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Standard Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS)[1]

This standard is issued under the fixed designation F2911; 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.

ε[1] NOTE—Corrected title editorially in March 2014.

1. Scope

1.1 This standard defines the production acceptance requirements for a small unmanned aircraft system (sUAS).

1.2 This standard is applicable to sUAS that comply with design, construction, and test requirements identified in Specification F2910. No sUAS may enter production until such compliance is demonstrated.

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:*[2]

F2585 Specification for Design and Performance of Pneumatic-Hydraulic Unmanned Aircraft System (UAS) Launch System

F2908 Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)

F2909 Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)

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

F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

F3005 Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS. The builder of kit built systems provided by a manufacturer must conform to the manufacturer's assembly and test instructions without deviation in order for that kit-built system to meet this standard.

3.1.2 *propulsion system, n*—consists of one or more power plants (for example, a combustion engine or an electric motor and, if used, a propeller or rotor) together with the associated installation of fuel system, control and electrical power supply (for example, batteries, electronic speed controls, fuel cells, or other energy supply).

3.1.3 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the UA and the control station. For purposes of this standard sUAS is synonymous with a small Remotely Piloted Aircraft System (sRPAS) and sUA is synonymous with a small Remotely Piloted Aircraft (sRPA).

3.1.4 *supplier, n*—any entity engaged in the design and production of components (other than a payload which is not required for safe operation of the sUAS) used on a sUAS.

3.1.4.1 *Discussion*—Where the supplier is not the manufacturer, the supplier can only ensure that the components comply with accepted consensus standards.

3.2 *Shall versus Should versus May*—Use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold values, test methods, oversight, reference to other standards). "Should" statements are provided as guidance towards the overall goal of improving safety, and could include only subjective statements. "Should" statements also represent parameters that could be used in safety evaluations, and could lead to development of future requirements. "May" statements

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[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.

are provided to clarify acceptability of a specific item or practice, and offer options for satisfying requirements.

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace defined by a nation's governing aviation authority (GAA). It is assumed that a visual observer(s) will provide for the sense-and-avoid requirement to prevent collisions with other aircraft and that the maximum range and altitude at which a sUAS can be flown will be specified by the nation's GAA. Unless otherwise specified by a nation's GAA this standard applies only to UA that have a maximum take off gross weight of 55 lb/25 kg or less.

5. Requirements

5.1 *Production:*

5.1.1 *General:*

5.1.1.1 The manufacturer is responsible for a product that complies with accepted consensus standards at the time of delivery and is demonstrated as fit and safe for flight. For sUAS assembled from components provided by a supplier, the supplier shall provide detailed instructions to the manufacturer concerning the assembly and test of those components. The components supplied by a supplier shall include a declaration that the components have been designed and manufactured in accordance with an accepted consensus standard and that the components, when assembled, tested, and maintained in accordance with the supplier's instructions, meet the safety standards implied by the applicable consensus standards. If required by a nation's GAA, the manufacturer/supplier shall also comply with any requirements for compliance with any applicable technical standard orders for specific components or systems, or both.

5.1.1.2 The manufacturer is responsible for ensuring that the sUAS has been assembled in accordance with the component supplier's instructions and complies with Specification F2910.

5.1.1.3 *Compliance with Quality Assurance Standard*—Quality assurance shall be exercised across production in accordance with Specification F3003.

5.1.2 *Structure*—sUAS airframe structures shall meet the requirements specified in Specification F2910. sUAS structures using materials that have no applicable certified material characteristics shall be demonstrated to be suitable for the mission involved.

5.1.2.1 *Material procurement*—Components used shall be consistent and uncontrolled variation or substitution shall be avoided.

5.1.2.2 *Assembly practices*—Consistent, accepted practices and assembly using materials such as epoxy, CA cements, shall be applied in accordance with product supplier's data sheets for safety and acceptable results.

5.1.2.3 *Tooling*—Molds, tooling, and jigs shall be used that produce an airframe which conforms to the engineering design in terms of part fit, assembly tolerances, defect size, and other requirements documented in the design.

5.1.2.4 *Fastening and joining*—Mechanical components such as fittings, pushrods, rotor structures and fittings shall be properly secured using safety wire, thread locking adhesives, crimping, welding or other effective means of restraining mechanical components.

5.1.2.5 *Lubrication*—Where lubrication of fittings is used, the manufacturer shall ensure that the lubricant used is appropriate to the application, thermal range and predicted load.

5.1.3 *Propulsion:*

5.1.3.1 *Motor/engine mounting*—Consistent, accepted practices and assembly using materials such as epoxy, CA cements, and the like shall be applied in accordance with product supplier's data sheets for safety and acceptable results.

5.1.3.2 *Security*—Motor/engine/propeller mounting shall be verified to meet manufacturer/supplier specified torque levels and security.

5.1.3.3 *Dynamic balancing*—Prior to installation, propellers or rotors or rotor blades shall be statically and dynamically balanced per design specification.

5.1.3.4 *Propulsion batteries*—For electric propulsion systems, provisions in Specification F3005 shall apply.

5.1.4 *Systems*—Systems that can be shown not to be impacted by, or to impact on, other subsystems may be demonstrated independent of all-up functional verification of systems. For example, a launch sub system that has no interface with the flight control system may be demonstrated to meet functionality with an airframe or a dummy airframe.

5.1.5 *Payload:*

5.1.5.1 *Physical*—Payload(s) shall be mounted in the manner specified by the sUAS design or manufacturer's instructions (or both) with attention given to proper shock and vibration attenuations. Current draw from primary power systems (batteries, generators, and so forth) shall be verified during production and functionality of circuit protection and fusing shall also be verified. If the manufacturer allows payloads to be installed post-production, then specific requirements for the design installation, and test of these type payloads shall be specified in the aircraft flight manual developed in accordance with Specification F2908 or the maintenance and continued airworthiness documentation developed in accordance with Practice F2909. Maximum safe gross weight of the system shall be determined and payload weight shall not result in a gross weight that exceeds maximum determined safe gross weight.

5.1.5.2 *Effect on CG location*—Payloads shall be located as specified by the sUAS designer and center of gravity for each aircraft shall be verified with payload installed. This shall include center of gravity changes due to fuel consumption or in-flight offloaded payloads, or both.

5.1.5.3 *Accountability for system design changes*—No change in physical location of components may be made without engineering definition of the impact of such change on flight performance or electronic or electrical compatibility of command and control systems that are impacted by such change. Where a change in systems performance is predicted for such physical change, the change shall be validated to ascertain that system functionality will remain within specification limits. When such changes are made to accommodate issues such as unavailability of parts or material, those changes shall be documented in an engineering change order (ECO)

using manufacturer's normally accepted format and processing/storage procedures.

5.1.6 *Ground Support Equipment:*

5.1.6.1 *Control station*—The control station may be as simple as a commercial off the shelf transmitter or as complex as a mobile shelter complete with control displays, C2 link receivers, warning devices, recording equipment, battery charging, independent electrical power and so forth. Whatever the production system, it shall be demonstrated as part of production acceptance to comply with the specifications of the system design and integration and supplier's specifications for the equipment used. The requirement is to ensure a consistent, known configuration that does not introduce errors in operation of the sUAS that can lead to degradation of the system or sUAS flight safety. Production verification shall include verification of the product for each control station produced to ensure that the sUAS will be controlled as required to comply with sUAS operational standards consistently.

5.1.6.2 *Launch and recovery systems (if required)*—The launch and recovery system may be as simple as hand launch or as complex as a bungee, pneumatic or hydraulic launcher. Whatever the production system, it shall be demonstrated to comply with the specifications of the system design and integration and suppliers specifications for the equipment used. The requirement is to ensure a consistent, known configuration that does not introduce errors in operation of the sUAS that can lead to system degradation, crew safety or sUAS flight safety. Production verification shall include verification of the product for each launch and recovery system produced to ensure that the sUAS will be launched safely within the launch envelope specified by manufacturer If applicable the launch system shall meet the requirements of F2585.

5.1.7 *System Level:*

5.1.7.1 *Configuration management plan*—The sUAS manufacturer shall develop a configuration management plan to ensure that a standard configuration for each sUAS is established and maintained and to provide objective evidence of production conformance to specifications and continued effectiveness of the quality management system.

5.1.7.2 *Product specification*—The sUAS characteristics shall be documented in a product specification in the manufacturer's normal accepted format. In this specification, the sUAS standard configuration shall be defined to provide a basis for product verification testing.

5.1.7.3 *Product verification plan*—A product verification plan shall be developed to ensure the following activities are included in the formal verification testing of the sUAS required in 5.1.7.4.

(1) Engineering design—The production of the sUAS shall be based on the standard configuration report and released engineering data (that is, drawings, processes, specifications, and so forth) in the manufacturer's normal accepted format that are specifically associated with that configuration. Design modifications required to meet production contingencies shall be documented in an ECO for that change and the change shall be identified by serial number block.

(2) Assembly instructions—Appropriate assembly instructions in the manufacturer's normal accepted format shall be used to assure the uniformity and repeatability of production processes.

(3) Tooling—Tooling appropriate to the sUAS design shall be used to assure control of critical dimensions and the repeatability of production from unit to unit.

(4) Material inspection—Manufacturers shall ensure that suppliers of material items (raw material, components, and assemblies) are in compliance with consensus standards for those material items. Incoming materials and equipment to be installed in the sUAS shall be inspected for proper configuration and quality of workmanship before their use. Inspections may be performed at the supplier's location or the manufacturer's location or both.

(5) In-process inspection—When appropriate, subassemblies of the sUAS shall be inspected (for proper configuration and quality of workmanship) before installation into the next higher assembly. Production plans shall delineate product flow with appropriate in-process inspection points identified.

5.1.7.4 *Design validation*—A formal validation of the sUAS component or system design shall be performed by the sUAS supplier or manufacturer in accordance with requirements in Specification F2910.

5.2 *System Level Production Acceptance:*

5.2.1 *Production In-Process Tests*—Major subassemblies of each sUAS shall be tested (as appropriate) to verify proper operation before their installation into the next higher assembly. These subassemblies can include, but are not necessarily limited to, the following:

5.2.1.1 *Structure*—Structures validated during engineering development and prototyping need be revalidated only if design changes or material and process changes are introduced that have not been validated during development and flight test of the design. In those instances, the segment of test for the structure that is affected by the design or material change shall be revalidated using the same procedure used during development.

5.2.1.2 *Propulsion*—The manufacturer shall subject a statistical sample of each serial block or model line of propulsion components to performance testing that validates that the propulsion system meets the supplier's stated performance.

5.2.1.3 *C2 links*—A production plan shall be generated and enforced by the manufacturer that ensures that all links involved are determined by production acceptance to meet the manufacturer's specification and the design requirements for the specific mission involved.

5.2.1.4 *Data link*—When a downlink is used to transmit information that is not necessary for command and control, that the link shall be tested to prove that it does not degrade primary flight control.

5.2.1.5 *Payload*—When a payload is used to generate the information or action needed for commercial function, any electric, thermal, or active payload shall be tested in the simulated operational environment to prove that the payload does not degrade primary flight control.

5.2.2 *Production Final Acceptance Test:*

5.2.2.1 The manufacturer shall test at least the first article sUAS in accordance with Specification F2910 to confirm that the design requirements and design operational capabilities are achieved in the final production systems. In this process, each design requirement shall be verified and the verification documented in the manufacturer's normal accepted format. This product verification shall be repeated for any major modification to the sUAS. If allowed or required by the nation's GAA, these product verification tests can also be performed by an independent entity.

5.2.2.2 All major components (air vehicle, control stations, launch and recovery equipment [if applicable], and the like) of the sUAS shall be tested by the manufacturer to ensure proper operation before shipment and operational use. Where major components are tested separately procedures shall be developed and implemented to ensure compatibility and proper function after shipment but before operational use. Testing of every production unit for range is not necessary since this is verified in the design, construct, and test phase.

5.3 *Quality Assurance*—Quality assurance shall be exercised across production in accordance with Specification F3003.

5.4 *Documentation:*

5.4.1 *General:*

5.4.1.1 *Configuration management plan*—A configuration management plan for use during production shall be prepared in the manufacturer's normal accepted format. The purpose of this plan is to ensure that consistency of the configuration of the sUAS in production is maintained.

5.4.1.2 *Aircraft flight manual*—An aircraft flight manual shall be prepared for each type sUAS. This document shall be prepared in accordance with Specification F2908.

5.4.1.3 *Maintenance and continued airworthiness documentation*—If not included in the aircraft flight manual, documentation that addresses maintenance and continued airworthiness shall be prepared in accordance with Practice F2909.

5.4.1.4 *Other maintenance manuals*—Other manuals may be prepared if desired or required by the manufacturer or nation's GAA or both. If such documents are required or desired they may be prepared in the manufacturer's normal accepted format.

5.4.2 *Production:*

5.4.2.1 *Standard configuration report*—A standard configuration report shall be prepared in the manufacturer's normal accepted format for each sUAS in accordance with section 5.1.7.1.

5.4.2.2 *Product specification*—A product specification shall be prepared in the manufacturer's normal accepted format in accordance with 5.1.7.2.

5.4.2.3 *Product verification plan*—A product verification plan shall be prepared in the manufacturer's normal accepted format for each sUAS in accordance with 5.1.7.3.

5.4.2.4 *Product verification report*—A product verification report that shows the results of product verification shall be prepared in the manufacturer's normal accepted format for each sUAS.

5.4.2.5 *As-built logs*—An "as-built log" shall be prepared in the manufacturer's normal accepted format for each delivered sUAS. In the log, the part number, name and serial number of each system configuration item shall be recorded. These records shall be retained by the supplier or manufacturer as long as the sUAS is in operational service. When a block of serial numbered sUAS are produced to the same specifications against the four documents listed immediately above, one as-built log will suffice for the block.

5.4.3 *Test:*

5.4.3.1 *Production in-process test report*—A production in-process test report for each delivered sUAS shall be prepared in the manufacturer's normal accepted format.

5.4.3.2 *Production final acceptance test report*—A production acceptance test report shall be prepared in the manufacturer's normal accepted format for each delivered sUAS in accordance with 5.2.2. These records shall be retained by the manufacturer as long as the sUAS is in operational service.

5.4.4 *Quality Assurance:*

5.4.4.1 *QA plan*—A QA plan for use during production shall be prepared in accordance with Specification F3003.

6. Keywords

6.1 production; small unmanned aircraft system; sUAS