Designation: F429 – 10

An American National Standard

Standard Test Method for Shock-Attenuation Characteristics of Protective Headgear for Football[1]

This standard is issued under the fixed designation F429; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the shock-attenuation characteristics of protective headgear for football.[2]

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

F717 Specification for Football Helmets

2.2 *SAE Document:*

J221 JUN 80 Instrumentation for Impact Tests, Requirements for Channel Class 1000[4]

2.3 *ISO Standard:*

ISO/DIS 6220 Headforms For Use in the Testing of Protective Helmets[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *basic plane*—an anatomical plane that includes the superior rims of the auditory meatuses (the upper edges of the external openings of the ears) and the notches of the inferior orbital ridges (the bottom of the eye sockets). See Fig. 1.

3.1.2 *coronal plane*—a vertical plane that is perpendicular to the median and reference planes and passes through the crown of the headform (lateral plane).

3.1.3 *crown*—a point in the median plane which is equal chord lengths from the anterior and posterior intersections of the median and reference planes.

3.1.4 *drop height*—the vertical distance between the lowest point (impact point) of the elevated helmet and the apex of the impact surface.

3.1.5 *g*—dimensionless ratio of the acceleration of the headform during impact to the acceleration due to gravity.

3.1.6 g_{max}—the maximum value of *g* encountered during impact.

3.1.7 *median plane*—a vertical plane that passes through the headform from front to back and divides it into right and left halves (mid-sagittal plane).

3.1.8 *protective headgear*—the assembled device and accessories as supplied by the manufacturer primarily intended to protect the wearer's head while participating in football.

3.1.9 *reference plane*—a plane that is located at a specified distance above and parallel to the basic plane.

4. Summary of Test Method

4.1 A headgear is mounted on a headform that is oriented in different positions and is dropped at a specific velocity onto an impact surface. A linear accelerometer mounted at the center of gravity of the headform monitors the acceleration and the time history of impact which are recorded with appropriate instrumentation.

5. Significance and Use

5.1 Maximum acceleration and time duration data obtained by the specified procedures are intended to determine the shock attenuation characteristics of a headgear.

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[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.53 on Headgear and Helmets.

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[2] Performance requirements for football helmets are found in Specification F717.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from the Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

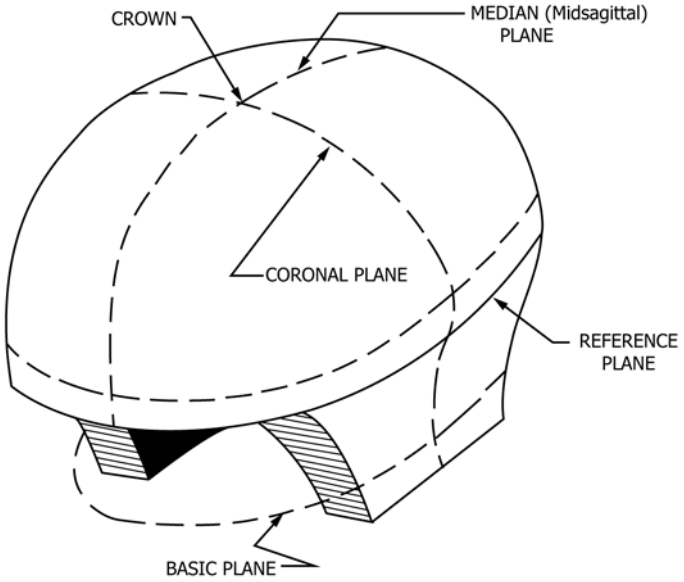
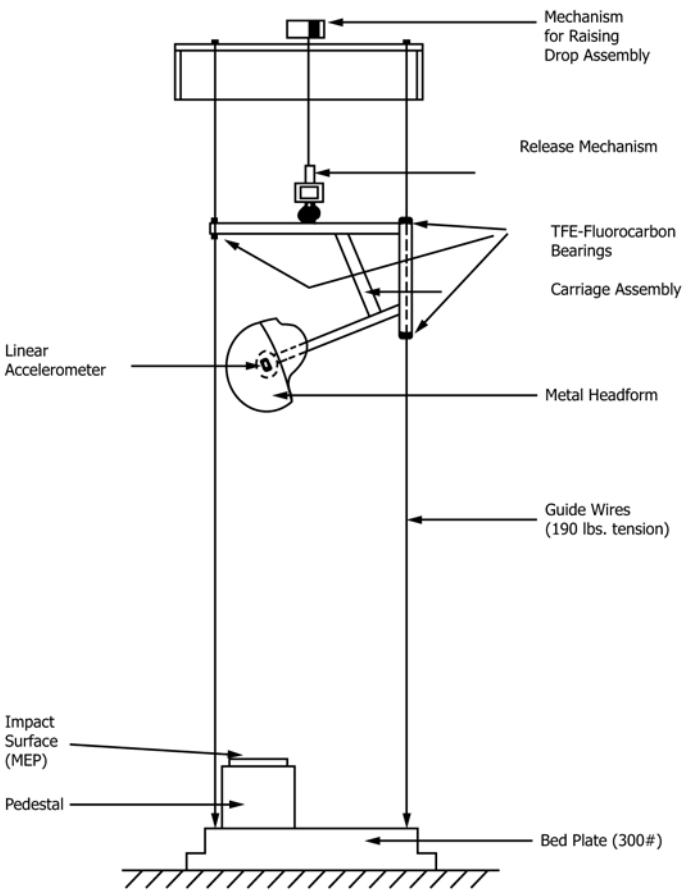


FIG. 1 ISO Headform—Basic, Reference, and Median Planes



NOTE 1—Rail-guided drop assemblies are also permissible.

FIG. 2 Schematic of Typical Drop Assembly

NOTE 1—These data can be used at a later date to assess the protection afforded to the head when blows are delivered to the helmet.

6. Apparatus[5]

6.1 *Guide Assembly*[6]—The headform shall be attached to the free-fall drop assembly carriage by an adjustable mounting which will allow impacts to be delivered to any prescribed point on the helmet (see Fig. 2). The carriage shall be free to slide on vertical guides. If wires are used they must be placed under at least 845-N tension (see 12.4 for guide assembly specifications and allowable weight of drop assembly).

6.2 *Recording Equipment*[6]—The recording equipment shall meet the following criteria:

6.2.1 *Acceleration Transducer*—The acceleration transducer is mounted at the center of gravity of the combined test headform and carriage assembly with the sensitive axis aligned to within 5° of the vertical when the helmet and headform are in the impact position. The acceleration data channel complies with SAE Recommended Practice J211 JUN 80 (a low pass filter having a 4-pole Butterworth transfer function and a corner frequency of 1650 Hz meets this requirement). Digital filtering at 1650 Hz can be substituted.

6.2.2 *System Accuracy*—The impact recording system shall be capable of measuring shocks of up to 500-*g* peak acceleration with an accuracy of ± 5 %.

6.2.3 *Impact Recording*—The impact shall be recorded on single- or dual-trace storage oscilloscope with 0.1-mV to 20-V deflection factor, 1 to 5-ms sweep speed-division, and 500-kHz bandwidth.

6.2.4 *Headforms*—Standard headforms as described in 12.4 will be used for helmet impact testing.

6.2.5 *Height Measuring Rod*—A metal rod accurate to ±2.5 mm shall be used for measuring drop heights.

6.2.6 *Impact Surfaces*—The impact surface for the instrument system check (see Section 10) shall be a flat, Modular Elastomer Programmer (MEP),[6] 152 mm in diameter and 25 mm in thickness. The MEP shall have a durometer of 60 ± 2 Shore "A." The MEP is mounted on an aluminum mounting plate with a minimum thickness of 5.59 mm after grinding. The MEP (including aluminum mounting plate) shall be firmly affixed to the top surface of a flat metal anvil. The base shall consist of a rigid slab weighing at least 136 kg. For helmet impacts, the instrument system check MEP is replaced with a MEP 13 mm in thickness, 152 mm in diameter, and a durometer of 38 ± 5 Shore "A."

6.2.7 *Spherical Impactor*[6]—A device made of low resonance material, for example, magnesium, aluminum alloy or stainless steel, that couples mechanically with the ball arm connector of the drop assembly in place of the impact test headform. When mounted, the device presents a spherically machined impact face with a radius of 73 mm on its bottom surface. All radii from the center of curvature of the impact face to its outer edge shall form angles of no less than 40° with

[6] The sole source of supply of the apparatus known to the committee at this time is the Research & Testing Co., 1415 Park Ave., Hoboken, NJ 07030. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

the downward vertical axis. The center of curvature shall be within 5 mm of the vertical axis drawn through the center of the ball arm. The mass of the drop assembly including the impactor shall meet the same requirements as those specified for the drop assembly incorporated with the test headforms (see section 12.4).

7. Sampling

7.1 Submit at least three specimen helmets, one for test under the various conditions as described in Section 11.

8. Test Specimen

8.1 At least three specimen helmets of each size to be tested as offered for sale on the open market shall be obtained for testing. These helmets shall be tested without accessories.

9. Preparation of Apparatus

9.1 Turn on all electronic equipment and allow to warm up for at least 30 min or as recommended by the manufacturer, whichever time is greater, prior to any testing.

10. Instrumentation System Check

10.1 The instrumentation of the entire system shall be checked before and after each series of tests, by dropping the spherical impactor, without a helmet, onto the MEP pad at a velocity of 5.44 m/s ± 0.04 m/s. This should produce a g_{max} of 389 ± 4 *g*.

10.2 Record at least three impacts as described in 10.1 immediately prior to and following each series of tests, and record on the report form.

10.3 If the maximum *g* readings are not within the tolerance limits prior to the test series, adjust or repair the system as necessary.

10.4 If the mean of the three g_{max} values following the test series differ by more than 10 *g* from the mean of the *g* readings of the impacts prior to the test series, discard the entire test series.

11. Conditioning

11.1 Prior to testing, condition each helmet in one of the following ways:

11.1.1 *Ambient Temperature*—Condition one helmet for a period of not less than 4 h at laboratory conditions which shall be at a temperature of 21 ± 5°C and a relative humidity of 50 ± 15 %. Record the temperature to the nearest degree and the relative humidity to the nearest percent at the time of testing on the report form for each test series.

11.1.2 *Low/High Temperature Cycle*—Condition the second helmet by exposing it to a temperature of −20°C for a minimum of 4 h, then condition it at +50°C for a minimum of 4 h before testing. Conditioning time in temperature transitions is not to be included in the time at high temperature with the interval between the two temperatures being no more than 1 h.

11.1.3 *Water Immersion*—Immerse the third helmet in water at a temperature of 21 ± 5°C for a period of not less than 4 nor more than 24 h.

11.1.4 *Testing for Conditioned Specimens*— Complete all testing on helmets within 5 min after removal from the conditioning environment. Helmets may be returned to the conditioning environment in order to meet this requirement. Prior to the resumption of testing, specimens must remain in the conditioning environment for a minimum of 15 min for each 5-min period they are out of the conditioning environment.

12. Test Procedures

12.1 *Testing Environment*—Conduct all testing under the recorded conditions of room temperature and humidity. These conditions must be in accordance with those stated in 11.1.1.

12.2 *Impact Locations*—Impact each helmet at not less than six sites. All distances referred to in this section are arch-length distances measured on the helmet. See Fig. 3 for a diagram of the impact sites.

12.2.1 *Front*—Located in the median plane and 81.8 mm above the anterior intersection of the median and reference planes.

12.2.2 *Front Boss*—A point in a plane 45° (0.78 rad) from the median plane as measured in a clockwise direction and 56.3 mm above the reference plane.

12.2.3 *Side*—Located at a point 30.9 mm above the intersection of the reference plane and the coronal plane, and 90°

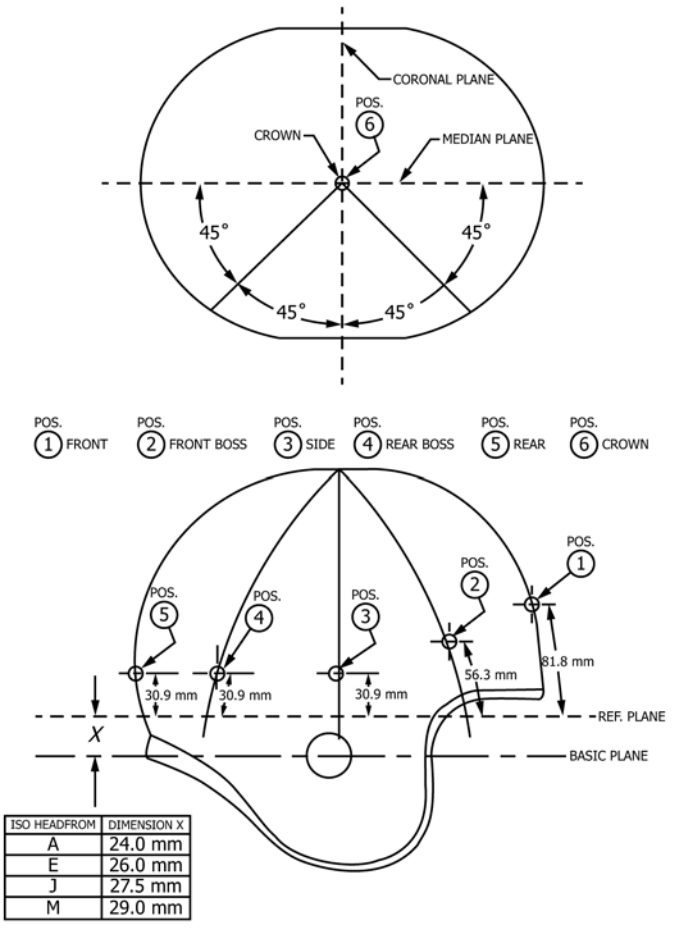


FIG. 3 Impact Locations

(1.57 rad) in a clockwise direction from the anterior intersection of the median and reference planes.

12.2.4 *Rear Boss*—A point in a plane 135° (2.36 rad) in a clockwise direction from the anterior intersection of the median and reference planes, and 30.9 mm above the reference plane.

12.2.5 *Rear*—A point 30.9 mm above the posterior intersection of the median and reference planes.

12.2.6 *Crown*—A point in the median plane that is equidistant from the anterior and posterior intersections of the median and reference planes.

12.3 *Multiple Impacts*—Each helmet tested under ambient temperature conditions shall receive a total of 24 impacts. Impact each of the six locations on the helmet (described in 12.2) three times with an impact velocity of 5.47 ± 0.04 m/s. Deliver three additional impacts to each of the two locations on the helmet at which the highest mean g_{max} readings were recorded.

12.4 *Headforms and Supporting Assembly*[6]—The test headforms to be used for helmet impact testing are Size A, E, J, and M headforms as described in ISO/DIS 6220. The combined weight of the instrumented headform (regardless of headform size) and the supporting assembly (exclusive of the test helmet) shall be 5 ± 0.1 kg (see Table 1).

NOTE 2—The weight of the supporting assembly shall not exceed 1.0 kg.

12.5 *Reference Marking*—Place the complete helmet to be tested on an appropriate-sized reference headform that is firmly placed, with the basic and reference planes horizontal. Apply a 45-N static load to the crown of the helmet, center the helmet laterally, and adjust it in accordance with the manufacturer's recommendations. Maintaining the static load, draw a test line on the outside of the helmet shell, corresponding to the reference plane of the headform. In addition to the test line, clearly mark each of the six impact points as described in 12.2.

12.6 *Helmet Positioning*—Prior to each test drop, adjust the helmet on the headform in accordance with the manufacturer's recommendations. Secure the helmet to the headform so it does not shift position prior to or during the impact. Place the retention system in such a position that it does not interfere with the free fall or the impact.

13. Calculation

13.1 Immediately after each impact, take the following measurements of the acceleration time-history trace:

13.1.1 *Maximum Acceleration*—Find the maximum amplitude of acceleration by measuring the perpendicular distance to the trace base line from the midpoint of the trace at maximum excursion and multiplying by the sensitivity factor. (Sensitivity factor = g per division deflection of the trace.)

13.1.2 *Duration of Impulse*—Determine the duration of the pulse by measuring the total width of the trace along the 50-g line in milliseconds.

13.1.3 *Oscillograms*—Take photographs of the oscilloscope on the third impact at each impact site conducted under ambient conditions. Affix these oscillograms to the final report of testing.

TABLE 1 Headform Reference Plane Location

Headform Size	Distance from Basic Plane to Reference Plane
A	24.0 mm
E	26.0 mm
J	27.5 mm
M	29.0 mm

14. Report

14.1 Each laboratory report shall be accompanied by the oscillograms prescribed in 13.1.3 and shall contain the following minimum information:

14.1.1 *Helmet Identification*—Complete identification of the helmet including but not limited to the following:

14.1.1.1 Manufacturer's identification,

14.1.1.2 Size,

14.1.1.3 Manufacturer's lot number,

14.1.1.4 Weight, and

14.1.1.5 External circumference at reference plane.

14.1.2 *Conditions of Test*—The report shall include detailed information of the conditions under which the tests were conducted as follows:

14.1.2.1 Date of test,

14.1.2.2 Temperature,

14.1.2.3 Humidity, and

14.1.2.4 Record of the instrument calibration.

14.1.3 *Test Results*—Detailed results of the impact testing shall include the following:

14.1.3.1 Impact location,

14.1.3.2 Drop height,

14.1.3.3 g_{max} for each impact,

14.1.3.4 Duration of pulse,

14.1.3.5 Other pertinent comments and remarks, and

14.1.3.6 Size of headform used.

14.2 Fig. 4 provides a sample data sheet for recording test conditions and test results.

Date:_____ Laboratory: _____ Testing Performed by: _____

Helmet Make and Model: _____ Size: _____ Lab Conditions: Temp_____ Humidity _____

Helmet's Circum. @ Ref. Plane: _____ Condition of Helmet Before Testing: _____

Instrument - System Check	Impact No.	Impact Velocity m/s	Drop Ht. (cm)	g max	Impact Duration (ms)	Remarks
PRE - TEST	1 2 3					
POST - TEST	1 2 3					

Helmet No.	Weight (g)
1	
2	
3	

Headform Size Used: A, E, J, or M _____

Helmet No.	Test Condition	Location	FRONT			FR. BOSS			SIDE			REAR BOSS			REAR			CROWN		
		Drop No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	Ambient	g max T (ms)																		
2	Low/High Temp.	g max T (ms)																		
3	Water Immersed	g max T (ms)																		
1	Ambient - 3 extra	g max T (ms)																		

Remarks: (Indicate helmet condition after testing) _____

Signed: _____ Date: _____

FIG. 4 Sample Data Sheet