

Comment: Drop mass. Several commenters favored a variable drop mass instead of the originally proposed 5 kg drop mass, which would have been used for testing both adults' and children's helmets. (The helmet's mass is not included in the drop mass.) Some respondents felt a reduced drop mass is especially important for testing young children's helmets. One respondent opposed lowering the drop mass, stating that there is no benefit in different drop masses for each headform.

Response: A 1979 study found that in head-first free fall, a child's body mass and orientation at impact have little influence on head loading (g-forces) during impact.⁹ The study also explains that head loading in adult falls is influenced by a more complex relationship between head mass and body mass. This suggests that the actual head mass of a child is an important factor in determining head loading during impact.

The helmet liner is designed to absorb the energy of impact by deformation, and to deform at force levels below that which would cause head injury. However, children's heads have less mass and their skulls are more flexible than those of adults. Therefore, a child's head may not deform the helmet's foam padding during impact if the foam is designed to protect the heavier adult head. This lack of deformation may result in greater kinetic energy being transferred to a child's brain, possibly resulting in a greater likelihood of intracranial injury. This strongly suggests that children's helmets should be tested with a lower headform mass than helmets for adults.

The Commission's Directorate for Epidemiology and Health Sciences concluded that the head mass of children under the age of 5 years ranges from approximately 2.8 to 3.9 kg. Accordingly, the Commission is proposing a reduced drop assembly mass of 3.90 kg \pm 0.1 kg for testing helmets for children under 5. The lower mass will better represent the head mass of children under 5 years of age than the 5 kg mass specified for testing helmets for older children and adults.

Testing helmets for children under 5 years with a more appropriate mass should lead to helmets that are better designed to accommodate maturational differences of a young child's head. An even lower mass is not feasible with current test rigs, because a drop assembly mass of less than 3.90 kg

would shift the center of gravity on current test equipment enough to potentially influence test results.

Comment: Extent of protection. Current U.S. voluntary bicycle helmet standards, and the originally proposed CPSC standard, specify an extent-of-protection boundary and an impact test line. The extent-of-protection boundary defines the area of the head that must be covered by the helmet. The impact line designates the lowest point on the helmet where the center of the anvil may be aligned for testing. A clearance is specified between the extent-of-protection boundary and the impact line to allow for the imprint of the test anvil.

A number of comments on the proposed standard concerned the extent-of-protection (or extent of coverage) requirements. One commenter stated that the extent-of-protection requirement was subjective since no test is applied in these areas. Some commenters believed the proposed extent-of-protection requirement was design-restrictive, since some helmets have features like rear vents that may rise above the extent of coverage line but nevertheless will provide protection if impacted on the test line.

Response: The Commission believes that a performance test using a single test line and no extent-of-protection requirement is adequate for testing the impact-attenuation capabilities of a helmet. Not requiring specific helmet coverage allows manufacturers the flexibility to include desirable features such as a central rear vent, provided the features do not hinder the helmet's ability to meet the impact requirements if tested anywhere on or above the test line. Accordingly, the Commission has deleted the extent-of-protection line from the revised proposed standard.

Comment: Extended coverage for young children's helmets. A number of commenters favored an extended area of coverage for young children's helmets. However, one commenter suggested that the coverage lines defined in the first CPSC-proposed standard were not practical, since portions of the test line extended lower than the edge of an impact headform.

Response: As noted above, young children's skulls lack the calcification of older children's and adult skulls. This is especially true of children under 5 years old, where the curve of head growth and skull development is steepest. The temporal region (area above and around the ear) is much thinner than other parts of the skull. As a result, a much smaller force at the temporal region can cause a serious injury than at other regions of the skull. Accordingly, the Commission concludes that helmets for children

under 5 years should have a greater area of protection than those for older children and adults.

A recent proposal for infant helmet test lines by the ASTM Headgear Subcommittee Infant/Toddler Working Group specifies a "two-step" test line that is measured directly from the reference plane of the ISO A and ISO E headforms. The Commission considers the proposed ASTM test line appropriate for testing helmets for children under 5 years. The revised test line (Figure 5) provides an increased area of protection, including the temporal area.

Many young children's helmets on the market already provide an area of protection comparable to the revised CPSC proposal, though it is not required by any current U.S. bike helmet standard. The revised CPSC test line is easier to define and mark on a helmet than the first proposed CPSC line, which was referenced from an adjusted basic plane inclined 15 degrees from horizontal. This new test line does not extend lower than the edge of the headform.

Comment: Determining which helmets are for young children. A commenter asked for clarification of how to determine whether helmets are "intended" for children 4 years and under. The concern is that small helmets are often sold to adults with small heads.

Response: Typically, helmets for children are advertised and promoted with children's themes. The Commission will consider relevant factors, such as the design and marketing of a helmet, to determine whether it is intended for young children.

However, it is also important that consumers not mistake adult and older children's helmets that are the same size as helmets for children under 5 years of age as complying with the extra coverage and other special provisions required for helmets intended for children under 5. Therefore, the proposal provides that helmets specifically designed for children under 5 years of age be labeled to read: "Complies with CPSC Safety Standard for Bicycle Helmets for Children Under 5 years."

Comment: Peripheral vision. One commenter recommended revising the peripheral vision requirement to specify clearances of two separate 105° arcs from the center of each eye.

Response: The existing requirement of 105° clearance from the central point K is an established criterion that provides sufficient peripheral vision and allows for helmet protective coverage to the

⁹Mohan D, Bowman B, Snyder RG, and Frost, DR. A Biomechanical Analysis of Head Impact Injuries to Children. J. Biomechanical Eng. 101, pp. 250-260, U.S., Nov. 1979.