Designation: F3389/F3389M – 21

Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts[1]

This standard is issued under the fixed designation F3389/F3389M; 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 is applicable to small unmanned aircraft (sUA) that are limited in the United States in accordance with 14 CFR § 107.3 to be less than 55 lbf. The test method provides a standardized method for assessing the safety of sUA impacts with a person on the ground. Results from testing using Methods A, B, C, or D are intended to be used to support an applicant in obtaining permission from the governing Civil Aviation Authority (CAA) for flight over people. Approval of reports for the conduct of tests and the decision to grant permission rests with the governing CAA based upon adherence to the methodologies outlined in this test method.

1.2 This test method is based on methods researched by the FAA Center of Excellence for Unmanned Aircraft Systems (UAS) supported by the Alliance for System Safety of UAS through Research Excellence (ASSURE). These methods expand on extensive research and testing conducted by the automotive industry to support quantitative automotive passenger safety standards and testing and test data on sUA collected by ASSURE.

1.3 The purpose of this test method is to define a method to establish confidence in the overall injury potential of a particular sUA configuration under probable failure conditions. This testing is not meant to simulate the worst possible impact for the most conservative set of the population. It is expected that CAAs should determine what injury thresholds are acceptable under their public policy and determine operational limitations for various operations by using the data from this testing in conjunction with the specific concept of operations proposed by the applicant.

1.4 The test method provides four methods for evaluating the potential for impact injury: a simple analytical method, a simplified test, a more rigorous test, and a test method normed to approximate energy transfer values with appropriate safety margins applied to each approach to address uncertainty in each of the approaches.

1.5 The applicant should understand the actual operating characteristics of their sUA before starting the process outlined in this test method. It is assumed that the applicant is able to substantiate the most probable, worst-case (MPWC) impact orientation of the sUA; typical and maximum operating heights and speeds; and terminal velocity of their sUA as a function of altitude to compare the results of the impact analysis with the proposed operation for the sUA. This test method is intended to supplement the verification requirements of Specification F3298 and Specification F3322, as well as a supplement to Specification F2910. This test method should not be used as a stand-alone document without consideration of other ASTM UAS standards.

1.6 These methods assume that a blunt force head impact is the most likely injury mechanism leading to serious injury or fatalities. The level of blunt force injury to the head may be adjusted for various applications (such as sUA operations around first responders with helmets) and compared with the amount of force or load factor that the sUA transfers during a collision.

1.7 Method B is not appropriate for foam-built fixed-wing sUA due to the stiffness of the FAA Hybrid III ATD Head and Neck. Until a different impactor can be developed for Method B, these sUA should use Method C or D for evaluation.

1.8 *Units*—The values stated in either International System (SI) units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.9 *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.*

1.10 *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.*

[1] This test method is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2910 Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)

F3060 Terminology for Aircraft

F3298 Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)

F3322 Specification for Small Unmanned Aircraft System (sUAS) Parachutes

F3341/F3341M Terminology for Unmanned Aircraft Systems

2.2 *Code of Federal Regulations:*[3]

14 CFR § 107.3 Definitions

49 CFR Section 571.208 Occupant crash protection

49 CFR Part 572 Subpart E Anthropomorphic Test Devices Subpart E - Hybrid III Test Dummy (§§ 572.30 - 572.36)

2.3 *FAA Documents:*[4]

DOT/FAA/AR-09/41 Neck Injury Criteria for Side-Facing Aircraft Seats

FAA AC 25.562-1 Rev B Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes

FAA Docket Number FAA-2018-1087 Operation of Small Unmanned Aircraft Systems Over People

2.4 *NHTSA Standards:*[5]

FMVSS 208 Federal Motor Vehicle Safety Standard 208 - Defined in 49 CFR Part 571.208

TP-208-14 Appendix A Part 572E (50th Male) Dummy Performance Calibration Test Procedure

2.5 *SAE Standards:*[6]

SAE J211/1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211/2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE J1727 Calculation Guidelines for Impact Testing

SAE J1733 Sign Convention for Vehicle Crash Testing

2.6 *UN Regulation:*[7]

UN Regulation No. 94 Occupant Protection in Frontal Collisions: Uniform Provisions Concerning the Approval of Vehicles with regard to the Protection of the Occupants in the Event of a Frontal Collision

3. Terminology

3.1 *Unique and Common Terminology*—Terminology used in multiple standards is defined in F3341/F3341M, UAS Terminology Standard, and F3060, Aircraft Terminology Standard. Terminology that is unique to this test method is defined in this section.

3.2 This test method uses terminology contained in Specification F3298 and Specification F3322. These terms are not duplicated in this test method.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *critical speed for Method D*—the critical speed for Method D testing varies from the definition in Terminology F3341/F3341M. The critical speed for Method D testing is either the highest ground speed achievable in powered flight, including the proposed environmental conditions (that is, wind), or the maximum resultant speed based on an unpowered free-fall from the maximum attainable altitude, whichever is higher. If parachutes are used as a mitigation, the critical speed is defined in Annex A1.

3.4 *Acronyms and Abbreviations:*

3.4.1 *AIS*—abbreviated injury scale

3.4.2 *ARC*—advisory rulemaking committee

3.4.3 *ASSURE*—Alliance for System Safety of UAS through Research Excellence

3.4.4 *ATD*—anthropomorphic test device; a crash test dummy

3.4.5 *CAA*—civil aviation authority

3.4.6 *CFC*—channel frequency class

3.4.7 *CONOPS*—concept of operations

3.4.8 *DAQ*—data acquisition

3.4.9 *IARV*—injury assessment reference values

3.4.10 *KE*—kinetic energy

3.4.11 *MPWC*—most probable, worst case

3.4.12 *NHTSA*—National Highway Traffic Safety Administration

3.4.13 *NIAR*—National Institute for Aviation Research at Wichita State University

3.4.14 N_{ij}—neck injury criteria

3.4.15 *NPRM*—notice of proposed rulemaking

3.4.16 *OEM*—original equipment manufacturer

3.4.17 *PMHS*—post mortem human surrogate

3.4.18 *PPE*—personal protective equipment

3.4.19 *sUA*—small unmanned aircraft; the flying aircraft only

3.4.20 *sUAS*—small unmanned aircraft system; an sUA and its associated elements (including communication links and the components that control the sUA) that are required for the safe and efficient operation of the sUA in a national airspace system.

3.4.21 *UAH*—The University of Alabama in Huntsville

4. Summary of Test Method

4.1 This test method describes four methods for assessment of the safety of an sUA to assess injury potential associated

[2] 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.

[3] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

[5] Available from National Highway Traffic Safety Administration (NHTSA), 1200 New Jersey Ave., SE, Washington, DC 20590; described in http://www.nhtsa.gov/cars/rules/import/FMVSS/#SN208.

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

[7] Available from GlobalAutoRegs, https://globalautoregs.com/rules/105-occupant-protection-in-frontal-collisions.