# 2024 STANDARD FOR PROTECTIVE HEADGEAR

## For Use with E-Bikes (ECE R22-05 light)

### ***Special Note to Helmet Users***

There are four reasons for you to be interested in this Standard:

1. E-Bike use imposes risks of death or permanent impairment due to head injury.
2. The proper use of protective helmets can minimize the risk of death or permanent impairment.
3. The protective capacity of a helmet is difficult to measure, particularly at the time of purchase or use.
4. Snell certification backed by ongoing random sample testing identifies those helmet models providing and maintaining the highest levels of head protection.

There are at least four critical elements affecting a helmet's protective properties:

1. Impact management - how well the helmet protects against collisions with large objects.
2. Helmet positional stability - whether the helmet will be in place, on the head, when it's needed.
3. Retention system strength - whether the chinstraps are sufficiently strong to hold the helmet throughout an incident involving head impact.
4. Extent of Protection - the area of the head protected by the helmet.

This Standard describes simple tests for all four of these items. However, the tests for the second item, helmet stability, of necessity presume that the helmet is well matched to the wearer's head and that it has been carefully adjusted to obtain the best fit possible. Unless you take similar care in the selection and fitting of your own helmet, you may not obtain the level of protection that current headgear can provide.

The Foundation recommends the simple, straightforward procedure recommended to consumers by most helmet manufacturers:

> Position the helmet on your head so that it sits low on your forehead; if you can't see the edge of the brim at the extreme upper range of your vision, the helmet is probably out of place. Adjust the chinstraps so that, when buckled, they hold the helmet firmly in place. This positioning and adjusting should be repeated to obtain the very best result possible. The procedure initially may be time consuming. <u>Take the time.</u>
>
> Try to remove the helmet without undoing the chinstrap. If the helmet comes off or shifts over your eyes, readjust and try again. If no adjustment seems to work, this helmet is not for you; try another.

This procedure is also the basis of the test for helmet stability described in this Standard. This test performs the same steps but uses standard head forms. Even though the helmet has met requirements on our standard head forms, we urge you to perform this procedure for yourself when buying a helmet and every time you wear a helmet. Only in this way will you be able to make all the proper adjustments in pads and strapping to get the best fit possible. Furthermore, your test on your own head will be an improvement on ours; you will determine whether the helmet is appropriate for you personally.

There are several other important aspects of helmets to consider. Bright colors and reflective patches will make you more visible to others and therefore less likely to be involved in a collision.

## *FOREWORD*

Riders of bicycles, E-bikes, mopeds and motorcycles are all at risk of serious injury or death. Helmets on the market today offer varying degrees of protection, but the consumer has little basis for judging the relative effectiveness of a given model. This Standard presents a rational means for identifying helmets suitable for users of E-bikes. Although this standard demands greater levels of protective performance than are generally urged for bicycling and the helmets meeting this standard are likely heavier and bigger than standard bicycle headgear, bicyclists who can ride comfortably with these helmets will do well to wear them. However, helmets which meet this standard may still not be appropriate for use with motorcycles and mopeds. Users of these vehicles are urged to consider helmets meeting M2025D or M2024R.

The Snell Foundation urges that protective helmets be required for all individuals participating in supervised events and encourages all users of two wheeled vehicles whether in casual riding or competition, to wear helmets which meet appropriate performance standards[1].

---

[1]The Foundation has also published Standards for headgear used in non-motorized sports, motorcycling, automobile racing, karting, skiing and snowboarding, equitation and harness racing. Copies of these Standards are available on request.

This 2024 Standard establishes performance characteristics suitable for E-bike use. **This Standard does not establish construction and material specifications. The Foundation does not recommend specific materials or designs.** Manufacturers submit helmets to be tested under this Standard and if the submitted helmets pass, a certification is issued.

The Foundation will make available the identity of those products which have been Snell certified but will not attempt to rank those products according to performance or to any other criteria. Neither does the Foundation distinguish between the needs of participants in competitive events and those of the general riding public.

**All of the requirements described herein, including both initial certification and random sample testing, are an integral part of this Standard. No helmet can satisfy the Standard unless it is subject to both certification and random sample testing by the Foundation.**

**Snell certification for protective headgear requires a specific contractual agreement between the primary headgear manufacturer and the Foundation. Certification procedures may be obtained upon application to the Foundation.**

## *INTRODUCTION*

This Standard addresses the problem of protecting the head from direct impact with various shapes of surfaces that may be encountered in a crash. The Standard prescribes direct measures of several factors bearing on a helmet's ability to protect the head as well as its general serviceability as headgear. Thus, this Standard is directed towards the kinds of performance bearing on head protection that may not readily be discernible by even knowledgeable consumers at the time of purchase.

Some of these performance requirements have been expressed in terms of limitations on the various components and features of the single general helmet configuration currently available. These expressions have been used only for the sake of clarity and should not be misinterpreted as requiring specific configurations or materials. As newer helmet technologies appear, these limitations will be re-examined and, perhaps, restated.

An E-Bike helmet consists generally of a rigid head covering and a retention system composed of flexible straps and hardware. The rigid covering protects the head from direct impact by its capacity to manage impact energy and also by its capacity to spread a concentrated load at its outer surface over a larger area of the wearer's head.

The retention system holds the headgear in position throughout normal usage and especially during falls and crashes. This Standard applies two different tests to the retention system. The first of these tests for stability by fitting the headgear to a standard head form and then attempting to displace it by applying tangential shock loadings. The second tests retention system strength by applying a shock load to the system components through a simulated chin.

The quality of the fit and the care taken with the adjustments are absolutely critical elements in these tests. **The manufacturer must provide suitable guidance so that the wearer will be able to select and adjust headgear to obtain the necessary quality of fit and positional stability.**

The capacity for impact protection is determined by direct measurement of the shock delivered through the helmet to a head form when the helmeted head form is dropped in a specified manner onto one of three unyielding anvils. The first of these puts a flat, horizontal surface directly under the falling head form and helmet. The helmet's impact managing material must cushion the head form sufficiently that the shock transmitted to the head form inside does not exceed specified limits. The second of these is a hemisphere which concentrates the impact to a smaller segment of the helmet's outer surface. The helmet shell must spread the loading to a broader portion of the helmet's impact liner and the liner itself must be sufficiently thick to keep the transmitted shock within specified limits.

For both these surfaces, the falling helmet and head form are dropped in guided fall, that is: the head form is constrained as much as possible to fall and then rebound directly upward with little or no rotation. However, the third anvil is flat, tilted at 45 degrees and topped with a high grit surface and the helmet and head form are not constrained so that they may rebound freely. This oblique anvil transmits a tangential shock to the surface of the falling helmet which may cause the head form to rotate. The helmet must isolate the head form from this shock sufficiently that specified limits on angular acceleration and velocity are not exceeded.

Most helmets are intended to accommodate a range of head sizes and shapes. Various thicknesses of resilient lining material may be placed within otherwise identical helmets during production to configure the fit to several different ranges of head size. This resilient padding does not significantly affect the way the helmet absorbs and attenuates impact and is not directly addressed in this Standard.

Other general features of helmets may include eyeshades, bright colors and reflective surfaces. These features all deal with matters of safety and comfort that are not directly addressed in this Standard but which merit the consideration of wearers as well as manufacturers.

Although helmet use has been shown to reduce head injuries significantly, there are limits to a helmet's protective capability. No helmet can protect the wearer against all foreseeable incidents. Therefore, injury, death or permanent impairment may occur in impacts which exceed the protective capability of any helmet including even those helmets meeting the requirements of this Standard.

A helmet's protective capability may be exhausted in an impact. Helmets are constructed so that the energy of a blow is managed by the helmet, which may cause its partial or total destruction. Because the damage may not be readily apparent, the Foundation strongly recommends that a crashed helmet be returned to the manufacturer for complete inspection. If it is not possible to return the helmet, the helmet should always be destroyed and replaced.

Finally, the protective capability may diminish over time. Some helmets are made of materials which deteriorate with age and therefore have a limited life span. At the present time, the Foundation recommends that helmets be replaced after five (5) years, or less if the manufacturer so recommends.

The remainder of this Standard is divided into sections on construction, qualifications for certification, modifications, random sample testing, labelling and marking, extent of protection, and testing. The section on qualifications for certification discusses helmets submitted for the Foundation's certification program. Construction, extent of protection and testing describe the requirements that helmets must meet to be admitted to the Foundation's program. These sections plus the sections on random sample testing, labelling and marking, and modifications describe the requirements that helmets must meet to continue in the Foundation's program.

## *CONSTRUCTION*

### A. General

The assembled helmet shall have smooth external and internal surfaces. Any feature projecting more than 5 mm beyond the outer surface must readily break away; all other projections on the outer surface shall be smoothly faired and offer minimal frictional resistance to tangential impact forces. There shall be no feature on the inner surface projecting more than 2 mm into the helmet interior. The helmet shall provide as nearly uniform impact protection over the entire protected area as is practicable.

If the absence of any detachable component of the helmet does not prevent its being worn, then this absence must not compromise either the retention system or the impact protection. If any part of the helmet detaches during testing, it must offer no laceration or puncture hazard nor reduce the area of coverage of the head.

If the manufacturer provides add-ons such as visors, face shields and neck curtains with the helmet, these add-ons must neither lessen the protective capability of the basic helmet nor create a direct hazard for the wearer.

### B. Materials

Ideally, materials used in the manufacture of the helmet should be of durable quality and not be harmed by exposure to sun, rain, dust, vibration, sweat or products applied to the skin or hair. Similarly, the materials should not degrade due to temperature extremes likely to be encountered in routine storage or transportation.

Materials which are known to cause skin irritation or are conducive to disease shall not be used for the parts which contact the skin. Materials that support the growth of fungi or algae shall not be used. Lining materials, if used, may be detachable for the purpose of washing.

**C. Finish**

All edges of the helmet shall be smoothed and rounded with no metallic parts or other rigid projections on the inside of the shell that might injure the wearer's head in the event of impact.

**D. Retention System**

The retention system shall be designed so as to discourage misuse. That is, of all the ways in which the retention system might be used, the design use shall be the simplest and quickest to implement. Helmets shall not be fitted with "non-essential" features which, if misused, can degrade the performance. Quick release buckles, if used, shall not be able to be released inadvertently.

**E. Peripheral Vision**

The helmet shall provide peripheral visual clearance. This clearance is defined using a reference head form appropriate to the size of the helmet and corresponds to a visual field of at least 105° to the right and to the left of straight ahead.

The helmet shall also provide an upward visual clearance. This clearance is defined using a reference head form appropriate to the size of the helmet and corresponds to a visual field of at least 7° upward from horizontal.

## *QUALIFICATIONS FOR CERTIFICATION*

For qualification testing, helmets shall be in the same condition as those offered for sale. No helmet or component which has been subjected to any tests described in this Standard shall be offered for sale after testing. At least eight (8) complete helmets and as many as ten (10) must be submitted by the manufacturer for a certification test program for each size of this model offered for sale. All but one of these samples will be destroyed in testing; the untested sample shall be retained for comparison and reference.

### *MODIFICATIONS*

Cosmetic changes to certified headgear are permissible. Such changes are generally limited to marking or trimming the headgear with manufacturer approved paint or tape.

Otherwise, modification of certified headgear creates new headgear which will not have the confidence and certification of the Foundation until samples have been submitted and evaluated. Manufacturers must not place the Foundation's certification label in any modified headgear for which they have not received written permission.

After-market modifiers of such certified headgear should be aware that any structural modification may adversely affect a helmet's protective capability and therefore invalidate the certification.

### *RANDOM SAMPLE TESTING*

In addition to the certification testing, the Foundation will routinely obtain and test samples of previously certified models. These samples will be selected from among those stocks intended for retail sale to consumers. In this manner, the Foundation will attempt to ensure that the helmets made available to the public continue to meet the performance requirements of this Standard.

In cases in which helmets are provided directly to users and do not pass through a normal sales distribution system, the Foundation will set up alternative procedures to monitor certified products. Specifically, if helmets are provided directly to teams or individuals for use in organized events, the Foundation must have access to the helmets for spot checking and non-destructive evaluation.

## *LABELING AND MARKING*

Each helmet shall have durable, visible and legible labeling identifying the manufacturer, the month and year of manufacture, the model and the size. Labeling shall be uncoded and either in English or a language common to the area where the helmets are to be distributed. The headgear shall also be labeled to the following effect:

1. Certified for E-bike and bicycle use only.
2. No helmet can protect the wearer against all foreseeable impacts. However, for maximum protection, the helmet must be of good fit and all retention straps must be securely fastened. The helmet, when fitted and fastened, shall resist any inadvertent dislodgement or removal.
3. This helmet is so constructed that the energy of an impact may be absorbed through its partial destruction, though damage may not be visible. If it suffers an impact, it must either be returned to the manufacturer for inspection or be destroyed and replaced.
4. Intended for head circumferences from XX cm through YY cm. (XX and YY represent numerical values for the smallest and largest head circumferences for which the helmet is intended.)

If any of the helmet components are sensitive to common solvents, adhesives, paints or cleansers; the helmet must also bear labels to the following effect:

> This helmet can be seriously damaged by some common substances without visible damage. Avoid contact with: (List damaging fluids, etc.) Apply only

the following: (Recommended cleaning agents, paints, adhesives and the like) as appropriate.

Each helmet shall also include one of the Foundation's serialized certification labels. The Snell certification label shall be placed either inside or on the outside of the helmet, as appropriate, in such a way that it cannot be removed intact.

The registered trademark (certification label) of the Snell Foundation may be used by the manufacturer only under license from the Snell Foundation. The specifics of licensure may be obtained from the Foundation.

## *HEAD FORMS*

This standard invokes six standard head forms for helmet inspection, marking and testing. The geometry of these head forms is according to the definitions for the ‘A’, ‘C’, ‘E’, ‘J’, ‘M’, and ‘O’ head forms described in International Standards Organization (ISO) Draft Standard ISO DIS 6220-1983. The impact mass specifications for the impact test phase are comparable to those in ECE 22-05 for these same head form designations.

ISO DIS 6220-1983 includes descriptions for half head forms suitable for guided fall impact testing or for full head forms such as those used in the positional stability tests. Figures 1 and 2 depict the general shapes of the head form configuration. The following table lists useful dimensions from the two references given above.

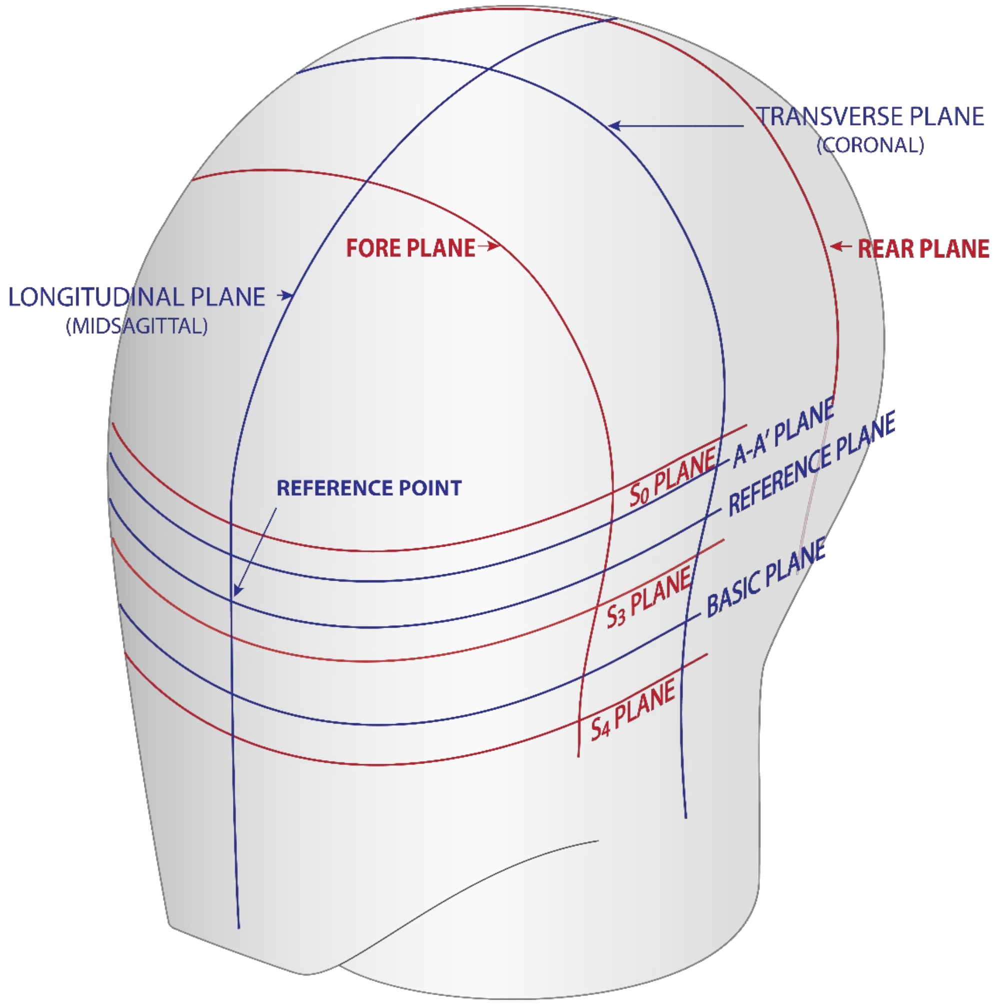


Figure 1 ISO Head Form – ISO DIS 6220-1983

| Table 1 Useful Head Form Parameters | | | | |
|---|---|---|---|---|
| Head Form | Circumference | Total Mass (entire drop assembly) | Crown to Basic Plane | Basic to Reference Plane |
| A | 50 cm | 3.100 kg ± 100 g | 113.5 mm | 24.0 mm |
| C | 52 cm | 3.600 kg ± 100 g | 118.0 mm | 25.0 mm |
| E | 54 cm | 4.100 kg ± 100 g | 122.0 mm | 26.0 mm |
| J | 57 cm | 4.700 kg ± 100 g | 130.0 mm | 27.5 mm |
| M | 60 cm | 5.600 kg ± 100 g | 136.0 mm | 29.0 mm |
| O | 62 mm | 6.100 kg ± 100 g | 140.0 mm | 30.0 mm |

## *EXTENT OF PROTECTION*

The extent of protection corresponds to that region of the head for which protection is sought.

There are a number of planes fixed in the geometry of these head forms as shown in Figure 2. This description of the extent of protection uses the ISO definitions of the basic plane, the longitudinal plane, the transverse plane and the reference plane. Other planes have also been defined strictly for convenience and clarity.

The basic plane corresponds to the anatomical plane (Frankfort plane) that includes the auditory meatuses and the inferior orbital rims. The reference plane is above and parallel to the basic plane. The longitudinal or mid-sagittal plane is perpendicular to the basic plane and is the plane of symmetry dividing the right half of the head form from the left. The transverse or coronal plane is perpendicular to both the longitudinal and basic planes. It corresponds to the anatomical plane that contains the two auditory meatuses and divides the front from the rear portions of the head.

These planes are all well-known entities. Several other planes, however, have proven useful. The $S_0$ and $S_3$ planes are parallel to the basic plane and lie above or below it at distances determined by the size of the head form. The rear plane divides the rear third of the head from the front two thirds. It is parallel to the transverse plane and lies at a given distance behind the point where the reference plane and longitudinal planes intersect with the front surface of the head form. The distance from this point, hereafter called the reference point, is determined by the size of the head form. The fore plane is also parallel to the transverse plane. It lies behind the reference point at a distance determined by the size of the head form.

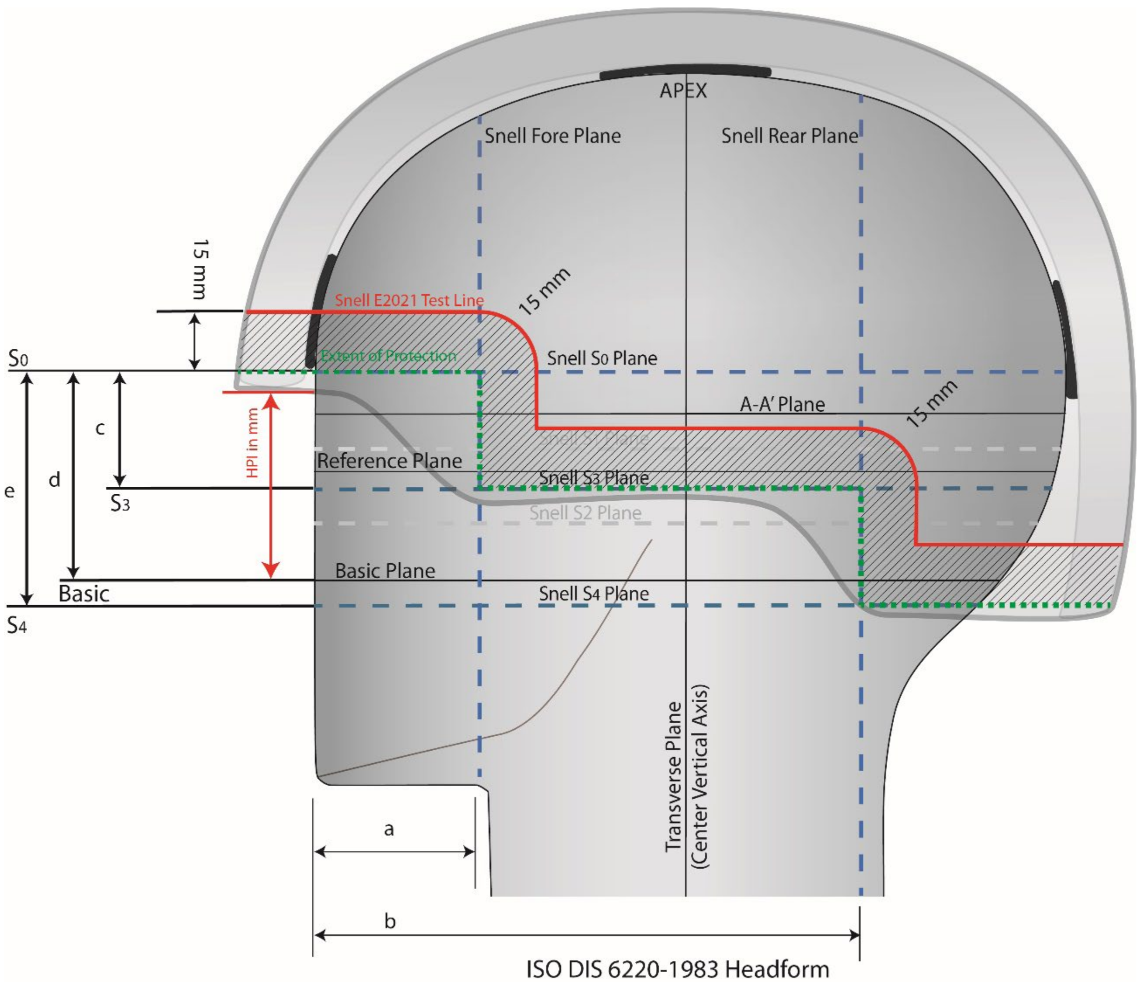


Figure 2 Extent of Protection

| Table 2 Extent of Protection | | | | | |
|---|---|---|---|---|---|
| Head form Designation | Parameters | | | | |
| | a | b | c | d | e |
| ISO A | 39.0 mm | 128.6 mm | 26.1 mm | 46.8 mm | 52.2 mm |
| ISO C | 40.6 mm | 133.8 mm | 27.2 mm | 48.4 mm | 54.3 mm |
| ISO E | 42.2 mm | 139.0 mm | 28.2 mm | 50.0 mm | 56.4 mm |
| ISO J | 45.2 mm | 148.4 mm | 30.0 mm | 53.0 mm | 60.0 mm |
| ISO M | 47.4 mm | 155.8 mm | 31.5 mm | 55.2 mm | 63.0 mm |
| ISO O | 49.2 mm | 161.5 mm | 32.2 mm | 57.2 mm | 64.5 mm |

The extent of protection provided by the helmet must include the entire region above the $S_0$ plane and forward of the fore plane, the entire region above the $S_3$ plane and between the fore and rear planes and the entire region above the $S_4$ plane and behind the rear plane. Figure 2 and the associated table lay out these additional defined features and show the extent of protection and the test line.

### *TESTING*

**A. Inspection**

Each helmet will be inspected for the required labels and for compliance with the general limitations made on structure. The weight and various circumferences will be recorded for comparison with other samples of the same make and model.

Some helmets may incorporate innovations and other features not anticipated by this Standard but which raise concerns about the safety and effectiveness of the headgear. These will be referred to members of the Foundation's Board of Directors for evaluation. Any feature found to reduce the protective capacity of the headgear, whether explicitly mentioned in this Standard or not, will be a cause for rejection.

**B. Head Forms and Helmet Positioning**

The determination of which head forms are appropriate to a helmet is based on the specified smallest and largest head circumferences for the helmet. For samples submitted for certification, this specification must include the smallest and largest values of head circumference for every possible fit pad configuration of the helmet. For helmets received for RST testing, the smallest and largest head circumferences will be taken directly from the helmet label.

If the smallest head circumference specified for the helmet is less than 50 cm, the A head form is the smallest appropriate. Otherwise, the smallest appropriate head form for a particular helmet is the largest of the six head forms whose circumference is no greater than the manufacturer’s specified smallest circumference. The largest appropriate head form is the largest of the six specified head forms whose circumference is no greater than the manufacturer’s specified largest circumference.

**Table 3. Test Head Forms as Determined by Size Specification**

| | | Largest Size Specified | | | | | |
|---|---|---|---|---|---|---|---|
| | | 50 - | 52 - 53 | 54 - 56 | 57-59 | 60 - 61 | >61 |
| Smallest Size Specified | <50- | A | A,C | A,E | A,J | A,M | A,O |
| | 52-53 | | C | C,E | C,J | C,M | C,O |
| | 54-56 | | | E | E,J | E,M | E,O |
| | 57-59 | | | | J | J,M | J,O |
| | 60-61 | | | | | M | M,O |
| | >61 | | | | | | O |

If the test samples are determined to be too small to accommodate the largest head form identified as appropriate, the next smaller head form shall be considered the largest appropriate. If the samples are too small for even the smallest appropriate head form as indicated by the manufacture specification, the samples shall be rejected for certification.

The table shows which head forms will be used in certification testing for various head size specifications. Since the largest head size should never be smaller than the smallest head size, most of the lower left region of the table is blank.

If the size specification corresponds to one of the gray cells along the table’s main diagonal, only a single test head form will be necessary and the manufacturer need only submit five samples identical samples configured with comfort padding for the largest intended head size for certification testing. Otherwise, two more samples are required, identical to the first five in all respects except that the comfort padding must be configured for the smallest intended head size.

During testing, helmets will be positioned on the selected test head form according to the manufacturer's specified helmet positioning indices (HPI). If the manufacturer fails to provide positioning information with certification samples, the helmets will be positioned according to the best judgment of the authorized technical personnel. If the helmets meet certification requirements, the helmet positioning indices will be those used in all future testing.

These helmet positioning indices represent distances on the front of the head form from the basic plane along the intersection with the longitudinal plane upward to the lower brow edge of the helmet. Helmet positioning indices will be assigned for all head form sizes appropriate to the headgear. Each headgear could conceivably require as many as six helmet positioning indices, one each for the 'A', 'C', 'E', 'J', 'M' and 'O' head forms.

**C. Marking**

The helmet is placed upon the largest appropriate ISO head form, positioned according to the apposite helmet positioning index (HPI) and held in place with an applied force of 50 newtons (11.25 lbs). The intersections of the shell with the various defined planes are then traced onto the outer surface of the helmet in the following manner:

The level of the S0 plane is marked on that portion of the helmet in front of the fore plane. The level of the $S_3$ plane is marked on that portion lying between the fore and rear planes. The level of the $S_4$ plane is marked on that portion behind the rear plane. Finally, line segments along the fore plane are marked to join the $S_0$ and $S_3$ planes and, similarly, line segments along the rear plane are marked to join the $S_3$ and $S_4$ planes.

These lines enclose the top of the helmet and are the boundary of the required extent of protection. A test line shall be drawn within this extent of protection so that it is 15 mm from the closest point on the boundary. (See Figure 2)

If identical helmets are to be configured with different thicknesses of comfort padding to accommodate different ranges of head size, the required extent of protection marked on the test samples shall include the required extent of protection for each different configuration as marked on the largest head form appropriate for each. That is: the helmet must meet all the requirements of this Standard in each of the intended configurations.

**D. Peripheral Vision**

The clearance for peripheral vision will be checked after removing any removable peaks, bills and shades that are not essential to either the impact protection or retention systems of the helmet and that may interfere with the required clearances. The helmet will be placed on each appropriate ISO head form, positioned according to the apposite helmet positioning index and held in place with a force of 50 newtons. The clearances must include the following solid angles to the front of the head form:

1. The upward visual clearance.
2. The lateral visual clearance.
3. The downward visual clearance.

The upward visual clearance is the solid angle bounded by the reference plane of the head form and a second plane tilted 7° up from the reference plane. This second plane intersects the reference plane at two points on the front surface of the head form that are 31 mm to the right and left of the longitudinal plane as shown in figure 3.

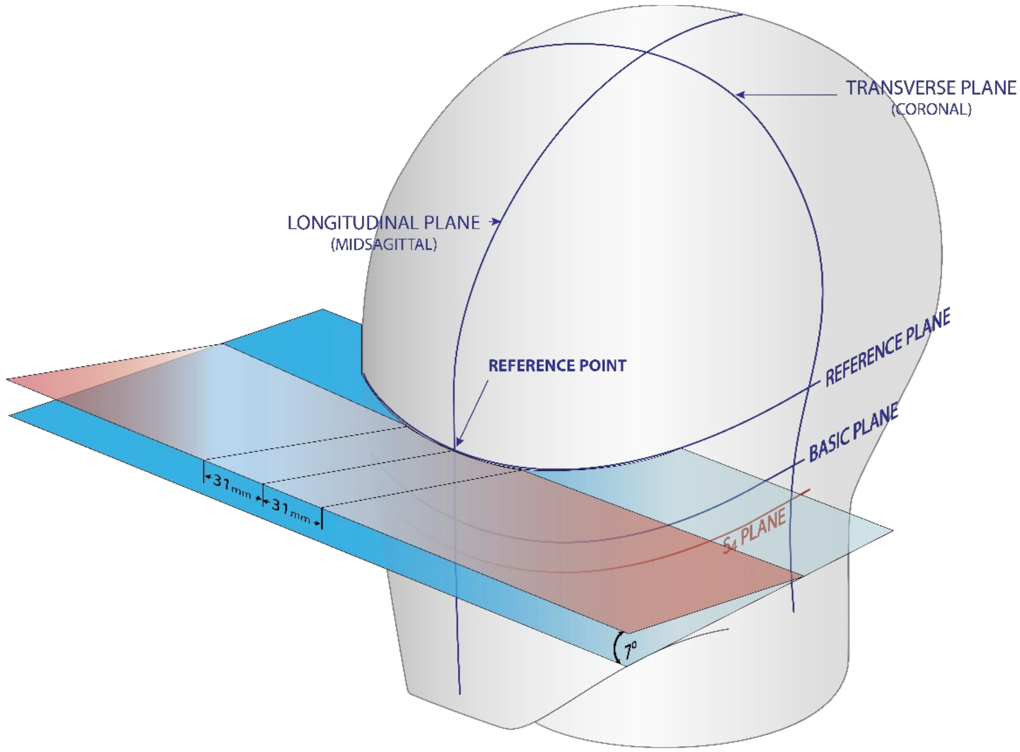


**Figure 3. Upward Visual Clearance**

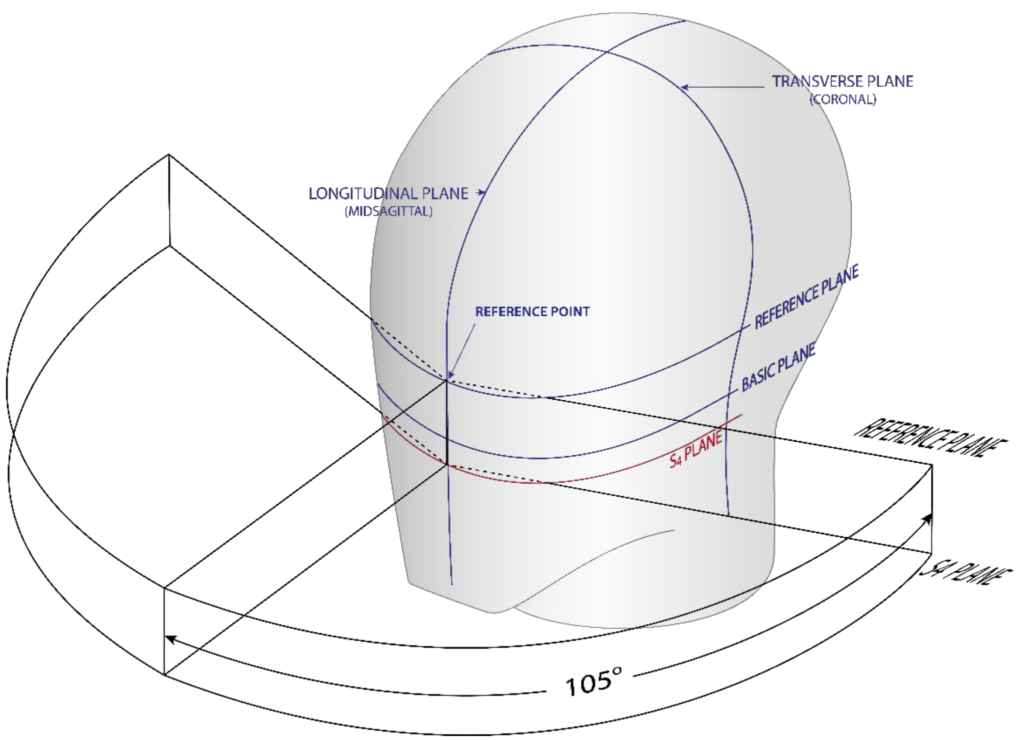


**Figure 4. Lateral Visual Clearance**

The lateral visual clearance, as shown in figure 4, is the solid angle bounded by the reference plane, the $S_4$ plane and two more planes that are perpendicular to the reference plane and that contain the point on the front of the head form where the longitudinal and reference planes intersect. One of these two planes forms an angle of 105° with the longitudinal plane and lies to the left of the head form. The other forms the same angle to the right of the head form.

The downward visual clearance is the solid angle bounded by the basic plane of the head form and a second plane tilted 30° down from the basic plane that intersects it at two points on the front surface of the head form that are 31 mm to the right and left of the longitudinal plan as shown in figure 5.

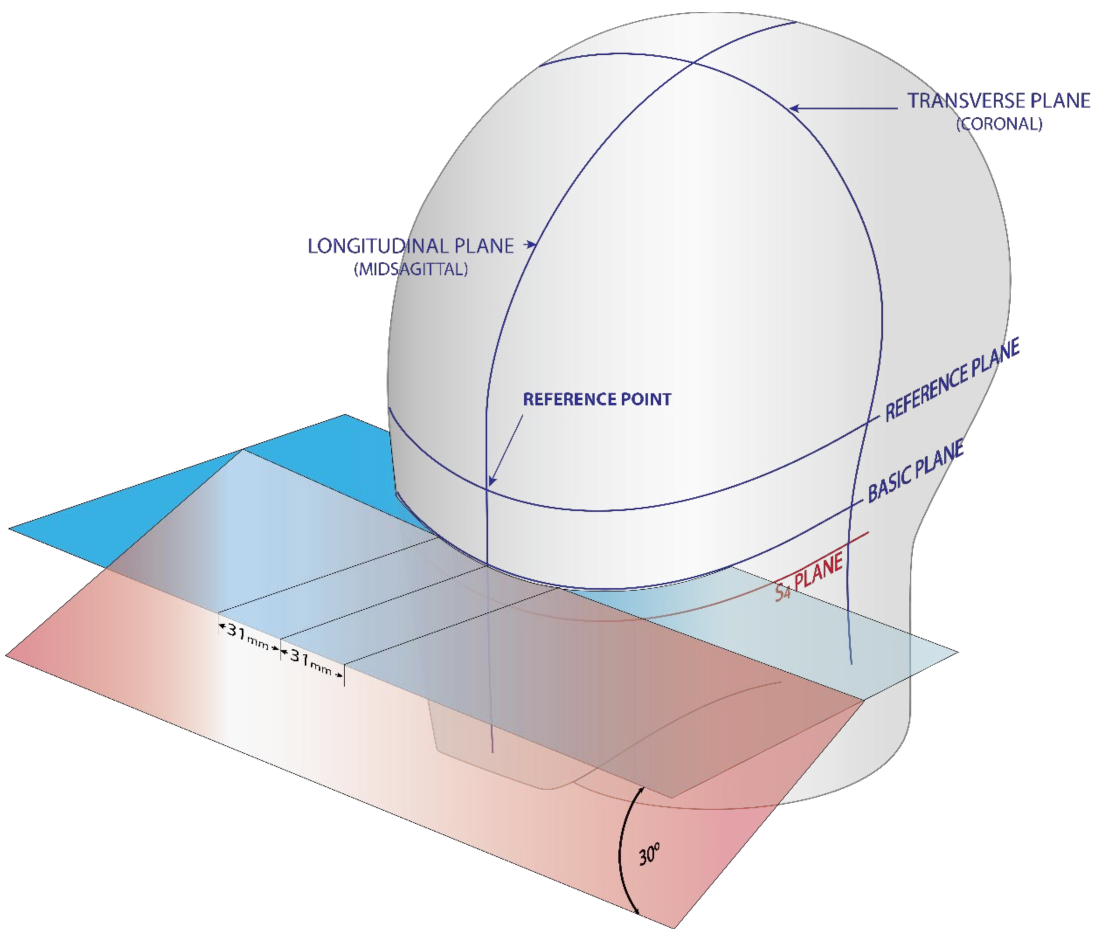


**Figure 5. Downward Visual Clearance**

## E. Performance Testing

The performance testing first subjects helmets to a dynamic test of retention system strength or to a test for positional stability. The helmets are then subjected to several impact management tests. These tests are conducted upon helmet samples either kept under laboratory ambient temperature and humidity or that have been conditioned in one of three environments simulating some of the conditions in which the helmet might reasonably be expected to be used.

In certification testing, the first of the five samples is kept at laboratory ambient temperature and humidity and allowed to come to equilibrium. It is subjected to the positional stability test and then to the impact management tests. The second, third and fourth samples are conditioned hot, cold and wet, respectively and a fifth sample is conditioned either hot, cold or wet according to the best judgement of the Foundation's technical personnel. The second through the fifth samples are subjected to the dynamic test of the retention system and then to the impact management tests.

In random sample testing, the sample may be at ambient temperature and humidity and subjected to either the test for positional stability or to the dynamic test of the retention system before being tested for impact management. Otherwise, the sample may be conditioned either hot, cold or wet and subjected to the dynamic test of the retention system before being tested for impact management.

### E1. Conditioning for Testing

**a. Cold.** The sample shall be conditioned by being exposed to a temperature of -20° C ± 2° C for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

**b. Heat.** The sample shall be conditioned by being exposed to a temperature of 50° C ± 2° C for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

**c. Wet.** The sample shall be conditioned by being continuously sprayed with water at a temperature of 25° C ± 5° C for a period of not less than four (4) hours, nor more than twenty-four (24) hours. All of the helmets external surfaces shall be wetted continuously throughout the spray cycle. The helmet shall not be subjected to total immersion.

All testing of these hot, cold and wet helmets shall begin within two (2) minutes from the time of removal from the conditioning apparatus. The samples shall be returned to the conditioning apparatus between tests.

**E2. Positional Stability (Roll-Off)**

The test for positional stability shall only be applied to samples kept at ambient laboratory temperature and humidity. The helmet shall not have been subjected to any prior performance testing.

The helmet shall be tested on the smallest appropriate standard full-face head form. The head form shall be supported on a stand so that its vertical axis points downward at an angle of 135° to the direction of gravity. The head form shall be oriented face down. The helmet shall be placed on the head form and adjusted to obtain the best configuration of the retention system. A wire rope shall be hooked to the edge of the helmet at the rear centerline and brought forward so that its free end hangs downward across the top of the helmet. An inertial hammer shall be suspended from the free end of the rope. This inertial hammer shall enable a 4.0 kg ± 50 g mass to be dropped through a 0.6 m guided fall in order to deliver an abrupt shock load to the headgear. The shock load will force the helmet to rotate forward on the head form. The helmet may be shifted but must remain on the head form.

The head form shall be repositioned so that it is facing upward but with the vertical axis still oriented downward at 135° to gravity. The helmet shall be positioned and adjusted to obtain the best configuration of the retention system. The wire rope/inertial hammer shall be hooked to the brow edge of the helmet at the center line so that the rope lies along the centerline and hammer is suspended from the top of the helmet. The shock weight shall be dropped through the 0.6 m guided fall delivering an abrupt shock load forcing the helmet to rotate rearward. The helmet may be shifted but must remain on the head form.

The entire portion of the inertial hammer assembly that participates in the loading of the helmet shall be such that its mass is no more than 5.0 kg including the 4.0 kg shock mass.

**E3. Dynamic Test of Retention System**

The dynamic test of the retention system may be applied to any sample either kept at ambient temperature and humidity or conditioned hot, cold or wet. However, the sample shall not have been subjected to any prior performance testing.

The helmet shall be placed on a head form in such a manner that the chin strap may be fastened under a device whose upper end approximates the contour of the bony structure of the jaw. The device will then be given a mechanical pre-load followed by a dynamic loading. The retention system fails if it cannot support the mechanical loads or if the maximum deflection during the dynamic load exceeds 30 mm. The retention system also fails if it cannot be easily and quickly unfastened after testing.

**a.** This chinstrap loading device shall consist of a simulated jaw and accommodations for the pre-load and dynamic load. The jaw portion shall consist of two metal bars or rollers, each one 12.7 mm ± 0.5 mm in diameter, separated by 76 mm ± 0.5 mm on center. The mass of this device shall not exceed 6.0 kg.

**b.** A pre-load shall be applied for at least 60 seconds. This pre-load plus the mass of the chinstrap loading device shall total 23 kg ± 500 g.

**c.** A 38 kg ± 500 g mass shall be dropped in a vertical guided fall a distance of 70 mm so as to load the retaining system abruptly; the 38 kg mass and pre-load mass shall not be additive. In order to protect the test mechanism, the impact of the 38 kg mass may be cushioned with a 00-93 durometer rubber pad 150 mm in diameter by 6½ mm thick, or its equivalent.

**E4. Guided Fall Impact Management Tests**

The impact management tests may be performed on samples kept at ambient temperature and humidity or conditioned hot, cold or wet. Samples may be first subjected to either positional stability testing or the test for retention system strength as well as to rigidity testing.

These tests involve a series of controlled impacts in which the helmet is positioned on a test head form. The helmeted head form is then dropped in guided falls onto specified test anvils. The impact site and the impact energy must meet certain requirements in order for the tests to be valid.

If the sample is so constructed that it interferes with the test equipment preventing impacts at sites within the test line, then, at the discretion of the Foundation's technical personnel, parts of the helmet may be cut away to facilitate testing. Every reasonable effort to minimize such cutting will be made. However, there shall be no relaxation of the impact levels or of the test criteria.

**E4.1 Guided Fall Impact Management Test Equipment**

The test equipment shall consist of at least the following items:

**a.** The smallest and largest of the head forms appropriate for the helmet sample. These head forms shall be of rigid, low resonance metal such as magnesium alloy and shall conform to the 'A', ‘C’, 'E', 'J', 'M' or ‘O’ geometries specified in ISO DIS 6220-1983.

**b.** A ball-arm/collar assembly which is fitted to a socket machined into the base of the head form. The ball/socket configuration shall be such that the geometrical center of the ball is located on the central vertical axis of the head form 12.7 mm above the reference plane as described in ISO DIS 6220-1983. The ball-arm/collar assembly shall also include a uniaxial accelerometer fixed firmly into the ball.

**c.** A head form support assembly rigidly attached to the ball-arm. This support assembly shall be such that it and consequently the head form may be guided in a vertical drop. The mass of this support assembly shall not exceed 1.2 kg. The total mass of the head form plus ball-arm/collar assembly plus head form support assembly shall be within 100 grams of: 3.1 kg for the ISO A head form, 3.6 kg for the ISO C head form, 4.1 kg for the ISO E head form, 4.7 kg for the ISO J head form, 5.6 kg for the ISO M head form and 6.1 kg for the ISO O head form.

**d.** A guidance system such that the head form/support assembly may be guided in a vertical drop onto a test anvil. This guidance system may consist of two or more wires or one or more rails. The head form/support - guidance system - test anvil alignment shall be such that:

**d1.** The drop trajectory shall be a straight line within 3° of vertical and within 5° of the sensitive axis of the uniaxial accelerometer.

**d2.** The line parallel to the drop trajectory and passing through the center of the head form ball-socket shall pass within 5 mm of the center of the test anvil, within 10 mm of the center of gravity of the head form/support assembly, and within 5 mm of the sensitive element of the uniaxial accelerometer.

**e.** A rigid anvil mount consisting of a solid mass of at least 500 kg. The upper surface of the anvil mount shall consist of a steel plate with a minimum thickness of 12 mm and a minimum surface area of at least 0.10 $m^2$.

**f.** Two test anvils: flat and hemispherical

**f1.** The flat anvil shall have a minimum surface area of 0.0127 $m^2$, e.g. 127 mm diameter face. When fixed in position on the anvil mount, the surface shall be perpendicular to the head form trajectory.

**f2.** The hemispherical anvil shall have a 48 mm ± 0.5 mm radius.

**g.** A uniaxial accelerometer. The acceleration data channel must comply with SAE recommended practice J 211 requirements for channel class 1000 with the exception that the frequency response need not include the range from dc to 10 hz which may not be obtainable using certain types of transducers.

**h.** A velocity measurement device which will yield the velocity of the head form/support assembly within the last 40 mm of travel before impact. The velocity measurements must be accurate to within ±1%.

### E4.2 Guided Fall Impact Test Definitions

a. The impact site refers to the portion of the helmet struck during an impact test. It is defined as the point where a line passing through the center of the head form ball and the center of the anvil intersects the outer surface of the helmet at the instant the helmet first touches the anvil.

b. The impact velocity is the velocity of the head form/support assembly as measured within no more than 4 cm of the first contact between the helmet and the impact surface.

c. This standard specifies nominal impact velocities which must be adjusted in order to allow for deviations between the actual mass of the test head form assembly and the specified ideal value. The actual test impact velocity shall be the specified nominal velocity multiplied by the square root of the value obtained by dividing the ideal head form assembly mass by the actual mass. For example, if, for the 'A' head form, the mass of the head form plus ball-arm/collar and support assembly as in paragraph E4.1c masses 3.2 kg instead of the ideal mass of 3.1 kg, the test impact velocities shall be obtained by multiplying the nominal velocities by a factor of 0.984.

d. There are two levels of test: the first is the standard level used to identify those helmets which definitely meet this standard. It is applied to samples submitted for certification testing and to those acquired for the Foundation's random sample test (RST) program. The second is the deviation level which is applied to samples acquired for second round RST procedures, that is: testing of samples of currently certified models for which previous samples have obtained failing results in RST testing. Failure to meet test criteria at the deviation levels indicates that the sample definitely does not meet the requirements of the standard.

**E4.3 Guided Fall Test Impact Severities**

Test impact sites shall be on or above the test line. Rivets, vents and any other helmet feature within this region shall be valid test sites. However, if an impact is sited closer than 120 mm to any previous impact, that later impact shall be declared invalid.

There is no restriction regarding test anvil selection. The impact velocities for each test impact depend on the type of test and on the head form designation. Second impacts do not apply to helmets in tests against the edge anvil.

The technician may select either the largest or smallest appropriate head form for any particular group of impacts. In all cases the technician may impact any site on the helmet surface on or within the test lines as drawn for any of the head forms considered appropriate for that helmet.

The nominal impact velocities are listed in table 4. These will be adjusted according to E5.2.c to allow for any differences between the ideal and the actual mass of the test head form assembly. If the impact velocity for any test impact exceeds the specified mass adjusted velocity by more than 1.5%, that impact shall be declared invalid.

**Please Note:** The impacts described above are based on specific velocities and not prescribed drop heights. To attain the proper velocity for an impact, it is likely that the drop height will need to be adjusted to compensate for frictions inherent in most mechanical helmet testing systems. Height adjustments for these frictions should not account for more than 10% of the total drop height. Also, the 1.5% margin allowed for impact velocity reflects the uncertainties expected even for well-maintained drop equipment. It is expected that drop heights will always be selected to produce, as closely as possible, the precise impact velocity as called out in the standards and adjusted for head form assembly drop mass. Each sample will be subjected to no more than four test impacts. Test impact sites shall be on or above the test line with no allowance for the cut of the helmet no matter how closely the edge of the helmet encroaches on this test line. However, if a test impact is sited closer than 120 mm to any previous test impact site on that sample, that impact shall be declared invalid.

| Table 4. Nominal Impact Velocity Table (m/sec) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Test Type | Anvil | Head Form | | | | | |
| | | A | C | E | J | M | O |
| Certification | Flat | 6.71 | 6.71 | 6.71 | 6.71 | 6.57 | 6.30 |
| | Hemi | 6.00 | 6.00 | 6.00 | 6.00 | 5.87 | 5.63 |
| Deviation | Flat | 6.37 | 6.37 | 6.37 | 6.37 | 6.23 | 5.98 |
| | Hemi | 5.69 | 5.69 | 5.69 | 5.69 | 5.57 | 5.34 |

### E4.4 Guided Fall Impact Test Interpretation

| Table 5. Peak Acceleration Criteria | | | | | |
|---|---|---|---|---|---|
| Head Form | | | | | |
| A | C | E | J | M | O |
| 275 G | 275 G | 275 G | 275 G | 264 G | 243 G |

The peak acceleration of the head form shall not exceed the values in the table above depending on the head form. The helmet’s protective structures shall not break apart throughout the testing. If the Foundation's technical personnel conclude that fracture of the helmet shell, impact liner, retention system or other components could reasonably imply an undue laceration hazard either from the impact surface or from the helmet itself, the sample shall be considered to have failed.

If, in certification testing, a sample is found to meet all the test criteria but any two of the impacts were at less than 97% of the specified impact velocity as adjusted for drop assembly mass, the testing for that sample shall be declared inconclusive and must be repeated. Finally, if an invalid impact produces a peak acceleration exceeding the test criterion, the testing for the sample shall be declared inconclusive and must be repeated.

The impact test procedures leave considerable latitude to the helmet tester regarding site and anvil selection. It is expected that the tester will orchestrate each standard test series in order to investigate potential weaknesses and to exercise each likely failure mode and will conduct deviation level testing to exercise the failure modes identified previously.

If at the end of a certification test series, the Foundation's technical personnel conclude that the results obtained in valid impacts are not sufficient to determine whether the helmet model meets the performance requirements of this standard, additional samples may be conditioned and tested. It is expected that all samples submitted will meet all the test requirements.

**E5. Oblique Impact**

Valid oblique impact management tests may only be performed on helmet samples kept at ambient temperature and humidity. The samples shall not have been subjected to the shell penetration test beforehand.

These tests involve a series of controlled impacts in which the helmet is positioned on a full test head form and positioned in a cradle which will guide it in a vertical fall onto a rigid, flat surface tilted at 45º. The cradle and guidance system are such that they no longer influence the motion of the head form and helmet from the instant the helmet contacts the anvil surface. The impact site and the impact energy must meet certain requirements in order for the tests to be valid.

If the helmet sample is so constructed that it interferes with the test equipment preventing impacts at otherwise allowable sites on the helmet shell, then, at the discretion of the Foundation's technical personnel, parts of the helmet may be cut away to facilitate testing. Every reasonable effort to minimize such cutting will be made. However, there shall be no relaxation of the impact levels or of the test criteria.

Special considerations apply when the helmet is a “flip-up” model, that is: configured with a chin bar that pivots up and away from the face of the wearer. For the first oblique impact on any flip-up sample, the test will be performed with the chin bar locked in the closed position. In this test the chin bar must not release and “flip-up” inadvertently. In certification testing, at least one sample shall be oriented for its first impact with the head form positioned for frontal impact with its longitudinal plane aligned parallel to a plane containing a vector normal to the impact surface and a vertical raised from the same point. Reasonably, this impact configuration will induce torques about the head form Y axis stressing the chin bar closure.

### E5.1 Oblique Impact Management Test Equipment

The test equipment shall consist of at least the following items:

**a.** The smallest and largest of the head forms appropriate for the helmet sample. This head form shall be of rigid, low resonance metal such as magnesium alloy and shall conform to the 'A', 'C', 'E', 'J', 'M' or 'O' geometries specified for full head forms in ISO DIS 6220-1983. Test head forms shall be coated with a thin layer of high performance platinum cure liquid silicone, over the entire crown of the head form down to at least the head form reference plane. (See Table 6.) During testing, this layer may be damaged; it shall be removed and reapplied as often as deemed necessary.

| **Table 6. Silicone Coating Specifications** | | |
|---|---|---|
| Shore A hardness | 10 | A |
| Specific gravity | 1.070 | g/cc |
| Specific volume | 25.8 | cu.in./lb. |
| Shrinkage | <0.1 | % |
| Tensile strength | 475 | psi |
| Die B tear strength | 102 | pli |
| Elongation at break % | 1,000 | % |
| 100% modulus | 22 | psi |
| Mixed viscosity | 23,000 | cps |

**b.** A cradle assembly which may be configured to hold a helmet and head form in any orientation deemed necessary until the instant the helmet makes first contact with the impact surface. From this instant forward, the cradle loses all contact so that the head form and helmet rebound freely from the anvil surface.

**c.** A guidance system such that the cradle assembly is guided in a vertical drop downward passing beyond the impact surface. This guidance system may consist of two or more wires or one or more rails. The drop trajectory shall be a straight line within 3º of vertical.

**d.** A rigid anvil mount consisting of a solid mass of at least 500 kg. The upper surface of the anvil mount shall consist of a steel plate with a minimum thickness of 12 mm. The upper face of this column shall be a flat surface oriented at 45º from the cylinder axis. This upper face is the impact surface. A sheet of grade 80 closed-coat aluminum oxide abrasive paper shall be fixed securely to the impact surface. During testing, this sheet will almost certainly be compromised; it shall be removed and replaced as often as deemed necessary.

**e.** An instrumentation package consisting of three linear accelerometers mounted triaxially at known positions and orientations within the head form and three angular rate transducers also mounted triaxially at known orientations within the head form. The accelerometer data channels must comply with SAE recommended practice J-211 requirements for channel class 1000. The angular velocity data shall be sampled at a minimum frequency of 10000 Hz and filtered in accordance with the latest edition of ISO 6487 (CFC 180).

**f.** A velocity measurement device which will yield the velocity of the cradle assembly within the last 40 mm of travel before contact between the test sample and the impact surface. The velocity measurement must be accurate to within ±1%.

### E5.2 Oblique Impact Test Definitions

**a.** The impact site refers to the portion of the helmet struck during an impact test. For purposes of oblique impact testing, the impact site refers to the orientation of the helmet and head form with respect to the impact surface. (See Figure 7.)

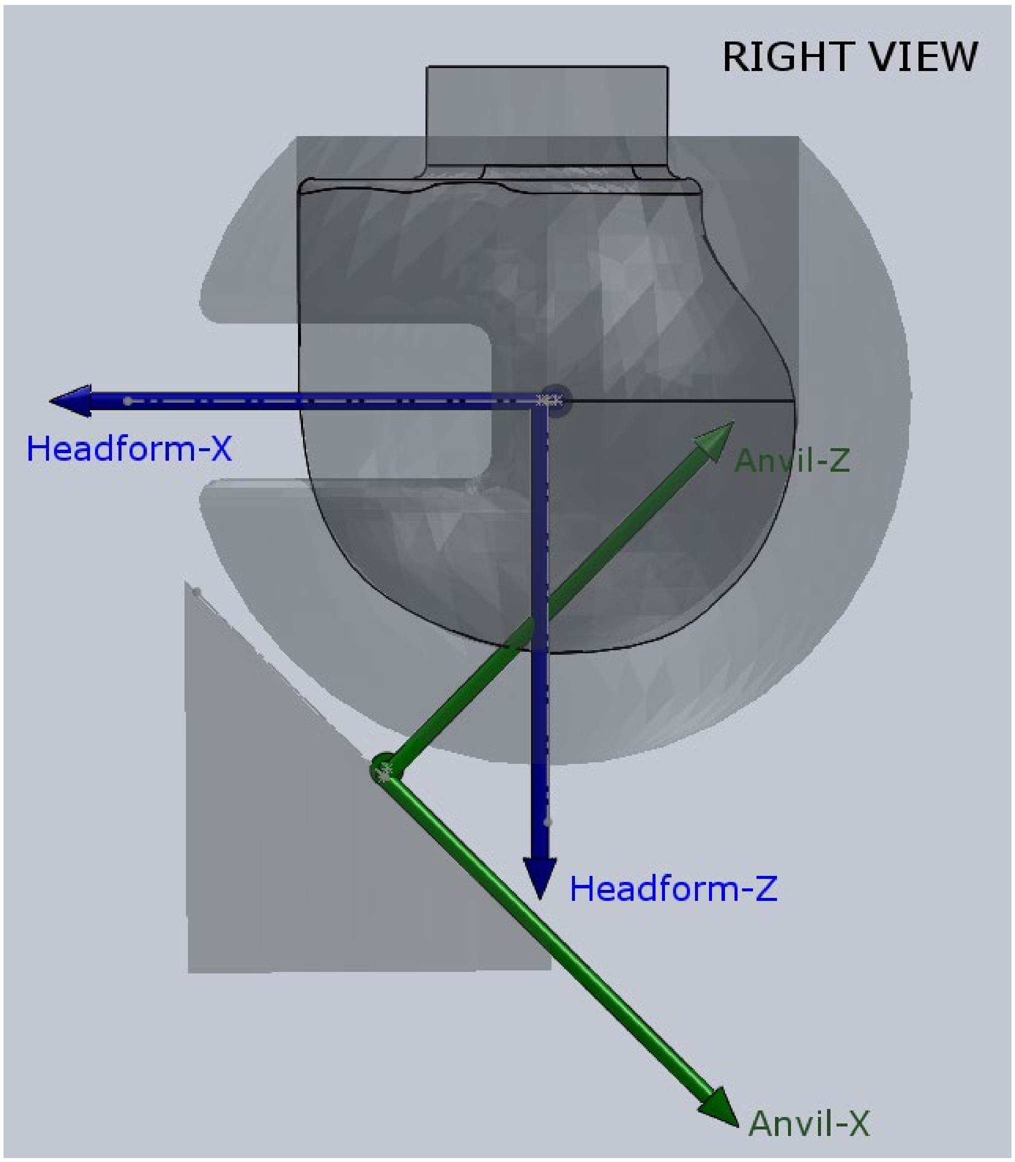


**Figure 7. Helmet, Head Form and Oblique Impact Surface**

**b.** An impact surface coordinate system has been defined as follows: its origin is at the intersection of the cylinder axis and the impact surface, the X axis points downslope, the Z axis is perpendicular to the impact surface and points out and away from it, and the Y axis is perpendicular to both Z and X, Reasonably, this impact surface Y axis must also be perpendicular to the direction of gravity.

**c.** The zeroth position[2] of the helmet and head form is with the head form Z axis pointing straight down at 45º to the impact surface X axis and 135º to the surface Z axis. In this position, the head form Y axis will be parallel to the impact surface Y axis. At this point, the longitudinal plane of a properly positioned head form and helmet must be within 5 mm of the surface X-Z plane. The impact site is then selected by rotating the helmet and head form about the head form Z axis to an angle chosen by the test technician. An angle of 0º would correspond to an impact in the brow of the helmet; an angle of 90º would correspond to an impact on the right side of the helmet. (See Figure 8.)

**d.** The impact velocity is the velocity of the head form/support assembly as measured within no more than 4 cm of the first contact between the helmet and the impact surface.

**e.** This Standard specifies an impact velocity of 6.00 meters per second ± 1.5%. This velocity shall not be adjusted for the masses of the test head forms.

---

[2] A helmet and head form tested in the zeroth position will strike the anvil on the center of the brow.

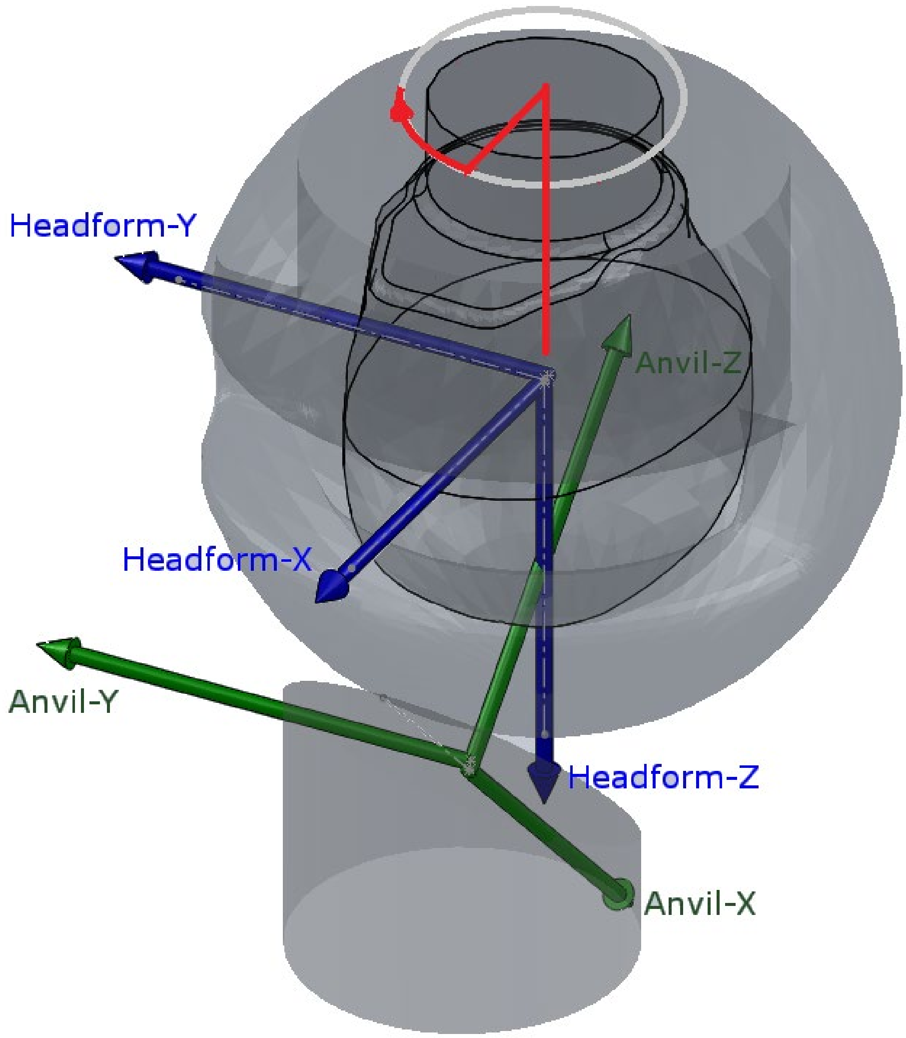


**Figure 8. Zeroth Position and Coordinate Systems**

**E5.3 Oblique Test Impacts**

Only helmets which have not been exposed previously to guided fall impact may be subjected to oblique impact testing. These shall be tested in the ambient condition.

The head form shall be placed within the helmet so that the helmet and head form longitudinal planes are appropriately aligned and with the proper HPI.

The helmet and head form shall be placed into the cradle carefully maintaining the proper alignment between the head form and helmet and in the zeroth position as defined above. The head form and helmet may then be rotated about the head form Z axis at the discretion of the test technician. Any impact site obtained by this procedure shall be considered valid regardless of the presence of rivets, vents, or any other helmet feature. Multiple test sites on the same helmet are permitted but impact orientations must be separated by at least 80º from previous oblique impact alignments.

At the discretion of the test technician, the helmet and head form may be secured in the cradle assembly with a paper tape or some similar frangible binding which will hold the test sample in the selected position and break away on impact with no reasonable interference to the impact response.

If the impact velocity for any test impact exceeds the specified velocity by more than 1.5%, that impact shall be declared invalid.

**E5.4 Oblique Impact Test Interpretation**

The value of the **Br**ain **I**njury **C**riterion (BrIC) and the magnitude of the angular acceleration recorded during the impact event shall not exceed the values in Table 7 from the onset of the impact event throughout until the magnitude of the translational acceleration drops below 5.0 G. BrIC is a calculation based on the time history of the head form angular velocity:

$$BrIC = \sqrt{\frac{\omega_x^2}{\omega_{xc}^2} + \frac{\omega_y^2}{\omega_{yc}^2} + \frac{\omega_z^2}{\omega_{zc}^2}}$$

Where: $\omega_{xc} = 66.25 \frac{rad}{sec}$ , $\omega_{yc} = 56.45 \frac{rad}{sec}$ , $\omega_{zc} = 42.87 \frac{rad}{sec}$

And $\omega_x$, $\omega_y$, and $\omega_z$ are the maximum values for each of the three components of angular velocity from the onset of the impact event until the magnitude of the translational acceleration drops below 5.0 G.

| Table 7. Oblique Impact Test Criteria | | | | | | |
|---|---|---|---|---|---|---|
| | Head Form | | | | | |
| | A | C | E | J | M | O |
| BrIC | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| Angular Acceleration Magnitude | 9000 rads/sec$^2$ | 9000 rads/sec$^2$ | 9000 rads/sec$^2$ | 9000 rads/sec$^2$ | 9000 rads/sec$^2$ | 9000 rads/sec$^2$ |

The helmet's protective structures shall not break apart throughout the testing. If the Foundation's technical personnel conclude that fracture of the helmet shell, impact liner, retention system or other components could reasonably imply an undue laceration hazard either from the impact surface or from the helmet itself, the sample shall be considered to have failed.

At least two samples shall be tested for a total of at least six oblique impact tests. If, in certification testing, a sample is found to meet all the test criteria but any two of the impacts were at less than 98.5% of the specified impact velocity, the testing for that sample shall be declared inconclusive and must be repeated. Finally, if an invalid impact produces peak values exceeding the test criterion, the testing for the sample shall be declared inconclusive and must be repeated.

The impact test procedures leave considerable latitude to the helmet tester regarding the impact sites. It is expected that the tester will orchestrate each standard test series in order to impose the most severe conditions reasonable as well as to investigate potential weaknesses and to exercise each likely failure mode for the samples being tested.

If at the end of a certification test series, the Foundation's technical personnel conclude that the results obtained in valid impacts are not sufficient to determine whether the helmet model meets the performance requirements of this Standard, additional samples may be conditioned and tested. It is expected that all samples submitted will meet all the test requirements.

**Certification Series Test Plan**

For a certification test series, it is expected that each test in this standard appropriate to the helmet configuration will be performed at least once. It is also expected that the test technician will conduct the testing so as to obtain the most exhaustive evaluation possible of likely failure modes. The table below represents a typical certification test plan by sample number, conditioning and tests in order of application. Bolding indicates that the particular test is routine for that sample; otherwise, the particular test might be performed on another sample if convenient. Italics indicate the test is optional for that sample at the discretion of the technician. Aside from comfort padding, all samples must be identical. The first six samples are to be equipped with comfort padding appropriate to the largest intended head circumference and will be tested on the largest appropriate head form. Samples #7 and #8 are necessary only when the smallest appropriate head form is not the same as the largest appropriate.

| Test Matrix | | |
|---|---|---|
| Sample | Conditioning | Appropriate Tests |
| #1 Archive | Ambient | **Marking and Visual Field Only** |
| #2 | Lab Ambient | **E2**, **E4** |
| #3 | Wet | **E3, E4** |
| #4 | Cold | **E3, E4** |
| #5 | Hot | **E3, E4** |
| #6 | Lab Ambient or Hot | **E3, E4** |
| #7 | Lab Ambient | *E3,* **E5** |
| #8 | Lab Ambient | *E3,* **E5** |
| #7 | Cold | **Visual Field, E2, E4** |
| #8 | Hot | **E3, E4** |