Designation: F3555 – 22

Standard Test Method for Measuring Impact Attenuation Characteristics of Helmets Under Induced Rotational Loading Using an Inclined Anvil[1]

This standard is issued under the fixed designation F3555; 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.

INTRODUCTION

This test method specifies equipment and procedures used for the evaluation of the impact attenuation characteristics of helmets under induced rotational loading using an incline anvil. It is the responsibility of each ASTM Committee to decide whether this test method is suitable for inclusion in their particular head protection standard. Individual ASTM performance standards (standard specifications) may use these procedures and equipment and may specify test conditions, pass-fail criteria, and other applicable performance requirements tailored to the needs of a particular activity (for example, hockey, football, baseball, etc.). This test method was developed using resources in medical, scientific, mechanical engineering, human factors, and biomechanical fields. However, it is recognized that it is not possible to write a performance standard that will include all possible impact scenarios. It is also recognized that serious injury or death can result from both low and high-energy impacts, even when a helmet is worn. This test method incorporates aspects of other recognized protective equipment performance standards. It draws from work done by others where appropriate for this test method. These standards are referenced within this standard test method. It should be noted that this test method specifies laboratory tests of helmets to measure its ability to reduce impact forces applied to the head and other selected parameters during normal use for the given activity.

1. Scope

1.1 This test method covers laboratory equipment, procedures, and basic requirements pertinent to testing the performance of helmets during rotational loading using an incline anvil. Deviations and additions to this test method will be specified, as required, in individual ASTM performance standards.

1.2 *Requirements*—The helmet may be tested under one or more specified environmental conditions for impact attenuation (the limiting of impact forces) as a result of a vertical free-fall onto an incline anvil.

1.3 Except where noted, the values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *SAE Standards:*[2]

SAE J211-1 Instrumentation for Impact Test – Part 1 – Electronic Instrumentation

SAE J1727 Calculation Guidelines for Impact Testing

2.2 *ISO Standard:*[3]

ISO 6344-2 Coated Abrasives – Determination and designation of grain size distribution – Part 2: Macrogrit sizes P12 to P220

3. Terminology

3.1 *Definitions:*

[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.

Current edition approved June 15, 2022. Published July 2022. DOI: 10.1520/F3555-22.

[2] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.1.1 *alpha (α), n*—abbreviation for angular acceleration, expressed in units of radians per second-squared.

3.1.2 *area of coverage, n*—a specified area of the protective device that is intended to provide protection and is subject to specific testing.

3.1.3 *coronal plane, n*—an anatomical plane perpendicular to both the basic and midsagittal planes and containing the midpoint of a line connecting the left and right auditory meatuses.

3.1.4 *Frankfort plane, n*—a plane connecting the highest point of the opening of the external auditory canal with the lowest point on the lower margin of the orbit.

3.1.5 *helmet carrier, n*—a device designed to carry the test headform and test helmet along the guided rail system toward the incline anvil and to release the test headform and test helmet immediately prior to impact with the incline anvil.

3.1.6 *helmet position index (HPI), n*—the vertical distance from the brow of the helmet to the headform reference plane when the helmet is placed on the reference headform.

3.1.7 *midsagittal plane, n*—an anatomical plane perpendicular to the basic plane and containing the midpoint of the line connecting the notches of the right and left inferior orbital ridges and the midpoint of the line connecting the superior rims of the right and left auditory meatuses.

3.1.8 *nine accelerometer package (NAP), n*—a practical method for calculating rotational acceleration inside a manikin headform, including geometric corrections due to accelerometer placements, as described by diMasi (1995).[4]

3.1.9 *omega (ω), n*—abbreviation for angular velocity, expressed in units of radians per second.

3.1.10 *tragion, n*—the superior point on the juncture of the cartilaginous flap (tragus) of the ear with the head.

4. Significance and Use

4.1 The purpose of these test methods is to provide reliable and repeatable tests for the evaluation of various types of protective headgear when subjected to rotational loading. Use of these test methods in conjunction with the specific individual performance standards is intended to reduce the likelihood of serious injury and death resulting from impacts to the head sustained by individuals participating in sports, recreation, and other leisure activities in which protective headgear is worn.

5. Certification

5.1 Unless otherwise specified in the individual performance standard, these test methods permit self-certification. It is recommended that each manufacturer employ an independent test laboratory at least annually to test each model and size of head protection product offered for sale.

6. Test Methodology

6.1 *Test Apparatus*—The test apparatus shall consist of the following components and characteristics.

6.1.1 *Impact Base*—The impact base (see Fig. 1 Part C) shall be solid and made of steel or a combination of steel and concrete. The base shall have a mass of at least 500 kg. At least the uppermost 25 mm shall consist of steel, which shall be firmly attached to the concrete if present.

6.1.2 *Test Anvil*—Unless otherwise specified in the individual performance standard, the test anvil shall consist of a solid steel cylinder with a minimum diameter of 130 mm. The cylinder shall include a minimum 130 mm diameter impact face that has a 45 ± 0.5° angle from the horizontal plane (see Fig. 1 Part A). The minimum height of the steel region beneath the impact face shall be 30 mm (see Fig. 1 Dimension h). The minimum height between the impact base and the test anvil shall be 200 mm (see Fig. 1 Part B) and the length/diameter ratio of Part B shall not be greater than five. Unless otherwise specified in the individual performance standard, the impact face of the test anvil shall be covered with an abrasive paper, with a grain size distribution of P80 according to ISO 6344-2. The abrasive paper shall be securely attached to the anvil to avoid slippage. Unless otherwise specified in the individual performance standard, the abrasive paper shall be replaced after three single tests or if significant damage occurs.

6.1.3 *Guidance System and Helmet Carrier*—The guidance system shall provide for the positioning of any initial headform angle and impact point on the helmet vertically above the anvil. Details regarding the position and orientation of the headform and helmet shall be provided in the individual performance standard. The guidance system shall be attached to the helmet carrier in a manner that keeps the helmet in the target impact position during the raising, release and dropping of the headform/helmet assembly. The helmet carrier shall be designed in a manner that it does not influence the response of the headform/helmet assembly during the impact with the test anvil.

6.1.4 *Impact Velocity*—The headform/helmet assembly vertical impact velocity shall be measured at a distance not more than 40 mm prior to the impact. The target impact velocity and allowable tolerance shall be specified in the designated standard.

6.1.5 *Test Headforms*—The test headforms used with this specification shall be full size headforms that are listed in Table 1 and meet the dimensional specifications of Annex 6 of the UN/ECE 22.06 standard.[5,6] The external surface of each test headform shall have a coefficient of friction of 0.27 to 0.33

[4] DiMasi, F.P., Transformation of Nine-Accelerometer-Package (NAP) Data for Replicating Headpart Kinematics and Dynamic Loading: Technical Report DOT HS-808 282. Washington, DC, United States Department of Transportation, National Highway Traffic Safety Administration, 1995.

[5] United Nations, Economic commission for Europe, working party WP29 on the Construction of Vehicles, Regulation No. 22, Uniform provisions concerning the approval of protective helmets for drivers and passengers of motorcycles and mopeds, Geneva, Initially passed 1958, amendment 03 1988, amendment 04 1995, amendment 05 1999, amendment 06 2020.

[6] The sole source of supply of the test headforms known to the committee at this time is Cellbond, a division of Encocam Limited, 5 Stukeley Business Centre, Blackstone Road, Huntingdon, Cambridgeshire, PE29 6EF, United Kingdom (sales@cellbond.com). 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.