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ABSTRACT

This handbook suggests safety guidelines for public playground equipment and describes various surfaces used under the equipment and possible injuries resulting from falls. The handbook is intended for use mainly by manufacturers, installers, school and park officials, and others interested in technical criteria for public playground equipment. Information and suggestions on what to look for and what to avoid are covered: (1) assembly, installation, and maintenance of equipment: (2) materials from which equipment is constructed: (3) strength of individual components and structures: (4) sharp points, corners, edges, and other safety hazards: (5) base configuration of rotating equipment: (6) moving impact of swings: (7) entrapment: (8) falls from equipment: and (9) safety guidelines for surfaces under playground equipment. (JD)

A HANDBOOK FOR PUBLIC PLAYGROUND SAFETY

Volume II: Technical Guidelines for Equipment and Surfacing

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

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1. Introduction

This handbook suggests safety guidelines for public playground equipment and describes characteristics of various surfaces used under the equipment as the surfaces relate to injuries from falls. These safety guidelines are based on work performed for the Consumer Product Safety Commission (CPSC) by the National Bureau of Standards (NBS). This particular handbook is technical and is intended for use mainly by manufacturers, installers, school and park officials and others interested in technical criteria for public playground equipment. Manufacturers can use this information to design new equipment, and purchasers such as school and park officials can use it to help in the selection of appropriate equipment. The handbook may also be helpful in considering design and layout for improving playground safety.

Because the majority of public playground equipment injuries involve falls from the equipment, this handbook also presents information regarding the methodology for assessing impact attenuation of surfaces in relation to head injury. The handbook contains information on surfacing materials commonly available which might minimize head injury in fall situations.

A companion handbook has been prepared for general use by the public which summarizes these safety guidelines in less technical terms. The companion handbook also offers some general advice on the design, maintenance, retrofit and surfacing of public playgrounds.

2. Background

The CPSC has been studying public playground equipment for a number of years in an attempt to reduce playground injuries. In 1977 alone, for example, an estimated 93,000 injuries associated with public playground equipment were treated in hospital emergency rooms.

The Commission first became involved with playground safety in 1974, when a consumer petitioned CPSC to develop mandatory safety standards for public playground equipment. The National Recreation and Park Association (NRPA) was selected by the Commission to develop a draft standard. In 1976, when the NRPA draft standard was completed, the Commission contracted with the National Bureau of Standards for additional technical work needed to revise the NRPA recommended standard. Because surfaces under equipment appeared to play a major role in equipment injuries, the Commission also asked NBS to develop a method for testing various surfaces commonly used under playground equipment. The results of the NBS studies and research provide the basis for this two-volume handbook for public playground safety.

While the Commission's initial work was clearly oriented toward developing mandatory safety standards for equipment, the Commission decided not to issue such a mandatory standard. Over the years, its evaluation of playground safety led the Commission to conclude that a mandatory specification rule by itself would not adequately address the problem of playground injuries. Such factors as the diverse ways equipment is used, the varying quality of supervision on equipment, equipment placement, and equipment maintenance all play a part in playground injuries. In addition, most injuries associated with playground equipment involved falls, which would not be addressed by equipment specifications alone.

The Commission believes, however, that the results of the studies and research conducted by the NRPA and NBS can serve as **guidelines** for the design of public playground equipment, and can be used by people involved with playground safety to help reduce the frequency and severity of injuries associated with equipment. Technical rationale is provided to explain each guideline. The guidelines are not a CPSC standard and are not mandatory requirements.

Since the guidelines are not a CPSC standard, the Commission is not endorsing them as the exclusive method of safe playground equipment construction. The Commission believes, however, that the safety features in many of the guidelines, such as those addressing protrusions, slip-resistant surfaces, durability and stability, and so forth, will contribute to greater equipment safety, and that publication of the guidelines as a whole will promote greater safety consciousness among manufacturers and purchasers of equipment.

The guidelines are recommended for playground equipment intended for use in play areas of parks, schools, institutions, multiple family dwellings, private resorts and recreation developments, and other areas of public institutional use. The guidelines are not intended to apply to amusement park equipment, equipment normally intended for sports' use or to home playground equipment. Components of equipment intended solely for use by the handicapped and necessarily modified to accommodate such users safely are also not covered by these guidelines.

3. Definitions

The following definitions apply for the purpose of these guidelines:

Accessible - Any part of the equipment that may be contacted by any body part under conditions of normal use.

Clearance height - The vertical distance between the underlying surface and the lowest part of the suspended member when the suspended member is in its rest position.

Composite unit - A combination of two or more play devices linked together to provide a variety of play activities in one integral unit (e.g., a combination climber, slide and balance beam).

Entrance height - The vertical distance between the underlying surface and the uppermost part of the inclined sliding surface of a slide.

Entrapment - Any condition which impedes withdrawal of a body or body part that has penetrated an opening.

Exit region - That part of the sliding surface at the exit end of a slide intended to aid the user in exiting safely.

Fasteners - Those parts of the equipment such as clamps, bolts, hooks, screws, or other hardware used to join components.

Hand railing - A device intended for use by the hands to provide body balance and support in maintaining a specific body posture.

Ladder - A device having a slope greater than 50 degrees from a horizontal plane, and consisting of a series of rungs or steps on which a person may step while ascending or descending.

Longitudinal component - A component (bar, rung, etc.) which provides an opportunity for climbing and is within 45 degrees from a horizontal plane.

Maximum user - A twelve year old child. Measurements of maximum user characteristics are the 95th percentile values for combined sexes. (See Reference 17).

Minimum user - A five year old child. Measurements of minimum user characteristics are the 5th percentile values for combined sexes. (See Reference 17).

Normal use - Use of the equipment in a manner intended by the designer or manufacturer or which conforms to play patterns that have been established by traditional practice.

Opening - A space bounded partially or completely by edges or surfaces of a structure.

Peak acceleration - The maximum acceleration imparted to a test headform during impact tests of suspended members or surfacing materials.

Pinch and crush point - The point at which the movement of elements relative to each other or to a fixed component represents a pinching, crushing, or shearing hazard to any body part.

Potential impact region - Any part of the front or rear surface of a suspended member which can contact an object in its intended path.

Protective barrier - A side enclosing device around an elevated surface that aids in the prevention of falls to lower levels.

Protrusion - An element or component that protrudes from the equipment in any plane or direction in a manner posing a potential impact hazard.

Reasonably foreseeable misuse - Use of the equipment in a manner not originally intended by the designer or manufacturer and not considered customary, but which may be anticipated through knowledge of children's behavioral patterns when using such equipment.

Rotating equipment - Any equipment which rotates about a vertical axis, such as merry-go-rounds, whirls, maypoles, etc.

Rung - A ladder crosspiece which is intended to be used as a foot support and as a hand grip in the normal use of the ladder.

Sharp edge - Any edge that can cut the skin during normal use.

Slide - An apparatus having an inclined surface used for sliding.

Spiral slide - A slide whose sliding surface (chute) when projected onto a horizontal plane is curved.

Stability - The ability of an apparatus to withstand maximum anticipated forces which act to tip or slide the equipment when properly assembled and installed.

Stairway - A device having a slope of 50 degrees or less from a horizontal plane and consisting of a series of steps which can be used for ascending or descending.

Step - A horizontal crosspiece of a ladder or stairway intended for use primarily as a foot support.

Straight slide - A slide with a sliding surface which when projected onto a horizontal plane is not curved.

Suspended member - That part of a swing assembly which is intended to be occupied by one or more users in the act of swinging.

Suspending elements - Those parts of the swing assembly, such as chains, ropes, cables, tubes, etc., that are used to suspend a suspended member from an overhead supporting structure.

Swing - Play equipment used for swinging, consisting of the supporting structure and one or more swing assemblies.

Swing assembly - An apparatus intended for use by one or more users for swinging, consisting of a suspended member and its necessary suspending elements and fasteners.

Underlying surface - The top level of the natural ground or surfacing material placed under and around the equipment.

Use zone - The total space under and around installed equipment that is necessary for the user to complete the intended activity (e.g., swinging out, exiting from a slide, etc.).

4. Assembly, Installation and Maintenance

Instructions - The manufacturer should include the following with each piece of equipment or composite unit: 4.1

- Instructions and necessary drawings, photos, or other illustrations for proper assembly that include torque specifications for bolts and nuts and a listing of all components that includes part names and numbers where appropriate.
- Instructions and necessary drawings, photos, or other illustrations that provide essential information for installing the equipment or composite unit in accordance with the safety design intentions of the manufacturer. (For swing assemblies, these instructions should specify the manufacturer's recommended maximum length for suspending elements.)
- The manufacturer's recommended use zones for determining the placement of equipment.
- Instructions for the general maintenance of the equipment or composite unit.

NOTE: **All promotional material and installation instructions should caution against installing playground equipment over paved surfaces such as concrete and asphalt because falls to these surfaces may result in more severe injuries than falls to more resilient surfaces.**

Identification - A durable label should be permanently attached to each major unit (e.g. slide, climber, etc.) or composite unit identifying: manufacturer, model and month and year of manufacture. This label should be placed on the equipment in a prominent location. 4.2

5. Materials of Manufacture and Construction

5.1 Durability - Generally, equipment should be constructed using materials that have a demonstrated record of durability in the playground or a similar outdoor setting. New materials without a demonstrated record of durability may need to be tested in a manner considered appropriate by the manufacturer.

5.2 Finish - Materials subject to corrosion or deterioration should be plated, galvanized, painted, preserved, or otherwise treated to resist these effects. The manufacturer should ensure that users of the playground equipment cannot ingest, inhale, or absorb through body surfaces any hazardous substances used in the treatment process.

5.3 Stability - 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.

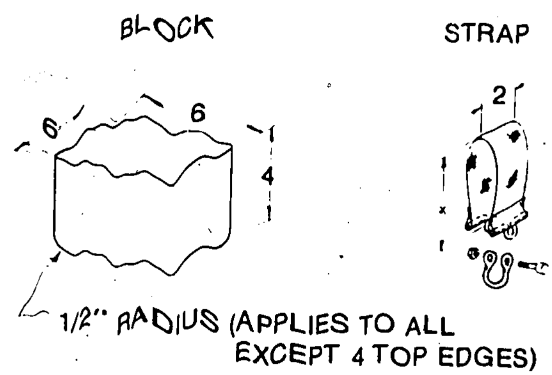
5.4 Hardware - Lock washers, self-locking nuts, or other locking means should be provided for all nuts and bolts. Fasteners and connecting and covering devices, when torqued and installed in accordance with the manufacturer's instructions, should not loosen or be removable without the use of tools.

6. Strength of Individual Components and Structures

Recommendation - Manufacturers should test their playground equipment to determine if it is strong enough for its intended use. 6.1

The NBS has developed strength tests that can be used for playground equipment components and supporting structures. NBS recommends that playground equipment, when tested in accordance with those tests described in paragraph 6.2, should withstand the specified loads. During and after the test there should be no visible crack or breakage of any component. There should be no other form of permanent deformation of any component that may adversely affect the structural integrity or safe use of the equipment. In the case of individual swing assemblies, hooks, shackles, rings and links should not open more than one-half of the cross sectional diameter of the component that they are intended to constrain.

Suggested Test Method - Make sure that the equipment is assembled and installed in accordance with the accompanying instructions, or supported in an equivalent manner. Test individual components and the supporting structure separately. Determine and apply the loads as specified in the following paragraphs. Apply the load gradually, attaining (but not exceeding) the specified value. Maintain the load for at least five minutes. Where specified, apply the load through appropriate load distribution devices of dimensions shown in Figure 1. 6.2



NOTE: (1) BLOCK MADE OF ANY RIGID MATERIAL.
(2) VARY DIMENSION "x" AS REQUIRED
(3) ALL DIMENSIONS ARE IN INCHES.

FIGURE 1 - LOAD DISTRIBUTION DEVICES

NOTE: If a structural member supports a composite unit, load the unit simultaneously in accordance with the appropriate paragraph of Section 6. For swing assemblies with foot supports, load the seat and foot support separately.

6.2.1 Swing Assemblies and Structures Supporting Swing Assemblies.

6.2.1.1 Single Occupancy Swing Assemblies - For swing assemblies intended for single occupancy, place a load distribution device on the center of the seat and apply a vertical downward force of 1200 pounds. Apply the force gradually until it attains but does not exceed 1200 pounds within a period of one minute. Maintain that force for five minutes.

6.2.1.2 Multiple Occupancy Swing Assembly - For swing assemblies intended for multiple occupancy, place a load distribution device on the center of each seat. Apply vertical downward force of 725 pounds to each loading device simultaneously. Apply the force gradually until it attains but does not exceed 725 pounds per device within a period of one minute. Maintain that force for five minutes.

6.2.1.3 Trapeze Bar - For swing assemblies consisting of a trapeze bar or ring, place a loading strap on the center of the trapeze bar or ring and apply a vertical downward force of 1200 pounds. Apply the force gradually, until it attains but does not exceed 1200 pounds within a period of one minute. Maintain that force for five minutes.

6.2.1.4 One Foot Support - Test individually foot supports that are intended to support only one foot (similar to the example shown in Figure 2). Place a load distribution device centered on the position intended to support a user's foot and apply a vertical downward force of 484 pounds. Apply the force gradually, until it attains but does not exceed 484 pounds within a period of one minute. Maintain that force for five minutes.

6.2.1.5 Both Feet Support - For foot supports that are intended to support both feet (similar to the example shown in Figure 3) place a load distribution device centered in the position intended to support each user's feet. Apply vertical downward force of 725 pounds gradually, until it attains but does not exceed 725 pounds per device within a period of one minute. Maintain that force for five minutes.

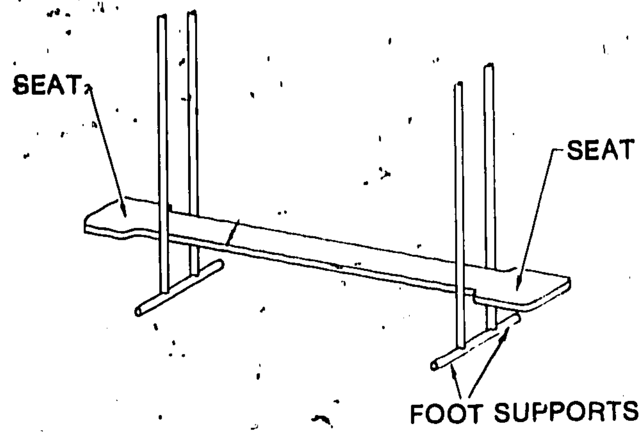


FIGURE 2 - FOOT SUPPORT INTENDED TO SUPPORT ONE FOOT

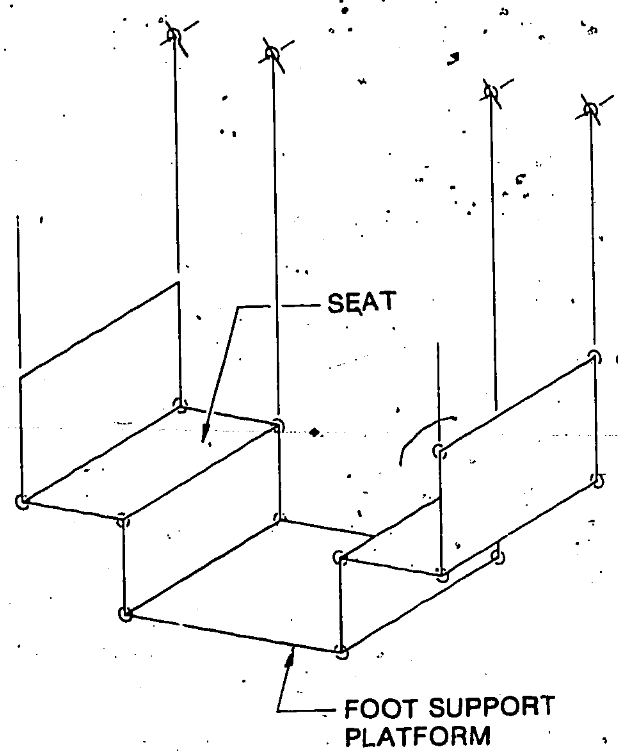
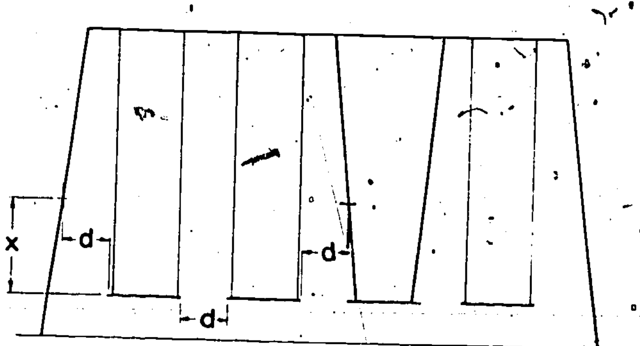


FIGURE 3 - FOOT SUPPORT INTENDED TO SUPPORT BOTH FEET

Structures Supporting Swing Assemblies - **6.2.1.6**
Center an appropriate load distribution device at each occupant position on all swing assemblies. Simultaneously, load each load distribution device with the force specified in Table 1.

TABLE 1		
Type of Swing Assembly	Vertical Downward Force In Pounds to Be Applied Per Load Distribution Device	
	Structures Supporting One Assembly	Structures Supporting Two or More Assemblies
Single occupancy swing assembly	1200	900
Multiple occupancy swing assembly	725	600

6.2.1.7 Minimum Clearance of Suspended Members - The recommended minimum clearance between adjacent suspended members and between a suspended member and the adjacent supporting structure should not be less than 18 inches when measured as shown in Figure 4.



d=18 inches minimum
x=33 inches minimum

FIGURE 4 - SWING CLEARANCE MEASUREMENT

6.2.2 Components and Structures Subjected to Vertical Loads - Estimate the number of simultaneous users, N, of a component or structure as specified in Paragraphs 6.2.2.1 through 6.2.2.6 of this section. Place N load distribution devices on the component or structure in a manner that simulates the anticipated load distribution. Simultaneously, load each load distribution device with a vertical downward force F_t given by the following equation:

$$F_t \text{ (pounds)} = 300\,(N + 1)/N$$

6.2.2.1 Individual Longitudinal Components - Measure the length of the component, L (in inches), and determine N from Table 2.

NOTE: It is sufficient to test one of several components identical in size, material and method of construction.

NOTE: Components such as side pieces of ladders, top support bar or pipe of swing assemblies and the like, with the obvious main function of supporting other components, need not be tested by this procedure.

TABLE 2	
Length of the Component in Inches	Estimated Number of Users
$L < 24$	$N = 1$
$24 \leqslant L < 88$	$N = L/16$
$L \geqslant 88$	$N = (L + 72)/32$
	Where necessary, round off to the nearest integer. Round up if the fractional part is .5.

6.2.2.2 Structures Containing Two or More Longitudinal Components - Count the number of longitudinal components, L, and determine N from Table 3.

TABLE 3	
Number of Longitudinal Components	Estimated Number of Users
$L \leqslant 5$	$N = L$
$L > 5$	$N = (L + 5)/2$ When N is not an integer, round down to the next integer.

6.2.2.3 Individual Surfaces - For playground equipment such as decks, platforms, ramps, stair steps, or the like, compute the surface area, A (in square feet), and determine N from Table 4.

TABLE 4

Area of the Surface in Square Feet	Estimated Number of Users
$A \leq 1$	$N = 1$
$1 < A \leq 10$	$N = A$
$A > 10$	$N = (A + 10)/2$
	Where necessary, round off to the nearest integer. Round up if the fractional part is .5.

6.2.2.4 Structures Supporting Two or More Surfaces - Estimate the number of users, N, for each surface from Table 4. Obtain N by adding the estimates for each surface:

$$N = N_1 + N_2 + N_3.....$$

6.2.2.5 Slide Beds - Estimate the number of users, N, as follows:

$$N = L/36,$$

where L is the length of the slide bed in inches.

6.2.2.6 Other Structures - For other structures such as merry-go-rounds, see-saws, spring rockers or the like, estimate the number of simultaneous users, N, as follows:

6.2.2.6.1 With Designated Occupancy - For apparatus with designated occupancy arrangements, N is equal to the number of designated occupancies.

6.2.2.6.2 Without Designated Occupancy - For apparatus without designated occupancy arrangements, make a reasonable estimate of N, including allowances for possible overloading.

6.2.3 Components Subjected to Lateral Loads - Components subjected to lateral loads such as guard rails, handrails, sides of barriers and enclosures, and the like, should be subjected to the two separate tests described below.

6.2.3.1 Concentrated Load - Place an appropriate load distribution device on the component at any point to produce the most adverse effect. Apply a 460 pound horizontal force to the load distribution device in a direction perpendicular to the length of the component and away from the enclosed structure.

Distributed Load - Apply a horizontal force, F, in a direction perpendicular to the length of the component and away from the enclosed structure. Apply the force near the top of the component and evenly distributed over the entire length of the component. 6.2.3.2

The test force is given by: F(pounds) = 150L, where L is the length of the component in feet.

7. Sharp Points, Corners and Edges; Pinch and Crush Points; Protrusions; Suspended Hazards

7.1 Sharp Points, Corners and Edges - Assemble in accordance with accompanying instructions. It is recommended that there be no accessible sharp edges or points that can cut or puncture human tissue. The exposed open ends of all tubing not resting on the ground, or otherwise covered, should be provided with caps or plugs that cannot be removed without the use of tools. Smooth finished caps, covers, or the equivalent, should be provided for the purpose of covering accessible bolt ends. 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. The caps or coverings should not be removable without the use of tools.

NOTE: *If the edge or point is questionable in terms of its injury potential, it should be considered as being sharp. A minimum radius of curvature of one-quarter inch is recommended for corners and edges of suspended members. This section does not apply to belts, straps, ropes and similar flexible components.*

Pinch and Crush Points - There should be no accessible pinch, crush or shear points caused by components moving relative to each other or to a fixed component when the equipment is moved through its anticipated use cycle. 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. 7.2

Protrusions - The following recommendations and suggested test procedures to measure protrusions are based on National Bureau of Standards reports submitted to CPSC. (See References 29 and 30). 7.3

Recommendation - When tested in accordance with Paragraph 7.3.2, no protrusion should extend beyond the face of any of the three gauges having dimensions shown in Figure 5. 7.3.1

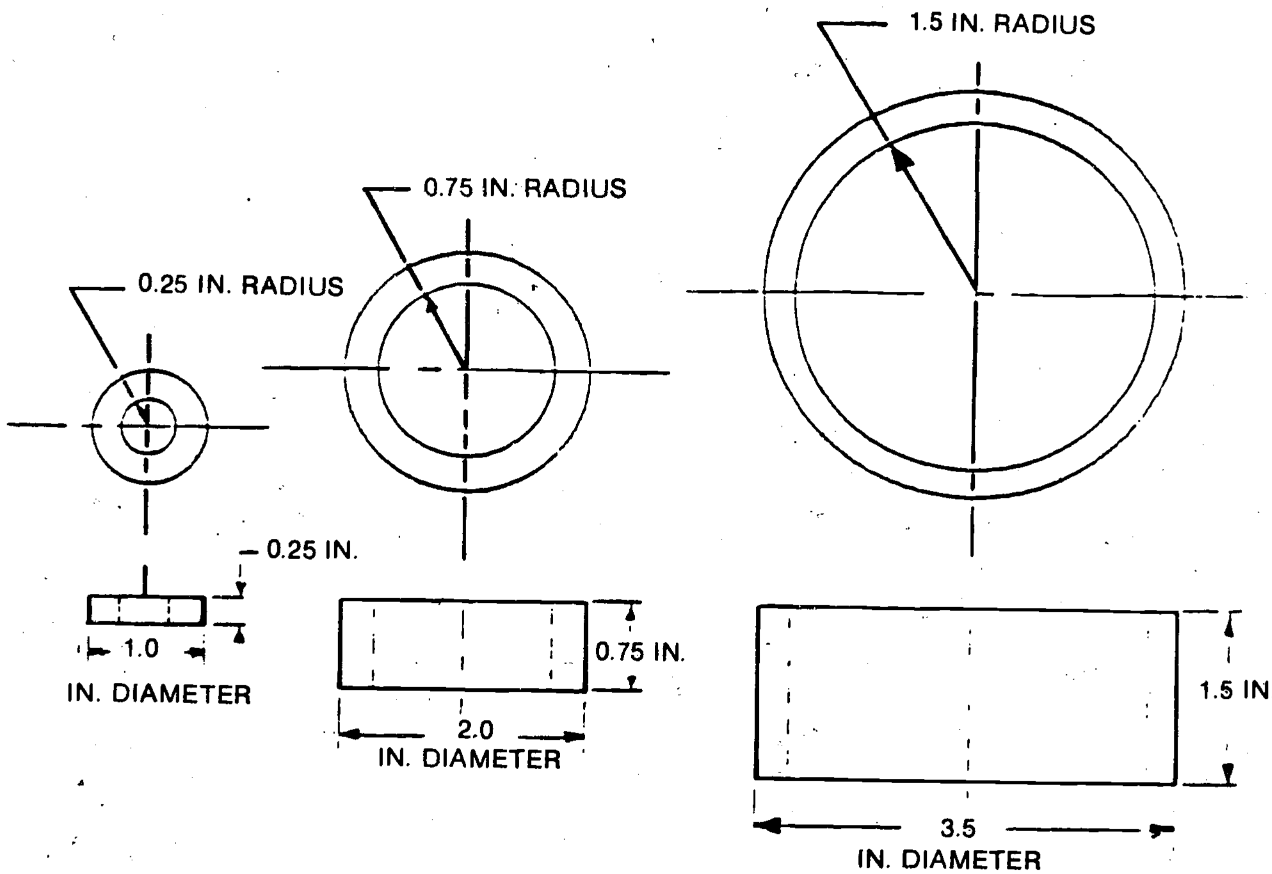


FIGURE 5 - PROTRUSION TEST GAUGES

7.3.2 Suggested Test Method - Successively place each gauge (see Figure 6) over each protrusion to determine if the protrusion extends beyond the face of the gauge.

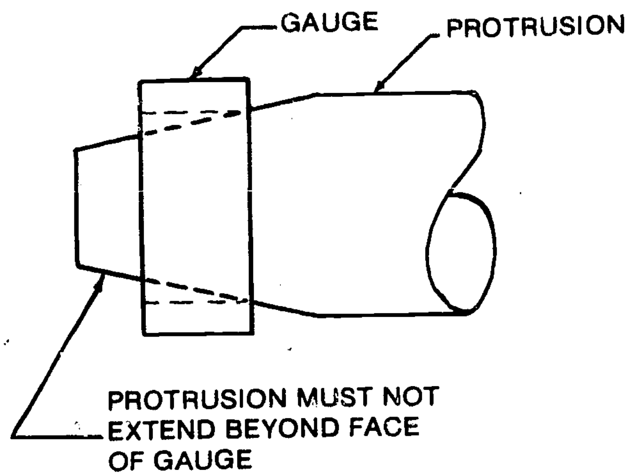


FIGURE 6 - PROTRUSION TEST

7.3.3 Exclusions - The above suggested test method does not apply to the following:

7.3.3.1 Inaccessible Protrusions - (except those that may be contacted by a child falling from the equipment).

7.3.3.2 Protrusions on the Front and Rear Surfaces of Suspended Members of Swing Assemblies.

7.3.3.2.1 Recommendation - When tested in accordance with Paragraph 7.3.3.2.2, no surface in the potential impact region should protrude through the hole beyond the face of the specified gauge.

7.3.3.2.2 Suggested Test Method - Conduct the test with the suspended member in its rest position. Place the gauge shown in Figure 7 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.

7.4 Suspended Hazard - Cables, wires, ropes, or similar components suspended between other components within 45 degrees of the horizontal are not recommended because they could be impacted by a rapidly moving child. This recommendation does not include cables, ropes and other such items located 7 feet or more above the ground or equivalent surface.

NOTE: It is not the intent of this recommendation to eliminate items such as guard railings or series of ropes or cables such as cargo nets and climbing grids. This should be considered when evaluating a potential hazard.

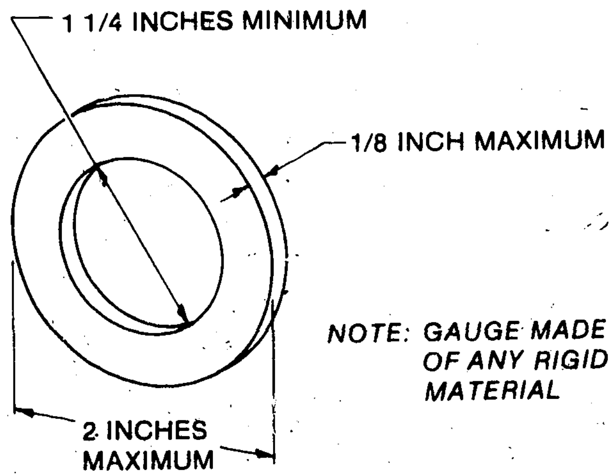
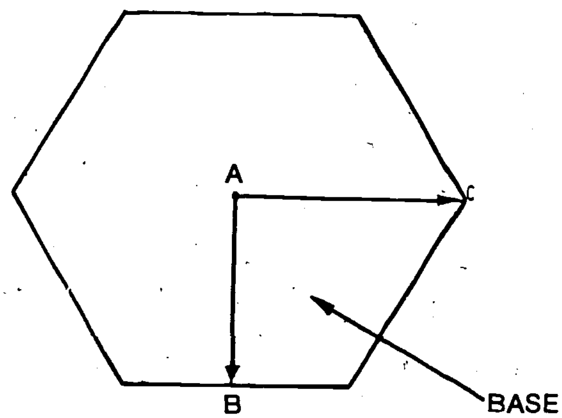


FIGURE 7 - PROTRUSION TEST GAUGE FOR SUSPENDED SWING ASSEMBLIES

8. Base Configuration of Rotating Equipment

Recommendation - The rotating components of all rotating apparatus intended to support standing or seated users should incorporate a continuous base that meets the following:

- The surface of the base should be continuous with no opening between the axis and the periphery that permits a rod having a diameter of 0.3 inches to penetrate through the surface.
- No component of the apparatus should extend beyond the perimeter of the base.
- The difference between the minimum radius and the maximum radius of a non circular base should not exceed 2.0 inches (see Figure 8).



A = AXIS OF ROTATION
AB = MINIMUM RADIUS
AC = MAXIMUM RADIUS

THE DIFFERENCE BETWEEN DIMENSION AC AND AB SHOULD NOT EXCEED 2.0 INCHES.

FIGURE 8 - MINIMUM AND MAXIMUM RADII OF NON CIRCULAR BASE

9. Moving Impact of Swings

Recommendation - When tested in accordance with suggested test method specified in Paragraph 9.2, a suspended member should not impart a peak acceleration in excess of 100 g's to the test headform (see Paragraph 9.2.2.1). This recommendation is intended to apply to any potential impact region of a suspended member having a clearance height of less than 64 inches (see Reference 29). **9.1**

Suggested Test Method. **9.2**

Ambient Laboratory Conditions - Ambient laboratory conditions are required for the test (62-82°F). Expose all test equipment and suspended members to these conditions for at least four hours prior to test. **9.2.1**

Test Equipment. **9.2.2**

Headform and Support Assembly - (See Reference 29). The peak acceleration imparted by a suspended member is determined by impacting an instrumented headform with the suspended member. The size "C" headform specified in the Federal Motor Vehicle Safety Standard No. 218 is used for this test. **9.2.2.1**

Construct the headform support assembly in such a manner that the total headform and support assembly weight does not exceed 10.5 pounds. Mount an accelerometer at the center of gravity (C.G.) of the headform and support assembly combination with the sensitive axis of the accelerometer aligned to within 5 degrees of the direction of travel of the headform.

Guidance Structure - The motion of the headform after impact must be restricted to horizontal travel with the headform centerline remaining in the central plane, as depicted in Figures 9, 9a, and 9b. Use a six-inch I beam (6I 12.5 American Standard I Beam) or an equivalent structure as the primary support structure to provide the required headform motion secured in such a manner that it is stationary during the test. The static coefficient of friction between the headform support assembly and the stationary guidance system structure must be less than 0.02. **9.2.2.2**

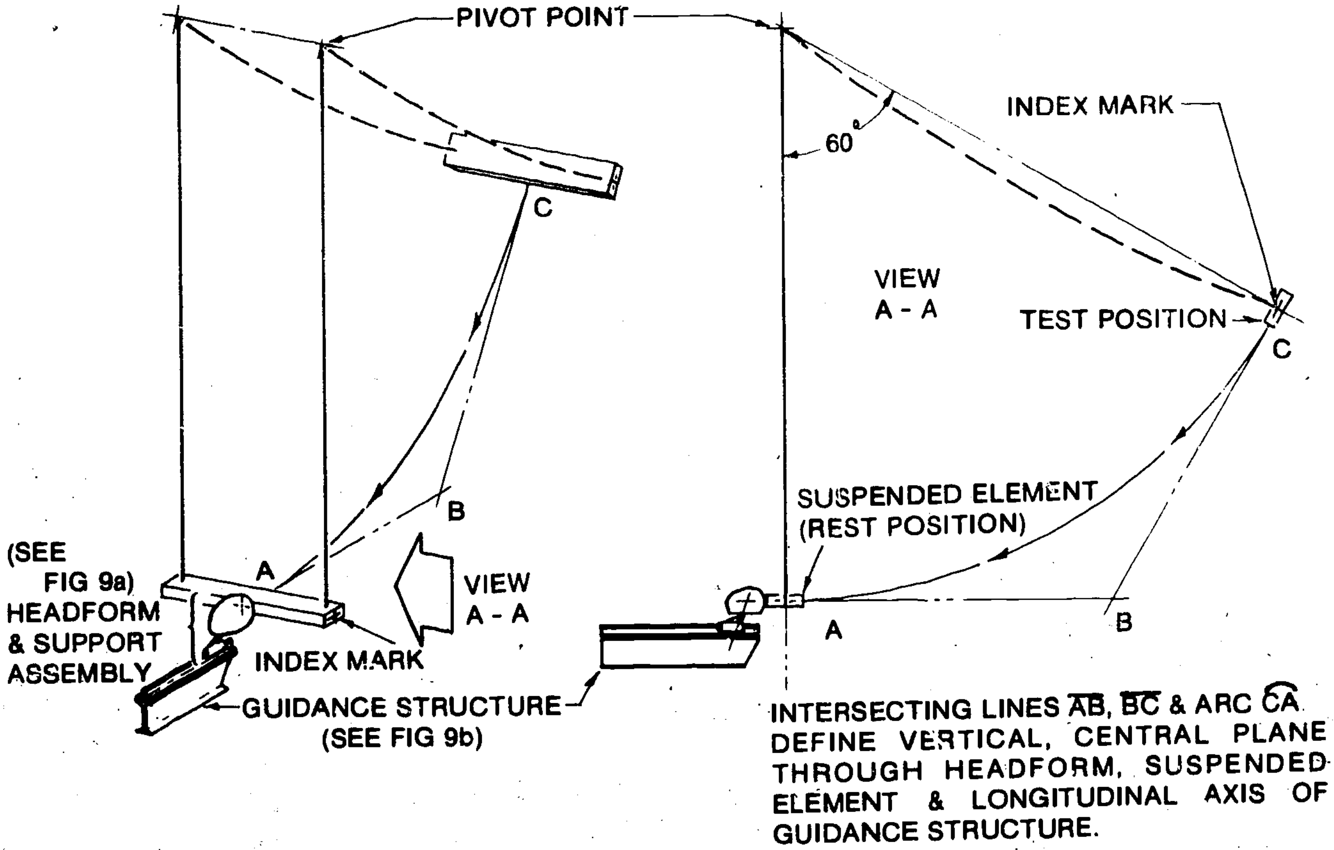


FIGURE 9 - IMPACT TEST SET-UP

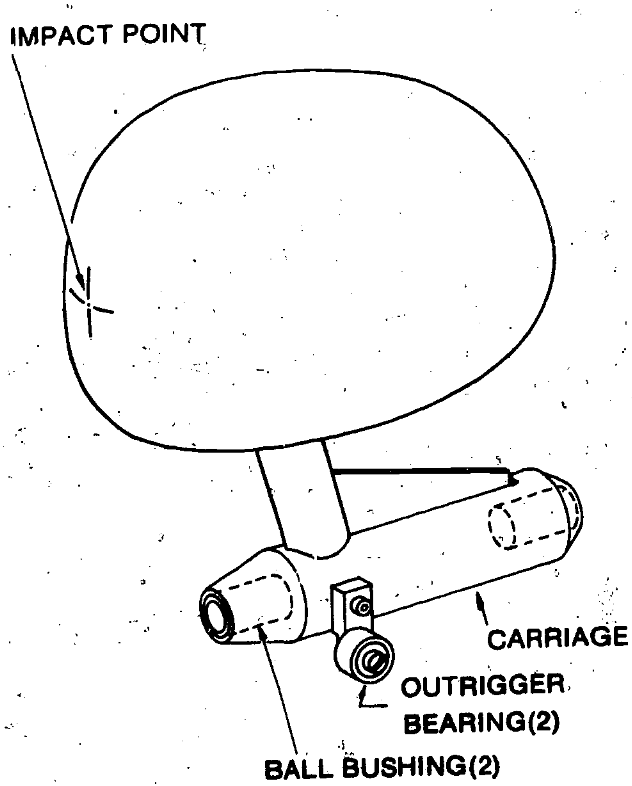


FIGURE 9a - HEADFORM & SUPPORT ASSEMBLY

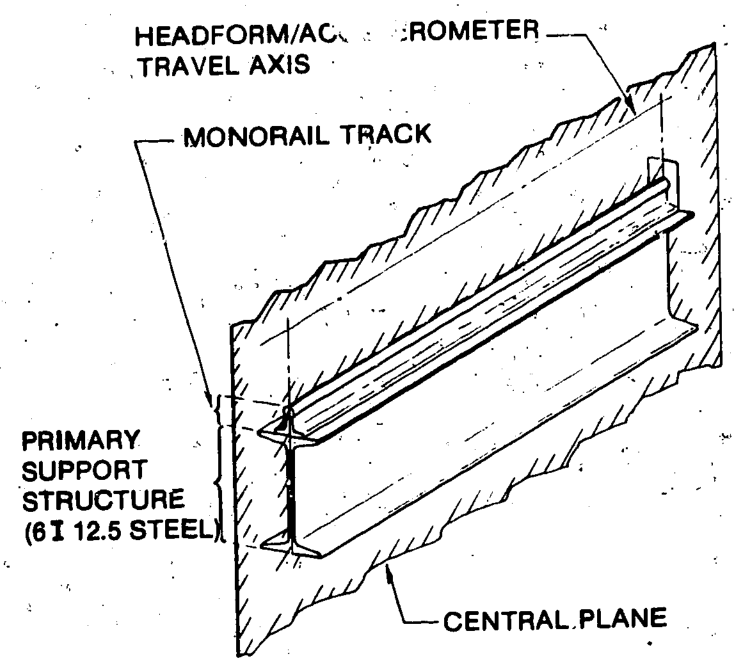


FIGURE 9b - GUIDANCE STRUCTURE

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

9.2.3 Step 1. Index Mark - Affix an index mark to the side of the suspended member to indicate its mass center (C.G.) projection in the side view. To determine the location of the index mark, the suspended member must be suspended in two successive alternate positions as illustrated in Figure 10. The mark location is determined by the intersection of the projection of vertical lines passing through the suspension point (see Figure 10) when the member is suspended at the successive alternate positions.

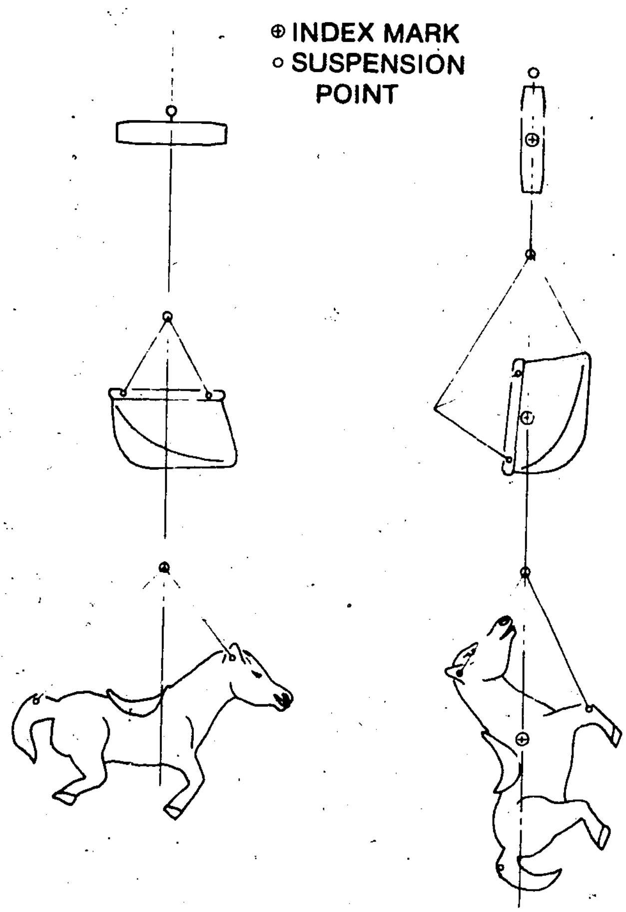


FIGURE 10 - TYPICAL INDEX MARK DETERMINATIONS

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

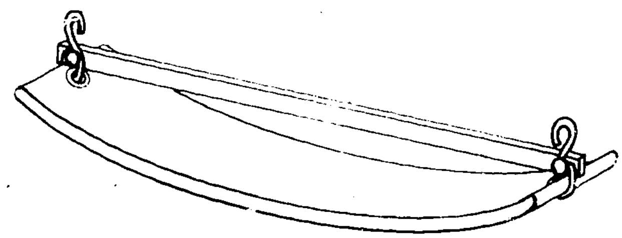


FIGURE 10a - BRACE FOR FLEXIBLE SEATS

Step 2. Assembly and Installation - Assemble 9.2.4
and install the suspended member to be tested according to the accompanying instructions, using the hardware and the maximum length suspending elements supplied with, or specified for, the equipment.

Step 3. Position of Suspended Member - Allow 9.2.5
the suspended member to assume its free hanging rest position (refer to Figure 9) and adjust the relative positions of the suspended member, headform, and guidance system to meet the following conditions:

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

Step 4. Placement of Suspended Member - 9.2.6
Place the suspended member in the test position indicated by one of the following methods.

Test Position 1 - Raise suspended members 9.2.6.1
which are supported by chains, ropes, cables or other non-rigid suspending elements along their arc of travel until the side view projection of a straight line through the pivot point and index mark forms an angle of 60 degrees with the vertical. Once the suspended member is raised to the test position, some curvature will be produced in the suspending elements. Adjust the suspended member position to de-

termine that curvature which provides a stable trajectory.

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

9.2.6.3 Additional Instructions - In the use of either of the test positions specified in Paragraphs 9.2.6.1 and 9.2.6.2 above, caution should be exercised to prevent damage to the test equipment. If an unusually heavy or hard suspended member is to be tested, preliminary tests should be made at lower test angles (e.g. 10 degrees, 20 degrees, 30 degrees, etc.) If the recommendations of Paragraph 9.1 are exceeded at a lower test angle than that specified in Paragraphs 9.2.6.1 or 9.2.6.2, the member does not agree with the guidelines and no further tests are necessary. Additionally, if there is doubt concerning the suspended member trajectory or stability, the headform and/or guidance structure should be set aside to allow trial releases without impacting the headform.

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

9.2.8 Step 6. Collection of Data - Once satisfactory system operation and calibration are obtained, collect data for ten impacts. Measure the peak acceleration in g's for each impact. If the data for any two of the ten impacts do not meet the recommendations of Paragraph 9.1, the suspended member does not agree with the guidelines.

10. Entrapment

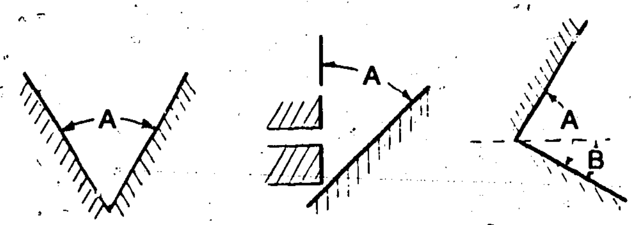
General - To ensure that a child's arms, hands, or other body parts cannot become lodged in the equipment when the momentum of the child or equipment is sufficient to cause injury or a loss of balance, accessible components of moving apparatus and components adjacent to sliding surfaces (protective barriers,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

Head Entrapment - To prevent a component or group of components from forming an angle or opening that can trap a user's head, the following guidelines are recommended for angles and openings that are accessible in accordance with Paragraph 10.2.2. 10.2

Recommendations. 10.2.1

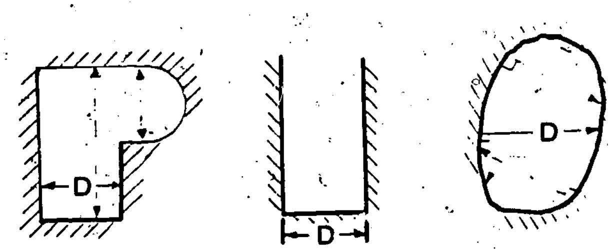
Angles - Angles formed by adjacent surfaces (see Figure 11) on the boundary of an accessible opening, should exceed 55 degrees. 10.2.1.1

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 (see Figure 12). 10.2.1.2



ANGLE A SHOULD EXCEED 55°. ANGLE A IS EXCLUDED IF ANGLE B IS MORE THAN 10° BELOW HORIZONTAL.

FIGURE 11 - ANGLES OF ACCESSIBLE OPENINGS



DISTANCE D SHOULD NOT BE LESS THAN 7 INCHES

FIGURE 12 - PERPENDICULAR DISTANCE BETWEEN OPPOSING SURFACES

10.2.1.3 Projected Lines of Intersection - For components that do not form a vertex as illustrated in Figure 13, the angle is determined from the projected lines of intersection. This angle should agree with the recommendation of Paragraph 10.2.1.1 Parallel surfaces should agree with the recommendation of Paragraph 10.2.1.2. For exception, see Paragraph 10.2.3.4.

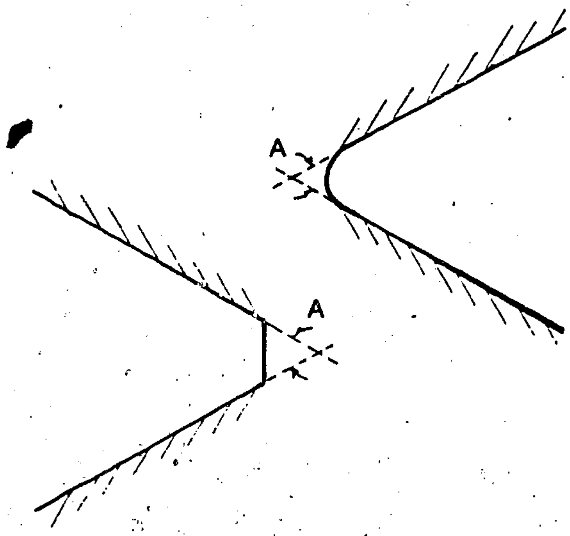


FIGURE 13 - PROJECTED LINES OF INTERSECTION FOR DETERMINING ANGLE A

10.2.2 Suggested Test Method - Attempt to insert a probe having dimensions as shown in Figure 14. 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 (see Figure 15) the opening can be considered accessible. If the opening meets the recommendations of Paragraph 10.2.1, it agrees with the guidelines.

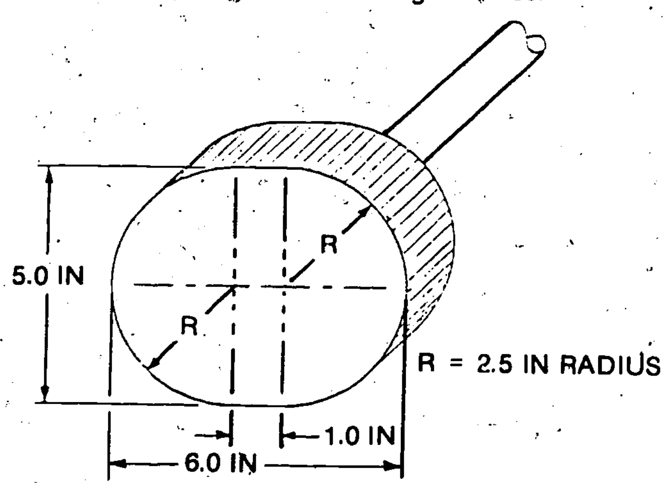


FIGURE 14 - PROBE FOR DETERMINING ACCESSIBLE OPENINGS

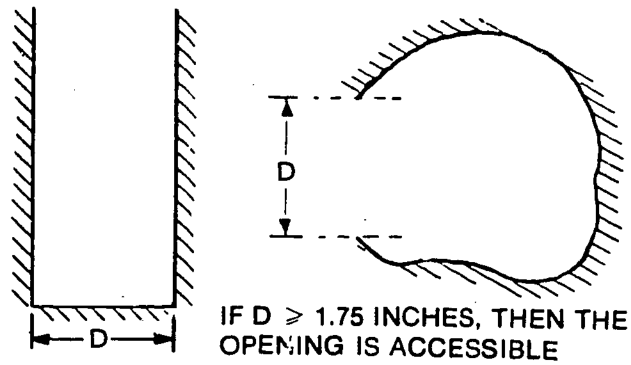


FIGURE 15 - PARTIALLY BOUNDED OPENINGS

Exceptions to Paragraph 10.2.1. **10.2.3**

Exception 1 - Angles less than 55 degrees with a lower leg projecting more than 10 degrees below horizontal. **10.2.3.1**

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. **10.2.3.2**

Exception 3 - Accessible openings that are completely unbounded by a lower surface (see Figure 16). **10.2.3.3**

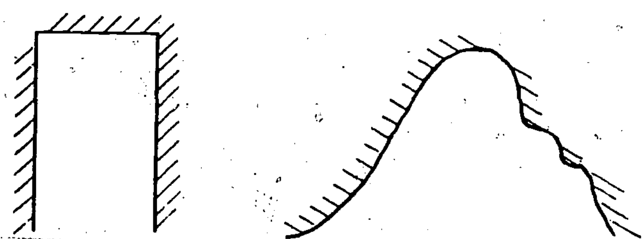


FIGURE 16 - UNBOUNDED LOWER SURFACE EXCLUSION

Exception 4 - Angles less than 55 degrees that have been filled or similarly covered such that the recommendation of Paragraph 10.2.1.2 of this section is met (see Figure 17). **10.2.3.4**

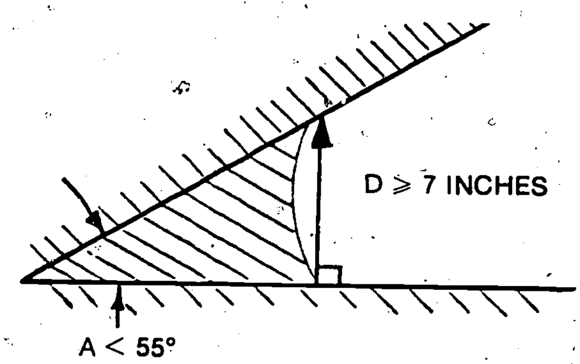


FIGURE 17 - LESS THAN 55° ANGLE EXCLUSION

11. Falls From Equipment

11.1 Elevated Surfaces - It is recommended that an elevated surface located more than 30 inches above the underlying surface and intended for use as a platform, deck, walkway, landing, transitional surface, or similar walking surface have a protective barrier at least 38 inches in height. The protective barrier should completely surround the surface except for necessary entrance and exit openings. The intent of this recommendation is to prevent falls through the barrier, preclude the possibility of entrapment and discourage climbing.

NOTE: This recommendation is not intended to apply to elevated surfaces where a protective barrier would encumber the normal intended use of the apparatus. For example, balance beams, most climbing apparatus, platforms or other equipment tiered or layered in a manner which would preclude a fall of more than 30 inches. Note, also, that slides, ladders, and stairways are discussed separately.

11.2 Hand Gripping Components - It is recommended that components intended to be grasped by the hands, such as rungs of horizontal ladders, climbing bars, hand rails, and the like, should not exceed 1.6 inches in diameter or in the maximum cross-sectional dimension (see Reference 30).

NOTE: This recommendation is based on anthropometric data relevant to a minimum user (hand size of a five year old child) and is intended as a guide.

When structural requirements cannot reasonably be met by 1.6 inch diameter components, care must be exercised in selecting alternate components and/or designs to insure that the hand gripping potential is not seriously impaired.

11.3 Ladders and Stairways - The following recommendations are given:

11.3.1 For Slope - When measured from a horizontal plane:

11.3.1.1 Ladders with Rungs - Ladders with rungs should have a slope between 75 and 90 degrees.

11.3.1.2 Ladders with Steps - Ladders with steps should have a slope between 50 and 75 degrees.

11.3.1.3 Stairways - Stairways should have a slope no greater than 35 degrees.

For Steps and Rungs. 11.3.2

Horizontality - Steps and rungs should be horizontal (± 2 degrees). 11.3.2.1

Width - Steps and rungs should be at least 15 inches wide (see Figure 18). 11.3.2.2

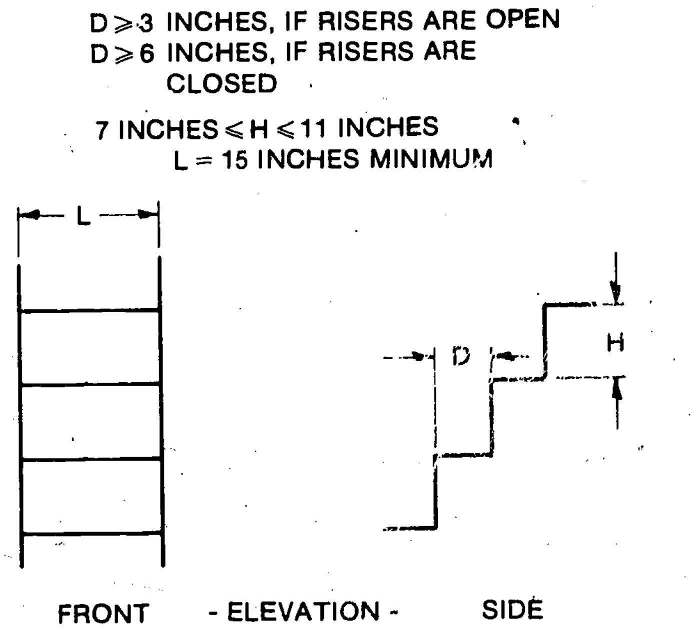


FIGURE 18 - STEPS AND RUNGS

Spacing - Steps and rungs should be evenly spaced. The spacing, when measured between the top surfaces of two consecutive steps or rungs, should be between 7 and 11 inches (see Figure 18). 11.3.2.3

Tread Depth - Steps should have a tread depth of 3 inches or more if the risers are open and 6 inches or more if the risers are closed (see Figure 18). 11.3.2.4

For Hand Rails - Stairways and ladders with steps should have continuous hand rails on both sides. The railings should be designed to maintain the user in an upright position over each step. 11.3.3

Slip-Resistant Surfaces - It is recommended that components intended primarily for use by the feet should have a finish that is slip-resistant under wet and dry conditions. 11.4

Straight Slides - The following recommendations are given: 11.5

For Side Height - Sides should project at least 11.5.1

2.5 inches above the sliding surface when measured perpendicular to that surface (see Figure 19). The sides should extend for the entire length of the sliding surface.

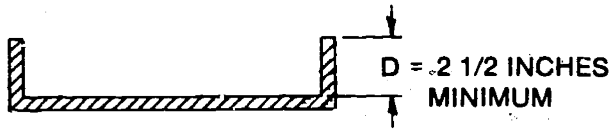
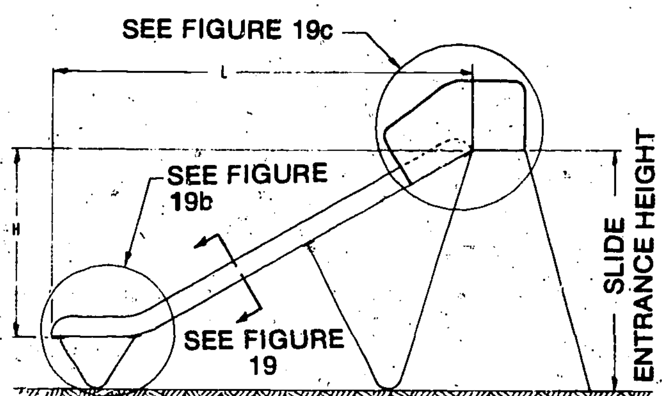


FIGURE 19 - SLIDE CROSS SECTION

11.5.2 For Slide Surface Slope.

11.5.2.1 Average Incline - The average incline of the sliding surface should not exceed 30 degrees as measured in accordance with Figure 19a.



NOTE: AVERAGE SLOPE SHOULD NOT EXCEED 30° OR H/L ≤ 0.577

FIGURE 19a - STRAIGHT SLIDE

11.5.2.2 Span - No span of the sliding surface should have a slope that exceeds 45 degrees as measured from a horizontal plane.

11.5.3 For Exit Region: Slope, Length, Height and Radius of Curvature - The recommendations of this subsection pertain to slides having a vertical drop height (H) or an entrance height (see Figure 19a) in excess of 4 feet. (Slides having a vertical drop height (H) or entrance height 4 feet or less are not subject to these guidelines).

11.5.3.1 Slope - The slope of the exit region should be between 0 and -4 degrees as measured from a plane parallel to the underlying surface (see Figure 19b).

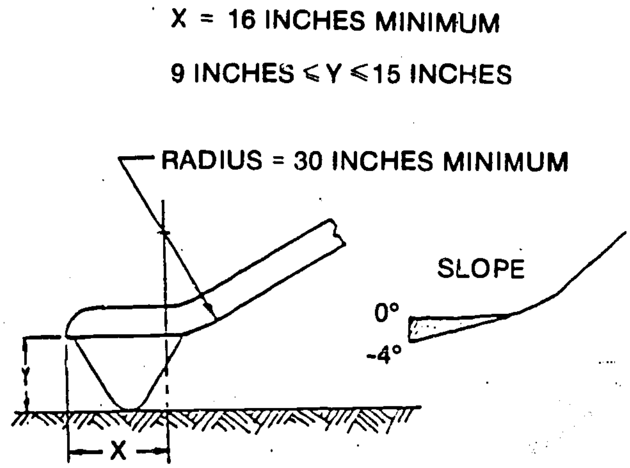


FIGURE 19b - EXIT REGION

Length - The exit surface of the slide should be at least 16 inches in length (see Figure 19b). **11.5.3.2**

Height - The exit surface should be at least 9 inches and no more than 15 inches above ground level (see Figure 19b). **11.5.3.3**

Radius - The radius of curvature of the sliding surface in the exit region should be at least 30 inches when measured as shown in Figure 19b. **11.5.3.4**

For Slide Surface Entrance - All slides should have features that facilitate transition to the inclined sliding surface. Slides having an entrance height of more than 30 inches should meet the following: **11.5.4**

Platform - The entrance to the inclined sliding surface should be a horizontal platform at least 10 inches in length and at least as wide as the contiguous inclined surface. **11.5.4.1**

Protective Barriers - Except for necessary exit and entrance openings, a barrier should completely surround the platform and extend down the sides of the inclined surface in accordance with minimum dimensions provided in Figure 19c. **11.5.4.2**

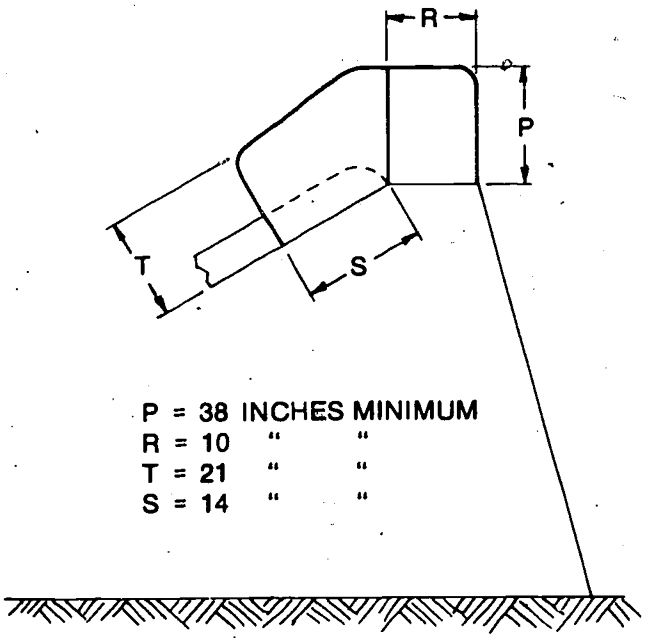


FIGURE 19c - SLIDE SURFACE ENTRANCE

11.5.4.2.1 To Maintain Body Balance - The barrier should provide the facility for the minimum as well as maximum user to maintain body balance and support when moving through the transition between ladder, platform, and sliding surface.

11.5.4.2.2 Prevention of Falls - The protective barrier should prevent falls through the barrier, preclude the possibility of entrapment and be of a design that neither encourages nor facilitates climbing.

NOTE: These recommendations may not be appropriate for all types of slides, e.g., slides built into a hill, extra wide slides that can accomodate more than a single user, or tubular (totally enclosed) slides.

11.6 Spiral Slides - Spiral slides, an example of which is shown in Figure 20, should be designed and constructed so as to prevent lateral discharge of the slider from the chute. Lateral discharge may occur in one of two ways, by tipping over or by sliding over the outer edge or by tipping over or sliding over the inner edge. To prevent these types of lateral discharge, follow the recommendations in Paragraphs 11.6.1 through 11.6.6.

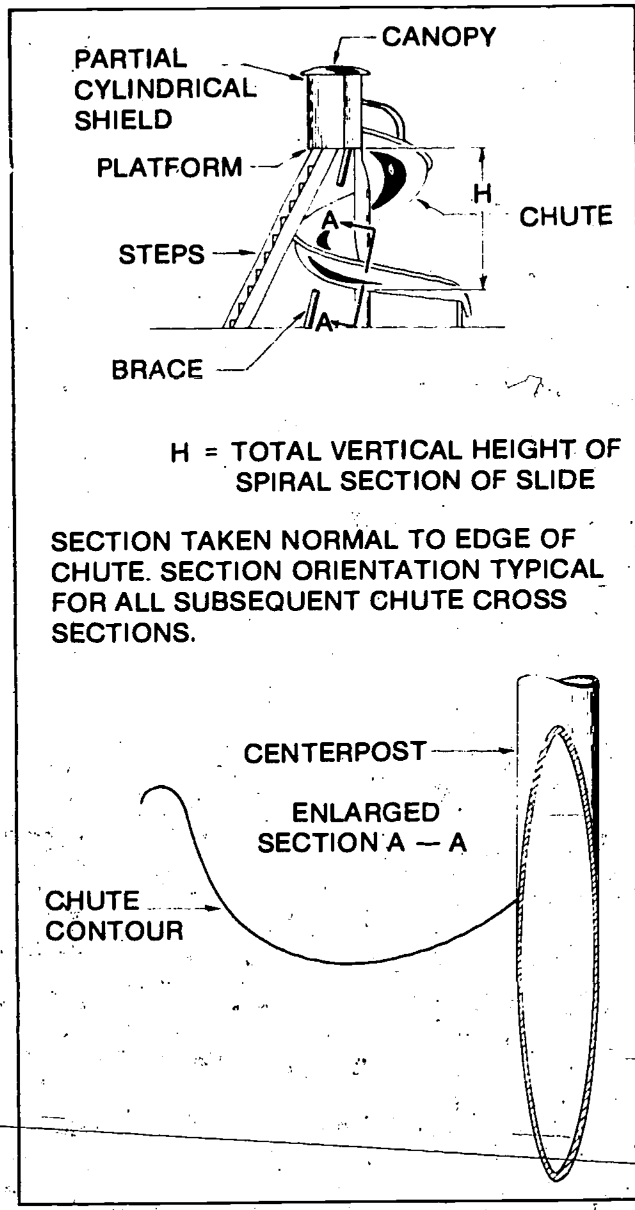


FIGURE 20 - SLIDE'S BASIC CONSTRUCTION, "H" & CHUTE CROSS SECTION

11.6.1 Lateral Discharge Mode by Tipping Over Outer Edge - This mode of lateral discharge may occur if the contour of a cross section of the chute is composed of perpendicular lines as shown in Figure 21a or has an abrupt change in contour as shown in Figure 21b. For such a spiral slide to prevent lateral discharge of the slider, the height of the outer edge of the chute, Y, must be equal to or greater than a value that is a function of the height of the spiral section of the slide (H in Figure 20), the radius of curvature of the turn (R), and the banking angle of the chute (θ) (see Paragraph 11.6.5.1 for computation of Y).

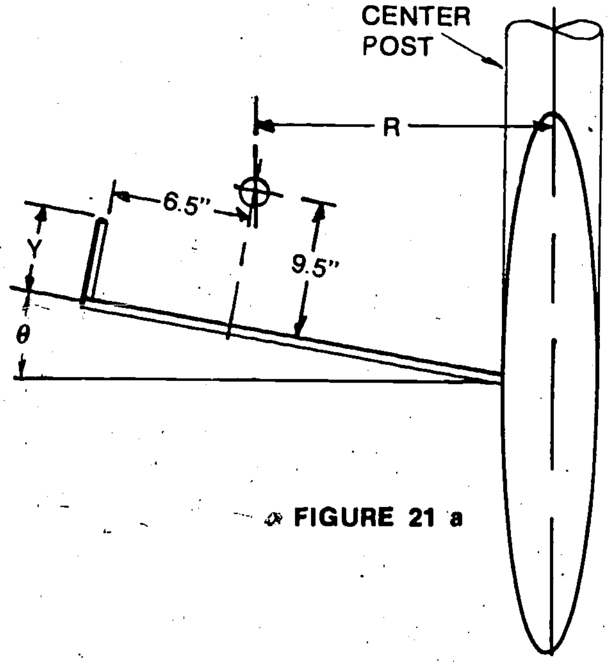


FIGURE 21 a

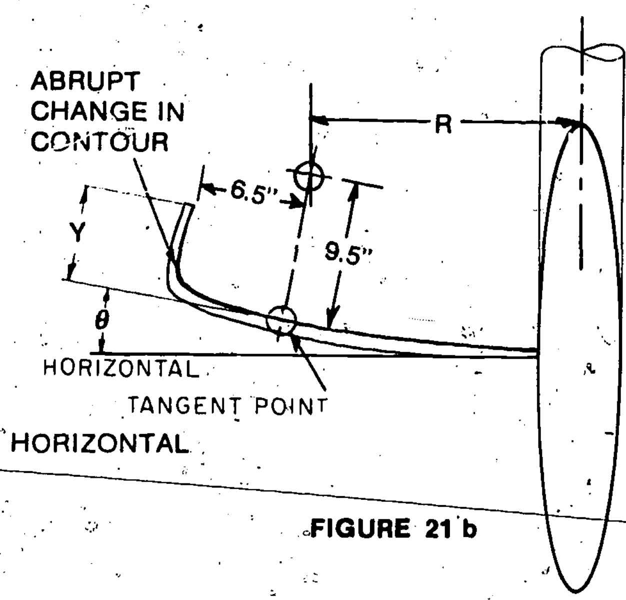


FIGURE 21 b

Y = HEIGHT OF OUTER EDGE OF CHUTE

R = RADIUS OF CURVATURE OF TURN

θ = BANKING ANGLE OF CHUTE

FIGURES 21a and 21b - CROSS SECTION OF CHUTES OF SPIRAL SLIDES WHOSE MODE OF LATERAL DISCHARGE IS TIPPING

Figure 22. For such a spiral slide to prevent lateral discharge of a slider, the effective banking angle, Φ, must be equal to or greater than a value that is a function of the height of the spiral section, (H), and the radius of curvature of the turn, (R) (see Paragraph 11.6.5.2 for computation of Φ).

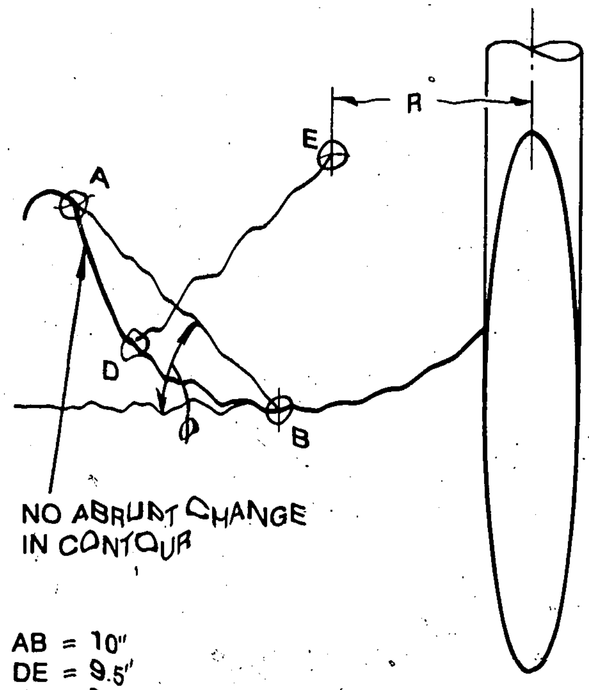


FIGURE 22 . CROSS SECTION OF CHUTE WHOSE MODE OF LATERAL DISCHARGE IS SLIDING

11.6.2 Lateral Discharge Mode by Sliding Over Outer Edge - This mode of lateral discharge may occur if the contour of a cross section of the chute is a continuous curve with no abrupt change in curvature such as that shown in

11.6.3 Lateral Discharge Mode Over Outer Edge Not Obvious - For some chutes the potential mode of lateral discharge may not be obvious. In such cases, a radius gauge should be constructed similar to the one shown in Figure 23a. If the gauge contacts the chute contour at two points, such as shown in Figure 23b, the potential mode of lateral discharge will be tipping. If the gauge contacts the chute at only one point, such as is shown in Figure 23c, the potential mode of lateral discharge will be sliding.

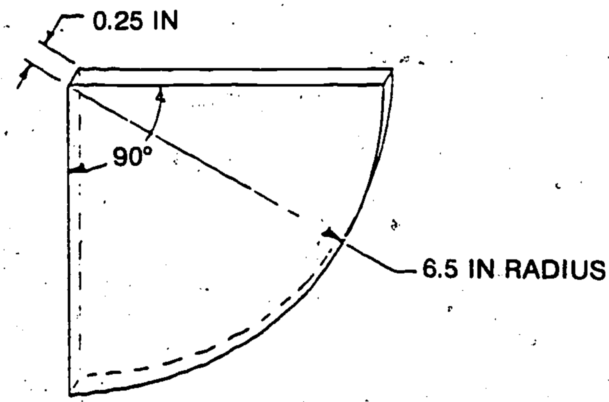


FIGURE 23a - RADIUS GAUGE TO DETERMINE POTENTIAL MODE OF LATERAL DISCHARGE FROM SPIRAL SLIDE

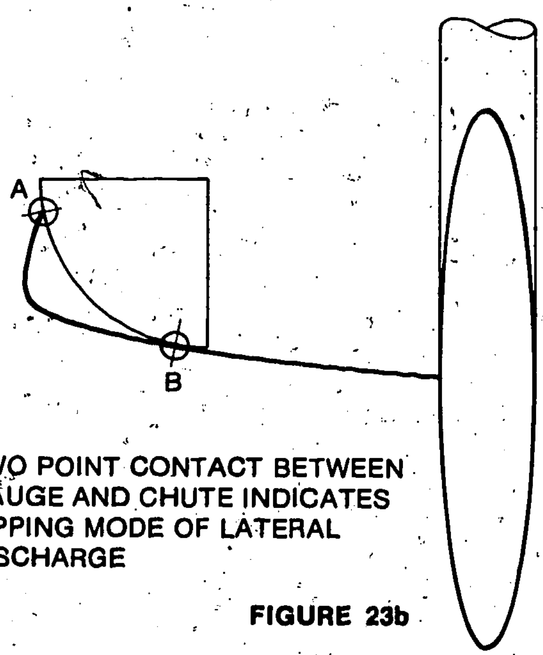
Determination of Factors to compute Outer Edge Discharge. 11.6.4

Maximum vertical drop of curved section of slide, (H) - Measure the vertical distance between the entrance to the slide and the lowest point on the spiral section of the chute (see Figure 20). 11.6.4.1

Radius of Curvature of the Turn, (R) - If the mode of lateral discharge is tipping, measure R as shown in Figures 21a or 21b. If the mode of lateral discharge is sliding, measure R as shown in Figure 22. 11.6.4.2

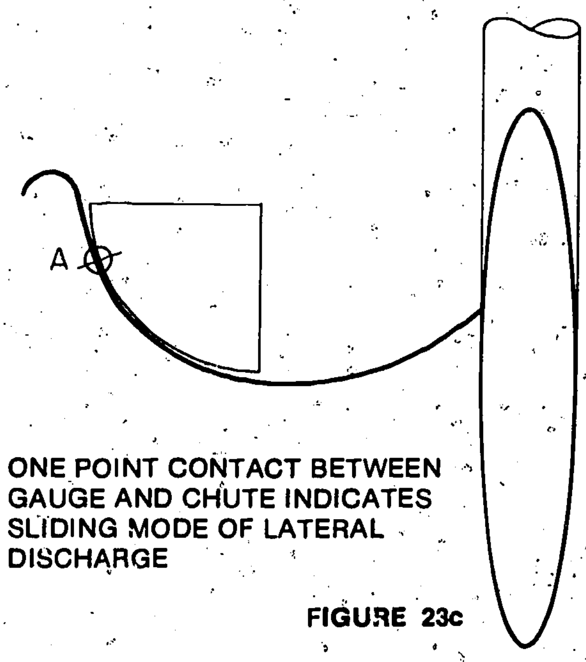
Measurement of Banking Angle, θ (theta), for Tipping Discharge Mode - If the mode of lateral discharge is tipping, measure θ as shown in Figures 21a or 21b. 11.6.4.3

Measurement of Effective Banking Angle, ϕ (phi), for Sliding Discharge Mode - If the mode of lateral discharge is sliding, measure ϕ as shown in Figure 22. 11.6.4.4



TWO POINT CONTACT BETWEEN GAUGE AND CHUTE INDICATES TIPPING MODE OF LATERAL DISCHARGE

FIGURE 23b



ONE POINT CONTACT BETWEEN GAUGE AND CHUTE INDICATES SLIDING MODE OF LATERAL DISCHARGE

FIGURE 23c

FIGURES 23b and 23c - USE OF RADIUS GAUGE TO DETERMINE POTENTIAL MODE OF LATERAL DISCHARGE

11.6.5 Computation of Parameters for Outer Edge Discharge.

11.6.5.1 Tipping - If the mode of lateral discharge is tipping, compute the effective edge height, Y, from the following expression:

$$Y \geqslant 9.5 - 6.5 \; \frac{1.6\,(H/R)\,\mathrm{TAN}\ \theta + 1}{1.6\,(H/R) - \mathrm{TAN}\ \theta}$$

NOTE: In no case should the effective edge height be less than 2.5 inches. Minimum values for Y have been computed for different values of H, R, and ϕ and are included in Tables 1 and 2.

Sliding - If the mode of lateral discharge is sliding, compute the effective banking angle, ϕ, from the following expression: **11.6.5.2**

$$\phi \geqslant \mathrm{TAN}^{-1}\,(1.6\ H/R) - 11.3°$$

NOTE: Minimum values for ϕ have been computed for different values of H and R and are included in Table 3.

TABLE 1. Minimum Effective Edge Heights, Y Inches: R = 15 Inches

$$Y = 9.5 - 6.5 \; \frac{1.6\,(H/R)\,\mathrm{TAN}\ \theta + 1}{1.6\,(H/R) - \mathrm{TAN}\ \theta}$$

H inches	θ degrees							
	0	10	15	20	25	30	35	40
	Y inches							
48	8.2	7.0	6.3	5.6	4.8	3.8	2.8	
60	8.5	7.3	6.6	5.9	5.1	4.3	3.3	
72	8.7	7.5	6.8	6.1	5.4	4.5	3.6	
84	8.8	7.6	7.0	6.3	5.5	4.7	3.8	2.7
96	8.9	7.7	7.0	6.4	5.7	4.9	3.9	2.9
108	8.9	7.8	7.1	6.5	5.8	5.0	4.1	3.0
120	9.0	7.8	7.2	6.5	5.8	5.0	4.2	3.1
132	9.0	7.9	7.3	6.0	5.9	5.1	4.2	3.2
144	9.1	7.9	7.3	6.6	5.9	5.2	4.3	3.3
156	9.1	8.0	7.3	6.7	6.0	5.2	4.3	3.3
168	9.1	8.0	7.4	6.7	6.0	5.3	4.4	3.4
180	9.2	8.0	7.4	6.7	6.0	5.3	4.4	3.4

TABLE 2. Minimum Effective Edge Heights, Y Inches: R = 21 Inches

$$Y = 9.5 - 6.5\,\frac{1.6\,(H/R)\,\tan\theta + 1}{1.6\,(H/R) - \tan\theta}$$

H inches \ θ°	0	10	15	20	25	30	35	40
	Y inches							
48	7.7	6.4	5.7	5.0	4.0	2.9		
60	8.1	6.8	6.1	5.4	4.5	3.6		
72	8.3	7.1	6.4	5.7	4.9	4.0	2.9	
84	8.5	7.3	6.6	5.9	5.1	4.3	3.2	
96	8.6	7.4	6.8	6.1	5.3	4.5	3.5	
108	8.7	7.5	6.9	6.2	5.4	4.6	3.7	2.5
120	8.8	7.6	7.0	6.3	5.6	4.7	3.8	2.7
132	8.9	7.7	7.0	6.4	5.6	4.8	3.9	2.8
144	8.9	7.7	7.1	6.4	5.7	4.9	4.0	3.0
156	9.0	7.8	7.2	6.5	5.8	8.9	4.1	3.0
168	9.0	7.8	7.2	6.5	5.8	5.0	4.2	3.1
180	9.4	7.9	7.2	6.6	5.9	5.1	4.2	3.2

TABLE 3. Minimum Effective Banking Angle, φ°

$$\phi = \tan^{-1}(1.6\,H/R) - 11.3°$$

H inches \ R inches	15	18	21	24
	θ degrees			
48	68	66	63	61
60	70	68	66	65
72	71	70	68	67
84	72	71	70	69
96	73	72	71	70
108	74	73	72	71
120	74	73	72	76
132	75	74	73	72
144	75	74	73	73
156	75	75	74	73
168	76	75	74	74
180	76	75	75	74

11.6.6 Lateral Discharge Mode by Tipping or Sliding Over Inner Edge - When measured in accordance with Figures 24a and 24b, the contour of the chute at the inner portion should be such that

$$D \geqslant 2.5 \text{ INCHES}$$

NOTE: If the slide has a centerpost, it can be taken as the inner edge.

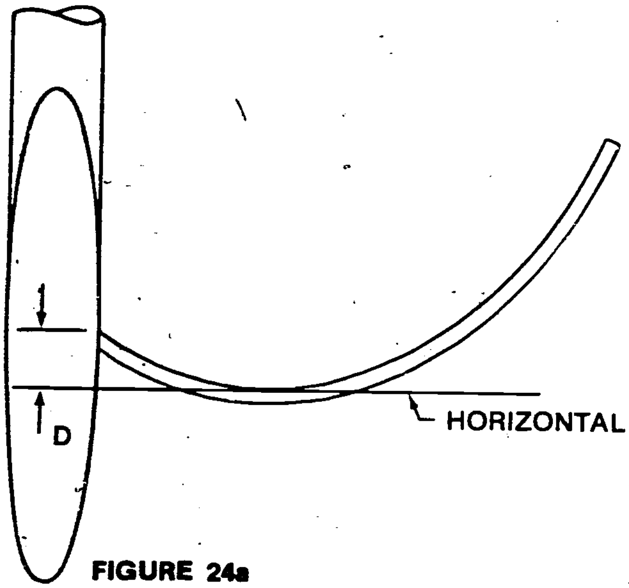


FIGURE 24a

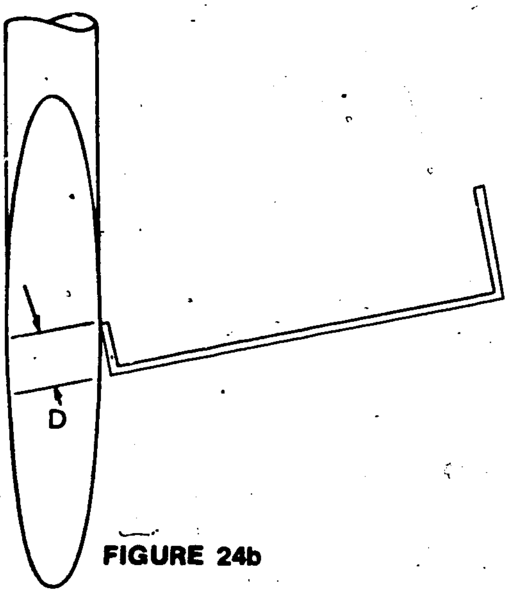


FIGURE 24b

FIGURES 24a and 24b - MEASUREMENT OF D

11.6.7 Exit Region: Slope, Length, Height and Radius of Curvature - Requirements of this section should be the same as those in Section 11.5.3.

11.6.8 Slide Surface Entrance - See Section 11.5.4.

12. Safety Guidelines for Surfaces Under Playground Equipment

Introductory Comments - The majority (60- **12.1**
70%) of public playground related injuries happen when children fall from the equipment and strike the underlying surface. Therefore, the objective of this section is to provide information about the relative ability of some surfaces to absorb the impact to a child's head, when the child falls. [The impact performance criterion for surfaces should be guided by head injury tolerance data for head-first falls of children (see Reference 32)].

Following are some types of surfaces commonly found in public playgrounds: blue stone dust (blue sandstone), crushed stone, cocoa shell mulch, pea gravel, pine bark mini-nuggets, pine bark mulch, rubber mats (both indoor and outdoor types), sand, shredded hardwood bark, synthetic turf on an asphalt base surface, tire mulch and paved surfaces such as asphalt, concrete, etc.

Generally, while hard surfacing materials such as macadam, black top, etc., may not require an excessive amount of maintenance or repair, they do not provide injury protection from accidental fall impacts and are therefore not recommended for use under playground equipment.

Soft surfacing materials, such as sand, pea gravel, bark, wood, rubber mulch, etc. which provide greater protection to the child, require continuous maintenance to retain their cushioning effectiveness.

Recommendation - When tested in accord- **12.2**
ance with the suggested test method in Paragraph 12.3, a surface should not impart a peak acceleration in excess of 200 g's to an instrumented ANSI headform dropped on a surface from the maximum estimated fall height (see Reference 32).

Suggested Test Method and Equipment - Use **12.3**
National Bureau of Standards' test method which requires dropping an instrumented headform in guided free fall and measuring some linear acceleration response of the headform during impact. For detailed procedures see Reference 32 for some applied surfaces and Reference 33 for soils.

Concrete, Asphalt and Similar Materials - Data **12.4**
obtained by the National Recreation and Park

Association and Roth and Burke (see Reference 1) and National Bureau of Standards (see Reference 33) indicated that even at low velocity impacts these materials would not meet the suggested 200 g criterion. **Because of this, it is suggested that all installation instructions and equipment catalogs contain statements recommending that paved surfaces, such as asphalt and concrete, not be used under playground equipment.**

12.5 Influence of Environment on Surfaces - In general, different surfacing materials are influenced by various environmental conditions existing in any specific location. Thus, selection of surfacing materials must take into account varying environmental factors. According to previous research, these surfaces generally can be affected by their environment as follows (see Reference 31):

12.5.1 Loose Materials.

12.5.1.1 Organic (e.g. pine bark mini-nuggets, pine bark mulch, shredded hardwood bark and cocoa shell mulch, etc.):

- The cushioning properties of these materials depend upon the air trapped within and between the individual particles. In rainy weather, or during periods of high humidity, these materials absorb moisture and tend to compact, thereby losing the trapped air necessary for protective cushioning.
- With the passage of time these materials decompose, are pulverized and become less cushioning.
- When wet and exposed to freezing temperatures, these materials will freeze and lose their cushioning protection.
- These materials, when wet, provide an ideal condition for micro-organism growth of various types which might allow transmission of communicable diseases.
- Wind blows these materials, reducing the thickness necessary for adequate cushioning.
- These materials may be blown or thrown into children's eyes.
- These materials are gradually displaced by the playing action of children, thereby reducing the thickness of protective layers in vital fall areas.
- These materials may harbor and conceal various insects, animal excrement and other trash such as broken glass, nails, pencils and other sharp objects that can cause puncture and cutting wounds.
- With use, these materials may combine with dirt and other foreign materials resulting in a loss of cushioning properties.
- Generally, these materials require replacement and continuous maintenance such as leveling, grading, and sifting to remove foreign matter in order to remain effective as cushioning materials.

Inorganic (e.g. sand, pea gravel, blue stone dust (blue sandstone) crushed stone, etc.): 12.5.1.2

- These materials could be blown or thrown into children's eyes.
- These materials could be displaced by the playing action of children, thereby reducing the thickness of protective layers in vital fall areas.
- These materials could harbor and conceal various insects, animal excrement and other trash such as broken glass, nails, pencils and other sharp objects that can cause puncture and cutting wounds.
- With use, these materials may be combined with dirt and other foreign materials, resulting in a loss of cushioning properties.
- With increasing amounts of moisture, sand becomes cohesive and less cushioning. When thoroughly wet, sand reacts as a rigid material when impacted from any direction.
- When wet and exposed to freezing temperatures, these materials will freeze and lose their cushioning protection.
- Pea gravel is difficult to walk on.
- Generally, these materials require replacement and continuous maintenance such as leveling, grading, and sifting to remove foreign matter in order to remain effective as cushioning materials.

Compact Materials (e.g. rubber mat - outdoor type, gym mat - indoor type, synthetic turf on asphalt base - stadium surface, etc.) (see Reference 32): 12.5.2

- These materials have to be used on almost level uniform surfaces.
- These materials may be subject to vandalism.

(defaced, ignited, cut, etc).

- Their performance will depend on the foundation or surface on which they are installed.

12.5.3 Soils - In general, the soils tested produced lower peak accelerations than asphalt but not as low as most of the loose surfacing materials (6 inches in depth) which were tested in the laboratory (see Reference 33). However, a perspective of test conditions must be maintained when making these comparisons. The soils were tested in-situ, but none of the loose materials were tested under conditions of a playground environment. Peak acceleration appears to be correlated with a soil's moisture content; other associations are not evidenced by the data gathered by NBS. This is not surprising in view of the limited number of soils tested, the large number of variables that characterize a soil, and the compounding of these variables in the soils tested.

REFERENCES

1. NRPA, "Proposed Safety Standards for Public Playground Equipment and Supporting Rationale," submitted by NRPA (National Recreation and Parks Association) to CPSC, May 1976.

2. McConel, W.H., et al., "Product Investigation Report Contract No. FDA73-6, Public Playground Equipment," October 15, 1973.

3. Douglass, J.M., Nahm, A.M., and Roberts, S.B., "Applications of Experimental Head Injury Research," Proc. 12th Stapp Car Crash Conference, S.A.E., 1968.

4. Gurdjian, E.S., "Recent Advances in the Study of the Mechanisms of Impact Injury of Head," reprint from *Clinical Neurosurgery*, Vol. 19, 1972.

5. Mahajan, B.M., "A Guide for Police Helmets," NBS Report 1975 (in print).

6. Rowbothan, G.F., "Acute Injuries of the Head," Williams and Williams, Baltimore, 1964.

7. Gurdjian, E.S., "Prevention and Mitigation of Head Injuries," reprint from *Clinical Neurosurgery*, Vol. 19, 1972.

8. Synder, R.G., "State-of-the-Art: Human Impact Tolerances," S.A.E. Paper No. 700398, 1970, reprinted in 1972.

9. Hodgson, V.R., Thomas, L.M., and Prasad, P., "Testing the Validity of the Severity Index," Proc. of 14th Stapp Car Crash Conference, S.A.E., 1970.

10. Berger, R.E. and Calvano, N., "Methodology for Choosing Test Parameters to Evaluate Protective Headgear," NBS Report No. NBSIR 78-1547, Nov. 1978.

11. Hodgson, V.R., et. al. "Injury to the Facial Bones," Proc. of 9th Stapp Car Crash Conference, S.A.E., Oct. 1966.

12. *Uniform Building Code*, International Conference of Building Officials, 1976.

13. *One and Two Family Dwelling Code*, Second Edition, 1975.

14. Fattal, S.G., Cattaneo, L.E., Turner, C.E., and Robinson, S.W., *A Model Performance Standard* for *Guardrails*, National Bureau of Standards Report, NBSIR76-1131, July 1976.

15. Australian Standard Specifications for Playground Equipment for Park, Schools and Domestic Use (Draft Standard for Public Review), Standards Association of Australia, January 1978.

16. *Safety Requirements for Home Playground Equipment Voluntary Product Standard, PS66-75*, National Bureau of Standards, July 1976 (Also published as American National Standards Institute Z304.1-1976, May 1976).

17. *Anthropometry of Infants, Children, and Youths to Age 18 for Product Safety Design*, University of Michigan, May 1977.

18. *The BOCA Basic Building Code, Building Officials and Code Administrators*, International, Inc., 1975.

19. Fattal, S.C. and Cattaneo, L.E., *Investigation of Guardrails for the Protection of Employees from Occupational Hazards*, National Bureau of Standards Report No. NBSIR76-1139, July 1976.

20. *Weight, Height, and Selected Body Dimensions of Adults U.S. 1960-62*, Public Health Service, Department of Health Education and Welfare.

21. CPSC, "Hazard Analysis of Injuries Relating to Playground Equipment" (NIIC-1201-75-M005), March 1975.

22. Roth, H.P. and Burke, D.M., "Head Impact G in Free Fall on Various Surfaces and Padding Materials," unpublished work submitted by D.M. Burke to CPSC, April 1975.

23. Thomas, L.M., Hodgson, V.R., and Gurdjian, E.S., "Skull Fracture and Management of Open Head Injury," *Neurological Surgery*, Vol. 2, W.B. Saunders Co., Phila., 1973.

24. Gurdjian, E.S., and Schuwan, H.K., "Management of Skull Fracture Involving the Frontal Sinus," *Annals of Surgery*, Vol. 95, 1932.

25. Mahajan, B.M., "Standards for Athletic Helmets - A State-of-the-Art and Recommendations," NBS Report No. NBSIR73-276, April 1974.

26. Gadd, C.W., "Use of a Weighted-Impulse," Proc. 10th Stapp Car Crash Conf., S.A.E., New York, 1966, pp. 164-174.

27. Mohan, D., Bowman, B., Snyder, R.G., and Foust, D.R., "A Biomechanical Analysis of Head Impact Injuries to Children," presented at the Ninth Annual Neuroelectric Society Meeting, December 1977.

28. Draper, N., and Smith, H., *Applied Regression Analysis*, John Wiley and Sons, New York, NY.

29. *Suggested Safety Requirements and Supporting Rationale for Swing Assemblies and Straight Slides*, Product Safety Technology Division, National Bureau of Standards, Memorandum Report to the CPSC, April 1978.

30. *Suggested Safety Guidelines and Supporting Rationale for Public Playground Equipment*, Product Technology Division, National Bureau of Standards, Memorandum Report to the CPSC, August, 1978.

31. *Report on Environmental Conditions that Affect Safety Attributes of Surfacing Materials Placed Under Playground Equipment*, CPSC-ESEP, Rivero, Memorandum Report, July 17, 1978.

32. *Impact Attenuation Performance of Surfaces Installed Under Playground Equipment*, Product Technology Division, National Bureau of Standards, NBSIR 79-1707, February, 1979.

33. *Soil Impact Attenuation Performance: A Field Study*, Product Technology Division, National Bureau of Standards, Memorandum Report to the CPSC, November, 1979.

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