming entrapped; therefore, such configurations are excluded. Similarly, openings which are completely unbounded by a lower surface are also excluded. "Surfaces and angles less than 24 inches above the ground or similar horizontal surfaces are exempt from the requirements because an entrapped user's feet will touch the ground or surface, thus providing necessary support." It is noted that "the standing erect height up to the bony prominence slightly below the neck of the minimum user is 31 inches." (NBS, 1978a). It is unclear exactly what this measurement is; however, a similar estimate would be the suprasternale height, which for a 5th percentile 5-year-old is 30.5 inches. For a 5th percentile 2-year-old, this dimension is 26.2 inches, and so 24 inches would not be as conservative, proportionately, for the younger age group.

The NBS documents recognize that "a test based solely on the ability to insert a probe (simulating head dimensions) as the means for identifying potential hazardous openings does not take into account the configuration of many hazardous openings." Two examples of openings which present such entrapment hazards are given. First, consider a vertical opening that is unbounded on the top which, although it would not allow insertion of the head probe, would allow insertion of a child's neck. In this situation a child who loses the ability for normal support would be trapped. Second, consider an enclosed opening with two rectangular compartments forming an L-shaped area. The dimensions could be such that the head probe can safely enter and exit one section, but only a child's neck would fit into the other section, causing a head entrapment hazard similar to that of the first example. (NBS, 1978a). The CPSC guidelines do not contain any recommendations which address these particular situations.

Issues:

Several sources reiterated the CPSC general recommendations and warnings regarding swinging exercise rings with diameters between 5 and 10 inches (Kane, 1989; Goldberger, 1987; Stoops, 1985; Sweeney, 1982, 1985, 1987). Others have also noted that entrapment of body parts, especially the head, is a common playground hazard, and equipment should be free of openings or angles that present such hazards (Frost, 1986b, 1986c, U. of Texas, 1989, unpublished manuscript; Frost and Henniger, 1979; Werner, 1982).

The organization of the entrapment recommendations in the current guidelines can be confusing as well as misleading. Volume 1 and Volume 2 present different information, both with regard to the level of detail and the specific recommendations. There is concern that if someone were to read only Volume 1, important information could be missed. For example, because no reference is made to the testing procedures or the dimensions for openings or angles which are given in Volume 2, one might assume that the only specific recommendations from the CPSC are those for swinging exercise rings. In addition, the recommendation in Volume 2 that distances between opposing interior surfaces should not be less than 7 inches conflicts, in certain cases, with the statement in Volume 1 that swinging exercise rings with diameters of 5 to 10 inches present an entrapment hazard and should be removed. Rings with diameters of 8, 9, or 10 inches, for example, are hazardous according to Volume 1; however, because the probe would determine that such rings were accessible openings and the distance between interior opposing surfaces is greater than 7 inches, they would pass the entrapment tests in Volume 2.

There is also evidence in the literature that the current entrapment guidelines are not adequate. For example, Preston (1988) noted that "entrapment incidents have occurred in openings which conformed to the recommendations in the current guidelines." Moore et al. (1987) stated that the language used by the CPSC is "not especially clear" for the recommended opening size. They indicated that many "manufacturers have adopted a simple formula: openings must be smaller than three inches or larger than seven inches." Many others also give recommendations for what constitutes a safe opening; the common factor is the suggestion of a range of distances which present entrapment hazards, in contrast to the CPSC guidelines which only state that openings should not be less than seven inches. L. Witt (personal communication, March 1989) stated that the age group at greatest risk for head entrapment is from 2 to 5 or 6 years, and that openings from about 3.5 to 10 inches are hazardous. Frost (U. of Texas, 1989, unpublished manuscript) noted that some toddlers' heads will pass through a 4.5 inch opening, so the tolerances proposed in the Seattle (1986) and Canadian (CAN/CSA-Z614, 1988) guidelines (openings must be less than 4.3 inches or more than 9.8 inches) are inappropriate. In order to protect 2-year-olds with 4.5 inch heads, Frost recommended that equipment not have any openings which are between 4 and 8 inches (Frost, 1986b, personal communication, February 1989; Frost and Wortham, 1988). Reasoning similar to Frost's was used by Esbensen (1987). For children 1 to 5 1/2 years old, the minimum head breadth is 4.5 inches and the maximum distance from chin to back of head is 8.9 inches; these head dimensions "mean that a child's head can become trapped in an opening that is between 4.5 and 9 inches." Beckwith (1988) explained that to prevent head entrapment, openings from 5 to 7 inches have to be removed or filled. D. Thompson (personal communication, February 1989) stated that openings should not be between 4 and 11 inches. Taking all views from the above sources into account, openings which range from 3 to 11 inches can be hazardous.

Fewer sources addressed requirements for hazardous angles. D. Thompson (personal communication, February 1989) simply noted that angles where equipment parts come together is one issue to be considered for head entrapment. Beckwith (1988) stated that any "V" shaped intersections of components which are 55 degrees or less, 10 degrees above the horizontal, or more than 24 inches above ground "must be removed or filled to prevent entrapment." Beckwith's recommendations are similar to those of the CPSC. It is interesting to note that "the current industry trend is to remove acute angles wherever possible," or to fill them in if they cannot be removed (R. Moore, personal communication, February 1989).

In addition to the general entrapment recommendations for openings and angles discussed above, several experts made comments regarding specific types or components of equipment. For example, L. Witt (personal communication, March 1989) explained that Montgomery County, Maryland, has removed some monkey bars and arch climbers because they posed entrapment hazards. The bar spacing at the top of some arch climbers, where the two halves come together, is between 5 and 6 inches. Another common entrapment scenario recognized by Witt is that children may climb off the side of an enclosed deck feet first but trap their heads, presumably between the guardrail or protective barrier and the platform; therefore, the guidelines should address feet first entry in the entrapment recommendations. M. Ridenour (personal communication, February 1989) also noted that feet first entrapments are common and suggested that openings should be smaller than the 5th percentile female hip breadth for 2-year-olds (6.3 inches), with a safety margin for compression.

Guard rails and protective barriers which enclose platforms must also be considered. Frost (1986b) stated he was aware of injuries and fatalities leading to lawsuits which included "apparent suffocation from entrapment of the head in guard rails." In his discussion of climbing structures, Esbensen (1987) stated that openings between 4.25 and 9 inches can cause fatal entrapments, and therefore, equipment should be inspected to ensure that boards and enclosure bars will not trap children's heads or arms. The Seattle draft standards stipulate that vertical infill for handrails and barriers must be no more than 5 inches apart to prevent head entrapment. Similarly, the British standards (BS 5696: Part 2, 1986) require that where vertical bars are used as guard rails, they must not have gaps greater than 4 inches. Further, infilling must not form finger, hand, limb, head, or wedge traps. The Canadian draft standards recommend that guard rails have no clear distances between 4 and 10 inches. In addition, they specify that "the maximum clear distance between horizontal components should be 12 inches and between vertical components, 4 inches."

Ladders are another source of potential head entrapment (Frost, 1986b). Correct spacing between rungs or steps on ladders is important "to prevent children slipping through and sustaining serious head, neck, and facial injuries" (Parry, 1982, cited in King and Ball, 1989). Geiger (1988) also recognized that steps must not be so closely spaced that children's feet or heads can squeeze through and get stuck. As with his treatment of climbing structures, Esbensen (1987) noted that if openings between rungs are between 4.25 and 9 inches, they must be filled to prevent head entrapment. Preston (1988) also made an important point regarding the spacing of ladder steps and rungs:

> The current spacing recommendation is between 7 and 11 inches when measured between the top surfaces of two consecutive steps or rungs. A vertical ladder could conform to this recommendation but its rung spacing could present a head entrapment hazard. Most people knowledgeable on the hazard of head entrapment believe that openings should have their interior boundaries no less than 9 inches apart.

Preston concluded that any recommendations concerning spacing of components to prevent entrapment ought to be consistent with recommendations for the spacing of steps and rungs on ladders.

A few other general comments regarding entrapment are noteworthy. Frost (U. of Texas, 1989, unpublished manuscript) suggested that horizontal openings are more likely to entrap children's heads than vertical openings. It is unclear whether "horizontal" and "vertical" were intended to refer to the plane of the opening, or if Frost was using "horizontal" to describe an opening with width greater than height and "vertical" to describe an opening with height greater than width. Frost further commented that openings are more likely to cause entrapment injuries in situations where a child can lose his or her footing than where the child can maintain footing and support the body by the legs rather than the head and neck. In addition, he recognized that "openings in equipment that originally would not entrap could change in configuration due to bending, warping, or loose installation," and therefore, "regular inspection and proper maintenance is essential."

The following two sections, 5.2.6.1 and 5.2.6.2, continue the discussion of entrapment issues with a comparison of the standards and a review of a recent CPSC report on structural entrapment.

5.2.6.1 Comparison of standards

The only standard reviewed which does not include specifications for test probes or templates is the Seattle draft standard (1986). Similar to the general CPSC guidelines, the Seattle draft standards recommend that components of equipment should not form hazardous angles and openings and define what dimensions are hazardous. "Play spaces shall have no angles or openings which can trap and injure part of the body." Distances between two opposing interior surfaces must not be less than 10 inches, measured perpendicular to each surface; if openings are completely unbounded on the bottom or less than 24 inches above ground, they are exempt from requirement. Note that these exemptions are identical to those of the CPSC in their recommendation that opposing interior surfaces not be less than 7 inches apart. The Seattle draft standard goes on to state that "to guard against strangulation, equipment openings must be less than 5 inches or more than 10 inches inside diameter." This is a similarity to the CPSC guidelines which state that swinging exercise rings with inside diameters between 5 and 10 inches present an entrapment hazard. However, unlike the CPSC guideline, this Seattle guideline does not conflict with their first specification, but it does apply a minimum as well as a maximum. The angle requirements given in the Seattle draft standards are also comparable to the CPSC guidelines. "All angles on equipment more than 10 degrees above the horizontal should exceed 55 degrees. Cover equipment angles less than 55 degrees."

The most striking difference between the CPSC's entrapment criteria and those of the foreign standards is that while the CPSC specifies only one test probe based on head dimensions of a minimum user, the Australian (AS 1924, Part 2, 1981), British (BS 5696: Parts 1 & 2, 1986), Canadian draft (CAN/CSA-Z614, 1988), and German (DIN 7926, Part 1, 1985) standards each specify two test probes to address both the minimum and maximum users. However, the Australian standards are the only source which state exactly who the minimum and maximum users are and what head dimensions the probes are based on. It is important to note that although the CPSC guidelines do not specify two probes, the criteria that accessible openings (as determined with the test probe based on the minimum user) should not be less than 7 inches for interior opposing surfaces are based on the maximum user's head height. Another important distinction between the standards is that only the Australian and Canadian draft standards address the possibility of neck entrapment by accounting for relevant neck dimensions in the design of their probes, as discussed below. However, the CPSC does take neck entrapment into account by using the 1.75-inch criterion to determine whether a partially-bounded opening is accessible.

Although the probes are different shapes and sizes, the general performance criteria of the foreign standards reviewed are comparable. Like the CPSC entrapment test, all of these standards account only for head first entry scenarios and do not address the possibility of feet first entry. As stated in the Australian standards, "the use of the two probes will ensure that any space which allows the entry and passage of the smallest head also allows entry and passage of the largest head." This is the basic criterion for the Australian, British, Canadian draft, and German standards. A opening can pass the test in one of two ways: 1) if the small probe does not enter; or 2) if the small probe does enter, the large probe must also be able to enter and exit freely. Implications for the design of the probes are as follows: the small probe must be smaller than the minimum user's head to prevent entry of the smallest head; the large probe must be larger than the maximum user's head to allow safe entry and exit of the largest head. Despite the similarity of the general criteria, the results of the test will vary because the test probes and the details of the actual procedures are different.

Table 5.2 - 1 presents a comparison of the test probes specified by the various standards. There are three different types of probes used. Both the CPSC and the British probes represent the head only: they are three dimensional with a cross-section that is a rectangle with radiused corners. As discussed previously, the CPSC's rationale stated that the dimensions of the probe correspond to the head height (6.5 inches) and head breadth (5.2 inches) of the minimum user, a 5th percentile 5-year-old (NBS, 1978a). The small British probe (Probe A) has the same dimensions as the CPSC probe. However, it is unclear what anthropometric measures guided the development of the British probes, small or large. For the small probe, they could have used head height and head breadth following the CPSC rationale, but it is also conceivable that they used head length and head breadth, since for a 5th percentile 5-year-old, both head height and head length are 6.5 inches. In trying to understand an anthropometric basis for the large British probe (Probe B) which presumably would parallel the dimensions of the small British probe (Probe A), there is one important distinction to be made: for the small probe, the dimensions are smaller than the corresponding anthropometric measures; but for the large probe, the dimensions should be equal to or greater than the corresponding anthropometric measures. For a 95th percentile 5-year-old, both head height and head length are 7.5 inches and head breadth is 5.8 inches; for a 95th percentile 12-year-old, head height is 8.5 inches, head length is 7.8 inches, and head breadth is 6.0 inches. The length of the larger British probe is approximately 8 inches, which would allow exit of the head length dimension but not the head height dimension of a 95th percentile 12-year-old. The 8-inch length of the probe would be a conservative measure for both the head height and head length dimensions of a 95th percentile 5-year-old. The width of the larger British probe is approximately 7 inches, which is sufficient to protect the head breadth dimension of a 95th percentile 5-year-old as well as a 95th percentile 12-year-old.

The Australian and the Canadian test probes simulate the head as well as the neck, for both minimum and maximum users. The probes consist of a sphere (to represent the head) which is connected to a cylinder (to represent the neck). The Australian standards explain that the diameter of the sphere on the smaller probe (Probe A), approximately 5 inches, is based on the minimum head dimension of the smallest likely user, which is the head breadth of a 5th percentile child from the 2- to 3 1/2-year-old group, 4.9 inches. The diameter of the sphere on the larger probe (Probe B), approximately 9 inches, is based on the maximum head dimension of the users in the 12- to 18-year-old group. The head heights of a 95th percentile 12-year-old, a 95th percentile 15-year-old, and a 95th percentile 18-year-old are 8.5, 9.0, and 9.3 inches, respectively. So, while this probe will protect the 12- to 15-year-olds, it will not protect 18-year-olds; however, because it appears questionable whether 12-year-olds are even at risk for head entrapment on playground equipment, 18-year-olds do not warrant attention in such tests.

The neck cylinder on the two Australian probes is the same. The diameter of the cylinder is based on the neck breadth of the minimum user, 2.4 inches, "with a reduction to account for compression of the neck tissues." Note that this is similar to the rationale for the CPSC procedures to test all partially enclosed spaces which have openings that are 1.75 inches or more, because they would admit the neck of the minimum user. Neck breadth, however, is not represented on the CPSC probe. The Australian standards do not explain their choice of 7.87 inches for the length of the cylinders.

The Canadian draft standards do not state their rationale for the dimensions chosen to represent the head and neck on their test probes. However, the dimensions of the cylinders on both the smaller (Probe A) and larger (Probe B) probes are identical to those of the Australian probes. With regard to the spheres, the Canadian probes are more conservative than the Australian probes: the smaller diameter (4.33 inches) is smaller than that of the Australian small probe (5.00 inches), and the larger diameter (9.84 inches) is larger than that of the Australian large probe (9.06 inches). The small Canadian probe would protect even the smallest dimension (head breadth) of a 5th percentile 10- to 12-month-old, which is 4.5 inches. The large probe is substantially larger than the head height dimension of any child likely to be at risk of entrapment, and therefore, should serve its purpose in identifying hazardous openings that would permit entry but not exit of the maximum user's head.

The German standards are unique in their approach to entrapment test probes, which are cylinders mounted on a handle. Probe A is "for the shoulders, body, and head of the smallest user:" the diameter is 4.72 inches and the length is 3.93 inches. Probe B is "for the head of the biggest user:" the diameter is 7.87 inches and the length 3.93 inches. There is no explanation for why these particular dimensions were chosen; however, a review of anthropometric data is helpful in evaluating the probes. With regard to the small probe for the shoulders, body, and head, assuming that a 5th percentile 2-year-old is the minimum user, the following anthropometric measures could be relevant: shoulder breadth (8.7 inches), hip breadth (6.2 inches), upper torso depth measured at the level of shoulder circumference (4.4 inches), buttocks depth (3.5 inches), and head breadth (5.0 inches). While this probe will prevent entry of the head breadth, hip breadth, and shoulder breadth dimensions of a 5th percentile 2-year-old, it is not small enough to prevent entry feet first entry based on buttocks depth or upper torso depth which could present an entrapment hazard for the head. With regard to the large probe designed for the head, the largest head dimension of the maximum user is the important measure. This German probe is sufficient to allow exit of the head height dimension of a 95th percentile 5-year-old (7.5 inches) but not that of a 95th percentile 12-year-old (8.5 inches). However, for a 95th percentile 5-year-old, the tip-of-chin to back-of-head distance is approximately 9 inches, which is larger than head height for this age, and the probe would not allow exit of this dimension.

As mentioned previously, although the general performance criteria are comparable for all of the foreign standards reviewed, the specific procedures required for the entrapment tests are different. One important detail of the various test methods is the orientation in which the probe is inserted and whether any rotation of the probe is required before withdrawal of the probe. The British standards are the most comprehensive on these two issues. They require that the probes be applied "in every accessible position and in any possible orientation that is likely to be reached by the child during use of the equipment." They further mandate rotation of the head-shaped probe through 90 degrees before attempting to remove them, which, in effect, tests the openings with both dimensions of the probe, length and width. This is presumably intended to address a problem common for young children: the head can pass through an opening in one orientation but cannot be withdrawn if the child then turns his or her head.

In contrast, the Australian standards explicitly state that the spherical shape of the probe "simplifies the test as it eliminated the need to alter its orientation as would be the case in using a head-shaped probe." Using the Australian probes, rotation would not affect the results because regardless of how a sphere is rotated, the same dimension (its diameter) is always being tested. Although a parallel explanation is not made in the Canadian draft standards, the similarity of the probes and test procedures allows the same argument for insertion of the probes in any orientation without rotation. The German standards do not discuss the orientation in which the probes are to be applied or the need for any rotation before removal. However, as was the case for the Canadian draft standards, the reasoning behind the Australian standard is applicable: like a sphere, the cross-section of a cylinder has only one relevant dimension to be tested, its diameter. Rotation is necessary with the British probes because they have two different cross-sectional dimensions, length and width, and the opening must not pose an entrapment hazard for either measure.

The Australian and Canadian draft standards are the only tests which contain procedures to determine potential neck entrapment spaces. In addition, they are the only tests which specifically address both enclosed and partially enclosed openings. The Australian standards require that for spaces which the larger probe can enter, the neck cylinder must be maneuvered into all angles or openings within the space boundaries to check for neck entrapment hazards. Further, for all partially enclosed spaces, the neck probe must be used to determine if any such spaces "would allow the neck of the probe to enter but then would entrap the head of the probe." The Canadian draft standards stipulate that if the cylinder portion of either probe (they are identical) can be inserted into an "open-ended spacing between two parts of a structure," there is the potential for neck entrapment. They explain that when playground equipment is tested in accordance with the suggested procedures and probes, "the size, shape, and design of accessible spaces, whether fully or partially enclosed, should allow passage or full insertion of Probe B without becoming entrapped in any way," referring to both the head and neck pieces of the probe.

Although the CPSC has separate criteria for angles, not all of the foreign standards do. The German standards make no mention of angles at all. The Australian standards include angles in their tests for openings, applying the same probes and procedures to both types of spaces. The Canadian draft standards are almost identical to the CPSC's recommendations for angles. They simply state that "angles formed by adjacent surfaces on the boundary of an accessible opening should be equal to or exceed 55 degrees." The two exceptions stated in the Canadian draft standards for angles are also similar to those of the CPSC, as discussed below. The British standards define a wedge trap as "any trap formed by an acute angle between two or more adjacent parts that converge in a downward direction." They specify that no wedge traps are allowed on any part of the equipment 3.3 feet or more above ground level "on which a child can walk or gain access to higher levels." Further, they recommend that in order to prevent wedge traps in the direction of motion on slides, handrails at the top of the slides should be infilled or solid.

Entrapment criteria for angular spaces was also addressed in ASTM F-1004-86 Standard Consumer Safety Specification for First-Generation Standard Expansion Gates and Expandable Enclosures. This specification addresses gates and enclosures which have both V-shaped and diamond-shaped openings. The test methods require the use of two templates. Because the children at risk for entrapment incidents associated with these products are aged 6 to 24 months, the actual dimensions of the test templates are not relevant to discussion of playground equipment, where the minimum user is generally thought to be a 2-year-old; however, the rationale behind the design of these templates highlights some interesting points. Test template A is used for the completely-bounded openings on these expandable gates or enclosures. It was determined that a child could either approach such an opening head-on or present the top of the head to it. The template is head-shaped and "represents head breadth circumference of the widest part of the top of the head of the child." The procedure for using this template is also important to note: "the size of any completely-bounded opening shall not permit passage of test template A when the template is rotated to any orientation about its own axis and parallel to the plane of the opening." Like the British standards, this ensures that both the length and width of the probe are tested. The length and width of this ASTM template correspond to the length and width associated with head breadth circumference, which presumably are the head length and head breadth dimensions. Test template B is used for the partially-bounded openings on these expandable gates or enclosures. The rationale explained that when dealing with head and neck entrapment in V-shaped openings, non-hazardous openings are those angles which are "too narrow to admit the smallest user's neck or too wide to entrap the largest user's head." The template shape is similar to a front view of the face. It "combines the smallest user's neck breadth with the largest user's head height and head breadth, and with an angle larger than the largest angle of a V-shaped or diamond-shaped opening at the respective base of the 'V' known to have entrapped a child's head." Further, it is noted that for some entrapment cases, the angles of hazardous V-shaped openings are known, and "those incidents support the CPSC's original belief that openings with less than approximately 75 degrees at the base of the 'V' may entrap a child's head or neck."

Several exceptions are stated in the CPSC guidelines for which the entrapment criteria do not apply. For example, openings or angles less than 24 inches above the ground or a similar supporting surface are exempt from the requirements. Both the Australian and German standards contain comparable exceptions in their testing criteria. The CPSC also exempts accessible openings that are completely unbounded by a lower surface. The Australian standards state a similar exception. Unlike the CPSC guidelines, the British standards do not apply to the means of access to equipment, and the German standards exempt ladder-type ascents. The only exceptions stated in the Canadian draft standards pertain to angles. Like the CPSC, the Canadian draft standards exempt angles which have at least 10 degrees below the horizontal. Further, "angles less than 55 degrees are permitted if they have been filled or similarly covered such that the surfaces forming the angle are a minimum of 9.8 inches apart." This specification is also like one of the CPSC exceptions; however, the Canadian 9.8-inch separation requirement (which corresponds to dimensions of the large head probe) is more conservative than the CPSC's 7-inch separation requirement. The ASTM standard (F1004-86) discussed above for expansion gates and expanable enclosures does not allow any exemptions; all openings, completely- and partially-bounded are subject to the test, regardless of their height above ground.

Entrapment hazards on moving equipment are addressed simply in a general statement in the CPSC guidelines. Only the British standards contain separate test procedures for moving equipment. The entrapment criteria specifically require the procedures for static equipment to be carried out, including use of the probes, for moving equipment in its stationary equilibrium position. Additional procedures are then given for moving equipment in order to address potential entrapment spaces exposed by its motion. These procedures are as follows:

> Set the equipment in motion and visually inspect throughout its range of motion, recording all positions of the equipment at which any part normally accessible, or any parts becoming exposed and likely to be reached by the child during use of the equipment, form a potential entrapment or crushing hazard with other adjacent or newly exposed stationary or moving parts.
>
> For the purposes of these tests it is assumed that a child can sit or lie in position so as to be just clear of the equipment when in motion.
>
> Rigidly support the equipment in each of the noted positions in turn. Apply the probes using the procedure described for all equipment.
>
> Caution. In the interests of safety, care should be taken to ensure that secure supports are used to keep moving equipment in a position away from its equilibrium position while tests are carried out. Several designs of equipment rely upon their weight and operating mechanism to return them quickly to an equilibrium position. Makeshift chocks of timber are not considered safe unless secured in position by clamps or other suitable means.

While this procedure is very thorough in that it mandates the testing of moving equipment in all potentially hazardous positions, it is unclear whether such additional, elaborate methods are warranted. None of the other foreign standards reviewed (Australian, Canadian draft, and German) contain separate tests for moving equipment, and although it is not always explicitly stated, their entrapment criteria presumably apply to all equipment.

One final issue in the comparison of standards is whether they include testing for entrapment of body parts other than the head and neck. The CPSC's general recommendation in Volume 1 is that no components or group of components should form an angle or openings which could trap "any part of child's body or a child's head." Volume 2 also makes reference in a general comment to configurations on moving equipment or sliding surfaces which may entrap "any part of a user's body." However, all of the specific guidelines and the testing procedures address head entrapment only. There is quite a range of treatments for this issue. The Canadian draft standards address only head and neck entrapment, without reference to any other body parts. The text of the German standards discusses only head entrapment; however, although the large probe is "for the head of the biggest user," the small probe was designed "for the shoulders, body and head of the smallest user." The Australian standards simply note that "care should be taken to ensure that the spaces inaccessible to the head and neck do not present hazards for potential finger, foot, limb, and torso traps." In contrast to the others, the British standards contain specifications for testing methods as well as probes to address finger, hand, and limb entrapment. The general procedures for testing with these probes are similar to those given for the head probes.

5.2.6.2 1989 CPSC structural entrapment report (Deppa, 1989)

CPSC recently completed a comprehensive examination and documentation of head entrapment problems for children's products, which includes special attention to the development of requirements for playground equipment (Procedures to Evaluate Openings in Children's Products for Head Entrapment Hazards, S. Deppa, June, 1989). Because head entrapment has been so thoroughly examined in this work, including the development of product safety entrapment criteria, the CPSC report has had a major influence on the current analysis. This section is devoted to reviewing key aspects of Deppa's report in detail; however, the reader is still strongly urged to study the paper in its entirety.

Deppa thoroughly analyzed head entrapment incidents in structural openings of seven product types: cribs, youth bed rails, bunk beds, accordion-style gates/enclosures, playground equipment, nursery/toddler equipment, and toys. "Four product characteristics contributed to accidents: product function, product weight/size, opening location, and opening configuration." Deppa determined that because product characteristics greatly affected the way in which entrapment incidents occurred, "a generic set of hazardous openings cannot be defined based on anthropometric data, without regard to particular products." Procedures were therefore developed to relate product characteristics to anthropometric data on a product-by-product basis, which include defining the scope of the problem, developing test fixtures, drafting test methods, defining performance criteria, and verifying preventive measures.

Deppa used playground equipment as an example to illustrate the five procedures to develop entrapment requirements. The first procedure, defining the scope of the problem, involves accident analysis and identification of relevant product characteristics. With regard to playground equipment, Deppa's analysis addressed public equipment, home equipment, preschool play equipment and toddler gym houses. Below is a summary of some of the main issues and findings as they relate to the development of test fixtures and methods, as well as performance criteria for playground equipment.

- Product function: playground equipment is categorized as a play value product, "intended to provide children with enjoyment and learning." It is important to recognize that children will use play value products in many ways not expected by adults. Openings on playground equipment must be small enough to prevent entrapment, or large enough to permit a child to pass through. However, the latter strategy may not be appropriate in all situations; for example, the purpose of protective barriers on high platforms is to prevent falls to the surface, so it would not be appropriate to allow a child to pass through the openings between rails.

- Product weight/size: children who become entrapped in openings of large or heavy products, or those mounted in the ground, are at greater risk for strangulation than on light portable products. "Because an entrapped child cannot move playground equipment, all openings which can entrap a head have the potential for causing strangulation."

- o Opening location: an opening's proximity to the ground and its orientation relative to the ground can "influence why a child enters an opening and affect the likelihood of strangulation." One possibility is that the lower boundary of the opening is the ground. In this case, it is unlikely that strangulation will occur, because a child's head is on the same level as the body so that no force is being applied to the neck. Another possibility is that an opening is close enough to the ground that an entrapped child could contact the ground. Because children need "the cognitive ability and motor skills to support their weight and to extract themselves," it is conceivable that a young child will be strangled if entrapped in such an opening; however, an older, more developmentally advanced child may be at less risk in this situation. It is important to recognize that "it takes only a small proportion of a child's weight applying pressure to the neck to cause strangulation since obstruction of the airway is not necessary to cause strangulation." A third possibility is that an opening is high enough that an entrapped child will not be able to reach the ground. "Both younger and older children will be at risk since they have no means for supporting their body weight."

  With regard to an opening's orientation, both horizontal and vertical openings on playground equipment present entrapment hazards. When children fall through openings in the horizontal plane, their bodies, and unsupported body weight, are then in the vertical plane and "considerable strength and motor skills" would be needed to pull themselves out. For vertical openings, children may deliberately enter or slide through and then not be able to extricate themselves.

- o Opening configuration: the size and shape of an opening also affects the potential for entrapment. If at least one of the opening's dimensions is close in size to one of a child's head dimensions, then it will be easier for a child's head to enter than to exit. The ears will press against the head if a child enters an opening face first, but in attempting to exit with the head in the same orientation, the ears could catch on the sides of the opening and hamper removal. Another problem is that children will enter openings in one orientation and then rotate their heads so that a larger dimension may cause entrapment. They only have the advantage of seeing the size and shape of the opening while entering so reorienting their heads to exit can be difficult.

  Completely-bounded openings are totally enclosed on all sides, while partially-bounded openings are enclosed on only three of four sides. The geometric shape of openings involved in entrapment can be either regular or irregular; rectangles are the most common regular shape.

  For completely-bounded openings, children became entrapped either head first or feet first. Head first entrapments occurred when children "inserted their heads into the opening, turned them to a larger orientation, and could not extract their heads." Feet first entrapments occurred when children "sat or lay down, slid their feet into the opening, and became entrapped by their heads." On playground equipment, openings between ladder steps and between climbing bars were involved in both head first and feet first entries; openings between tot swing seats and their support bars and within support braces were involved in head first entries; and openings between guard rails and the platform and between glider swing seat and backrest were involved in feet first entries.

For partially-bounded openings, the incidents studied included openings which were not bounded on the upper edge. Children became entrapped neck first "when they inserted their necks into the unbounded side, and could not extricate their heads by pulling back." On playground equipment, entrapments did not occur in partially-bounded openings.

o Users at risk: "the risk of becoming entrapped in completely-bounded openings declined as children approached five years of age; the risk of entrapment in partially-bounded openings declined by about two years of age." For public playground equipment, the intended users are from 2 to 12 years of age. However, "the oldest user at risk appears to be five years of age," for head entrapment incidents on playground equipment. Children are not at risk of neck first entry into partially-bounded openings on playground equipment because the intended users are at least age 2.

Because the playground equipment and entrapment patterns varied so much in the accident data, Deppa concluded that "it appears that children may become entrapped in any playground equipment opening large enough to allow entry of the torso or head, yet small enough to prevent exit of the head in its largest orientation."

The next procedure that Deppa spoke of, after defining the scope of the problem, is to develop test fixtures. First, opening dimensions which are likely to present entrapment hazards must be matched to children's dimensions. Most often, the openings are two-dimensional and require a planar test template to assess both dimensions simultaneously. "To prevent entrapment, openings must be either smaller in one dimension, or larger in both dimensions, than a child." Openings that are three-dimensional require a spatial test probe; however, adding depth to the two-dimensional fixture is often sufficient because all this dimension evaluates is the depth of penetration.

The corresponding child dimensions also need to be identified, according to those which would either "prevent a child from becoming entrapped at a critical dimension (chest, neck, head) or, when appropriate, allow a child's head to pass through the opening." Information regarding child shape can be obtained using circumference, when there are two critical dimensions, and this will play a role in choosing the shape of the test fixture.

Once anthropometric data for the critical dimensions has been collected, test fixture shapes can be selected. "The specific shape will depend on child dimensions, opening shape (completely- or partially-bounded), and test fixture goal (prevent entry or allow exit)." Different ages and percentiles have different dimensions and shapes; therefore, geometric shapes must be chosen for the particular age and percentile of the child at risk. To determine what shape best approximates the child shape in question, the circumference or perimeter formed by the two critical child dimensions must be compared to the perimeter of a simple geometric shape. For example, to approximate the shape of the top of a child's head, the critical dimensions would be head breadth and head length, and the perimeter of a simple geometric shape would be compared to head circumference. Because the two child dimensions will be unequal, it is important that the geometric shape chosen has unequal sides. An ellipse and a rectangle with radiused corners are the two simple geometric shapes which are applicable to test fixture design. The reader is referred to Deppa's detailed explanation of how to determine which of these two shapes is a better approximation for the child shape of interest using mathematical equations.

The most accurate results would be obtained by developing test fixture shapes based on actual child shapes. "However, while shape data exist for some contours of the head, they do not exist for the neck or torso. In addition, because actual shapes are irregular, they can be difficult to specify."

Opening shape and test fixture goal also influence the selection of test fixture shape. For example, completely-bounded and partially-bounded openings should be tested with different fixtures; and, preventing entry of the smallest head requires a different fixture than allowing exit of the largest head. These issues are discussed more thoroughly below.

When test fixtures have been developed, test methods must be drafted, the third procedure. This should include procedural instructions and diagrams to explain when and how to apply the test fixtures. Procedure four, the determination of performance criteria, is needed to define what passes and fails the test. "For head entrapment, it distinguishes between hazardous and non-hazardous openings by defining a danger zone." The final procedure is the verfication of the test methods and performance criteria.

Deppa developed test fixtures, and also drafted test methods and performance criteria for playground equipment as examples of how to use the procedures outlined in her report. The remainder of this section recounts Deppa's treatment of playground equipment, including the factors she considered when determining the size and shape of the test fixtures, and the test methods and performance criteria she drafted.

COMPLETELY-BOUNDED OPENINGS

As previously discussed, Deppa defined the scope of the problem for playground equipment to include all completely-bounded openings, except those where the ground is the lower boundary. Also, although the users of playground equipment are children aged 2 to 12 years, injury data indicated that 5-year-olds are the oldest users at risk for entrapment in completely-bounded openings. Therefore, entrapment tests for playground equipment should address the hazard potential of completely-bounded openings for children between the ages of 2 and 5 years. In addition, because injury data showed that entrapment scenarios included both head first and feet first entry, the tests should address both possibilities.

Head First Entry

In order to ensure that children cannot enter completely-bounded openings head first and become entrapped, the procedures require the use of two test fixtures: one to prevent entry of the smallest head and one to allow exit of the largest head.

<u>Prevent entry of the smallest head</u>: the opening must be smaller in one dimension than the corresponding child's dimension. "Either the opening must be small enough to prevent smallest user's head (breadth, length, and circumference) from entering opening in smallest orientation, or the product's design must prevent child from rotating head (height)." The relevant anthropometric data for the minimum user at risk, a 5th percentile 25- to 30-month-old, are as follows:

Head breadth	=	5.0 inches
Head length	=	6.4 inches
Head circumference	=	18.7 inches
Head height	=	6.3 inches

For the top-of-head shape, there is contour data for the actual shape; however, its irregular shape could cause difficulties in specifying and constructing the test fixture. An ellipse based on head breadth and head length yields a perimeter of 18.0 inches. A rectangle with radiused corners (R = 2.4 inches) based on head breadth and head length provides a better approximation: its perimeter (18.7 inches) is equal to head circumference.

The **Small Top of Head Probe** is a rectangle with radiused corners corresponding to head breadth, head length, and head circumference of a 5th percentile 25- to 30-month-old (width = 5.0 inches, height = 6.4 inches, perimeter = 18.7, radius of corners = 2.4 inches) with a depth corresponding to head height (depth = 6.3 inches). "This will determine whether a child's head can enter an opening with enough clearance to turn the head."

<u>Allow exit of the largest head</u>: the opening must be larger than both corresponding child dimensions to allow passage of the head. "Openings must be large enough to allow largest user's head (breadth, tip-of-chin to back-of-head distance, and tip-of-chin to back-of-head circumference) to exit opening in largest orientation." The relevant anthropometric data for the maximum user at risk, a 95th percentile 5-year-old, are as follows (these data were extrapolated up to 5 years, because they are available only through the age of 48 months):

	43-48 months	5 years
Tip-of-chin to back-of-head distance	(8.7 inches)	= 9.0 inches
Head breadth	(5.7 inches)	= 5.8 inches

If the actual shape was approximated, a template would represent both the small (head breadth) and large dimension (tip-of-chin to back-of-head). However, unless a child can exit the opening in any orientation, entrapment will not be prevented. Rotating such a template about its own axis would indicate that the larger dimension is the determining one.

The **Large Head Template** is a circle corresponding to tip-of-chin to back-of-head distance of a 95th percentile 5-year-old (diameter = 9.0 inches). "This will determine whether a child's head can exit an opening."

Test procedures and performance criteria for head first entry into completely-bounded openings:

> Place the Small Top of Head Probe in the opening with the face of the probe parallel to the plane of the opening. Rotate the probe, keeping the face parallel to the opening.
>
> If the Small Top of Head Probe can be inserted to the full depth through the opening, place the Large Head Template in the opening so its plane is parallel to the plane of the opening.

An opening can pass this test when tested in accordance with the above procedures in one of two ways: 1) the opening does not admit the Small Top of Head Probe, or 2) the opening admits the Small Top of Head Probe and also admits the Large Head Template. An opening fails the test under the following conditions: the opening admits the Small Top of Head Probe but does not admit the Large Head Template.

Feet First Entry

In order to ensure that children cannot enter completely-bounded openings feet first and become entrapped, the testing procedures require the use of two probes: one to prevent entry of the smallest torso and one to allow exit of the largest head.

Prevent entry of the smallest torso: the opening must be smaller in one dimension than the corresponding child's dimension. "Opening must be small enough to prevent smallest user's lower torso (breadth, depth, and circumference) from entering opening, since becoming entrapped by the chest could restrict breathing." The relevant anthropometric data for the minimum user at risk, a 5th percentile 2-year-old, are as follows:

Buttocks depth	(23-24 months)	= 3.5 inches
Hip breadth	(2-2.5 years)	= 6.2 inches
Hip circumference	(2-2.5 years)	= 17.3 inches

Contour data are not available for this shape. Further, an ellipse based on buttocks depth and hip breadth does not provide a good approximation because its perimeter (15.6 inches) is not very close to hip circumference. A rectangle with radiused corners (R = 1.2 inches) based on buttocks depth and hip breadth provides a very good approximation, with a perimeter (17.3 inches) equal to that of hip circumference.

The **Small Torso Template** is a rectangle with radiused corners corresponding to buttocks depth, hip breadth, and hip circumference of a 5th percentile 2-year-old (width = 3.5 inches, length = 6.2 inches, perimeter = 17.3 inches, radius of corners = 1.2 inches). "This will determine whether a child's lower torso can enter an opening."

Allow exit of the largest head: the opening must be larger than both corresponding child dimensions to allow passage of the head. "Openings must be large enough to allow largest user's head (breadth, tip-of-chin to back-of-head distance, and tip-of-chin to back-of-head circumference) to exit opening, since becoming entrapped by the shoulder breadth cannot cause strangulation."

The template required to test "whether children will become entrapped at a critical location" due to feet first entry is the same as the template for head first entry: the **Large Head Template**, as previously described. This 9-inch diameter template will also prevent entrapment of the chest for the maximum user at risk, a 95th percentile 5-year-old, because chest breadth is 8 inches and chest depth is 5.7 inches.

Test procedures and performance criteria for feet first entry into completely-bounded openings:

> Place the Small Torso Template in the opening with the plane of the template parallel to the plane of the opening. Rotate template while keeping it parallel to the opening.
>
> If the Small Torso Template can be inserted into the opening, place the Large Head Template into the opening so its plane is parallel to the plane of the opening.

An opening can pass this test when tested in accordance with the above procedures in one of two ways: 1) the opening does not admit the Small Torso Template, or 2) the opening admits the Small Torso Template and also admits the Large Head Template. An opening fails the test under the following conditions: the opening admits the Small Torso Template but does not admit the Large Head Template.

Head or Feet First Entry

Playground equipment often has completely-bounded openings which could present entrapment hazards for both head and feet first entries. These should be tested in accordance with the fixtures, methods, and performance criteria described for feet first entry, because the Small Torso Template is smaller than the Small Top of Head Probe.

PARTIALLY-BOUNDED OPENINGS

When defining the scope of the problem, Deppa concluded that children are not at risk for neck first entrapment in partially-bounded openings on playground equipment. The justification was that the users at risk for entrapment in partially-bounded openings in general "declined by about two years," while the intended users of playground equipment "start at two years of age." Further, injury data for playground equipment did not include any entrapments in partially-bounded openings.

Deppa's treatment of playground equipment did include details for the development of test fixtures, test methods, and performance criteria for partially-bounded openings, even though such incidents were not occurring. However, it was specifically stated that this was intended to serve only "as a point of illustration" for this general entrapment scenario, rather than being directly applicable to playground equipment.

5.2.6.3 Recommendations regarding head and neck entrapment

The following recommendations regarding head and neck entrapment are derived in large part from Deppa's (1989) report, particularly her development of requirements for playground equipment, and also from the additional review of in-depth investigations for entrapment cases. The reader is referred to the Deppa report for the detailed rationale supporting the recommendations.

The intended users of public playground equipment generally range from 2 to 12 years of age. However, injury data indicates that the oldest user at risk of entrapment on playground equipment is a 5-year-old. Since the age groups defined throughout this report as younger children (2- to 5-year-olds) and older children (4- to 12-year-olds) overlap, 5-year-olds are considered in recommendations for equipment designed for either age group; therefore, the entrapment recommendations below are applicable to all equipment. When addressing the two age groups together for the entrapment guidelines, anthropometric data should be correlated to the users at risk, rather than all of the intended users of the equipment. Most children in the upper age range are not in danger with regard to head entrapment, so the guidelines would be overly conservative if anthropometric data for a 95th percentile 12-year-old were used in the development of test fixtures. Instead, a 95th percentile 5-year-old is defined as the maximum user at risk. To determine the minimum user at risk, one must assume that an adventurous 2- or 3-year-old will occasionally play on equipment designed for older children, especially because it is impossible to always control which children play on various pieces of equipment on a large public playground. Defining the minimum user at risk as a 5th percentile 2-year-old for both age groups provides the maximum protection from potentially fatal head entrapments for all children on all equipment.

All completely-bounded openings are a potential entrapment hazard and should be tested, with the exception of an opening where the ground serves as its lower boundary. Injury data indicated that openings in both the horizontal and vertical planes can cause dangerous entrapments. Further, all openings, regardless of their height above ground should be tested. Even those openings which are low enough that children can reach the ground present a risk of strangulation for an entrapped child, because a younger child may not have the necessary cognitive ability and motor skills to extricate his or her head, especially if scared or panicked.

With regard to partially-bounded openings, the major conclusion from review of the literature, playground injury studies, and in-depth investigations is that this type of opening does not appear to constitute a significant hazard on public playground equipment, and guidelines for test fixtures and methods are, therefore, not warranted. This is consistent with Deppa's (1989) finding that the risk of entrapment in partially-bounded openings in general declines by age two and further that since the youngest intended user of playground equipment is a 2-year-old, children are not in danger of such entrapments on playgrounds. Injury data also support this conclusion since there were no cases of entrapments in partially-bounded openings on playground equipment. The only exception was one non-fatal case that involved a vertex formed by adjacent components on the A frame of a home swing set, which could be considered a partially-bounded opening since the other boundaries of the space were so far apart. This case was head-first entry whereas entrapments in partially-bounded openings are generally considered neck first. A review of current catalogs showed that public equipment usually does not incorporate such designs; and further, recommendations regarding swing set support frames would preclude the use of horizontal components similar to that which caused the entrapment (see Section 5.7.2.3.4.1). Thorough review of current catalogs and on-site examination of equipment also indicated that partially-bounded openings are unlikely to be found on public playgrounds. The entrapment recommendations, therefore, address only head entrapment in completely-bounded openings.

Injury data indicated that children's heads can become entrapped in completely-bounded openings through either head or feet first entry. However, in most cases it does not appear that particular types of openings are hazardous for only head first or only feet first entrapments. Instead, it seems reasonable to assume that 4- and 5-year-olds will find ways to climb up, on, and around all types of equipment, and could then enter, intentionally or unintentionally, any completely-bounded opening either head or feet first. In order for such an opening to be free of entrapment hazards, the dimensions must either prevent entry of both the head and torso of the smallest user at risk or they must allow exit of the head of the largest user at risk. Because the critical torso dimensions of a 5th percentile 2-year-old are smaller than the critical head dimensions, the recommended procedure uses a test fixture based on the torso shape. Using the more conservative test ensures that no opening presents either hazard, while eliminating the need for separate fixtures and methods for the two possible entry conditions. The test fixture used to ensure exit of the largest head dimension would be the same for either test, head first or feet first entry. Because the largest head dimension of a 95th percentile 5-year-old is greater than the largest chest dimension, this test fixture also ensures that the chest of the largest user at risk will not become entrapped.

In general, an opening may present an entrapment hazard if the distance between any interior opposing surfaces is greater than 3.5 inches or less than 9 inches; when one dimension of an opening is within this potentially hazardous range, all dimensions of the opening must be considered together to fully evaluate the possibility of entrapment. The most appropriate way to determine whether an opening is hazardous is to test it using the following fixtures, methods, and performance criteria. These recommendations apply to all playground equipment, both for preschool-age and school-age children; fixed equipment as well as moving equipment (in its stationary position) should be tested for entrapment hazards. There are two special cases for which separate procedures are given: completely-bounded openings where depth of penetration is a critical issue; and, openings formed by non-rigid climbing components.

Test fixtures. Two templates are required to test completely-bounded, rigid openings for entrapment hazards.

The **Small Torso Template** ensures that the torso of the smallest user at risk cannot enter the opening; this will also ensure that the head of the smallest user at risk cannot enter the opening. The critical child dimensions are the buttocks depth, hip breadth, and hip circumference of a 5th percentile 2-year-old. The corresponding anthropometric values are 3.5 inches, 6.2 inches, and 17.3 inches, respectively. These data correspond to a template that is a rectangle with radiused corners, as seen in Figure 5.2 - 1, (width = 3.5 inches, length = 6.2 inches, perimeter = 17.3 inches, radius of corners = 1.2 inches).

The **Large Head Template** ensures that the head of the largest user at risk can safely exit the opening; this will also ensure that the chest of the largest user at risk cannot be entrapped. Because the child must be able to exit the opening in any orientation, only the largest head dimension is relevant: the tip-of-chin to back-of-head distance of a 95th percentile 5-year-old. These data are available only through the age of 4 years (8.7 inches), so they were extrapolated up to the age of 5 years (9.0 inches). The resulting template is a circle with a 9.0-inch diameter, as seen in Figure 5.2 - 2.

<u>Test procedures and performance criteria (Deppa, 1989)</u>. Place the Small Torso Template in the opening with the plane of the template parallel to the plane of the opening; rotate the template while keeping it parallel to the opening. If the Small Torso Template can be inserted into the opening, place the Large Head Template in the opening with the plane of the template parallel to the plane of the opening. The test procedure is illustrated in Figure 5.2 - 3.

An opening can pass this test when tested in accordance with the above procedures in one of two ways:
(1) the opening does not admit the Small Torso Template when it is rotated to any orientation about its own axis;
(2) the opening admits the Small Torso Template and also admits the Large Head Template.

An opening fails the test under the following conditions: the opening admits the Small Torso Template but does not admit the Large Head Template.

<u>Completely-bounded openings where depth of penetration is a critical issue</u>. The configuration of some openings may be such that the depth of penetration is a critical issue for determining the entrapment potential; this is a special case for which separate procedures are necessary. For example, if there is a vertical wall or some other barrier behind a stepladder, the entrapment potential depends not only on the dimensions of the opening between two steps but also on the depth of the opening, which is the horizontal space between the lower boundary of the opening and the barrier. One possible entrapment scenario is as follows: entering feet first, the torso of the smallest user at risk can get into the opening between two steps and can also pass through the space between the ladder and the barrier, but the head of the largest user at risk cannot exit the opening between the steps. In effect, there are openings in two different planes which have entrapment potential and must, therefore, be tested. Figure 5.2 - 4 illustrates these two planes for a stepladder as well as for a generic opening: Plane A is the plane of the completely-bounded opening in question; Plane B is the plane of the opening encompassing the horizontal space between the lower boundary of the opening in Plane A and the barrier.

In addition to the feet first entrapment scenario, a child could conceivably become entrapped in a completely-bounded opening where depth of penetration is a critical issue following head first entry. As previously discussed, it is reasonable to assume that young children will find ways, intentionally or unintentionally, to enter openings either head first or feet first. Because different configurations do not necessarily preclude a particular type of entry, the test procedure must address both scenarios. Therefore, in order for an opening where depth of penetration is a critical issue to be free of entrapment hazards, the dimensions must either prevent entry of both the head and torso of the smallest user at risk or they must allow exit of the head of the largest user at risk. The feet first scenario and critical torso dimensions provide the more stringent test, ensuring that an opening does not present any entrapment hazards, while eliminating the need for separate fixtures and methods for the two possible entry conditions, as discussed above on page 5.2 - 43.

The procedures and performance criteria for testing openings where the depth of penetration is a critical issue depend on a series of questions, as described below and illustrated in the flow chart in Figure 5.2 - 5.

The first step is to determine whether or not the smallest user at risk can enter the opening in Plane A. The Small Torso Template is used to test this.

Place the Small Torso Template in the opening in Plane A with its plane parallel to Plane A; rotate the template while keeping it parallel to Plane A. Does the opening in Plane A admit the Small Torso Template in any orientation when rotated about its own axis?

NO: If the opening in Plane A does not admit the Small Torso Template in any orientation, then the opening is small enough to prevent either head first or feet first entry by the smallest user at risk so there is not an entrapment hazard. The test is passed.

YES: If the opening in Plane A admits the Small Torso Template, then the smallest user at risk can enter the opening in Plane A. The entrapment potential depends on whether or not the smallest user at risk can enter the opening in Plane B. The Small Torso Template is used to test this.

Place the Small Torso Template in the opening in Plane B, in a horizontal orientation, with one of the template's long edges (i.e., the 6.2-inch dimension) placed against the edge of Plane A's lower boundary that is closest to the barrier. Does the opening in Plane B admit the 3.5-inch dimension of the Small Torso Template?

NO: If the opening in Plane B does not admit the 3.5-inch dimension of the Small Torso Template, then there is not an entrapment hazard for either feet first or head first entry: the opening in Plane B is small enough to prevent feet first entry by the smallest user at risk; the depth (the horizontal space between the lower boundary of the opening in Plane A and the barrier) is small enough to preclude entrapment resulting from head first entry in the opening in Plane A by the smallest user at risk. The test is passed.

YES: If the opening in Plane B admits the 3.5-inch dimension of the Small Torso Template, then the smallest user at risk can enter the opening in Plane B. The entrapment potential for either feet first or head first entry depends on whether or not the largest user at risk can exit the opening in Plane A. The Large Head Template is used to test this.

Place the Large Head Template in the opening in Plane A with its plane parallel to Plane A. Does the opening in Plane A admit the Large Head Template?

NO: If the opening in Plane A does not admit the Large Head Template, then the largest user at risk cannot exit the opening in Plane A. This presents an entrapment hazard because while the smallest user at risk can enter the opening in Plane A as well as the opening in Plane B, the largest user at risk can be entrapped in the opening in Plane A. The test is failed.

YES: If the opening in Plane A admits the Large Head Template, then the largest user at risk can exit the opening in Plane A. The entrapment potential depends on whether or not the largest user at risk can exit the opening in Plane B. The Large Head Template is used to test this.

Place the Large Head Template in the opening in Plane B, in a horizontal orientation, with the template tangent to the edge of Plane A's lower boundary that is closest to the barrier. Does the opening in Plane B admit the Large Head Template?

NO: If the opening in Plane B does not admit the Large Head Template, then the largest user at risk cannot exit the opening in Plane B. This presents an entrapment hazard because while the smallest user at risk can enter the opening in Plane A as well as the opening in Plane B, and the largest user at risk can exit the opening in Plane A, the largest user at risk can be entrapped in the opening in Plane B. The test is failed.

YES: If the opening in Plane B admits the Large Head Template, then the largest user at risk can exit the opening in Plane B so there is not an entrapment hazard. The test is passed.

<u>Non-rigid openings</u>. Climbing components such as flexible nets are a special case for the entrapment tests because the size and shape of openings on this equipment change as children play on it. The entrapment scenarios (head first or feet first into completely-bounded openings) are not different, nor are the relevant anthropometric data. However, because the original openings formed by segments of a flexible net climber can be altered when force is applied, either intentionally or simply when a child climbs on it, children are potentially at risk of entrapment in these distorted openings. The test method for such openings should, therefore, incorporate forcing a probe into the opening to determine whether a child will be able to enter the opening. With regard to exiting the opening, the

test does not need modification because an entrapped child should not have to use excessive force to extricate his or her head; the goal of the Large Head Template is to ensure that if a child's head can enter the opening it can also exit freely.

Because the procedure includes the use of force, a three-dimensional test probe or wedge is needed. The perimeter of the wedge should increase from top to bottom to facilitate the application of force. The critictal factors for determining the entrapment potential of a non-rigid opening are the dimensions of the bottom or base of the wedge. Therefore, the dimensions and shape of the Small Torso Template (see Figure 5.2 - 1) are applicable to the design of such a probe: a rectangle with radiused corners, identical to the Small Torso Template (width = 3.5 inches, length = 6.2 inches, perimeter = 17.3 inches, radius of corners = 1.2 inches), forms the base of the wedge, as seen in Figure 5.2 - 6. The important characteristic of upper surface or top of the wedge is that its perimeter is smaller than that of the base: the top of the wedge should be a rectangle with radiused corners which is half the size of the base, as seen in Figure 5.2 - 6 (width = 1.75 inches, length = 3.10 inches, perimeter = 8.67 inches, radius of corners = 0.60 inches). The perpendicular distance between the top and base of the wedge, which is height of the wedge, should be 6 inches, as seen in Figure 5.2 - 7.

As described above, the **Small Torso Probe** ensures that the torso and head of the smallest user at risk cannot enter the non-rigid opening (see Figures 5.2 - 6 and 5.2 - 7). The **Large Head Template**, as previously specified and seen in Figure 5.2 - 2, is then used to ensure that the largest user at risk can freely exit the non-rigid opening.

The recommended testing procedure for non-rigid openings is as follows: place the Small Torso Probe in the opening, tapered-end first, with the plane of its base parallel to the plane of the opening; rotate the probe while keeping its base parallel to the plane of the opening; apply 50 pounds of force (the approximate weight of the maximum user at risk, a 95th percentile 5-year-old) while attempting to push the probe through the opening. If the base of the probe passes through the opening when it is rotated about its own axis in any orientation and 50 pounds of force is applied, place the Large Head Template in the opening so its plane is parallel to the plane of the opening.

A non-rigid opening can pass the test when tested in accordance with the above procedures in one of two ways:
(1) the opening does not allow the Small Torso Probe to be inserted so deep that the opening admits the base of the probe when it is rotated to any orientation about its own axis;
(2) the opening allows full passage of the Small Torso Probe and also admits the Large Head Template.

A non-rigid opening fails the test under the following conditions: the opening allows full passage of the Small Torso Probe but does not admit the Large Head Template.

This test will identify non-rigid openings that could have passed the test for rigid openings, but that could be hazardous if force is applied. In some cases, a non-rigid opening which would not admit the Small Torso Template (thereby passing the regular test) will allow full passage of the Small Torso Probe but then not admit the Large Head Template (thereby failing the modified test).

Angles. Although there is no empirical data indicating that components which form a vertex are a frequent and serious cause of injury on public playgrounds, it is conceivable that such a configuration could cause strangulation if a child's head or neck became entrapped. Therefore, the current guidelines regarding angles should be retained, as follows. The angle of any vertex formed by adjacent components should not be less than 55 degrees, unless the lower leg projects mores than 10 degrees below horizontal.

5.2.6.4 Recommendations regarding entrapment of other body parts

Generally, the trapping of other body parts, such as arms, legs, hands, and feet, is considered a pinch, crush, or shearing hazard. Recommendations in Section 5.2.4 address these hazards.

Children tend to put their fingers into small openings, which creates a concern about finger entrapment. Attention to this potential hazard is important as a general design consideration. This is discussed more thoroughly in conjunction with the size of chain link used to suspend swings (see Section 5.7.2.3.2) and the design of merry-go-round platforms (see Section 5.7.4.3.1). For example, drainage holes on platforms, steps, or tire swings or perforated infill on protective barriers should not present finger entrapment hazards. Preferred treatments would not provide any accessible openings large enough for children to insert their fingers in. One possible design solution is to ensure that openings are less than 5/16 of an inch, which would preclude entry by the index finger of a 5th percentile 2-year-old.

5.2.7 TRIPPING HAZARDS

Guideline content:

The current guidelines note that equipment should be firmly anchored in the ground with concrete. To prevent tripping and protect children in case of a fall, all concrete footings should be placed below ground level. Further, any exposed concrete footings should be covered with earth or padding. "Also consider recovering worn surfaces where rocks or other hazards may protrude." (Volume 1)

Probable rationale:

The only rationale for these recommendations are those which are implied in the guidelines: to prevent tripping incidents and to protect children from additional injuries if they do fall.

Issues:

King and Ball (1989) observed that one of the causes of playground accidents is "the presence of objects near equipment which can cause tripping." Faulty anchoring of equipment, especially exposed concrete footings or other supports, clearly presents a trip hazard to children on the playground; all anchoring devices need to be set below ground level (Aronson, 1988; Burke, 1980; Frost, 1986c; Frost and Wortham, 1988; Goldberger, 1987; Werner, 1982). Aronson recognized that the supports must be "sunk deep enough below the surface that they will not be uncovered by play." Frost noted that roots, rocks, and other environmental obstacles also present tripping hazards. Stoops (1985) and Sweeney (1982, 1985, 1987) both reported the CPSC recommendations to avoid exposed concrete footings.

Standards have also addressed potential trip hazards. The Canadian draft standards (CAN/CSA-Z614, 1988) recommend that the top edge of all foundations be a minimum of 7.87 inches below subgrade, not extending into the protective surfacing. Similarly, the Seattle draft standards (1986) suggest that metal equipment be set in concrete footings which are a minimum of 8 inches below grade. The German standards (DIN 7296, Part 1, 1985) are more conservative. They state that "the foundations shall be installed or laid in such a way that they do not represent a hazard." This is to be achieved by recessing the pedestals or other fixing equipment at least 15.75 inches below the playing surface, "if they are not effectively covered by items of equipment or equipment parts."

Although there appears to be awareness of this problem, tripping hazards still exist on many playgrounds. The AALR survey of elementary school playgrounds found an average of 5.6 exposed concrete footings around the support structures of equipment on each playground studied (Bruya and Langendorfer, 1988).

In addition to exposed footings, stone curbing too close to playground equipment can also be a trip hazard (Burke, 1980). A common use of curbing is as retainer walls for loose surfacing materials. Both Moore et al. (1987) and Beckwith (1988) recognize that retainer walls must be designed with attention to potential trip hazards, which exist in both directions, in and out of play areas. Each presented three similar methods of dealing with this problem but also acknowledged that further research is needed to establish the most effective means of using retainer walls without creating a tripping hazard.

The first technique is applied where ground cover is added over existing grade and then a retainer wall is built to contain the loose surfacing materials. This approach simplifies drainage requirements. The Play For All Guidelines (Moore et al., 1987) suggests that in this case, the approach height of the wall should be a minimum of 16 inches: 8 inches for loose materials and 8 inches for containment. Beckwith (1988) called for an approach height of 20 inches: 12 inches for loose materials and 8 inches for containment. Both noted that this design provides little trip hazard because the retainer wall must be intentionally climbed to go into the play area. Upon exiting, a minor hazard will exist because the child may be unaware of the drop off after climbing the wall: 16 inches for Moore et al.'s design and 20 inches for Beckwith's design.

Another option is to dig a low pit with a retainer wall above grade. Moore et al. (1987) recommended an 8 inch pit with an additional 8 inch barrier for this technique. The same trip hazard is then present for both entering and exiting the area. Beckwith (1988) also suggested an 8 inch pit; however, the retainer wall would be 12 inches. Assuming that 12 inches of loose surfacing materials are used, 4 inches of the wall would hold the materials to grade and 8 inches would serve as containment. This reduces the climb for entrance, relative to the first technique; and, although there is the same trip hazard upon exiting as with the previous technique, the drop to ground level is only 8 or 12 inches (instead of 16 or 20 inches).

The final technique is to dig a deeper pit and backfill with loose surfacing materials. Moore et al. (1987) called for a 16 inch pit, while Beckwith (1988) suggested a 20 inch pit. This will present an obstacle which must be intentionally climbed in the exit direction. The step down into the pit may surprise some children, causing a stumble or possibly even a fall. However, both sources noted that falling into sand, pea gravel or some other protective material is less hazardous than falling upon exit onto hard surfaces such as concrete.

The Seattle draft standards include the following discussion of retainer walls:

> Edging, curbing or other containment devices are required around play areas with loose surface materials. It should be flush with grade to avoid tripping children or between 8 to 12 inches high for visibility and sitting.

Recommendations:

The current guidelines regarding trip hazards are warranted. Although the hazard of tripping is not unique to playgrounds, there are certain tripping issues which are especially relevant to playground safety. All anchoring devices for playground equipment, such as concrete footings or horizontal bars at the bottom of flexible climbers, should be installed below ground level to eliminate the hazard of tripping. This will also prevent children who do fall from sustaining additional injuries due to exposed footings. Further, attention should be given to environmental obstacles in the play area, including rocks, roots and other protrusions from the ground which may cause children to trip.

Retainer walls are commonly used to help contain loose surfacing materials. Although research is needed to better understand the implications of various designs on the degree of the tripping hazard, certain conclusions can be drawn. In order to minimize the trip hazard, retainer walls should be highly visible and any change of elevation should be obvious. The use of bright colors can contribute to better visibility. Another means for increasing visibility and decreasing the trip hazard is the use of a retainer wall that must be climbed by the child. In this case, the retainer wall should be elevated from all directions of travel, with the height of the wall the same when approaching it from either side.

5.2.8 SUSPENDED HAZARDS

Guideline content:

It is recommended that there be no cables, wires, ropes or other similar components suspended between play units within 45 degrees of the horizontal. Volume 1 explains that children might accidentally run into such obstructions or trip over them. Similarly, Volume 2 notes that they could be impacted by a rapidly moving child. This guideline does not include cables, ropes or other components which are located 7 feet or more above ground or an equivalent surface. Further, items such as guard railings or a series of ropes or cables for cargo nets and climbing grids are not intended to be eliminated by this recommendation. When evaluating a potential suspended hazard, these exclusions should be considered. (Volume 1; Volume 2, 7.4)

Probable rationale:

The intent of the above recommendation is "to ensure that individual wires, cables, ropes, cords or the like are not suspended in a manner that a user could contact them, especially at head or neck level," while moving rapidly between the points of suspension. A child riding a bike could, for example, could be injured by contacting a suspended cable at neck height. (NBS, 1978a)

Issues:

The Seattle draft standards (1986) contain a recommendation comparable to the CPSC guideline. They also note that all suspended members must be highly visible to the playground users. If there are suspended cables, wires or ropes in the play area, they must be more than one inch in diameter. With regard to maintenance, it is recognized that any cables, wires or ropes which are not a part of the regular equipment or which have been suspended in a hazardous manner should be removed.

The Canadian draft standards (CAN/CSA-Z614, 1988) state that there should not be any suspended elements with a diameter less than one inch in diameter anywhere in a play area where children will be active which are stretched horizontally or stretched between an element and the ground. This includes cables, cords, tree guy wires, wires for utility poles, or other similar components. "If their presence is absolutely necessary, they should be made clearly visible to the child and preferably placed in a hollow tube with a diameter of one inch or greater." Suspended elements which are brightly colored will have better visibility.

Frost (U. of Texas, 1989, unpublished manuscript) reported the CPSC guideline for suspended elements. He also discussed a new design of cable and chain balance equipment not mentioned in the handbooks. One cable is suspended horizontally near the ground for children to walk on, while another cable to hold onto is suspended above. Frost noted that children have been injured because they have run into these cables, and, therefore, some means of protection is needed. The installation of barriers was suggested. There is another potential injury scenario. A 1982 in-depth injury investigation provided by the CPSC reported that a 9-year-old became entangled in the cables of this type of equipment; she hung by her neck and lost consciousness, but was rescued by a passerby and suffered no permanent injuries.

Recommendations:

The current guidelines for suspended hazards are reasonable. However, additional recommendations are also warranted.

There should be no cables, wires, ropes, or other similar components suspended between play units or from the ground to a play unit within 45 degrees of the horizontal. This is to prevent injuries caused by children running into or tripping over suspended elements. To further protect pedestrians and bicyclers, it is further recommended that no suspended elements cross probable paths of traffic. Cables, ropes, or other similar components which are located 7 feet or more above ground or an equivalent surface are exempt from these requirements.

All suspended elements should be taut so that they cannot loop back on themselves or contact another suspended element. It is very important that all suspended elements be highly visible to people on the playground. Using bright colors is one factor which increases visibility of suspended elements. Size can also play a role: it is recommended that all suspended elements have a minimum diameter of one inch, as suggested in the Seattle and Canadian draft standards. Another design technique which has merit is the use of plastic tubes or sleeves to cover suspended elements; this treatment can be used to add both color and size and thereby increase visibility. Further, impact with a plastic-covered cable or wire would presumably have less potential for injury than impact with a bare cable or wire.

Flexible climbers are not intended to be eliminated by the recommendations regarding suspended hazards. However, high visibility through the use of bright colors is also important for ropes and cables connected in series to create climbing nets and grids.

5.2.9 ELECTRICAL HAZARDS

Guideline content:

The current guidelines do not address electrical hazards on playgrounds.

Probable rationale:

Not applicable.

Issues:

It is important that playgrounds be free of electrical hazards (Frost and Wortham, 1988). Lawsuits have resulted from children being electrocuted by accessible electrical equipment on playgrounds (Frost, 1986b).

Frost (U. of Texas, 1989, unpublished manuscript) discussed electrical hazards in detail:

> Although none of the national standards/guidelines refer to electrical hazards on playgrounds they are all too common. Perhaps the most common is the existence of exposed air conditioners and electrical switch boxes on preschool playgrounds, particularly preschools which are former residences. All such electrical equipment should be fenced and non-accessible to children. Care should also be taken to ensure that electrical boxes, commonly located in yards of residences, containing connections for underground electrical utilities, be securely locked. Boxes with missing locks invite young children to attempt to play inside the boxes, and result in serious injuries and fatalities. Other hazards include electrocution or serious shock and burns resulting from children climbing guy wires, support poles via service ladders and transmission towers. Television cable companies lease space on existing electrical poles and sometimes install additional guy wires, leading to increased ease of climbing. Children climb to the vicinity of the electrical transmission lines and are severely shocked by high voltage lines. Older children with some knowledge of electricity are sometimes victims. Believing that they must touch the wires in order to be shocked they avoid direct contact but are shocked by the arcing phenomenon, more likely in humid areas. Several such cases as these have occurred in Texas during recent months. Adults must not only shield electrical apparatus from children but must also alert them to the potential hazards of playing on or in close proximity to such apparatus.

The Seattle draft standards (1986) address potential electrical hazards. They stipulate that any electrical conduit and wiring in or around a play area must be underground. Also, "locate provisions for utility metering, weatherproof electrical enclosures, transformers and the like away from the play area and in locked vaults or utility rooms."

Recommendations:

Playgrounds should not present any electrical hazards to children. This includes accessible electrical switch boxes, utility meters, air conditioners, and any other electrical equipment. Where electrical switch boxes or other meters are necessary, they should be secured by locked enclosures; all wiring should be located such that children cannot climb equipment or trees to reach it.

TABLE 5.2 - 1

Comparison of Standards for Entrapment Criteria: Test Probes.
(all dimensions given in inches)

Probes to Represent the Head Only: three-dimensional probe with a cross-section that is a rectangle with radiused corners, attached to a handle.

	CPSC (1986)	BRITISH (1981)	
		Probe A	Probe B
Length of Rectangle	6.00	6.02	8.07
Width of Rectangle	5.00	5.04	7.00
Radius of Corners	2.50	2.52	3.50
Depth of Probe	not stated	3.93	3.93

Probes to Represent the Head and Neck: spheres (head) connected to cylinders (neck).

	AUSTRALIAN (1981)		CANADIAN (1988)	
	Probe A	Probe B	Probe A	Probe B
Diameter of Sphere	5.00	9.06	4.33	9.84
Diameter of Cylinder	1.77	1.77	1.77	1.77
Length of Cylinder	7.87	7.87	7.87	7.87

Probes to Represent Shoulders, Body and Head: cylinders, attached to a handle.

	GERMAN (1985)	
	Probe A	Probe B (head only)
Diameter of Cylinder	4.72	7.87
Length of Cylinder	3.93	3.93

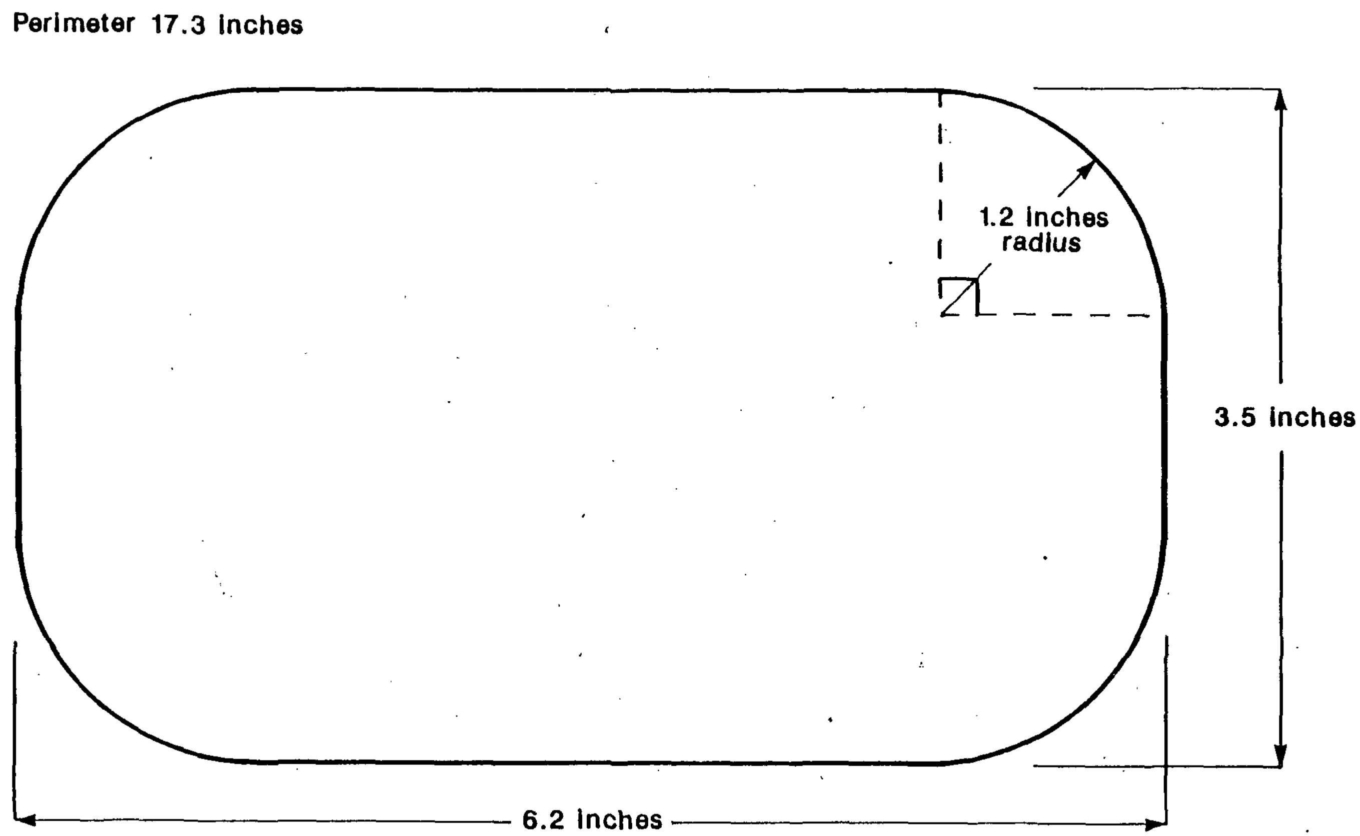


FIGURE 5.2 – 1: SMALL TORSO TEMPLATE
(Rectangle with radiused corners)

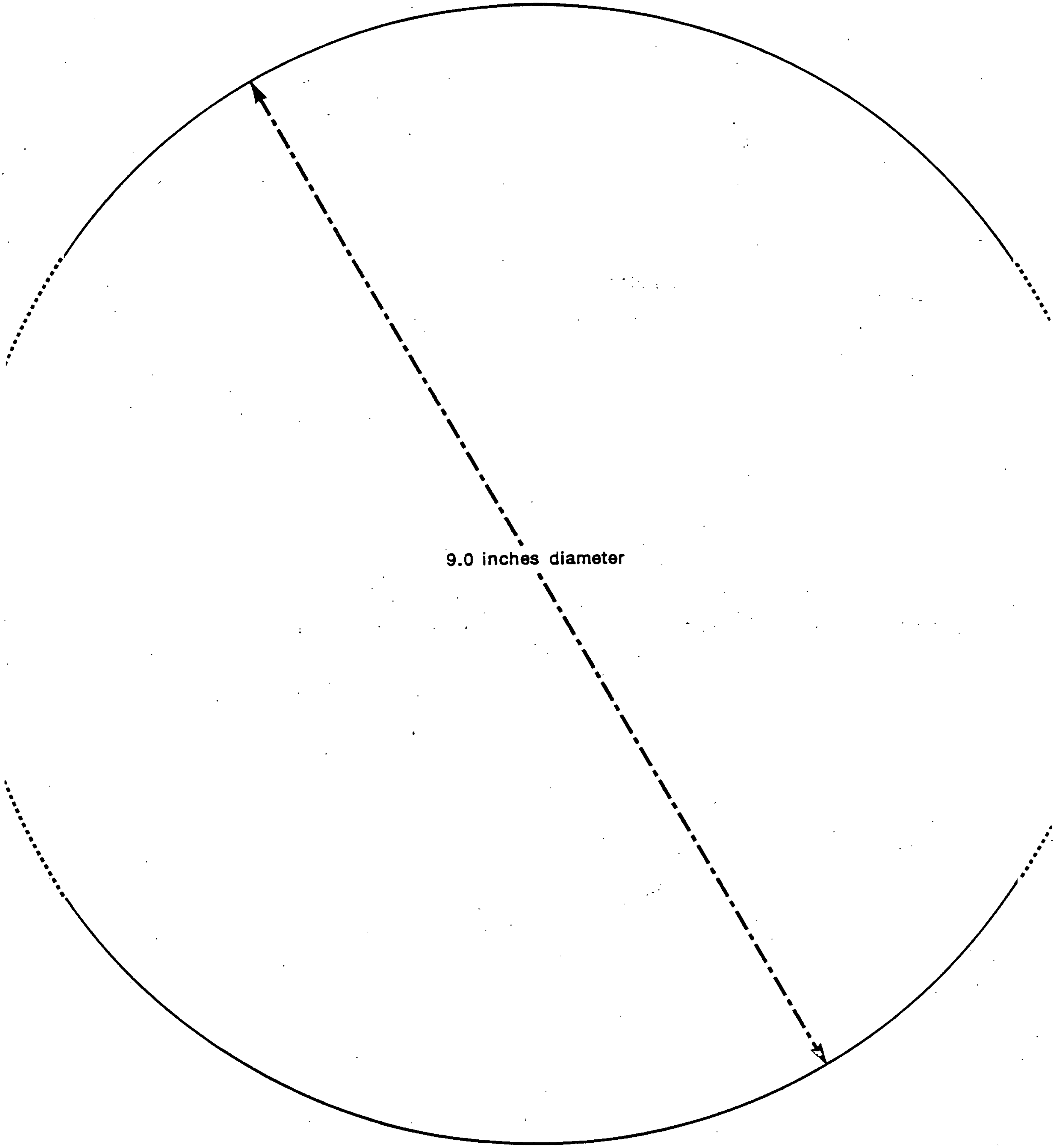
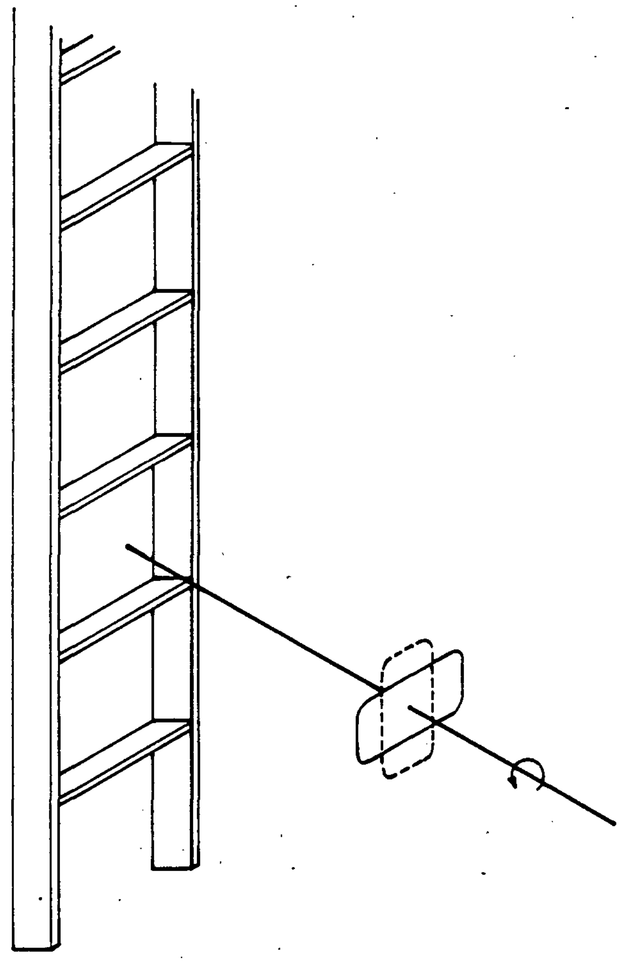


FIGURE 5.2 - 2: LARGE HEAD TEMPLATE
(Circle with 9-inch diameter)



Test procedures and performance criteria for completely-bounded openings.

Place the Small Torso Template in the opening with the plane of the template parallel to the plane of the opening; rotate the template while keeping it parallel to the opening. If the Small Torso Template can be inserted into the opening, place the Large Head Template in the opening with the plane of the template parallel to the plane of the opening.

An opening can pass this test when tested in accordance with the above procedures in one of two ways:
(1) the opening does not admit the Small Torso Template when it is rotated to any orientation about its own axis;
(2) the opening admits the Small Torso Template and also admits the Large Head Template.

An opening fails the test under the following conditions: the opening admits the Small Torso Template but does not admit the Large Head Template.

FIGURE 5.2 - 3: ENTRAPMENT TEST FOR COMPLETELY-BOUNDED OPENINGS

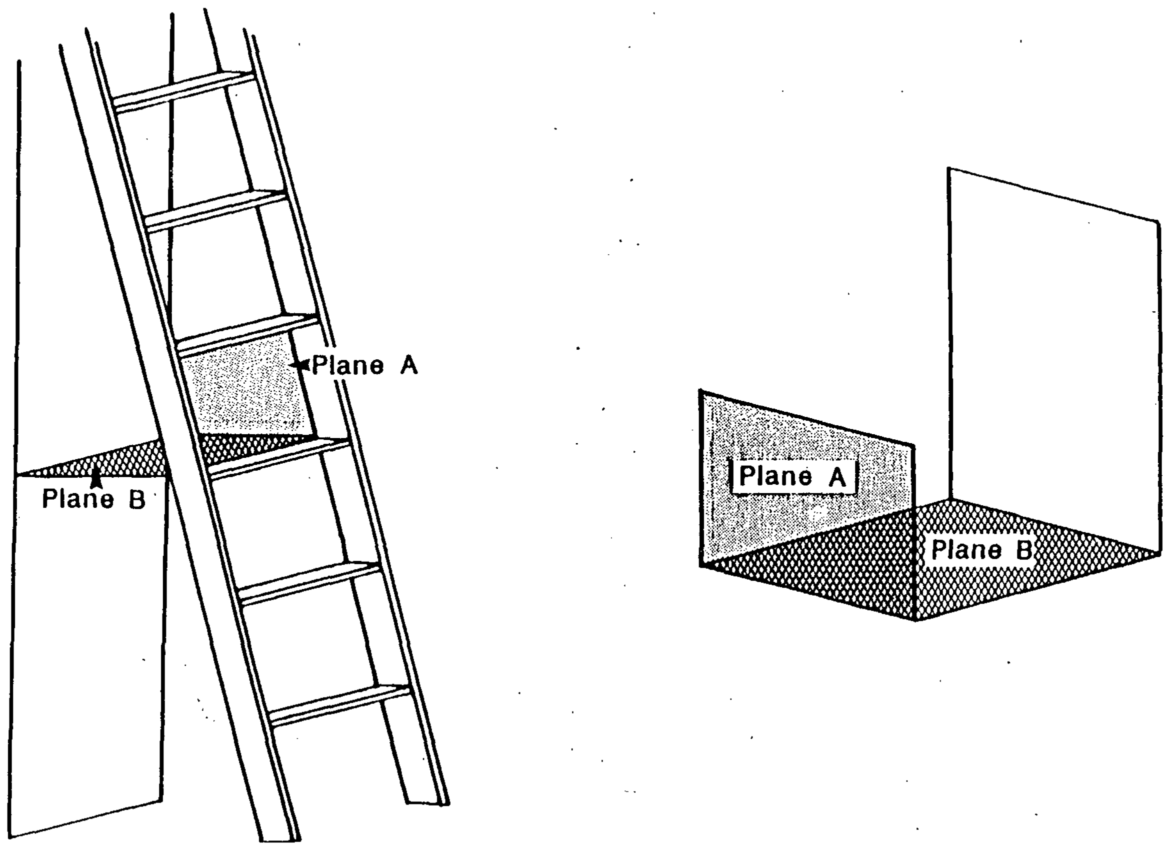


FIGURE 5.2 – 4: EXAMPLES OF COMPLETELY-BOUNDED OPENINGS WHERE DEPTH OF PENETRATION IS A CRITICAL ISSUE

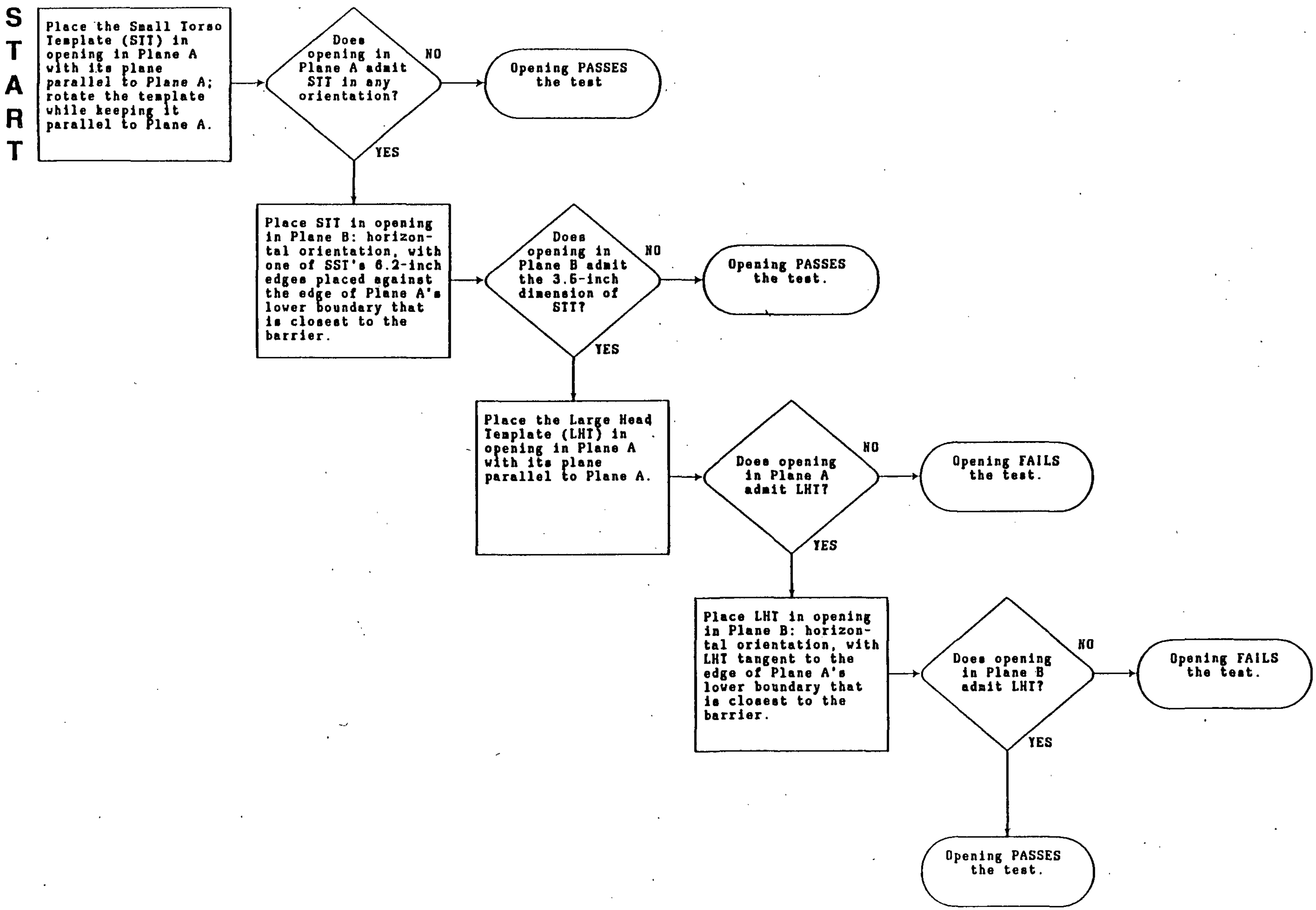


FIGURE 5.2 – 5: ENTRAPMENT TEST FOR COMPLETELY-BOUNDED OPENINGS WHERE DEPTH OF PENETRATION IS A CRITICAL ISSUE

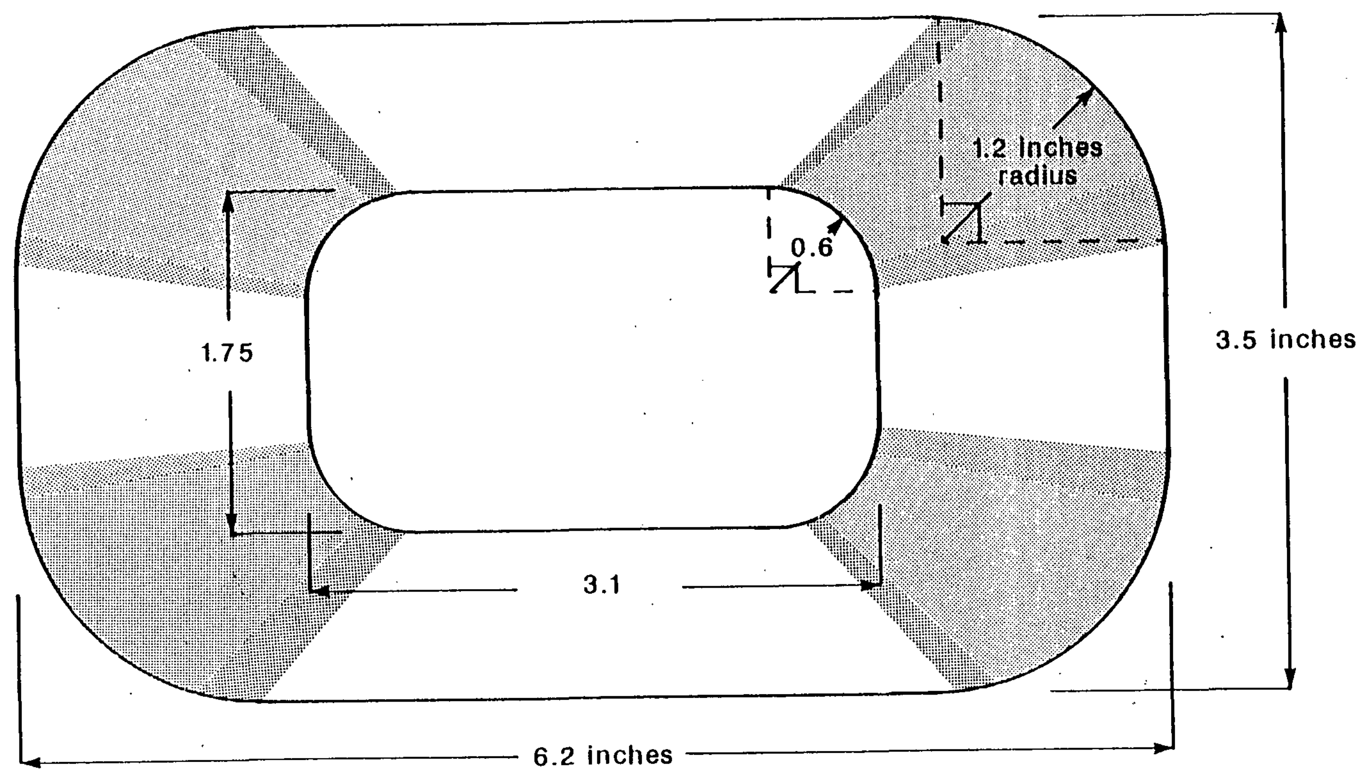


FIGURE 5.2 – 6: SMALL TORSO PROBE: TOP VIEW

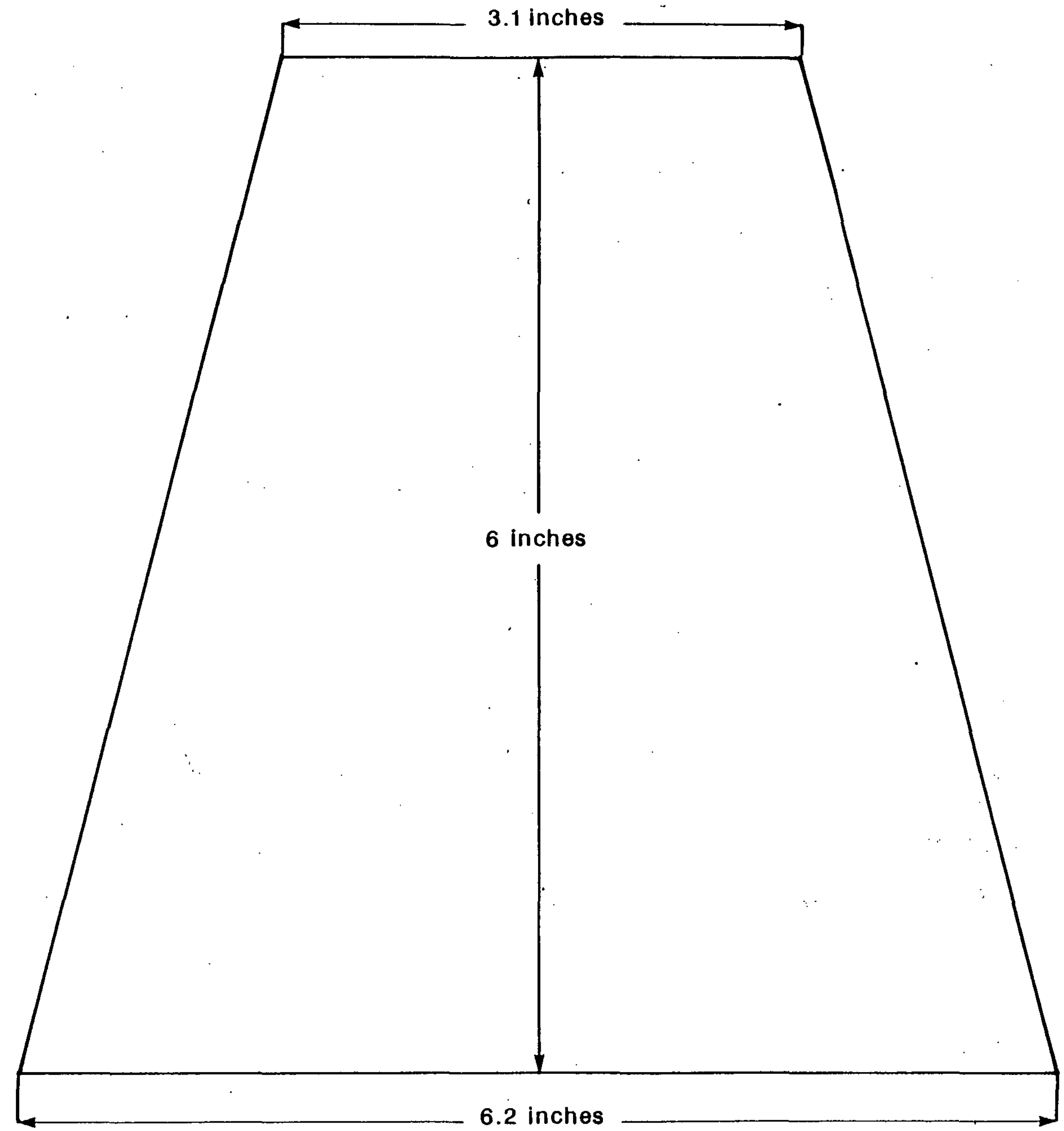


FIGURE 5.2 – 7: SMALL TORSO PROBE: SIDE VIEW

5.3 LAYOUT AND DESIGN

5.3.1 WHAT TO INCLUDE ON PLAYGROUNDS

5.3.2 LAYOUT OF EQUIPMENT

5.3.2.1 Location of equipment

5.3.2.2 Use and fall zones

5.3.2.3 Traffic and pathways

5.3.2.4 Multi-use equipment

5.3.2.5 Age separation of equipment

5.3.3 SITE SELECTION

5.3.1 WHAT TO INCLUDE ON PLAYGROUNDS

Guideline content:

Volume 1 of the current handbook addresses the question of what playgrounds should include. Volume 2 does not address layout and design considerations.

> To encourage a child's perceptual and motor development, a well-planned playground should offer a wide variety of play opportunities. Activities which involve running, walking, climbing, dodging, swinging, sliding, catching and throwing, or pulling and pushing, for example, help children learn to move confidently, gain muscle strength and control, and refine their coordination. Of course, many playgrounds are used by different age groups whose interests and abilities vary greatly. To allow space appropriate to both the child and the activity, therefore, some planners set aside sections of the playground for special use. (Volume 1)

A list of possible activity areas is given to help guide playground design. The list includes the following: an area for conventional playground equipment; an open field for ball games, tag, kite-flying, etc.; a free play area for activities such as tether tennis or hopscotch; a paved, multiple use area for court games, dancing, general play; an area for quiet activities or individual play such as arts and crafts, music, drama, solitary games; and other options such as wading pools, shelter houses, and landscaped areas. It is noted that in addition to the creative play opportunities provided, separation of these areas can improve playground safety. (Volume 1)

It is also recommended that playground planners should consider providing restrooms and pay telephones with permanently affixed emergency numbers, "whenever space and resources permit." Further, both children and adults generally "appreciate" benches or some other seating. (Volume 1)

Probable rationale:

Neither the NBS nor NRPA rationale documents address any of the layout and design considerations. The goals of such recommendations are, however, evident from the text of Volume 1 of the guidelines: to promote safe play while enhancing children's motor and perceptual development.

Issues:

Although the original aim of playgrounds and playground equipment was geared mainly toward physical exercise and motor development, today's playground designers are increasingly concerned with addressing *all* aspects of children's development. There is an abundance of discussion in playground literature of the various facets of development and the related forms of play. Fortunately, there is also good agreement: simply stated, the conclusion is that a developmentally appropriate playground includes a variety of equipment, materials, and space to encourage and enhance the motor, social, cognitive, and emotional development of children through all the forms of play children engage in. Moreover, "safe, exciting, fun playground play occurs when developmentally appropriate outdoor environment is combined with appropriate supervision to support child-initiated learning" (Aronson, 1988).

Because discussion in the literature of what a developmentally appropriate playground should include is so extensive, yet reaches consensus on the general issues, discussion here is limited, while the recommendations highlight the conclusions. The various aspects of development and types of play were addressed in the section on developmental considerations (see Section 4). Additional background and rationale for the recommendations regarding developmentally appropriate playgrounds include the following sources: Aronson, 1988; Beckwith, 1985, 1988; Bowers, 1988a; Brown, 1978; Esbensen, 1987; Frost, 1986a, 1986b, 1988, U. of Texas, 1989, unpublished manuscript; Frost and Wortham, 1988; Lovell and Harms, 1985; Monroe, 1985; Moore et al., 1987; Stoops, 1985; Werner, 1980; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986.

One important consideration is that of providing a *challenging* play environment. "The goal of playground safety programs is NOT to remove excitement and challenge but rather to control hazard. Clearly, children seek out and enjoy the stimulation of challenge" (Beckwith, 1988). So, what is a challenge, and what is a hazard? Beckwith, Moore et al. (1987), and the Seattle draft standards (1986) provide similar explanations: a hazard is hidden danger, something which a child may not see or perceive as dangerous; a challenge is a risk that the child can see and then decide whether or not to undertake. Designers of play environments, therefore, need to maximize challenge while minimizing hazard. As stated by Winter (1988), "Since life is full of hazards, the playground should not necessarily be without hazard. The children can identify and deal with risk, but the penalty for failure should be minimal."

It is generally agreed that playground equipment should offer graduated challenges to accommodate children at various levels of development, since not all children advance at the same pace, physically or mentally (Beckwith, 1985; Bowers, 1988a; Frost and Henniger, 1979; Lovell and Harms, 1985; Moore et al., 1987; Stoops, 1985; Werner, 1980). Complexity provided through variation in the size and shape of play structures will increase children's interest in the equipment while challenging them in all facets of development. Further, the diversity and stimulation of graduated challenges tend to promote safer play on the equipment. The lack of higher levels of challenge and novelty for children who have mastered usage of play components may increase the likelihood of experimentation with more hazardous modes of use. Emotionally, graduated challenge is beneficial in helping children to form a positive self-image as they master higher levels of challenge.

The Seattle draft standards thoroughly address the need for challenge on the playground, including recommendations such as the following:

> Play areas should provide highly challenging environments without exposure to unnecessary hazards.
>
> Challenge in the play area should not be related to heights and danger but to increasing mastery of physical skills and judgment.

Provide activities which have clearly visible stages of accomplishment. Activities should be arranged so that the next level of challenge is apparent.

Recommendations:

The following recommendations represent current consensus, as indicated in a wide variety of standards and guidelines, journal articles, and practices.

The design of playground equipment should meet the developmental needs and abilities of the users. While motor and perceptual development is a major consideration, cognitive, social, and emotional development can also be enhanced on the playground, if given proper attention during the design process. Children will be more interested in a playground which contains many options and a diverse range of activities; this will encourage extended as well as safe play. Providing for graduated challenges is perhaps the most important facet of such complexity, because this allows children at various levels of development to enjoy the equipment safely as they learn from it. Variation in the size and shape of structures, and also sensory stimuli such as color and texture add to the complexity and play value presented by playground equipment.

Motor development: Playgrounds should contain activities for large and small muscle development, as well as those to enhance balance and coordination skills. Important activities include: climbing, sliding, swinging, crawling, walking, running, jumping, bouncing, balancing, hopping, skipping, pushing, pulling, lifting, throwing, catching. Climbing activities should also promote spatial awareness with opportunities to climb up, down, in, out, over, under, left and right. Equipment which provides these activities should be scaled appropriately to the size and abilities of the user age group, as discussed in the sections on each type of equipment (see Section 5.7). In addition to playground equipment, it is important to provide open space for active play. Children benefit from both hard and soft surface areas. An open field provides a place for ball games, tag, kite-flying, etc. where children can run freely without jeopardizing the safety of children playing on the equipment. A paved area provides a place for group as well as solitary play such as court games, dancing, hopscotch, or for learning to ride wheeled toys. Older children have a great need for these large, open spaces so that they can engage in large group activities and games with rules.

Cognitive, social, emotional development: Playgrounds should foster cognitive development through opportunities for constructive play, dramatic play, and decision making. Playgrounds should foster social development through opportunities for solitary play, parallel play, associative play, and cooperative play, so that children can practice taking turns, sharing, planning, and cooperating. Playgrounds should foster emotional development through opportunities for children to build self-esteem by succeeding in mastering various challenges. Creative playground design encourages all forms of play in which children engage.

Many current designers stress the importance of loose or transportable materials on playgrounds, because their inclusion increases complexity and allows children to use their imaginations to create and manipulate their environment. Loose equipment and materials introduce a new novelty and flexibility to the playground. Fluid materials--sand, soil, water--are infinitely adaptable, and provide tremendous value for play while adding greatly to opportunities for cognitive and social development. Other creative, loose equipment and materials include buckets, shovels, rakes, stacking materials, outdoor blocks, balls, boxes, crates, spools, dolls, dramatic props, construction materials, gardening materials, arts and crafts materials, and wheeled vehicles. Sand can serve as an impact-absorbing surfacing material under equipment and enhance constructive and dramatic play there; however, it is preferable to also have a separate sand box area. Young children will gain the most from the inclusion of these apparatus and materials on playgrounds. Although this may not be feasible on all public playgrounds, it is desirable to provide loose equipment and materials wherever possible because of the benefits for cognitive and social development. In day care, preschool, and school settings, these materials may at least be provided for use during supervised outdoor play periods.

Children enjoy pretending. Dramatic play, which generally focuses on role playing, is supported not only by loose equipment and materials but also by partially-enclosed spaces on the playground. Both quiet, imaginative play and small group interaction occur within the spaces. Playgrounds should have these partially-enclosed spaces and other areas for children to retreat, alone or in small groups: the areas can be part of the equipment's design (tunnels, tube slides, playhouses, areas under platforms, etc.) or part of the playground's landscaping (shaded areas under trees, small hills, niches, etc.). Partially-enclosed spaces should be designed so that children can move through and within them easily and safely. To facilitate supervision while still giving children a sense of enclosure, these spaces should either incorporate the use of translucent materials or be open on one or more sides. As with loose equipment and materials, it is young children who tend to benefit most from these spaces.

Other design considerations: Attention should be given to the natural features of the playground because they can improve aesthetics while also adding to children's play. Safe trees and shrubs can provide both learning opportunities and shade; small hills can provide climbing places. Care must be taken that the landscaping of the playground does not contain any poisonous elements or prickly thorns.

Playgrounds should have drinking fountains, at comfortable heights for children and adults. Litter containers should be anchored firmly to the ground and located away from the normal circulation of playing children, to prevent them from becoming obstacles. When resources permit, consideration should be given to providing restroom facilities and pay telephones, that can reached by children, with permanently affixed emergency numbers. Sufficient storage facilities should be provided to house any available loose equipment and materials. This is especially important for day care and school sites, to expedite the clean-up process after outdoor play.

Benches and tables should be provided: there should be enough benches to accommodate adult supervisors on the playground; and the benches should be oriented to facilitate supervision of children on the equipment as well as in other areas of the playground. Their design, as with all extra features, should not present general hazards to the children playing on the playground. Shelter areas for picnics, arts and crafts or other quiet activities would also be welcomed by many playground users.

Bike racks are an important consideration for all playgrounds. They should be firmly anchored to the ground, near the entrance of the playground area where they will not interfere with children's play activities but would still be clearly visible.

5.3.2 LAYOUT OF EQUIPMENT

5.3.2.1 Location of equipment

Guideline content:

Volume 1 of the current guidelines notes that "equipment should also be arranged to accommodate the traffic of children at play...poorly placed equipment can lead to misuse and accidents." It is important to separate play equipment from ball fields and other active, open areas, to prevent children from accidentally running "in front of swings, exit areas of slides, etc." In addition, placement of equipment should not be such that one area is overcrowded while another is underused. The guidelines also state that the site should be free of visual barriers which might hamper supervision. (Volume 1)

Probable rationale:

Neither the NBS nor NRPA rationale documents address any of the layout and design considerations. Rutherford (1979) recognized that "playground planning to separate activities such as ball playing from the area of the equipment may help to reduce injuries from running into equipment." A similar rationale for increased attention to the location of equipment on the playground is stated in Volume 1 of the guidelines.

Issues:

There is good agreement in the literature regarding the need to separate different activities on the playground, such as active and quiet play. Play equipment, open fields or paved areas for activities such as ball games, and more passive places such as sand boxes should all be in separate areas on the playground (Burke, 1987; Geiger, 1988; Lovell and Harms, 1985; Moore et al., 1987; Stoops, 1985; Werner, 1980, 1982; Australian standards, AS 2155, 1982; British standards, BS 5695: Part 3: 1979; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986). The rationale behind these statements is generally to minimize interference between children engaging in different types of activities.

The Play For All Guidelines (Moore et al., 1987) states that "well-defined activity areas facilitate children's play in all areas," and that injuries are more probable if activity areas are not differentiated. Further, children are able to recognize and understand what activities are appropriate for the different areas. This then dictates clear definition of boundaries, which is important not only for showing children the limits for the behavior acceptable to each area but also to facilitate supervision. Moore et al. give the following recommendation:

> Define boundaries using objects and/or acoustic, tactile, visual and olfactory cues...Articulate edges by contrasting field/ground relationships through color, materials, spatial relationships and sun/shade patterns.

Although not quite as detailed, the Seattle draft standards also promote the separation of activity zones with defined edges and clear entry points. They note that buffers between zones should "not interfere with visual and hearing contact."

Consideration should also be given to controlling the density of children in different areas of the playground. The Seattle draft standards include the following suggestion: "disperse the location of heavy-use and attractive activities so all the children are not likely to congregate in any one place at one time." Burke (1987) also made a similar recommendation.

Another important factor which impacts the location of equipment is unobstructed visibility of all areas of the playground. The Play For All Guidelines (Moore et al., 1987) points out that layout should facilitate supervision through clear visibility over, under, and around all equipment and areas of the playground.

The location of moving equipment warrants special attention. It is important that moving parts do not cross paths with children who are walking or running between pieces of play equipment or activities (Aronson, 1988; Geiger, 1988; Werner, 1982; Seattle draft standards, 1986). Both Werner and the Seattle draft standards recommend that moving equipment should be located toward the edge or corner of the play area. This issue is discussed more thoroughly in the sections on swings and merry-go-rounds (see Sections 5.7.2.3.5, 5.7.5.4).

Recommendations:

The current guidelines regarding the general location and separation of equipment are basically adequate. The playground should be organized into different areas to prevent injuries caused by conflicting activities and children running between activities. Active, physical activities should be separate from more passive or quiet activities: areas for play equipment, open fields and paved areas, and sand boxes should be located in different sections of the playground. In addition, popular, heavy-use pieces of equipment or activities should be dispersed to avoid crowding in any one area. The layout of equipment and activity areas should be without visual barriers so that there are clear sight lines everywhere on the playground to facilitate supervision. Moving equipment, such as swings and merry-go-rounds should be located toward a corner or edge of the play area. Slides should also be located in an uncongested area of the playground. Further, it is important to place metal equipment, such as slides, in shaded areas.

5.3.2.2 Use and fall zones

Guideline content:

Volume 1 contains only a general discussion of use zones, without addressing fall zones or recommending what the use zones should be for various pieces of equipment. "No matter how play areas are organized, it is essential to provide adequate space around each piece of playground equipment. Planning should take into account the equipment's 'use zone,' that is, any activity or movement which can be expected around the equipment." Examples include allowing sufficient space for swings travelling through their largest arcs, children jumping off swings, children exiting from slides, and children "spinning-off" from merry-go-rounds. The only specific recommendation is the following: "buildings, paths and walkways, gates, fences, and other play areas such as sand boxes should be located at least 8 feet away from the estimated use zone associated with a piece of playground equipment." (Volume 1)

Probable rationale:

Neither the NBS nor NRPA rationale documents address any of the layout and design considerations. Both Brown (1978) and Rutherford (1979) observed that injuries caused by falls in which the victim strikes another piece of equipment could be reduced by proper spacing of equipment.

Issues:

Within the area for equipment on a playground, adequate spacing between pieces of equipment is an important design consideration which will help prevent injuries (Brown, 1978; Rutherford, 1979; Bowers, 1988b). Burke (1980) recognized that "proper separation of everything on the site that extends from the ground--whether a tree, fence post, curbing, or play apparatus--is key to safe conditions." Based on their survey of elementary school playgrounds, Bruya and Langendorfer (1988) reported that there was at least 10 feet between pieces of equipment on 70% of the playgrounds studied, "either by design or by accident." They concluded that spacing tended to be good on playgrounds located on large, open lots. Henniger, Strickland, and Frost (1982) pointed out disadvantages for both inadequate and excessive spacing:

> Typically, it is desirable to cluster equipment into zones to accommodate use of soft surfaces and to stimulate action and enhance dramatic play, but equipment that is placed too close together can lead to unnecessary injuries. For example, a child who gains momentum from leaping out of a swing needs some space to regain control to avoid running or stumbling into a hazard in an adjoining play space. The opposite problem of too much space between pieces of equipment can lead to difficulty in adult supervision.

Similarly, Lovell and Harms (1985) noted that the organization of space and equipment on the playground should ensure that children are readily visible and easily supervised by adults.

Preston (1988) noted that the current guidelines for use zones are too general and that more specific definitions are needed. There is quite a range of definitions, and lack thereof, in the literature as well as in the standards.

Beckwith (1988) stated that "a use zone is made up of spaces which surround the equipment and through which players are likely to pass during use of a specific piece of equipment." It dictates what separation is required between pieces of traditional play equipment. Beckwith also defined a fall zone, which is part of the use zone: "the fall zone includes a determination of the space needed around a piece of equipment in which safe falls can occur." Therefore, the fall zone is the area underneath and immediately surrounding the equipment in which protective surfacing is required. Fall zones are also discussed by Aronson (1988), who noted that they need to protect even "the most adventuresome child." Beckwith explained that the fall zone dimensions can be calculated using the elevation of structure as a guide: for all equipment under 6 feet in height, a 6-foot fall zone is adequate; for all equipment over 6 feet in height, an extra foot of fall zone is added for each additional foot in elevation (e.g., a 7-foot structure requires a 7-foot fall zone, an 8-foot structure requires an 8-foot fall zone, and so on). Beckwith's is the only general rule or definition for fall zones in the literature; other sources, including the standards and guidelines reviewed, treat each type of equipment separately, stating each time what the fall zone should be (as discussed in the sections for each type of equipment in this report). Typically, the fall zones specified in the standards are similar to the recommendations which Beckwith's definition would yield.

Beckwith (1988) mentioned that the use and fall zones of a particular piece of equipment are often equivalent. Others have defined a use zone comprised of two parts, one being the area for protective surfacing (comparable to Beckwith's fall zone) and the other an extension beyond that to complete the use zone. For example, the Canadian draft standards (CAN/CSA-Z614, 1988) specify for various types of equipment the dimensions which define a protective surfacing area and, additionally, a no-encroachment zone. Similarly, Burke (1980; 1987) discussed a resilient material area and an extension of that called an "exclusivity zone," where no other object or piece of equipment should intrude. The British standards (BS 5696: Part 3: 1979) also refer to several areas within the use zone: "the minimum space requirements for equipment (i.e., the space occupied by the item) and the area of operation (i.e., the space occupied by children using the item) together with an allowance for free movement of children between items is termed the minimum use zone." Although the British standard does not explicitly explain the requirements for each area, it appears that the operating area is designed for protective surfacing and the added area for circulation of children is comparable to a no- encroachment zone. The minimum use zones for individual pieces of equipment, as explained in the British standards, should not overlap.

The Seattle draft standards (1986) discuss the need for a "clear zone" around each piece of equipment, which is defined exactly like the "use zone" in the current guidelines. However, the dimensions given for the clear zone for various types of equipment dictate the area in which protective surfacing is required. This makes the Seattle zone more comparable to a fall zone rather than a use zone, which includes space beyond the protective surfacing. The Seattle draft standards specify that the clear zones for two adjacent pieces of equipment should not overlap, similar to the British requirement. The German standards (DIN 7926, Part 1, 1985) also define a zone where protective surfacing is required, the "safety zone," without requiring an additional no-encroachment zone. In contrast to the Seattle and British versions, the German standards allow safety zones to overlap.

Beckwith (1988) noted the importance of ensuring that no other equipment or obstacles are in the fall zone, since one of the goals is to prevent injuries caused by falls onto other pieces of equipment. Both Aronson (1988) and J. Frost (personal communication, February 1989) also recognized that fall zones should be free of protruding objects or obstacles. Frost observed that support posts should be located underneath equipment and should not extend beyond the perimeter of the equipment, so falls to the surface below or to another part of the equipment on a multi-use structure are not obstructed by protruding components. The only standard reviewed which addresses this potential problem is the German specification: no objects or support struts are allowed in the safety zone where children might fall on them or be otherwise injured.

Recommendations:

The use zone for each piece of equipment is made up of two parts: 1) the fall zone: an area where protective surfacing is required; and, 2) the no-encroachment zone: an additional area beyond the resilient materials where children using the equipment can be expected to move about. The use zones of adjacent pieces of equipment should not overlap; this is intended to ensure that children have adequate space to engage in all activities associated with each piece of equipment and to prevent interference between children playing on adjacent structures. The use zone recommended for each type of equipment, including both the fall zone and the no-encroachment zone, is specified in detail in the relevant sections of the report. Regardless of the type of equipment, the use zone should be free of obstacles that children could run into or fall on top of and thus be injured; for example, there should not be any vertical posts or other objects protruding from the ground in the area around a piece of equipment. More specific recommendations on certain structural configurations that present obstacles in the use zones of slides and climbers are made in Sections 5.7.1.3.5 and 5.7.3.3.1.

For all equipment less than 6 feet in height, the fall zone should extend a minimum of 6 feet in all directions from the perimeter of the equipment. When equipment is higher than 6 feet above ground, the fall zone needs to be larger: the area for protective surfacing should extend one additional foot for each extra foot in height above 6 feet. This may define irregular shapes for the minimum fall zone of certain pieces of equipment. For example, if a piece of equipment is 8 feet high at one end and 4 feet high at the other, the fall zone at the higher end should extend at least 8 feet from the perimeter of the equipment but it would only have to extend at least 6 feet from the perimeter of the equipment at the lower end. This definition of the fall zone is based on Beckwith (1988). It provides a reasonable fall zone, incoporating a logical relationship based on height that dictates an expanded fall zone for taller equipment. Since empirical data on where children fall are lacking, the fall zone criteria cannot be supported by objective findings. However, the fall zones defined above are reasonable and generally consistent with other standards for specific types of equipment.

The dimensions of the no-encroachment zone required may also vary for different types of equipment. For example, moving equipment or equipment from which the child is in motion as he or she exits should have a larger no-encroachment zone in the direction of motion. This allows more space for children to regain their balance upon exiting the equipment and also provides added protection against other children running into a moving part.

5.3.2.3 Traffic and pathways

Guideline content:

Volume 1 of the current guidelines contains the following discussion of traffic and pathways on the playground:

> Generally, mapping out playground space before purchasing or installing permanent pieces of play equipment can encourage varied and safe activity. As areas are mapped out, planners should consider the traffic patterns which will result. Ample pathways should link activity areas, provide easy access from one piece of equipment to another and offer unobstructed vision from a child's height. Smoothly flowing traffic will eliminate many accidents such as collisions between children and equipment and between children and other children. (Volume 1)

Probable rationale:

Neither the NBS nor NRPA rationale documents address any of the layout and design considerations. Brown (1978) concluded that "a playground area designed to direct or control the flow of traffic can enhance safety." As stated in Volume 1, careful planning of pathways can minimize the risk of collisions and other interference between children moving among various activities.

Issues:

The literature and standards strongly support the CPSC recommendations regarding traffic and pathways. Many sources agree that circulation of children on playgrounds is a crucial issue warranting attention; the safe flow of traffic between activities should be directed through the use of clear pathways (Aronson, 1988; Frost, 1986c; Lovell and Harms, 1985; Moore et al., 1987; Stoops, 1985; Sweeney, 1982, 1985, 1987; Werner, 1980; British standards, BS 5696: Part 3: 1979; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986). Beckwith (1988) noted that traffic routes should be wide enough to accommodate multi-directional movement. The following explanation by Burke (1987) highlights the need for, and importance of, pathways:

> When having fun and forgetting all safety precautions, children will invariably be bumped or knocked down through contact with a child on a swing, or a child also running, or a stationary piece of equipment or other object in the way. The chance of an accident diminishes however, when pathways give silent direction to children regarding the routes they should take when moving from place to place.

Burke also noted that children are more likely to use pathways which link areas that are farther apart. Therefore, such pathways will not only promote safe flow of traffic but also help reduce congestion in any one area, which supports recommendations to separate the popular, heavy-use activities or pieces of equipment.

The Play For All Guidelines (Moore et al., 1987) devotes an entire chapter to the design of pathways on playgrounds. Its basic premise in calling for pathways is similar to that expressed above: to facilitate increased and safer circulation of children between activities and thereby increase the usage of the entire playground. The level of detail regarding specifications for pathways in the Play For All Guidelines is well above that of the current CPSC handbook, covering such details as pavement materials and treatment, edging and curbs, width, and other dimensions.

Recommendations:

The current guidelines are certainly warranted. Controlling the traffic of children on playgrounds will help to reduce injuries caused by collisions between two children and between a child and a piece of equipment. Pathways should direct children travelling from one piece of equipment to another and from one activity area to another with an easy route to follow and unobstructed vision at a child's height. The range of approximate standing eye heights for younger and older children, respectively, are as follows: 30.4 inches, for a 5th percentile 2-year-old, to 41.9 inches, for a 95th percentile 5-year-old; 33.5 inches, for a 5th percentile 4-year-old, to 58.9 inches, for a 95th percentile 12-year-old. Pathways should allow multi-directional traffic. In addition to reducing injuries, smoothly flowing traffic will help prevent interference between children moving from one activity to another and other children engaged in different activities along the way. Good circulation of children around the playground will promote greater usage of the range of activities and equipment provided.

5.3.2.4 Multi-use equipment

Guideline content:

The current guidelines do not address multi-use equipment.

Probable rationale:

Not applicable.

Issues:

Perhaps the most significant trend in recent playground equipment design is the move to link play components into what is called multi-use equipment, or superstructures. Rather than the traditional, separate pieces of equipment, contemporary structures connect everything from slides, overhead horizontal ladders, stepped platforms, flexible net climbers, tunnels, and ramps, to exercise rings and sometimes even swings. Most would agree that this is a positive sign for children's play environments. The following sources all address the merits of multi-use equipment: Beckwith, 1985, 1988; Bowers, 1988a, 1988b; Bruya and Langendorfer, 1988; Frost, 1980, 1986a, 1988, U. of Texas, 1989, unpublished manuscript; Frost and Wortham, 1988; Moore et al., 1987; Stoops, 1985; Wallach, 1983; Ward, 1987; Werner, 1980; Seattle draft standards, 1986. Some of the benefits of multi-use equipment are listed below.

- o Increased complexity and challenge: multi-use equipment generally provides a broader array of opportunities in all areas of development than traditional equipment. For example, there are numerous platforms which serve as stages for dramatic play or observation and partially-enclosed spaces which can be built in under platforms. Creative play is further enhanced by the use of sand as the resilient material under superstructures, or the addition of other loose equipment and materials.

- o Play in small groups: traditional designs basically ignore the fact that children usually play in small groups, while superstructures facilitate such play.

- o Linkage, flow of traffic: the physical connection of play components promotes better circulation and flow of traffic on the equipment. In addition, these designs offer more choices, thus supporting decision making and problem solving skills, which is an important developmental consideration. Other advantages of linkage on multi-use equipment are similar to those discussed in conjunction with pathways between play areas or activities; linkage is also discussed in the climbing equipment section (see Section 5.7.3.7).

- o Continuous nature of play; extended play: related to the flow of traffic, superstructures recognize the continuous nature of play in allowing for uninterrupted play and avoiding queuing problems common on traditional equipment. In addition, superstructures have been observed to support uninterrupted, more unified play for extended periods, in contrast to separate pieces of equipment which do not foster connected sequences of play.

- o <u>Smaller area</u>: multi-use equipment requires less space than traditional pieces of equipment, and therefore, it is easier to provide proper protective surfacing; supervision is more convenient.

Recommendations:

Multi-use equipment has a number of advantages over traditional, separate pieces of playground equipment. However, care should be taken to ensure that the relationships between adjacent components on superstructures and the resulting play and traffic patterns of children on the equipment are complementary. Some of the potentially hazardous arrangements of components are discussed in the sections on slides, swings, and climbing equipment (see Sections 5.7.1.3.1.2, 5.7.2.3.5, 5.7.3.7).

5.3.2.5 Age separation of equipment

Guideline content:

One of the examples given in Volume 1 for what playgrounds might include is "an area for preschool children, equipped with appropriately sized swings, low slides, sand boxes, etc." Later, it is explained that such areas can help protect younger children from older children's more active play. It is also suggested that equipment could be color coded for different age groups or that explanatory signs could be posted. (Volume 1)

Probable rationale:

Neither the NBS nor NRPA rationale documents address any of the layout and design considerations. With regard to age group separation, Brown (1978) included the following: "an over-loaded piece of equipment complicated by children of mixed age ranges utilizing it becomes analogous to 'survival of the fittest.' For this and other reasons, there is strong support for the separation of play spaces either by age group or equipment design and preferably both."

Issues:

When planning a playground, designers often consider mapping out the area in zones. As discussed above, play areas are often zoned by the type of activity or developmental aspect served. Another possibility is to separate areas by the age of the users. There is good agreement that playground equipment and materials should be designed for the age, size, and developmental level of the users. Further, since toddlers are not as advanced as older children, in all facets of development, their play patterns are different and should have separate playground areas with appropriately scaled-down equipment and materials (Bruya and Langendorfer, 1988; Burke, 1980, 1987; Corrado, 1978; Frost, 1980, 1986a, 1988; Frost and Wortham, 1988; Henniger et al., 1982; Lovell and Harms, 1985; Moore et al., 1987; Simpson, 1988; Stoops, 1985, Werner, 1980; Canadian draft standards CAN/CSA-Z614, 1988; Seattle draft standards, 1986). However, it should be noted that this conclusion is only true for the separation of toddlers from school-age children, and does not support the separation of children at the two ends of the school-age range.

The reasons for designing separate playgrounds for toddlers are mainly safety-related. For example, injuries may result from younger children using equipment designed for older children for which they do not yet have the necessary motor skills, such as strength, coordination, and balance (Bruya and Langendorfer, 1988; Moore et al., 1987; Stoops, 1985). Moore et al. point out that older children are also sometimes injured using smaller equipment designed for toddlers. A common, but hazardous, situation arises when all ages play together, especially if equipment is crowded and older children try to force younger children off the equipment, as in a "king of the mountain" or "survival of the fittest" game (Brown, 1978; Stoops, 1985).

The play patterns of younger children also differ, and therefore, dictate different equipment and materials. Older children, for example, need more space and larger equipment for active play, and open fields for organized games (Burke, 1987; Frost, 1988; Stoops, 1985), while younger children tend to benefit more from creative, loose equipment and materials and partially-enclosed spaces (Frost, 1986a, 1988; Moore et al., 1987; Seattle draft standards, Canadian draft standards).

It is often unclear exactly what "separation by age" is intended to mean. Some playgrounds have both small and large equipment together in the same area; some have small and large equipment in different areas; some have small and large equipment in different areas separated by fences or other enclosures. In addition, Bruya and Langendorfer (1988) noted that schools which do not have two sets of equipment sometimes try to alleviate age conflicts through different play times for different age groups; however, this would not solve the safety problems created by young children using equipment which is too big for them. Some sources simply state that toddler play areas should be separate, without any explanation of what "separate" means (Bruya and Langendorfer, 1988; Corrado, 1978; Frost, 1980; Simpson, 1988). Also without definition, Stoops (1985) promoted consideration of "some degree of play area separation," and Werner (1980) called for "natural separation." Burke (1980; 1987) suggested that where all age groups play, a large site is needed so that separate play areas can be located "some distance" apart, providing "a buffer zone between the two, for safety and control." The most stringent recommendation is in the Play For All Guidelines (Moore et al., 1987), which notes that "physical barriers may be needed to facilitate supervision."

As noted previously, there is no support for age separation except in the case of toddlers. Both the Seattle draft standards and the Play For All Guidelines (Moore et al., 1987) state that playground zoning should be based on activity characteristics or developmental stages, not age; they then note that preschoolers are a special population which require of separate areas. Siblings and friends have a need for and enjoy playing in mixed age groups (Moore et al., 1987; R. Moore, personal communication, February 1989). Frost (1980) also supports allowing all older children (4 to 12 years) to play together. He explained that both ends of the age range benefit from such interactions as the older children teach the younger ones "various cultural learnings, cooperations, games, language, etc." With regard to the safety of the younger part of the group, Frost suggested that they may be equally safe in a mixed age group as they are in a homogeneous group. Further, Frost noted that with increased attention to protective surfacing, children are able to use "larger, more challenging equipment with greater safety." Other problems stem from the fast pace with which 4- to 6-year-olds grow and learn:

> When young children (4-6) are grouped by age for play, the play equipment, if selected for that age group, rapidly outlives its usefulness. If given regular reasonably lengthy periods of time for play the children will quickly master the perceptual-motor activities required to use equipment designed for their age group...Designing play environments to accommodate a wide range of age groups allows for the breadth of equipment sized and challenges to promote continued perceptual-motor development. (Frost, 1980)

It is important to remember that Frost advocated separate play areas and materials for toddlers.

The only discussion in the literature or standards regarding age labeling of separate equipment or areas for different age groups deals with signs. The Seattle draft standards note that while signs are not mandatory, they can be an amenity. It is recommended that signs indicate zones designed for preschool-age children. They explain the following:

> Signage can be used to direct parents about play opportunities for their children and warn children about level of difficulty. Use of signs to reinforce visible indications that spaces or events are more suitable for very young children tends to keep older children out.

Additional specifications are given for the actual design of the signs. The Play For All Guidelines (Moore et al., 1987) also addresses signs, although not in direct reference to separate areas for toddlers. Discussion includes four types of signs: informational, directional, identification, and regulatory. An identification sign could be used to mark a preschool area. Like the Seattle draft standards, Moore et al. include general guidelines for readability, giving consideration to specifications for letter character size and shape as well as the use of symbols.

Recommendations:

Playgrounds should have equipment and materials designed with attention to the age, size, and physical abilities, as well as cognitive, social, and emotional development of the intended users. Because younger children differ greatly from older children on such variables, it is recommended that playgrounds have separate areas for younger children with appropriately sized equipment and materials to serve their less advanced developmental levels. It is also important to recognize that preschoolers require more attentive supervision on playgrounds. Throughout this report, consideration is given to specific recommendations for equipment designed for preschool-age children (2 to 5 years). The design and scale of equipment should make the intended user group obvious. Some playgrounds, often referred to as tot lots, are designed only for younger children, so separation is not an issue. Other playgrounds are intended to serve all ages: in this case, there should be two separate areas, one for preschool-age children and one for school-age children. The layout of pathways and the landscaping of the playground should show two distinct areas for the two age groups: they should be separated at least by a buffer zone of ample physical space. Signs can be used to give some guidance to adults; for example, signs posted at the different areas could explain the various equipment and activities to parents so that they could determine what is appropriate for the age of their child. Color coding of equipment designed for different age groups or other informational schemes directed at children are probably of limited value, because although young children could learn the rules they could not be relied upon to follow them.

There is not a need to separate children within the older age group (4 to 12 years). Children at both ends of the range will benefit from sharing play areas and the resulting social interaction.

5.3.3 SITE SELECTION

Guideline content:

Volume 1 of the current handbook makes a couple of points regarding site selection: in order to keep children within the playground area and prevent them from running into the street, a fence or a relatively impenetrable border, such as trees or shrubbery, should enclose the entire site; the site should be designed to allow for maximum drainage. (Volume 1)

Probable rationale:

No rationale is stated beyond that which is stated in Volume 1 of the guidelines.

Issues:

Accessibility and neighboring areas: Choosing the site for a playground requires careful planning. The Canadian draft standards (CAN/CSA-Z614, 1988) note that playgrounds are well suited either in residential areas or attached to local schools and community centers; the British standards (BS 5696: Part 3: 1979) recognize that playground location may vary from "an open field in the country to an urban development or a derelict site in a densely built-up area." Both the Canadian draft and British standards, as well as the New Zealand standards (NZ 5828: Part 1: 1986) explain that wherever a playground is located, one important factor to consider is the users' access to it. The safety of children traveling through the surrounding area to reach the playground must be judged. The Canadian draft standards note that "obviously potential hazards en route, such as secluded, wooded areas, would be restrictive." Nearby lakes, rivers, or creeks could pose similar hazards (Australian standards, AS 2155, 1982). Aronson (1988) also suggested that easy access and proximity to emergency services were important.

Public visibility: Related to the concern for children's safety en route to the playground is their safety while on the playground. The Canadian and Seattle draft standards (1986) note that public visibility into the play area must be considered. More specifically, as stated in both the Australian and New Zealand standards, the playground should be "within the sight of local residents who would become aware of any accident or the presence of any undesirable visitors." Stoops (1985) explained the concept of defensible space as follows:

> Defensible space refers to the design concept that allows for good sight lines in order to avoid hidden areas where deviant behavior or crimes could occur unnoticed. It also allows for some safe means of ingress and egress in any particular environment. Taken to its extreme, it is the antithesis of visual surprise, privacy, or seclusion. Defensible space is of concern in children's play areas in order to avoid creating a setting that fosters deviant behaviors. It also aids in control of vandalism, because proper siting and layout of facilities can allow easy surveillance by other park users, neighbors, and the police.

Moore et al. (1987) include a similar discussion of defensible space and the importance of public visibility; therefore, high continuous, opaque barriers should not be used around or within the playground site. Similarly, Bruya and Langendorfer (1988) recognized that walls or impenetrable shrubbery used as a barrier around the playground, as recommended by the CPSC, could limit visibility, thus creating a concern regarding inappropriate play behaviors and the safety of playing children. Beckwith (1988) also recommended that natural sight lines be kept open to facilitate monitoring of the play area.

Questions on the AALR survey of elementary school playgrounds addressed whether or not the playground was in view of nearby residents and/or passersby (Bruya and Langendorfer, 1988). The results indicated that 78% of the playgrounds surveyed were open to view, and therefore, easily monitored.

Bruya and Langendorfer (1988) recognized that it may not always be desirable for the playground to be open to view, in light of recent concern regarding kidnapping. "Some institutions located adjacent to major thoroughfares or within dangerous urban areas may feel inclined to minimize attracting passersby to play areas by constructing privacy fences or other enclosures that limit visibility."

Safety from traffic; fencing: Attention to traffic safety is imperative when choosing a playground site; the potential conflict between children and traffic should be minimized (Corrado,1978; Moore et al., 1987; Seattle draft standards, 1986). Corrado stated that "locating a play area next to a roadway...is just plain dumb." There is good agreement that playground areas should be well defined and physically separate and protected from vehicular traffic (Aronson, 1988; Burke, 1987; Frost, 1986c; Frost and Wortham, 1988; Lovell and Harms, 1985; Werner, 1980; Winter, 1988). Most translate this concern into a need for some sort of fencing or other border around the site.

There are several important design considerations for fencing. As discussed above, public visibility into play areas should not be hampered by the enclosure. Bruya and Langendorfer (1988) were critical of the CPSC guidelines suggesting the use of shrubbery or other impenetrable barriers for this reason; they noted that "many would consider walls or shrubbery to be less adequate than an open-type of fencing for enclosing the play environment." The goal of the fencing should be considered: its primary function is to protect preoccupied, playing children from running out into the street without thinking about the dangers of traffic (Bruya and Langendorfer, 1988; Burke, 1987). Burke explained that the height of the enclosure should, therefore, allow adequate vision of traffic from a child's level, and that in contrast to a tall fence, this will facilitate supervision. Frost and Wortham (1988) suggested that fences should be a minimum of 4 feet high. Actually, height cannot serve as the sole criterion for whether a fence facilitates or restricts visibility, from a child's or an adult's viewpoint; instead, the more important measure is the openness or opaqueness of the barrier.

Exposure to local climatic conditions; good drainage: When choosing a playground site and planning its layout, attention to the local climatic conditions is important; there should be adequate sun as well as shade, and protection from wind, rain, and snow (Moore et al., 1987; Australian standards; British standards; Canadian draft standards; New Zealand standards; Seattle draft standards). In addition, it is essential to provide for good drainage under all expected weather conditions (Aronson, 1988; Frost and Wortham, 1988; Moore et al., 1987; British standards; Canadian draft standards; Seattle draft standards).

Recommendations:

Selection of a playground site requires careful planning and attention to the characteristics of the neighborhood: children should not be confronted with hazards or obstacles in traveling to or from the playground. Protecting children on the playground from vehicular traffic is another important consideration. A barrier designed to prevent play from spilling over into dangerous areas should surround the playground; this will protect preoccupied, playing children from running inadvertently into the street to chase a ball, for example. The barrier should not preclude supervision or provide children with places to hide. In some sites, a higher degree of barrier protection may be warranted to prevent children from intentionally climbing over the enclosure and out of the play area.

Consideration of the local climate is also important when choosing a playground site. The design and layout of the playground should allow for a good mix of sun and shade, while providing adequate protection from heavy wind, rain, or snow. Further, the site should be designed to provide maximum drainage.

5.4 ASSEMBLY, INSTALLATION, AND MAINTENANCE

5.4 ASSEMBLY, INSTALLATION, AND MAINTENANCE

5.4.1 ASSEMBLY AND INSTALLATION

5.4.2 MAINTENANCE

5.4.3 IDENTIFICATION

5.4.1 ASSEMBLY AND INSTALLATION

Guideline content:

The current Handbook recommends that the manufacturers of playground equipment provide "instructions and necessary drawings, photos, or other illustrations" for proper assembly and installation. This includes details such as torque specifications for nuts and bolts, a full listing of components with appropriate part names and numbers, requirements for secure anchoring of the equipment in the ground, and the recommended use zones. It suggests that, specifically for swing assemblies, manufacturers recommend the maximum length for suspending elements. In addition, a note in Volume 2, as well as discussion in Volume 1, highlights the need for impact absorbent surfacing: "all promotional material and installation instructions should caution against installing playground equipment over paved surfaces such as concrete or asphalt because falls to these surfaces may result in more severe injuries than falls to more resilient surfaces." Volume 1 recognizes the importance of carefully following the manufacturer instructions for assembling and installing all playground equipment. (Volume 1; Volume 2, 4.1)

A "Suggested Public Playground Planners' and Installers' Checklist" is included in Volume 1. It is a summary of recommendations from various sections of the guidelines, and its scope goes beyond the specifications which might be found in a manufacturer's instructions for proper assembly and installation of equipment.

Stability: The current guideline regarding stability states that "when properly installed as directed in the installation instructions or as specified on construction drawings, the equipment should withstand maximum anticipated forces generated by the users which might tend to tip or slide it." (Volume 2, 5.3)

Probable rationale:

The excerpt below from the NBS documents contains the rationale for recommendations regarding instructions for assembly, installation, and maintenance (see Section 5.4.2 for a discussion of maintenance).

> If playground equipment is improperly installed or maintained, the intent of these guidelines as well as the manufacturer's interest in safe play equipment, may be negated. The manufacturer has control over his product up to delivery, then it becomes the responsibility of the buyer/installer. The manufacturer is in the best position to have expert knowledge concerning proper methods of installation and maintenance and consequently should provide this information. Literature included with the equipment is a practical method for conveying this information: it ensures that the buyer/installer is provided the necessary information for proper installation and maintenance. (NBS 1978a)

Stability: The intent of this recommendation is to ensure that properly installed equipment cannot be overturned by a user or group of users. As stated by the NRPA, "no performance test is specified here as stability can normally be calculated by accepted engineering analysis." In general, stability is a function of the means of installation, and it must be recognized that different soil conditions will require different footing sizes and depths. Other recommendations address the need for manufacturers to provide detailed installation instructions to ensure the correct anchoring of equipment. (NBS 1978a; NRPA 1976a)

The NRPA also mentioned that injury data does not indicate that stability is a frequent problem: "in the accident reports we have yet to see an injury caused by the equipment tipping over--and even if it did, it is likely an installation and maintenance problem that is beyond the control of the manufacturer." (NRPA 1976a)

Issues:

It is clear that correct assembly and installation of equipment is key to the safety of children on playgrounds. As stated by Beckwith (1988), "even with the best design and the highest quality equipment the lack of proper installation can still jeopardize the final quality of the environment." Improper installation of equipment is recognized as one of the hazards which causes injuries on playgrounds (Frost, 1986a; Frost and Henniger, 1979; King and Ball, 1989).

Both J. Frost (personal communication, February 1989) and Werner (1980) noted that manufacturers should be required to specify the correct installation procedures for playground equipment. Consensus in the standards reviewed is clearly that manufacturers must provide detailed instructions with appropriate drawings and diagrams for correct assembly and installation (Australian standards, AS 2155, 1982; British standards, BS 5696: Part 3: 1979; German standards, DIN 7926, Part 1, 1985; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986). Beckwith (1988) and Moore et al. (1987) stated that most current manufacturers do in fact supply detailed and thorough installation instructions. Further, Beckwith noted that these are usually complete with schematic drawings; he concluded that "graphic installation instructions are the clearest, the most easily understood, and the overall best type of installation guide." Similarly, Moore et al. recognize that the companies which rely heavily on export of their goods tend to provide purely graphic instructions; they conclude that "not only does such an approach resolve translation problems but it provides appropriate guidance for the nonreading installer."

The Australian, British, and Canadian draft standards stipulate that assembly and installation should be carried out strictly in accordance with the manufacturer's instructions and recommendations. The Canadian draft standards note that substitute procedures should not be used; the British standards explain that if incorrect or unsuitable methods are applied, the operation and safety of the equipment may be adversely affected. The Seattle draft standards recognize that correct installation is important "to ensure maximum safety and to extend the length of equipment life."

The level of detail in the standards and other sources varies with regard to exactly what should be addressed in assembly and installation instructions. The references cited below recommend that manufacturers provide specifications for the following factors: any foundations or necessary anchoring (Moore et al., 1987; Werner, 1980; Australian standards; British standards; German standards; Canadian draft standards); site preparation (British standards; Canadian draft standards); the erection sequence (Moore et al., 1987; Australian standards; British standards); torque tightening figures for bolts and similar hardware (Australian standards; British standards); and the estimated time required for construction (Moore et al., 1987). In addition, some have suggested that the manufacturer include a parts list for the equipment (Moore et al., 1987; Canadian draft standards; Seattle draft standards). Both the Australian and British standards note that all parts should be readily identifiable and labeled if necessary. "A check list against which correct assembly and safe operation can be assessed" is also recommended by the Australian and British standards.

The area around each piece of playground equipment needs special attention during the assembly and installation process, and should be viewed as part of the equipment itself. Resilient surfacing, for example, is a key factor to the safety of all playground equipment. Similar to the surfacing notes in the current Handbook, Butwinick (1980) and Beckwith (1988) each recognized the importance of strong warnings by the manufacturers of playground equipment which highlight the danger of concrete, asphalt, and other hard surfaces while emphasizing the need for impact-absorbing surfacing directly under equipment and within fall distances. Sweeney (1979a; 1980) advocated the use of a label on all equipment to warn of the injury causing potential of hard surfaces. (Labels regarding surfacing are discussed more thoroughly in Section 5.1.3.6). Both the German and Canadian draft standards recommend that installation instructions contain specifications for the nature of the surface required. The Australian, German, Canadian draft, and Seattle draft standards all indicate that manufacturers should provide information pertaining to the minimum area needed around each piece of equipment for safe use, and some specifically suggest that the dimensions of the area in which protective surfacing is required should be included in the installation instructions. (Recommendations for the actual dimensions of these zones are discussed in Section 5.3.2.2).

The Australian, British, and Canadian draft standards also stipulate that before the equipment is used, it should be carefully inspected and checked for compliance with the manufacturer's specifications and the applicable standards. The British standards give details for visual and mechanical inspections for orientation, assembly, dimensions, function (stability and general hazards for stationary equipment; free movement of parts, good alignment of parts, and correct lubrication and use of joint sealants for moving equipment), finish, and site. They also note that ground clearances and safety areas should be checked. Similarly, the Canadian draft standards also stress inspection of surfacing and all joints and connections before the equipment is used.

Moore et al. (1987) recognize that "ideally, factory representatives should inspect final installations of play equipment for compliance with manufacturers' standards." Further, they suggest that the purchaser obtain a letter from the inspectors for documentation that the equipment is installed in accordance with factory specifications. Beckwith (1988) made similar recommendations. Both of these sources also discuss keeping a document file for the equipment, which should include the records of purchase, the manufacturer's assembly and installation instructions, the installer's qualifications and insurance, the manufacturer's verification of proper assembly and installation, and photographs of the installed equipment.

Moore et al. (1987) note that "play equipment manufacturers' promotional materials, catalogs and installation documents accompanying specific pieces should be improved as a source of information for prospective users," because these can be important vehicles for public education and thereby may help increase safety on playgrounds. A review of current catalogs indicated that many manufacturers do include safety information in their catalogs. Many have warnings about hard surfaces on every page. Other general safety considerations, including specifications for use and fall zones, are also discussed by several manufacturers, and readers are sometimes referred to safety guidelines such as the CPSC Handbook.

Stability: There is good agreement that structural stability is essential, and that this dictates a need for secure anchoring of playground equipment (Aronson, 1988; Butwinick, 1980; Esbensen, 1987; Frost and Wortham, 1988; Geiger, 1988; Lovell and Harms, 1985, Werner, 1982; Australian standards, AS 1924, Part 1, 1981; British standards, BS 5696: Part 2, 1986; German standards, DIN 7926, Part 2, 1984; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986). Aronson, Butwinick, Frost and Wortham, Werner, and the Seattle draft standards all recommend that equipment be anchored with concrete footings, noting that these must be adequately recessed to avoid trip hazards. (Trip hazards are discussed in Section 5.2.7). Frost (1980) suggested that the guidelines should address the type of anchoring required for stability. Details for various anchoring techniques are included in the Australian and Seattle draft standards. However, both these standards, as well as many other sources, including the current CPSC guidelines, recommend that the manufacturer's installation instructions should contain information on the anchoring necessary for each piece of equipment.

Descriptions of the degree of required stability vary somewhat. For example, Geiger (1988) noted that equipment must be "anchored solidly enough to hold up under active use," while Frost and Wortham (1988) stated that "equipment should be structurally sound--no bending, warping, breaking, or sinking." The Seattle draft standards recognize that "equipment should not move when walked on, pushed or pulled by an adult." Additionally, they recommend that anchoring be stable enough to "prevent vibration or oscillation," and "to withstand anticipated forces generated by users which might tend to tip or slide it." The latter specification is identical to the CPSC guideline. The Australian and Canadian draft standards contain parallel recommendations: the righting moment of any piece of playground equipment should be at least 50 percent in excess of any overturning moment under the most adverse conditions of use; either natural stability or appropriate anchoring should assure this condition. The German standards refer to other German standards for the basis of design calculations for the stability of playground equipment.

Recommendations:

Proper assembly and installation of playground equipment are extremely important for its overall safety. While the current guidelines are appropriate, a few general additions are warranted.

Manufacturers should provide detailed instructions for the assembly and installation of each piece of playground equipment, including drawings, diagrams or other illustrations. Graphic instructions tend to be clearer and more understandable for all readers. A list of all equipment components and parts should also be provided by the manufacturer; all components should be easily identifiable, and, if necessary, labeled. The assembly and installation instructions should include at least the following: the erection sequence; torque tightening figures for nuts, bolts, and other hardware; and requirements for secure anchoring of the equipment. Proper attention must also be given to the area under and around playground equipment. Thus, the assembly and installation instructions should also include strong warnings regarding the dangers of hard surfaces and recommendations stressing the need for protective surfacing under each piece of equipment, as well as information to guide the placement of equipment so that each piece has adequate use and fall zones. Manufacturers' specifications regarding surfacing and use and fall zones should be comparable to the recommendations given in Sections 5.1, 5.1.3.6, and 5.3.2.2, respectively. Manufacturers should also specify what age children are intended to use the equipment.

The people who assemble and install playground equipment should follow the manufacturer's instructions very carefully. If procedures other than those specified are adopted, the stability and, therefore, safety of the equipment may be jeopardized. The manufacturer's instructions could include a warning to this effect. All playground equipment should be thoroughly inspected before its first use; it is recommended that a representative of the manufacturer conduct this inspection to ensure that the equipment as installed complies with the factory specifications. Further, it is recommended that following such inspection the purchaser/installer obtain written documentation that the equipment is in compliance with the manufacturer's specifications. As a precaution, this documentation and all other materials collected about the equipment should be kept, including the assembly and installation instructions provided by the manufacturer.

Stability: The stability of playground equipment is crucial to its overall safety. As currently recommended, equipment should withstand the maximum anticipated forces generated by active use which might cause it to overturn, tip, slide, or move in any way, when properly installed as directed by the manufacturer's instructions and specifications. Secure anchoring is a key factor to stable installation, and because the required footing sizes and depths may vary, the anchoring process for each piece of equipment should be completed in strict accordance with the manufacturer's specifications.

5.4.2 MAINTENANCE

Guideline content:

Both volumes of the current guidelines recommend that manufacturers provide instructions for the general maintenance and upkeep of equipment. Volume 1 also contains a "Suggested Public Playground Maintenance Checklist." It notes that "inspections should be conducted on a frequent, regularly scheduled basis." The checklist provides a summary, derived from recommendations throughout the Handbook, of "some danger points" which should be watched for during each inspection; the focus is on attention to general hazards, ensuring that connecting hardware is tightly fastened, and checking for deteriorated, vandalized, or otherwise damaged equipment parts. (Volume 1; Volume 2, 4.1)

Probable rationale:

The rationale supporting the recommendations regarding maintenance is discussed in Section 5.4.1, in conjunction with assembly and installation.

Issues:

Poorly maintained equipment is a common playground hazard (Frost, 1986a; Frost and Henniger, 1979; Henniger et al., 1982; Monroe, 1985). Injuries which result from inadequate maintenance of equipment are perhaps the most preventable of all injuries which occur on playgrounds; however, King and Ball (1989) concluded that such injuries are not infrequent, which shows that this problem is not adequately addressed. An Australian study (Parry, 1982) discussed by King and Ball implicated faulty maintenance in more playground injuries (34% of all injuries) than any other cause. Data for 1982-1987 from the Zoological Society of London reported by King and Ball showed that high standards of maintenance can contribute to a lower incidence of injuries. Similarly, L. Witt (personal communication, February 1989) explained that in the four years since a rigorous inspection and maintenance system was started in Montgomery County, Maryland, there have not been any injuries reported which required hospitalization. He also believes that involvement of the inspection and maintenance personnel from the beginning stages of the planning process has contributed to the county's record of no serious injuries.

King and Ball (1989) reported that a "significant number of both serious and fatal accidents were caused by equipment falling onto the victim." It is important to recognize, however, that some of the studies from which King and Ball drew this conclusion included home equipment in their data, and that this equipment may be more likely to be involved in such incidents than public equipment. The collapse of equipment may be attributable to inadequate maintenance, but improper installation may also be a factor in some incidents. Data collected by the CPSC indicated that 3 of the 28 fatalities which occurred on playground equipment (including both public and home equipment) during 1985-87 were the result of children being crushed by equipment, there were two climber-related cases and one slide-related case (King and Ball, 1989). Rutherford (1979) reported that 3 of 36 deaths involving public playground equipment from 1973-77 occurred when equipment collapsed on top of children; two involved swings and one involved a climber.

As stated in the Play For All Guidelines (Moore et al., 1987), "the need for carefully planned and professionally administered maintenance programs has become a critical aspect of public play provisions." Similarly, Stoops (1985) noted that in order to keep playgrounds safe, proper, ongoing maintenance is imperative. Consensus in the standards is that manufacturers should be responsible for providing detailed instructions and schedules for maintenance of equipment (Australian standards, AS 1924, Part 1, 1981; British standards, BS 5696: Part 2: 1986; German standards, DIN 7926, Part 1, 1988; Canadian draft standards, CAN/CSA-Z614, 1988; Seattle draft standards, 1986). The Canadian draft standards recognize the importance of carrying out the maintenance, repair, and replacement of equipment components strictly in accordance with the manufacturer's recommendations. Beckwith (1988) and Moore et al. (1987) also recommend that maintenance procedures follow the manufacturer's specifications.

The Australian, British, German, and Canadian draft standards each recognize that maintenance instructions should give special attention to moving equipment and each contain similar specifications. Instructions should include lubrication requirements and details for checking joints. In addition, information should be provided regarding the degree of permissible wear or fitting tolerance for all moving parts and a possible schedule for replacement. The Australian and British standards recommend listing the parts which are subject to wear and will, therefore, require more attentive maintenance and replacement, or identifying them in a diagram. For all equipment, the Australian and Canadian draft standards also specify that maintenance instructions should address the periodic tightening of bolts and other connecting hardware, inspection of foundations for security, and checks for corrosion, decay, or insect attack.

While no one questions the importance of good maintenance, a schedule for what constitutes adequate inspection and maintenance is not agreed upon. For example, Beckwith (1988) recommends a daily inspection and a periodic "tear down" inspection, as often as monthly during heavy use, "to examine features such as bearings and footings for deterioration." Frost (U. of Texas, 1989, unpublished manuscript) suggests a normal weekly inspection supplemented by an exhaustive check each month. The approach in the Play For All Guidelines advocates a combination of daily to weekly visual reviews to check for hazards, three times monthly to monthly recorded inspections, and bi-annual to annual "tear down" inspections similar to that described by Beckwith. In the Canadian draft standards, three types of inspections are recommended: daily visual inspection, "to identify superficial defects and emerging problems"; detailed inspection every three months, or monthly during the summer or on large, well used playgrounds; and, an annual comprehensive inspection. The Australian standards also discuss three levels of maintenance. They note that "all apparatus, fittings, and surfaces should be inspected frequently for defects or faults," and that this may need to be daily for playgrounds in constant use. A detailed inspection at intervals of not less than six months is also required. Beyond these regular maintenance inspections, "it is strongly recommended that an appropriately experienced engineer make a thorough inspection at least once every twelve months."

The equipment on school playgrounds is widely used and abused; however, maintenance on these playgrounds tends to be inadequate, partially because custodial personnel "are not trained to detect playground hazards, and they are not in the habit of regularly checking playground equipment for potential hazards" (Henniger et al., 1982). Frost (U. of Texas, 1989, unpublished manuscript) explained that "training should be provided for all involved adults (play leaders, teachers) on all aspects of safety to help ensure that they are constantly alert to potential hazards involving both equipment and child behavior." Similarly, Moore et al. (1987) and the Australian standards note that inspections of playground equipment should be conducted by trained staff.

Further, to ensure that inspections are thoroughly and systematically carried out, there is support for the use of maintenance checklists (Beckwith, 1988; Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987; Australian standards; Canadian draft standards). The literature and standards contain many examples of maintenance or safety checklists, some of which also include items to evaluate the design of playground equipment (Beckwith, 1988; Christiansen, 1988; Esbensen, 1987; Frost, 1986c, U. of Texas, 1989, unpublished manuscript; Frost and Henniger, 1979; Hogan, 1988; Moore et al., 1987; Australian standards; Canadian draft standards; Seattle draft standards). The Australian standards explain that the checklists can be used as documentation of inspections. Others have also stressed the need to keep permanent, detailed records of inspections (Beckwith, 1988; Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987; Canadian draft standards).

The only negative opinion of maintenance checklists was expressed during a personal communication with a playground equipment safety supervisor for a suburban county. He explained that the county inspection and maintenance crews originally used checklists but stopped because it was determined that they made the work repetitive and monotonous. Further, if there were fifty items to check, people tended not to check all fifty; for example, they might assume that a swing chain had not worn out in the two weeks between inspections and then mark off that item automatically. Also, there may be reasons from a liability standpoint not to use a checklist procedure. In order to have a comprehensive checklist, it would have to be extremely long, and children would still find ways to get hurt. Instead, the inspectors have a mental checklist and complete a safety inspection form following each inspection to report exactly what they did. The information is then entered into a computerized record-keeping system.

Unfortunately, even with quality inspectors, inspections alone will not solve the problem of inadequate maintenance. As recognized by Moore et al. (1987), a comprehensive maintenance program must also include "prompt repair of discovered problems." The Canadian draft standards are comparable, stating that defects should be "repaired as soon as possible." Like documentation of inspections, it is very important to retain thorough records of all repairs made to the equipment (Frost, U. of Texas, 1989, unpublished manuscript; Moore et al., 1987; Australian standards; Canadian draft standards).

Recommendations:

Inadequate maintenance of equipment can lead to injuries on the playground. The general maintenance guidelines in the Handbook need be expanded beyond a simple recommendation that manufacturers should provide instructions for maintenance.

Manufacturers should provide detailed instructions for the maintenance of each piece of playground equipment, including drawings, diagrams or other illustrations. Graphic instructions tend to be clearer and more understandable for all readers. In addition, the manufacturer should suggest an appropriate schedule for the inspection of equipment, addressing the various degrees of inspection which are required at different time intervals. Any parts which will require special maintenance or are subject to wear should be identified in the instructions; maintenance specifications should address such parts and their needs for replacement in detail. The instructions for maintenance provided by the manufacturer should also address at least the following: lubrication requirements and details for checking the joints and bearings of all moving parts; periodic tightening of all nuts, bolts, and other hardware; inspection of equipment foundations to ensure that the anchoring is secure; checks for any corrosion or decay; and, examination of the equipment for any potential hazards.

Following correct assembly and installation, the safety of playground equipment and its suitability for use depend on good inspection and maintenance. It is very important to strictly follow the manufacturer's maintenance instructions and recommended inspection schedules. The material provided by the manufacturer should stress the dangers of inadequate or faulty maintenance.

A comprehensive maintenance program should be developed for each playground as a whole. Generally, all equipment should be inspected frequently for any emerging hazards, and the playground area should also be checked frequently for broken glass or other dangerous debris. For each piece of equipment, the frequency of thorough inspections will depend on the type of equipment, the amount of use, and the local climate. Based on the manufacturer's recommendations regarding maintenance schedules for each piece of equipment, a maintenance schedule for the entire playground can be created. The detailed inspections should give special attention to moving parts and other components which can be expected to wear. Inspections should be carried out in a systematic manner by trained personnel. One possible procedure is the use of checklists. An example of a general maintenance checklist is given below; it is based on the recommendations of this section as well as the ckecklist sources previously cited. Some manufacturers supply checklists, for general and/or detailed inspections, with their maintenance instructions; these can be used to ensure that inspections are in compliance with the manufacturer's specifications.

Inspections alone do not constitute a comprehensive maintenance program. All hazards or defects identified during inspections should be repaired promptly. All repairs and replacements of equipment parts should be completed in accordance with the manufacturer's instructions.

Documentation is also an important component of a comprehensive maintenance program. It is recommended that a thorough record of all inspections and repairs be retained, along with the manufacturer's instructions.

SUGGESTED GENERAL MAINTENANCE CHECKLIST

This is a general checklist which can be used as a guide for frequent routine inspections of public playgrounds. In addition to general maintenance inspections as described below, more detailed inspections should be conducted on a regular basis. The procedures for these thorough inspections and the intervals at which they should be conducted will depend on the types and amount of equipment on the playground, the level of use, and the local climate, as well as the maintenance instructions provided by equipment manufacturers. Therefore, this general checklist is only one of many elements which should be considered in the development of a comprehensive inspection schedule and system of maintenance. Any damage or hazards detected during inspections should be repaired immediately, in accordance with the manufacturer's instructions for repair and replacement of parts.

Complete documentation of all maintenance inspections and repairs should be retained, including any checklists used. It is also recommended that a record of any accidents and injuries reported to have occurred on the playground be collected; this will help identify potential hazards or dangerous design features which warrant attention. Similarly, maintenance personnel should observe children's play patterns to check whether equipment design or layout lead to any unsafe behaviors.

This checklist only addresses general maintenance concerns; it does not provide a complete safety evaluation of equipment design and layout. For example, the items listed below are not intended to address the risk of falls from equipment, moving impact incidents, or head entrapment. Therefore, it is essential to use this checklist only for general inspection purposes and to use the detailed design specifications contained in the Handbook to evaluate the safety of each piece of equipment and the playground as a whole.

General upkeep of playground	o	Check the entire playground area for miscellaneous debris or litter.
	o	Check for missing trash receptacles or those which are full.
	o	Check for any damage (i.e., any broken or missing components) to equipment or other playground features caused by vandalism or wear; for example, check for any broken or missing handrails, guardrails, protective barriers, or steps or rungs on ladders, and for damage to any fences, benches, or signs on the playground.
Surfacing	o	Check for equipment which does not have adequate protective surfacing and for surfacing materials which have deteriorated.
	o	Check loose surfacing materials for foreign objects or debris.
	o	Check loose surfacing materials for compaction and reduced depth, with special attention to heavy use areas such as those under swings and slide exit regions.
General hazards	o	Check all equipment and other playground features for any hazards which may have emerged.
	o	Check for sharp points, corners, and edges; for example check the sides and sliding surface of slide chutes for sharp or rough edges caused by deterioration.
	o	Check for protrusions and projections.
	o	Check for missing or damaged protective caps or plugs.
	o	Check for potential clothing entanglement hazards, such as open S hooks.
	o	Check for pinch, crush, and shearing points or exposed moving parts.
	o	Check for trip hazards, such as exposed footings on anchoring devices and rocks, roots, or any other environmental obstacles in the play area.
Deterioration of equipment	o	Check all equipment and other playground features for rust, rot, cracks, and splinters, with special attention to possible corrosion where structures come in contact with the ground.
	o	Check for unstable anchoring of equipment.
Security of hardware	o	Check for any loose or worn connecting, covering, or fastening devices; for example, check the S hooks at both ends of suspending elements of swings and all connection points on flexible climbing devices for wear.
	o	Check all moving parts, such as swing bearing hangers, for wear.
Equipment use zones	o	Check for obstacles in equipment use zones.
Drainage systems	o	Check the entire play area for drainage problems, with special attention to heavy use areas such as those under swings and slide exit regions.

5.4.3 IDENTIFICATION

Guideline content:

The current Handbook recommends that each major piece of equipment or composite unit have a durable, permanently affixed label to identify the manufacturer, model, and month and year of manufacture. The label should be in a "prominent location." Volume 1 explains that "this data will allow purchasers to reach the manufacturer for additional information or to order parts for repair." (Volume 1; Volume 2, 4.2)

Probable rationale:

Similar to the reasoning stated in Volume 1, the NBS documents recognized that proper labeling is important because it provides a means to readily identify the manufacturer when a hazard has been found in order to get information regarding the deficiency and its remedy. (NBS 1978a)

Issues:

Butwinick (1980), Frost (1980), and Davis (1980) were all supportive of the need for identification labels on equipment. Butwinick and Frost each noted the importance of being able to trace the origins of a certain piece of equipment. Davis explained that creating a reasonably permanent label should not be a problem for the manufacturers. With regard to the location of the label, he suggested that it should not be "in such a prominent location that it is easily accessible to the users," because they may disfigure or remove it. The Seattle draft standards (1986) contain specifications for identification of equipment which are identical to those of the current guidelines.

Foreign standards reviewed have specifications for permanently affixed, visible, identification labels in varying degrees. The German standards (DIN 7926, Part 1, 1985) require the name and address of the manufacturer; the Australian (AS 1924, Part 1, 1981) and British (BS 5696: Part 2: 1986) standards require the name and address of the manufacturer, and the year of manufacture; the Canadian draft standards (CAN/CSA-Z614, 1988) require the name and address of the manufacturer, the year of manufacture, and the model number. In addition to the identification label, the German standards suggest that manufacturers can indicate that their equipment is in compliance with the German standard by marking it with "DIN 7926." Similarly, the British standards note that "the manufacturer shall when requested by the purchaser provide a certificate stating that the equipment complies with this British standard."

Recommendations:

The current guidelines regarding identification labels for playground equipment are warranted. Because users of public playground equipment need to be able to identify and contact the manufacturer, a durable label should be permanently affixed in a prominent location to all playground equipment with the following information: the name and address of the manufacturer, the date of manufacture, and the model name or number of the structure.