

SNELL / FIA CM2016
STANDARD FOR PROTECTIVE HEADGEAR
For Use in Children's Motor Sports Activities

FOREWORD

In motor sports accident, participants may suffer 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 rational methods for identifying those helmet models which definitely meet specified standards for impact (crash) protection and retention system strength and, afterwards, identifying those which definitely have ceased to meet these standards.

The Snell Memorial Foundation and the Federation Internationale de l'Automobile (FIA) urge that protective helmets be required for all individuals participating in supervised racing events and encourage the general public to wear helmets which meet appropriate performance standards¹. To this end, the Snell Memorial Foundation and the FIA jointly announce this Standard for children's motor sports helmets.

This Standard does not establish construction and material specifications.

This Standard establishes performance characteristics suitable for children's use in motor sports involving motorcycles, power boats, karting, all-terrain vehicles and snowmobiles. Manufacturers voluntarily submit helmets to be tested to this Standard and if the submitted helmets pass, a certification is issued.

¹ The Foundation has also published Standards for headgear used in bicycling, non-motorized sports, automobile racing, motorcycling, karting, competitive skiing, skiing and snowboarding and equestrian activities. Copies of these Standards are available upon request.

The Snell Memorial Foundation and the FIA will make available the identity of those products which have been certified. These products are for both competition and general use for the age categories and activities specified.

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.

Snell/FIA 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.

SNELL MEMORIAL FOUNDATION is a registered certification mark. CM2016, CMS2016 and CMR2016 are certification marks jointly held by the Snell Memorial Foundation and the FIA.

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 five (5) and as many as seven (7) complete helmets must be submitted by the manufacturer for a certification test program for each distinct structural configuration of the models offered for sale. All but one of these samples will be destroyed in testing; the untested sample shall be retained for comparison and reference. If different fit pad configurations are planned in order to accommodate this head gear for different size ranges, five of the samples

submitted must be configured for the largest size range. If seven samples are considered necessary, the remaining two samples must be configured for the smallest intended size. Additional samples representing different fit pad configurations may also be provided at the discretion of the submitter.

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, modifications to certified headgear effectively create new configurations which shall not have the confidence and certification of Snell/FIA until properly evaluated. Manufacturers must not place the Snell/FIA certification label in any modified headgear without express written authorization.

The Snell Memorial Foundation and FIA strongly recommend that helmet owners not modify or contract someone else to modify their helmets. Custom paint and decoration may add appreciably to the helmet weight and any structural modification may adversely affect a helmet's protective capability. The Snell/FIA certification and, quite likely, all manufacturer warranties apply to the headgear only in its "as manufactured" condition.

RANDOM SAMPLE TESTING

In addition to the certification testing, the Snell/FIA program 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 program 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 program will set up alternative procedures to monitor certified products. Specifically, if helmets are provided directly to teams or individuals for use in events, the program must have access to the helmets for spot checking and non-destructive evaluation.

CONSTRUCTION

A. General

Helmets intended for heads sixty centimeters in circumference or greater are considered adult headgear and will not be accepted for certification to this standard. Children who require headgear in these sizes are urged to wear appropriate helmets certified to adult standards.

The assembled helmet shall have smooth external and internal surfaces. Any feature projecting more than 7 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. Rivets and similar projections into the helmet interior must offer no laceration or puncture hazard. Restraint clips may be used at the rear or on the side of the helmet.

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 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. Shell

If rivets are used, the heads shall not have sharp edges and shall not project more than 2 mm from the outer or inner surfaces of the helmet shell.

C. Materials

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.

D. 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.

E. 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.

Fabric chin straps, if used, shall not be secured to the shell by a bolt, pin or rivet passing through the fabric itself. Although other alternatives may be proposed, the preferred method of attachment is that the strap be looped through and sewn about a metal hanger which can then be secured to the shell by bolt, rivet or other appropriate means. The shell attachment shall be such that the chin strap cannot be dismantled without destroying the fixation.

The chin strap release must be reasonably accessible and effective in case of emergencies. Double D-Rings, if used, shall be equipped with a short, flexible pull tab at least 5 mm wide and 20 mm long. This tab shall be fixed to the bottom edge of the inside D-ring element in such a way that the tab cannot be displaced more than 7 mm from the bottom edge center.

F. Peripheral Vision

The helmet shall provide peripheral visual clearance as measured using a reference head form appropriate to the size of the helmet. This peripheral vision includes a horizontal clearance of at least 210°, an upward clearance of at least 7° and a downward clearance of at least 30°. However, this downward clearance makes specific allowance for breath deflectors. These clearances are described in terms of planes fixed in the reference head forms.

Some competitive four-wheeled applications may permit helmets with more restricted visual fields. For such helmets, a second set of peripheral vision requirements is specified. The minimum horizontal, upward and downward

requirements for this more restricted field are 180°, 5° and 20° respectively. Helmets satisfying this visual field requirement but not the broader visual field specified generally are also subject to additional labeling requirements warning that the headgear is considered appropriate only for certain uses.

G. Weight

Permissible helmet weights depend on the smallest head circumference for which the helmet is intended and whether the helmet is configured to accept a face shield. Headgear shall be weighed in the most massive configuration possible with accompanying helmet paraphernalia.

Maximum Permissible Helmet Weight in Grams versus Helmet Size in Centimeters												
Smallest Size (centimeters)	<49	49	50	51	52	53	54	55	56	57	58	59
Helmets configured without face shields	1000 g		1050 g		1100 g		1150 g			1200 g		
Helmets configured to accept face shields	1100 g		1150 g		1200 g		1250 g			1300 g		

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. No helmet can protect the wearer against all foreseeable impacts. However, for maximum protection, the helmet must be of good fit and the retention

system must be securely fastened to retain the helmet. The helmet, when fitted and fastened, shall not be removed easily.

2. 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.
3. The smallest and largest head circumferences for which the helmet is appropriate in centimeters.
4. If the helmet does not satisfy the broader visual field requirements set for general use the helmet must be labeled to the following effect: “RESTRICTED VISUAL FIELD – MAY NOT BE APPROPRIATE FOR SOME ACTIVITIES”

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

If the helmet model was certified according to a special addendum to this standard, each helmet shall also include the warning labels required by that addendum.

Each helmet shall also include one of two Snell/FIA serialized CM2016 certification labels. The CMR2016 label indicates that the helmet meets the narrower visual field requirement and is certified only for certain activities. The CMS2016 label indicates that the helmet meets the broader visual field requirement and is certified for

all the activities mentioned. Helmets meeting the broader visual field requirements may include either of these labels. This 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 Memorial Foundation and the wording "FIA" may be used by the manufacturer only under license. However, under no circumstances shall the FIA logo be used. The specifics of licensure may be obtained from the Snell Memorial Foundation.

MARKING AND LABELING OF CRITICAL COMPONENTS

If a helmet component may reasonably be replaced with an inappropriate

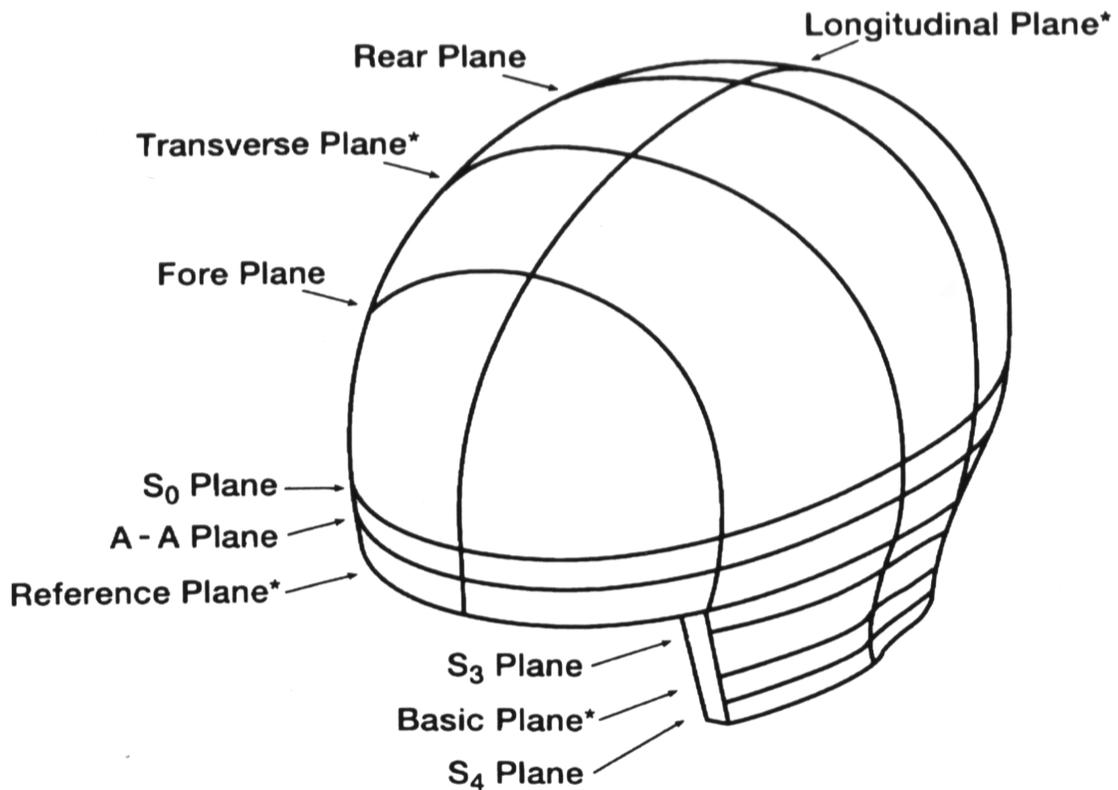


Figure 1 ISO Head form -- ISO DIS 6220-1983

substitute that might degrade wearer safety and performance in any of the tests called out in this standard, the manufacturer must mark those components so that users may avoid the purchase and use of inappropriate replacement parts. In particular, face shields on full face helmets must be marked to identify the manufacturer and the month and year of manufacture.

HEAD FORMS

This standard invokes four 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' and 'J' 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 half head form configuration.

The following table lists useful dimensions from the two references given above.

Head Form	Circumference	Mass	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

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 1. 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 longitudinal or midsagittal 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 plane is parallel to the basic plane and lies above it at a distance determined by the size of the head form. The S_3 plane is parallel to the S_0 plane and the basic plane and lies between them. The S_4 plane is also parallel to these planes and lies below the basic plane.

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.

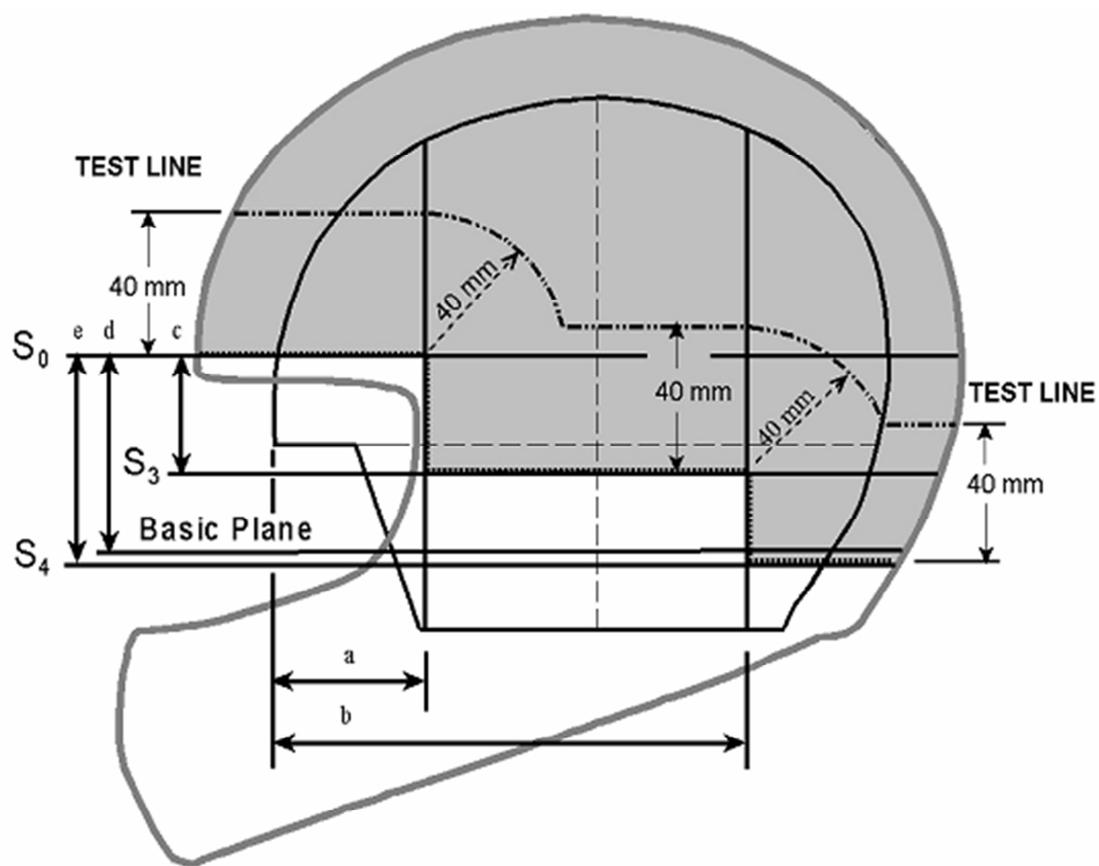


Figure 2 Extent of Protection

Head form	Parameters				
Designation	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

The extent of protection provided by the helmet must include the entire region above the S0 plane and forward of the fore plane, the entire region above the S3 plane and between the fore and rear planes and the entire region above the S4 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. Samples received for certification testing must incorporate all the critical component labels but other labeling is not necessary for evaluation. Samples received for RST (enforcement) testing must have all the required labels.

The weight and various measurements will be recorded for comparison with other samples of the same make and model. At least one headgear will be weighed in its most massive configuration. The weight limits set for helmets depend on the smallest appropriate head circumference for which the helmet is intended and on whether the helmet is configured with, or without, a face shield. Note: if the helmet is configured for use with a face shield, a face shield must be supplied and shall be included in the weighing.

Maximum Permissible Helmet Weight			
	Smallest size	Configured without face shield	Configured with face shield
A	<49 cm	1000 grams	1100 grams
	49 cm	1000 grams	1100 grams
	50 cm	1050 grams	1150 grams
	51 cm	1050 grams	1150 grams
C	52 cm	1100 grams	1200 grams
	53 cm	1100 grams	1200 grams

E	54 cm	1150 grams	1250 grams
	55 cm	1150 grams	1250 grams
	56 cm	1150 grams	1250 grams
J	57 cm	1200 grams	1300 grams
	58 cm	1200 grams	1300 grams
	59 cm	1200 grams	1300 grams

At the discretion of the technician, additional helmet assemblies may be required to make this determination with appropriate levels of confidence.

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 and/or authorities at the FIA for evaluation. Any feature deemed 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.

The smallest appropriate head form for a particular helmet is the largest of the four head forms whose circumference is no greater than the manufacturer's specified smallest circumference. The largest appropriate head form is the largest of the four

specified head forms whose circumference is no greater than the manufacturer's specified largest circumference.

If any of the test sample helmets is 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 any sample is too small for even the smallest appropriate head form as indicated by the manufacture specification, the samples shall be rejected for certification.

The following 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 light gray cells, only a single head form will be necessary and only five helmet samples, configured for the largest head size specified, are required for testing. Otherwise, the tests will involve two head forms and seven samples are required, five configured for the largest head size specified and two configured for the smallest size specified.

Test Head Forms as Determined by Size Specification											
		Largest Head Circumference Specified									
		50	51	52	53	54	55	56	57	58	59
Smallest Specified Size	<50	A	A	A,C	A,C	A,E	A,E	A,E	A,J	A,J	A,J
	50	A	A	A,C	A,C	A,E	A,E	A,E	A,J	A,J	A,J
	51		A	A,C	A,C	A,E	A,E	A,E	A,J	A,J	A,J
	52			C	C	C,E	C,E	C,E	C,J	C,J	C,J
	53				C	C,E	C,E	C,E	C,J	C,J	C,J
	54					E	E	E	E,J	E,J	E,J
	55						E	E	E,J	E,J	E,J
	56							E	E,J	E,J	E,J
	57								J	J	J
	58									J	J
	59										J

Each helmet will be positioned on the smallest, largest or any of the intervening head forms for testing according to the helmet positioning index specified. 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 head form measured from the basic plane along the intersection with the longitudinal plane to the lower edge of the helmet. Helmet positioning indices will be assigned for all head form sizes appropriate to the headgear. Each headgear could conceivably require four helmet positioning indices, one each for the 'A', 'C', 'E' and 'J' head forms

C. Marking

The helmet is placed upon the largest appropriate ISO head form, positioned according to the corresponding helmet positioning index and held in place with an applied force of 50 newtons (11.25 lbs). If the helmet has a hinged face plate which may be opened to expose the face or closed to cover the entire face and chin such as in a "flip-up" or "system" configuration, the face plate shall be closed and latched. 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 S_0 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 considered the boundary of extent of protection. However, it shall not be a cause for rejection if parts of this boundary fall below the edge of the helmet. Instead, a test line shall be constructed within the extent of protection 40 mm from the closest point on the boundary as shown in figure 2. This test line bounds the area over which the helmet must withstand impact and shell penetration testing.

Generally, the test line as marked on the largest appropriate head form will include the entire test area obtained if the helmet were to be marked on a smaller appropriate head forms. However, at the discretion of the test technician, this marking may be duplicated on smaller head forms to determine whether the helmet positioning indices or fit pad configurations might lower portions of the test line beyond those for the largest head form. In such a case, the test line will be the line bounding the union of the test areas determined by this marking. That is: the helmet must meet all of the requirements of this Standard in each of the intended configurations.

D. Shell Edge Lower Limit

Helmets shall be placed upon the smallest appropriate ISO head form, positioned according to the corresponding helmet positioning index and held in place with an applied force of 50 newtons (11.25 lbs). If the helmet is configured with a moveable face plate, the face plate shall be closed and latched. The vertical distance from the basic plane of the head form to the lowest point on the helmet shell shall be measured at the front and rear in the midsagittal plane and right and left in the transverse plane.

This measurement shall include edge beading but shall not include any helmet comfort and fit padding which may protrude below the edges of the helmet shell. This distance shall not exceed 14.0 cm in front, 9.0 cm on the right and left, or 4.0 cm in the rear.

E. Peripheral Vision

The clearance for peripheral vision will be checked by placing the helmet on each appropriate ISO head form, positioning it according to the corresponding helmet positioning index and holding it in place with a force of 50 newtons. If additional samples configured with fit pads have been provided as part of a submission for certification, the peripheral vision checks will use the configuration appropriate to the head form. The clearance 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 except for the breath deflector allowance.

The upward visual clearance is the solid angle bounded by the reference plane of the head form and a second plane tilted up from the reference plane. This angle is 7° for the general requirements and 5° for the restricted vision requirement. The 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 figures 3 and 3b.

The general requirement for lateral visual clearance is shown in figure 4. It 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 lie to the right and left, respectively. These

right and left planes pass through the head forms reference point and form angles of 105° with the longitudinal plane.

The restricted visual field requirement is shown in figure 4b. Here, the right and left planes are coplanar and perpendicular to the longitudinal plane and the reference plane. The right and left planes intersect the front of the head form at points on the reference plane and 31 mm to the right and left of the longitudinal plane.

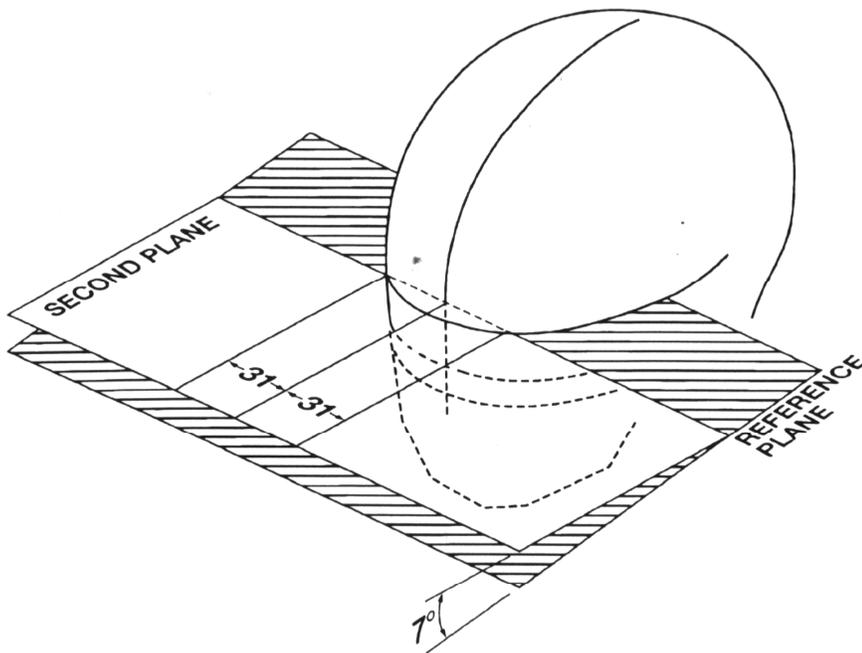


Figure 3 Upward Visual Clearance – General Requirement

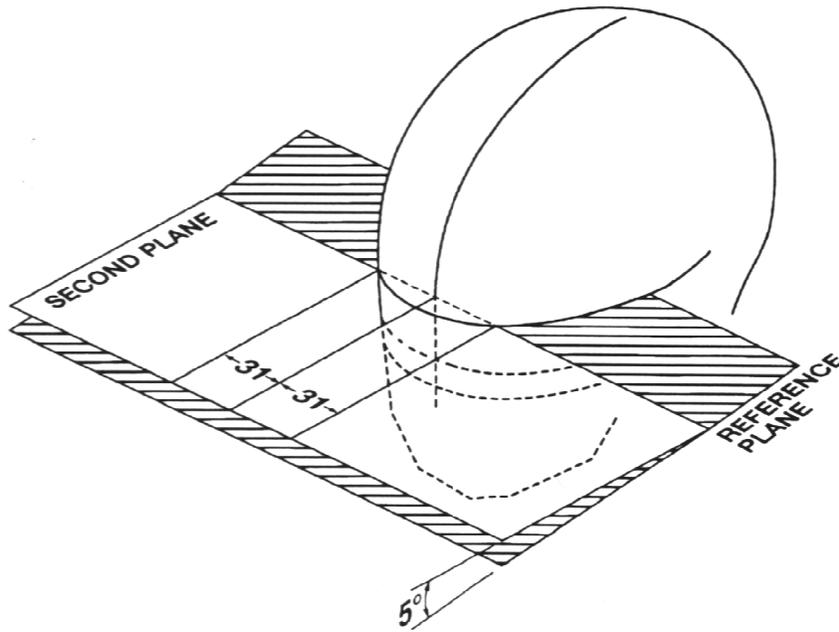


Figure 3b Upward Visual Clearance – Restricted Field Requirement

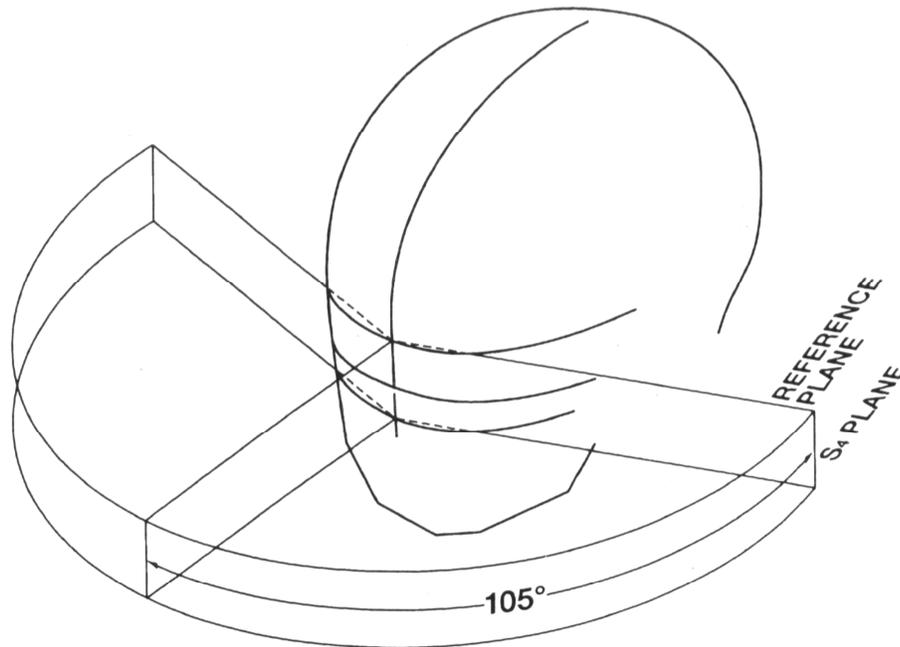


Figure 4 Lateral Visual Clearance – General Requirement

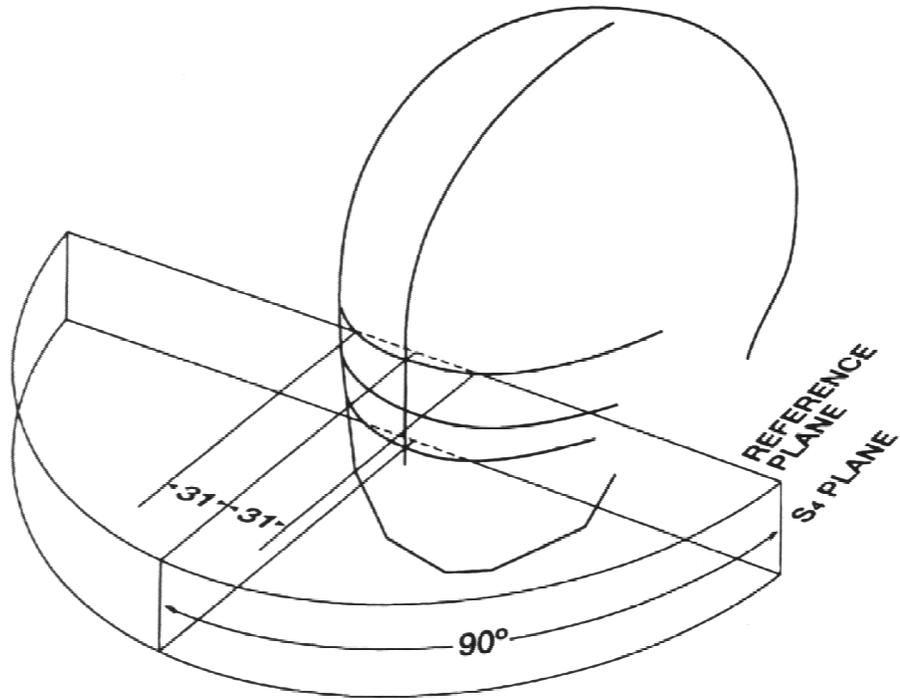


Figure 4b Lateral Visual Clearance – Restricted Field Requirement

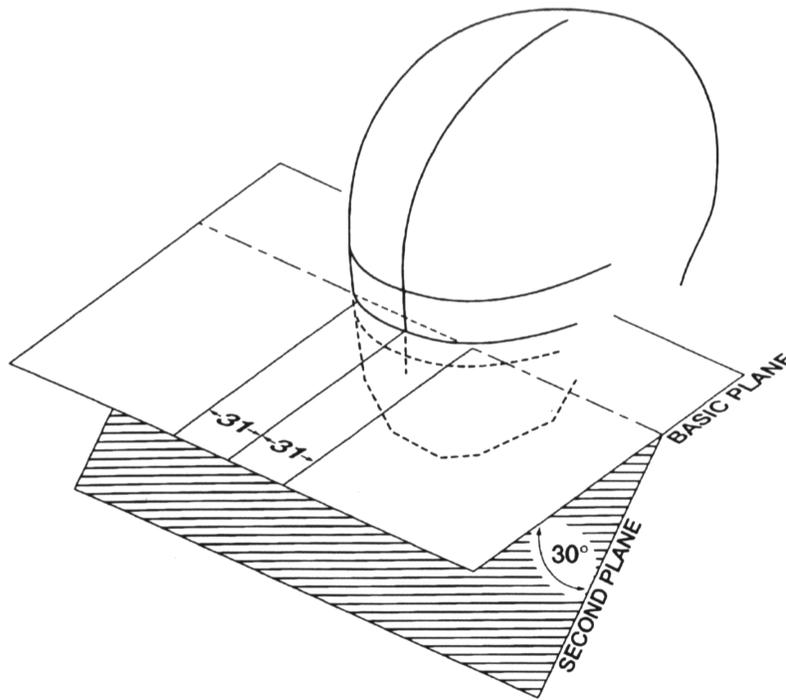


Figure 5 Downward Visual Clearance –General Requirement

The downward visual clearance is the solid angle bounded by the basic plane of the head form and a second plane tilted down from the basic plane and 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 plane as shown in figures 5 and 5b. The degree of downward tilt is 30° for the general requirement and 20° for the restricted visual field requirement. However, intrusions into these downward clearances are permitted so long as the intrusions are within the breath deflector allowance.

The breath deflector allowance is shown in figure 6. It includes the region that is within 31 mm to the right and left of the longitudinal plane and that lies below the two planes that form 45° angles with the longitudinal plane and that intersect it at the level of the S₄ plane.

In order to meet the general visual field requirements, no part of the helmet except the face shield may intrude into the solid angles shown in figures 3 and 4 nor into those parts of the solid angle in figure 5 outside the breath deflector allowance. In order to meet the restricted visual field requirements, no part of the helmet except the face shield may intrude into the solid angles shown in figures 3b and 4b not into those parts of the solid angle in figure 5b outside the breath deflector allowance. These requirements do not apply to face shield fixtures such as hold tear-off shields.

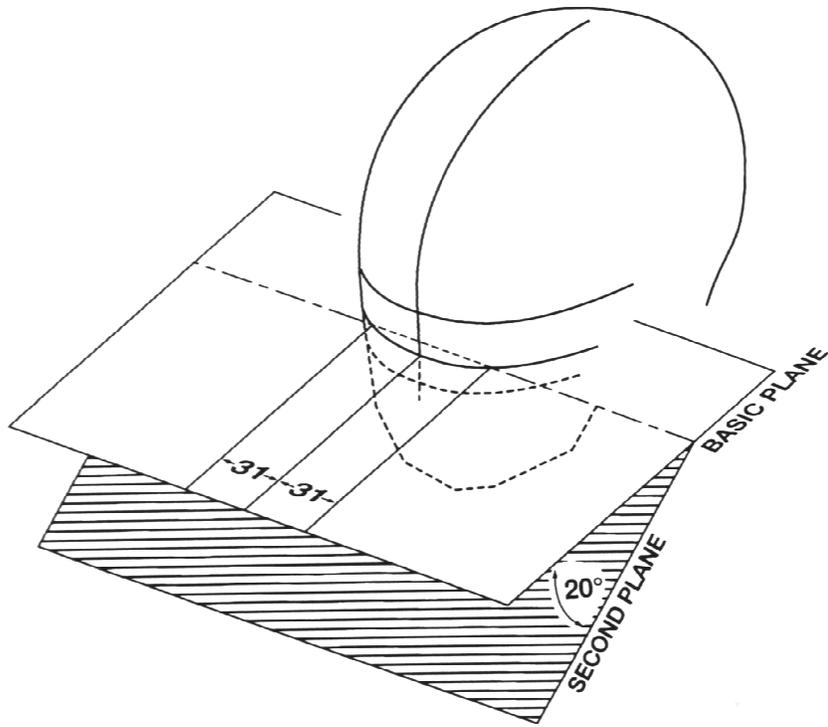


Figure 5b Downward Visual Clearance – Restricted Visual Field

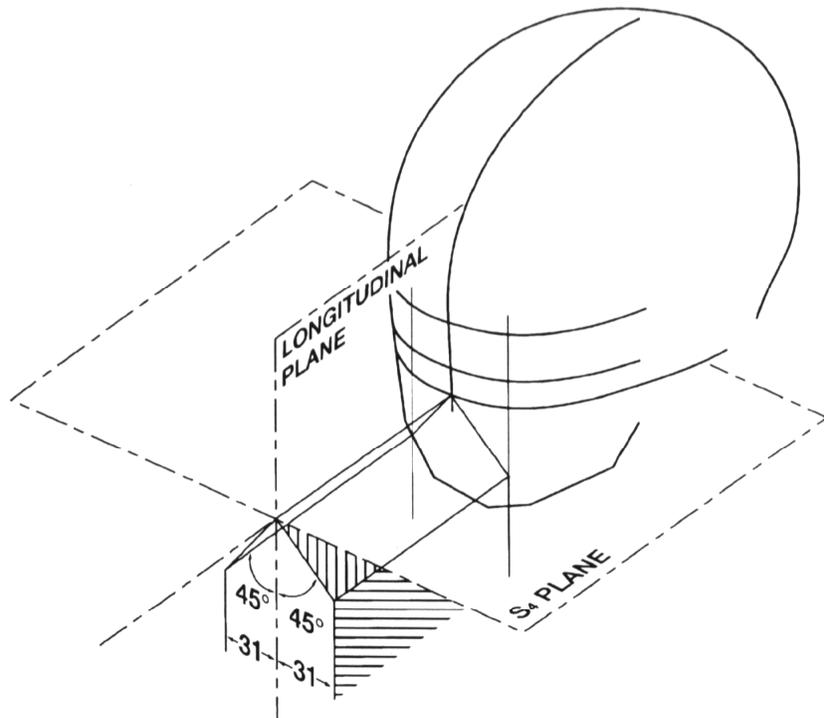


Figure 6 Breath Deflector Allowance

F. Performance Testing

The performance testing subjects helmets to:

- A dynamic test of retention system strength.
- A test for positional stability.
- Impact management tests.
- Helmet shell penetration tests.
- A removability test
- And to chin bar and face shield tests if appropriate.

These tests are conducted upon helmet samples 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.

Prior to conditioning and testing, samples may be exposed to solvents common to motor sports which have been found to attack and degrade some helmet components.

In certification testing, the first of the four samples is kept at laboratory ambient temperature and humidity and allowed to come to equilibrium. It is subjected first to the positional stability test and then to the impact management and other tests. The second, third and fourth samples are conditioned hot, cold and wet, and subjected to the dynamic test of the retention system, the impact management test and the other tests.

The selection of tests, conditioning and special conditioning is left to the discretion of the authorized technical personnel. However, for certification testing, each

of the specified tests shall be applied to at least one sample. Furthermore, it is expected that all testing will be conducted so as to exercise all the likely failure modes of the helmet.

F1. Conditioning for Testing

Test samples may be kept at laboratory ambient temperature and humidity or may be conditioned either cold, hot or wet according to the specifications given below. At the discretion of the authorized technical personnel and at any point during the testing, a sample previously kept at ambient may be conditioned cold, hot or wet. However, once a sample has been conditioned cold, hot or wet, the sample must be maintained in that condition throughout the rest of the testing.

The special solvent wipe conditioning described below may be applied to any sample at the discretion of the authorized technical personnel.

a. Special Conditioning. Prior to any impact or retention system testing helmets may first be conditioned with a solvent mix of 50% toluene and 50% isooctane. A cotton cloth or suitable substitute shall be soaked in the solvent and used as an applicator. The solvent will be applied to the shell first in an area within 5 mm of the chin strap attachments for not less than five (5) seconds on each side and then applied to the remainder of the shell for not less than ten (10) seconds. At least thirty minutes shall elapse before further conditioning and testing.

b. Cold. The sample shall be conditioned by being exposed to a temperature of $-20 \pm 2^{\circ}$ C for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

c. Heat. The sample shall be conditioned by being exposed to a temperature of $50 \pm 2^\circ$ C for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

d. Wet. The sample shall be conditioned by being continuously sprayed with water at a temperature of $25 \pm 5^\circ$ C for a period of not less than four (4) hours, nor more than twenty-four (24) hours. This spray shall be directed at the helmet's external surfaces. 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.

F2. 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 non-elastic strap 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 strap. This inertial hammer shall enable a $4.0 \text{ kg} \pm 50 \text{ g}$ 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 strap/inertial hammer shall be hooked to the brow edge of the helmet at the center line so that the strap lies along the centerline and the 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.

F3. 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. This test may be performed before, after, or between any of the other procedures in the test sequence. However, the retention test shall not be valid if an integral chin bar has been removed from a full face helmet.

The helmet shall be placed on the largest appropriate 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 ± 0.5 mm in diameter, separated by 76 ± 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 $23 \text{ kg} \pm 500 \text{ g}$.

c. A $38 \text{ kg} \pm 500 \text{ g}$ mass shall be dropped in a vertical guided fall a distance of 120 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 $6\frac{1}{2}$ mm thick, or its equivalent.

F4. Impact Management Tests

The impact management tests may be performed on samples kept at ambient temperature and humidity or conditioned hot, cold or wet. The sample 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 test head form. The helmeted head form is then dropped in guided falls onto specified test anvils. The impact site and the impact velocity 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 authorized 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.

Certain tests shall not be valid when performed on samples that have been cut for impact testing: the dynamic strength of retention system test of section F3., the positional stability test of section F2., the chin bar test of section F5. and the removability test of section F8.

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. Whenever possible, the impact tests will be performed with the chin bar locked in the closed position. In these tests, in addition to all the other test criteria, the chin bar must not release and 'flip-up' inadvertently.

F4.1 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' or 'J' 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 and 4.7 kg for the ISO J head form.

d. A guidance system such that the head form/support assembly is 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 0.10 m².

f. Three test anvils: flat, hemispherical and edge.

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 ± 0.5 mm radius.

f3. The edge anvil shall have a striking face 6.3 ± 0.5 mm wide by at least 180 mm long with a depth of at least 35 mm. The radius of the edges on the impact face shall not exceed 0.5 mm. When in position, the striking face shall be perpendicular to the head form trajectory.

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 $\pm 1\%$.

F4.2 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 3 cm of the first contact between the helmet and the impact surface.

c. 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.

F4.3 Test Impacts

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. Each impact site will be subjected to a group of one or two impacts according to the anvil selected for that site.

The impact site for the first impact within a group is the target for the successive impacts in the same group. However, if an impact group is sited closer than 120 mm to any previous impact group, that later impact shall be declared invalid.

There is no restriction regarding test anvil selection. 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.

Test Impact Velocities		
Certification	1 st	7.75 m/s
	2 nd	6.00 m/s
Deviation	1 st	7.48 m/s
	2 nd	5.80 m/s

a. Each site tested against the flat anvil shall be tested according to the values in the test impact velocity table.

b. Each site tested against the hemispherical anvil shall be tested according to the values in the test impact velocity table.

c. Each site tested against the edge anvil shall be tested according to the values in the test impact velocity table. No helmet shall be subjected to the second impact for this anvil.

d. If the impact velocity for any test impact exceeds the velocity specified 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 velocities called out in the standards.

F4.4 Impact Test Interpretation

The peak acceleration of the head form shall not exceed 290 G's for any valid certification impact or 300 G's for any other valid test impact. The helmet's protective structures shall not break apart throughout the testing. If the authorized 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. A flip-up configuration tested with the chin bar closure locked at the outset of a valid impact and which releases inadvertently as a result of the impact will also be deemed 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 98% of the impact velocity specified, the testing for that sample shall be declared inconclusive and must be repeated. Similarly, if there are two instances where an impact falls beyond 10 mm from the first impacts in its group, the testing for the 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 authorized 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.

F5. Chin Bar Tests

There are two tests for facial protection:

F5.a. Chin Bar Rigidity

At least one helmet in each certification series shall be tested. The sample shall not have been previously tested in chin bar impact. The helmet shall be firmly mounted on a rigid base so that the chin bar faces up and the reference plane is at $65 \pm 5^\circ$ from horizontal. A mass of $5 \pm .2$ kg with a flat striking face of 0.01 m^2 minimum area shall be dropped in a guided fall so as to strike the central portion of the chin bar with an impact velocity of 3.5 ± 0.2 m/sec. The maximum downward deflection of the chin bar must not exceed 60 mm nor any component fail so as to cause a potential injury to the wearer.

F5.b. Chin Bar Impact

At least one helmet in each certification series shall be tested. The sample shall not have previously been tested in chin bar rigidity, retention strength or in positional stability. The helmet shall be placed upon the largest appropriate full face head form and the chin strap shall be firmly secured beneath the head form's chin. Reasonable effort shall be made to position the helmet according to the correct helmet positioning index (HPI). The helmet shall then be tested in a guided free fall in the following manner:

The helmet shall be placed in a special cradle which can move downward freely along guide wires or one or more rigid rails delivering its contents to impact against a flat anvil such as described in paragraph **f1.** of section **F4.1** of this standard. The helmet shall be positioned in the cradle in such a manner that the helmet's longitudinal plane is within 3° of vertical and the helmet's Z axis is tilted to $65^\circ \pm 3^\circ$. The planes and

axes of the helmet coordinate system correspond to those of the appropriate head form when the helmet is placed on the head form, held in place with a force of 50 newtons applied to its crown and positioned according to its established helmet positioning index. If the impact point will be within 15 mm of the rim, the helmet and head form shall be repositioned so that the impact point is not less than 15 mm from the rim. Once the helmet and head form have been positioned in the cradle, the helmet may be secured to the cradle by strapping with Velcro closures or some comparable mechanism that will release reliably at the onset of impact.

The cradle with the helmet and head form shall be dropped along the guides such that the chin bar will strike the flat anvil. The velocity of the falling cradle shall be measured in the manner described in paragraph **h.** of section **F4.1** of this standard. The shock acceleration at the design center of gravity of the head form shall be measured by means of a tri-axial accelerometer and data recording system meeting the requirements of SAE J211.

If the impact velocity measurement is 5.5 m/s or more and the peak magnitude of the recorded acceleration of the head form is 275 G or less, the sample shall be deemed to meet the test requirement. If the impact velocity is less than 5.65 m/s and the peak magnitude of the acceleration exceeds 275 G, the sample shall be deemed not to meet the test requirement. If the test measurements do not meet one of these two conditions, the test is inconclusive and must be repeated.

F6. Shell Penetration Test

The shell penetration test may be applied to helmets kept at laboratory ambient temperature and humidity or helmets conditioned hot, cold or wet. At least one helmet

sample shall be tested in shell penetration. The complete helmet shall be placed on a rigidly mounted head form. The test head form for the penetration test need not be the standard ISO head form shape used in the impact testing and helmet marking. It is expected only that the device used will provide reasonable support for the helmet and conformance with the interior of the helmet immediately beneath the site of the penetration test. If the helmet contains a sling or some other adjustable sizing component, it shall be relaxed to its most extendable position.

The penetration test striker shall have a mass of 3 kg \pm 50 g and the point of the striker shall be a cone with an included angle of $60^{\circ} \pm 0.5^{\circ}$ and an altitude of 38 ± 0.38 mm. The striking tip shall have a hardness of 60 Rockwell (scale C \pm 3 points) and a radius of 0.5 ± 0.1 mm. The region of the support head form directly beneath the striker tip shall be wax or soft plastic and covered with a thin tell-tale of paper, foil, tape or some similar material.

The striker shall be dropped to strike the surface of the helmet shell at a velocity of 7.45 ± 0.15 meters per second as measured within no more than 4 centimeters of contact with the helmet. The helmet may be oriented on the support head form so that the test striker is directed at any site on or above the test line but the penetration test site must be at least 7.5 cm removed from the center of any impact test site or any other penetration test site. At the test technician's discretion, samples may be tested at more than one site on the shell. For all penetration tests performed, the test striker must not penetrate through the helmet wall so as to mark the tell-tale between the helmet and the support head form.

F7. Face Shield Penetration Test

If a face shield is provided, this face shield shall be tested for penetration resistance in the following manner:

The face shield shall be tested on the appropriate helmet, correctly deployed across the facial opening and under laboratory ambient conditions. A soft lead pellet weighing 1 ± 0.1 g with a diameter of 5.5 ± 0.1 mm and traveling at a velocity of 500 ± 20 km per hour shall strike the face shield normal to the surface. The face shield shall be tested in at least three different locations: the center line and 80 ± 5 mm to either side of the center line. The pellet must not penetrate to the interior of the helmet.

F8. Removability

The helmet removability test determines whether the helmet can be removed from an unconscious victim without resorting to any buckles, clasps or other mechanisms which may be rendered non-functional by impact stresses. The helmet is placed on the largest appropriate complete ISO head form with all the closures and retention systems engaged. A technician must remove the helmet from the head form using simple, common hand tools but without accessing any of the helmet mechanisms.

The hand tools for this test are limited to shears, simple edged tools and flat bladed screw drivers. The operation must not require more than thirty seconds.

F9. Post-testing Disassembly and Inspection

If a set of helmets is submitted for and passes certification testing, one or more the tested samples shall be disassembled and inspected. If any of the helmet samples appear to have been specially configured to meet test requirements and are not reasonably representative of an economically viable production helmet, the model shall

be rejected. In particular, samples must not be configured with extra layers of hand cut padding and materials inserted between shell and liner or applied to the inner surface of the liner. Elements such as these may confer an advantage in satisfying test requirements but are all too likely to be left out of production units afterwards.

If an internal projection on the helmet shell is deemed to present an undue laceration or puncture hazard, the model shall be rejected. In evaluating these internal projections, no allowance shall be made for liner thickness.