
1990
**STANDARD
FOR PROTECTIVE
HEADGEAR**

*For Use with Motorcycles and
Other Automotive Vehicles*

SNELL MEMORIAL FOUNDATION, INC.

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FOREWORD

In a motorcycle accident, the rider 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 a rational means for differentiating between helmets which meet specified standards for impact (crash) protection and retention system strength and those which do not.

The Snell Foundation urges that protective helmets be required for all individuals participating in supervised racing events and encourages the general public to wear helmets which meet appropriate performance standards.

This 1990 Standard establishes performance characteristics suitable for motorcycling and for use with other open motorized vehicles in which the driver and passengers may not be enclosed such as boats, carts, all-terrain vehicles and snowmobiles. This Standard does not establish construction and material specifications. The Foundation neither recommends specific products nor imposes its specifications on manufacturers or consumers. Manufacturers voluntarily submit helmets to be tested to 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 nor to any other criteria. Neither does the Foundation distinguish between the needs of participants in competitive events and those of the general public.

All of the requirements described herein, including both certification and random testing, are an integral part of this Standard. No helmet can satisfy the Standard unless it is subject to both certification and random 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 surfaces or objects that might be encountered in a motorcycling accident. 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 motorcyclist headgear. Thus, this Standard is directed towards the kinds of performance bearing on head protection that may not readily be discernable 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.

A motorcycle helmet consists generally of a rigid head covering and a retention system composed of flexible straps and hardware. The rigid covering consists of a stiff outer shell and a crushable liner. The stiff outer shell protects by its capacity to spread a concentrated load at its outer surface over a larger area of the liner and the wearer's head. The crushable liner protects the head from direct impact by its capacity to manage impact energy.

The retention system holds the headgear in position throughout normal usage and especially during falls and accidents. This Standard tests the strength of the retention system but does not address whether it will hold the headgear in position on a particular wearer's head. *The manufacturer must provide suitable guidance to the wearer so that he will be able to satisfy himself of the quality of fit and the positional stability of a particular helmet before using it.*

The capacity for impact protection is determined by direct measurement of the shock delivered through the helmet to a headform when the helmeted headform is dropped in a specified manner onto each of three unyielding anvils. The strength of the retention system is tested by placing the helmet on a headform and shock loading the strap with a mechanical structure simulating the human jaw.

Most motorcycle helmets are intended to accommodate a range of head sizes and shapes. Various thicknesses of resilient lining material are sometimes placed within otherwise identical helmets during production or during fitting to configure the helmet 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; however, such padding may degrade the positional stability of the helmet.

The helmet must also resist penetration by projectiles such as parts of exploding engines or other damaged mechanical assemblies. This capacity is tested by placing the helmet on a headform and dropping a metal cone of specified mass and geometry onto the shell. The tip of this cone must not penetrate to the headform.

Similarly, the helmets must resist chemical attack by solvents and petrochemicals associated with motorsports. This capacity may be tested by applying a solvent mix before further conditioning and testing.

Full face helmets provide a measure of facial protection in addition to the impact protection generally sought. The principle feature of a full face helmet is a chin bar that extends forward to cover the jaw area converting the facial opening into a visual port. Frequently, a face shield is also provided so that the wearer's face is completely covered.

In order to be considered a full face helmet, the chin bar must be an integral part of the helmet structure. The Standard then tests the rigidity of the chin bar by dropping a weight onto it at a specified velocity so as to attempt to force the chin bar toward the interior of the helmet. The chin bar must not deflect more than a specified amount.

If a face shield is provided with a full face helmet, then this face shield must resist penetration by small particles. A sharp lead pellet of a specified weight is directed into the face shield at a specified velocity. The pellet must not penetrate into the helmet interior.

Inadequate ventilation may render a helmet useless in warm climates, especially if the helmet is full faced and intended for prolonged wear. This Standard limits the diameter of ventilation

holes in the helmet shell but makes no direct demands on either the quantity or quality of air flow to the wearer.

Other general features of motorcycle helmets may include eyeshades and accommodations for goggles, and visibility enhancements such as 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 the risk of head injuries significantly, there are limits to a helmet's protective capability. No helmet can protect the wearer against all foreseeable accidents. Therefore injury may occur in accidents 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 protecting the wearer in an accident. Helmets are constructed so that the energy of a blow is managed by the helmet, causing its partial destruction. The damage may not be readily apparent and the Foundation strongly recommends that a helmet involved in an accident be returned to the manufacturer for complete inspection. If it is not possible to do so, 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 motorcycle helmets be replaced after five (5) years, or less if the manufacturer so recommends.

CONSTRUCTION

A. General

The assembled helmet shall have smooth external and internal surfaces. Any feature projecting more than 7 mm beyond the outer surfaces 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. The helmet shall provide as nearly uniform impact protection over the entire protected area as is possible.

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.

B. Shell

Shell ventilation holes, if used, shall not exceed 13 mm in diameter. If rivets are used, the heads shall not have sharp edges and shall not project more than 2 mm from the outer surface of the helmet.

C. 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. As a practical matter, however, if such causes are likely to affect the protective capabilities of a helmet, they must also produce obvious changes in the external appearance of the helmet. The manufacturer shall provide suitable warnings and information with each helmet describing factors degrading helmet materials and the signs of such degradation.

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

D. Finish

All edges of the helmet shall be smoothed and rounded.

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 release inadvertently.

F. Peripheral Vision

The helmet shall provide peripheral visual clearance. This clearance is defined using a reference headform 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.

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. A total of five (5) complete helmets must be submitted by the manufacturer for a certification test program for each distinct structural configuration of the models offered for sale. Four of these samples will be destroyed in testing; the fifth shall be retained for comparison and reference.

Any modification of a Snell certified helmet other than decorating, marking or trimming the external shell with manufacturer approved paints and tape may invalidate the certification. Any modification that involves changes to the shell, liner, or the retention system invalidates the certification unless specifically authorized in writing by the Foundation.

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 where 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 the continuing quality of certified products. Specifically, if helmets are provided directly to teams or individuals for use in organized events, the Foundation may demand guaranteed access to the helmets for spot checking and non-destructive evaluation.

LABELLING AND MARKING

Each helmet shall have durable, visible and legible labelling identifying the manufacturer, the month and year of manufacture and the size. The Snell decal shall be placed inside the helmet so that it cannot be removed intact. Labelling shall be uncoded and in English. The headgear shall also be labelled 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 all retention straps must be securely fastened to retain the helmet. The helmet, when fitted, shall not be removed easily under this condition.

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 such an impact, it must either be returned to the manufacturer for inspection or be destroyed and replaced.

3. If any of the helmet components are sensitive to commonly encountered fluids, solvents or other treatments then the labelling must also include: 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.)

4. Certified as a full face helmet. (or) Certified as an open face helmet. (as appropriate.)

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

EXTENT OF PROTECTION

The extent of protection corresponds to that region of the head which the helmet must protect. This region is defined according to the geometry of the three reference headforms: Small, Medium and Large which are derived from the Department of Transportation Federal Motor Vehicle Safety Standard 218 (DOT FMVSS 218).

There are a number of planes fixed in the geometry of these headforms as shown in Figure 1. This description of the extent of protection uses the commonly accepted definitions of the basic plane, the longitudinal plane, the transverse plane, and the reference plane as well as three more planes defined strictly for convenience and clarity.

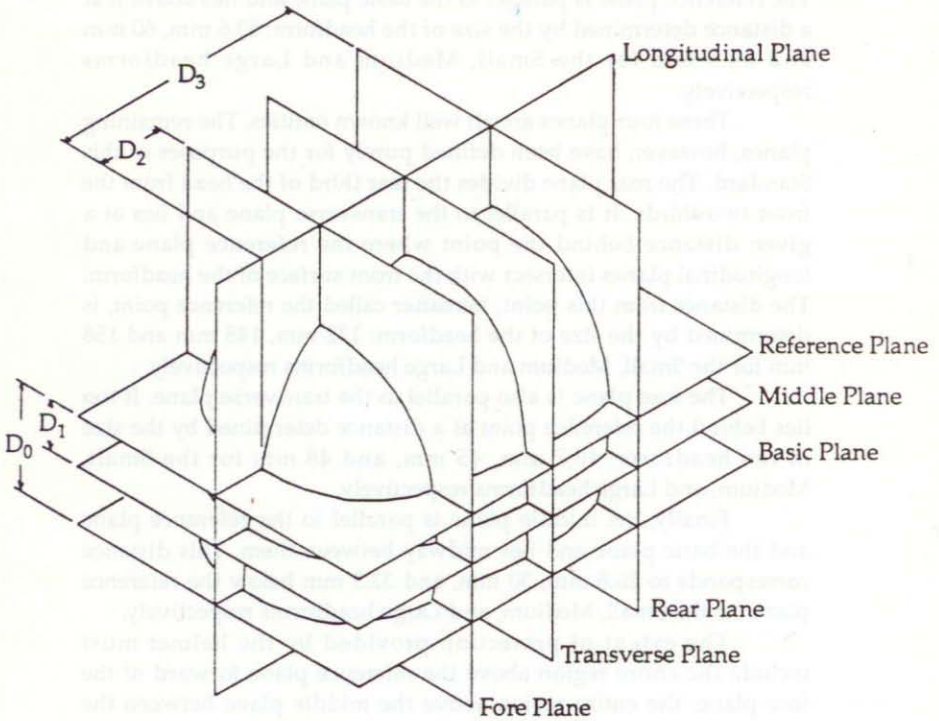


Figure 1. Headform Geometry

Table: Headform Geometry

Headform	D_0	D_1	D_2	D_3
Small A	53.6	26.8	40.7	132
Medium C	60	30	45	148
Large D	64.5	32.3	48	158

The basic plane corresponds to the anatomical 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 headform 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. The reference plane is parallel to the basic plane and lies above it at a distance determined by the size of the headform: 53.6 mm, 60 mm and 64.5 mm for the Small, Medium and Large headforms respectively.

These four planes are all well known entities. The remaining planes, however, have been defined purely for the purposes of this Standard. 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 headform. The distance from this point, hereafter called the reference point, is determined by the size of the headform: 132 mm, 148 mm and 158 mm for the Small, Medium and Large headforms respectively.

The fore plane is also parallel to the transverse plane. It too lies behind the reference point at a distance determined by the size of the headform: 40.7 mm, 45 mm, and 48 mm for the Small, Medium, and Large headforms respectively.

Finally, the middle plane is parallel to the reference plane and the basic plane and lies midway between them. This distance corresponds to 26.8 mm, 30 mm, and 32.3 mm below the reference plane for the Small, Medium, and Large headforms respectively.

The extent of protection provided by the helmet must include the entire region above the reference plane forward of the fore plane, the entire region above the middle plane between the fore and rear planes, and the entire area above the basic plane behind the rear plane. (See Figure 2.)

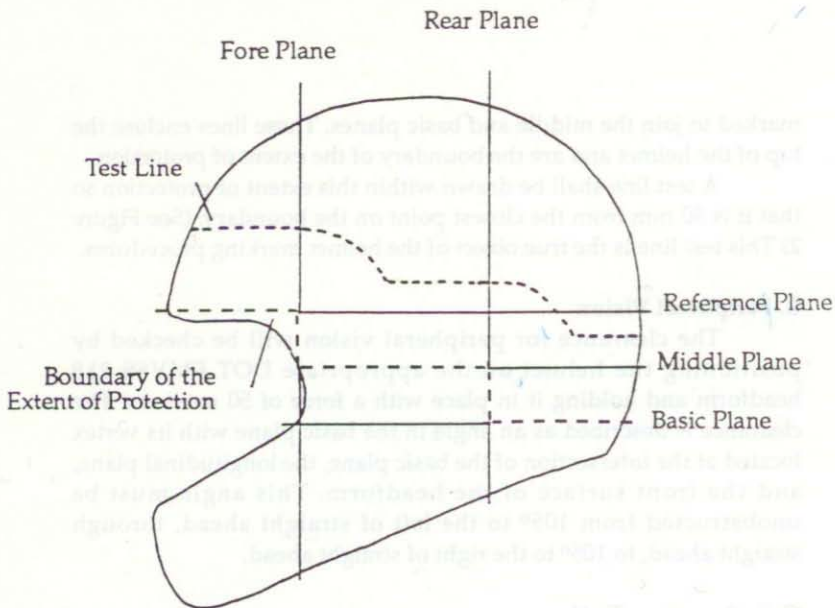


Figure 2. Helmet Marking

TESTING

A. Inspection and Marking

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.

A line drawn on the outer surface of the helmet marks the boundary of the extent of protection. The helmet is positioned upon the appropriate FMVSS 218 headform 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 reference plane is marked on that portion of the helmet in front of the fore plane. The level of the middle plane is marked on either side of the helmet for those portions lying between the fore and rear planes. The level of the basic plane is marked on the portion of the helmet behind the rear plane. Finally, line segments along the fore plane are marked to join the reference and middle planes and the line segments along the rear plane are

marked to join the middle and basic planes. These lines enclose the top of the helmet and are the boundary of the extent of protection.

A test line shall be drawn within this extent of protection so that it is 50 mm from the closest point on the boundary. (See Figure 2) This test line is the true object of the helmet marking procedures.

B. Peripheral Vision

The clearance for peripheral vision will be checked by positioning the helmet on the appropriate DOT FMVSS 218 headform and holding it in place with a force of 50 newtons. The clearance is described as an angle in the basic plane with its vertex located at the intersection of the basic plane, the longitudinal plane, and the front surface of the headform. This angle must be unobstructed from 105° to the left of straight ahead, through straight ahead, to 105° to the right of straight ahead.

C. Performance Testing

The performance testing subjects helmets to several shock absorption tests and to a dynamic test of the retention system in that order. These tests are conducted upon helmet samples that are first conditioned in environments simulating some of the conditions in which the helmet might reasonably be expected to be used.

C1. Conditioning for Testing

a. Cold. In addition to testing at ambient temperature, a second helmet shall be conditioned by being exposed to a temperature of $-10^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

b. Heat. A third helmet shall be conditioned by being exposed to a temperature of $50^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

c. Rain. A fourth helmet shall be conditioned by being continuously sprayed with or immersed in water at a temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for a period of not less than four (4) hours, nor more than twenty-four (24) hours.

d. All testing of these hot, cold and wet helmets shall begin within two (2) minutes from the time of removal from the conditioning apparatus.

e. **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 chinstrap 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 (30) minutes shall elapse before further conditioning and testing.

C2. Shock Absorption Test

a. Shock absorption shall be measured by determining imparted acceleration to an appropriately instrumented test headform dropped in a guided fall upon a fixed rigid steel anvil. Each helmet shall receive two impacts on each of two sites against the flat anvil and two impacts on each of two sites against the hemispherical anvil. Each helmet shall also receive a single impact with the edge anvil. The helmet thus will have a total of nine impacts at five different sites.

b. The impact sites shall be separated from each other by a distance of not less than one-sixth of the circumference of the helmet at the reference plane. The impacts must be centered at any point within the area marked by the test line and no closer than 50 mm to the boundary of the extent of protection. Rivets, vents and any other helmet feature within this region shall be valid test sites.

c. Three anvil configurations shall be used, one flat, one hemispherical and one edge. The flat anvil shall have a minimum surface area of 0.0127 m^2 , e.g. 127 mm diameter face; the hemispherical anvil shall have a $48 \text{ mm} \pm 0.5 \text{ mm}$ radius; and the edge anvil shall be 6.3 mm by $180 \text{ mm} \pm 10 \text{ mm}$.

d. The rigid mount for all of the anvils shall consist of a solid mass of at least 135 kg, the upper surface of which shall consist of a steel plate with minimum thickness of 25 mm and minimum surface area of 0.3 m^2 .

e. The test headform shall be of rigid, low resonance material such as a magnesium alloy and shall conform to the DOT Small, Medium and Large sizes as specified in FMVSS 218.

f. For each impact test, the input energy shall not exceed $\pm 3\%$ of the joules (j) specified. The input energy for each helmet test shall be calculated by using the drop test weight (without helmet) and the measured impact velocity.

g. The drop test weight shall be the total weight of the instrumented test headform (which includes the "neckshaft", ball, collar, and accelerometer) and the support arm assembly (which includes all the other hardware rigidly fixed to the headform in the guided fall). The weight of the helmet will not be included in the drop test weight. The support arm assembly shall not exceed 25% of the drop test weight. For example, for a 5.1 kg drop test weight, the support arm shall not weigh more than 1.275 kg. The total drop mass of the supporting assembly with instrumented headform, without the helmet, shall not exceed 6.5 kg.

h. The center of gravity of the test headform and supporting assembly shall lie within 10 mm horizontally of the design center of gravity of the test headform.

i. At each test locus of impact against the flat or hemispherical anvil, the impact energy shall be 150 j for the first impact and 110 j for the second impact regardless of headform size or weight. Given an ideal frictionless mechanical test facility, this first impact energy represents a 3+ meter drop of a 5 kg headform and supporting assembly. The drop against the edge anvil is to be at 150 j regardless of headform size or weight.

j. The peak acceleration of the helmeted headform for each of the nine (9) impacts shall not exceed 300G. The helmet shall remain structurally intact throughout impact testing. Non-structural elements may break loose but must not present a risk of laceration or other injury.

k. The acceleration transducer sensitive element shall be mounted at the design center of gravity of the test headform. The sensitive axis shall be aligned to within 5° of the vertical axis when the test headform is in the impact position. 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.

C3. Dynamic Test of Retention System

Each helmet in the series shall be tested in the following manner: The helmet shall be placed on a headform with the chin

strap fastened under a device whose upper end approximates the shape 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 of the simulated jaw during the dynamic load exceeds 30 mm. The retention system also fails if it cannot be easily and quickly unfastened after testing.

a. This simulated jaw shall consist of two metal bars or rollers, each one $12.7 \text{ mm} \pm 0.5 \text{ mm}$ in diameter, separated by $76 \text{ mm} \pm 0.5 \text{ mm}$ on center.

b. A pre-load of 23 kg shall be applied for at least 120 seconds.

c. A 38 kg mass shall be dropped in a vertical guided fall a distance of 120 mm so as to load the retention system abruptly; the 38 kg mass and 23 kg mass shall not be additive. In order to protect the test mechanism, the impact of the 38 kg mass may be cushioned with a rubber pad 150 mm in diameter by 6.5 mm thick, or its equivalent.

C4. Chin Bar Test

The chin bar test applies to full face helmets only. At least one helmet in each certification series shall be tested. The helmet shall be firmly mounted on a rigid base so that the chin bar faces up and the reference plane is at $65^\circ \pm 5^\circ$ from horizontal. A mass of $5 \text{ kg} \pm 0.2 \text{ kg}$ 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 $3.5 \text{ m/sec.} \pm 0.2 \text{ m/sec.}$ The maximum downward deflection of the chin bar must not exceed 60 mm.

C5. Shell Penetration Test

The complete helmet shall be placed on a rigidly mounted headform. 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 $3 \text{ kg} \pm 50$ grams. The striker shall fall through a height of $3 \text{ m} \pm 15 \text{ mm}$. The point of the striker shall be a cone with an included angle of $60^\circ \pm 0.5^\circ$ and an altitude of $38 \text{ mm} \pm 0.38 \text{ mm}$. The striking tip shall have a hardness of 60 Rockwell (scale C ± 3 points) and a radius of $.5 \text{ mm} \pm .01 \text{ mm}$.

The test striker must not penetrate to achieve even momentary contact with the test headform.

C6. Face Shield Penetration Test

If a face shield is provided with a full face helmet, this face shield shall be tested for penetration resistance in the following manner: A sharp, soft lead pellet weighing $1 \text{ gm} \pm 0.1 \text{ gm}$ with a diameter of $5.5 \text{ mm} \pm 0.1 \text{ mm}$ and travelling at a velocity of $500 \text{ km per hour} \pm 20 \text{ km}$ 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 $80 \text{ mm} \pm 5 \text{ mm}$ to either side of the center line. The pellet must not penetrate to the interior of the helmet.