



Designation: F3316/F3316M – 19

Standard Specification for Electrical Systems for Aircraft with Electric or Hybrid- Electric Propulsion¹

This standard is issued under the fixed designation F3316/F3316M; 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 specification covers the electrical systems, electrical equipment, and electrical power distribution aspects of airworthiness and design for aircraft with Electric or Hybrid-Electric Propulsion. This specification was written with the focus on electric propulsion systems with conventional system layout, characteristics, and operation. This specification does not address all of the requirements that may be necessary for possible hybrid-electric configurations where an EPU and a combustion engine are used in combination to provide propulsion. The use of this specification combined with the applicable portions of Specification **F2331/F2331M** may be necessary for hybrid-electric configurations. This material was developed through open consensus of international experts in general aviation. This material was created by focusing on Normal Category Aeroplanes. The content may be more broadly applicable; it is the responsibility of the applicant to substantiate broader applicability as a specific means of compliance.

1.2 An applicant intending to propose this information as a means of compliance for design approval shall seek guidance from their respective oversight authority (for example, published guidance from applicable CAAs) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this standard (in whole or in part) as a Means of Compliance to their regulatory requirements (Hereinafter referred to as “the Rules”), refer to ASTM F44 webpage (www.ASTM.org/COMMITTEE/F44.htm).

1.3 *Units*—This standard may present information in either SI units, English Engineering units, or both. 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 This specification is under the jurisdiction of ASTM Committee **F44** on General Aviation Aircraft and is the direct responsibility of Subcommittee **F44.50** on Systems and Equipment.

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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 ASTM Standards:²

F2490 – 05 Standard Guide for Aircraft Electrical Load and Power Source Capacity Analysis

F2639 Practice for Design, Alteration, and Certification of Aircraft Electrical Wiring Systems

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Small Aircraft

F3066/F3066M Specification for Aircraft Powerplant Installation Hazard Mitigation

F3231/F3231M Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation

F3235 Specification for Aircraft Storage Batteries

F3239 Specification for Aircraft Electric Propulsion Systems

F3338 Specification for Design of Electric Propulsion Units for General Aviation Aircraft

2.2 FAA Standard:³

DOT/FAA/AR-00/12 Aircraft Materials Fire Test Handbook

3. Terminology

3.1 Terminology specific to this specification is provided below. For general terminology, refer to Terminology **F3060**.

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 Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, <http://www.faa.gov>.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *aircraft type code, n*—an Aircraft Type Code (ATC) is defined by considering both the technical considerations regarding the design of the aircraft and the airworthiness level established based upon risk-based criteria; the method of defining an ATC applicable to this specification is defined in Specification **F3061/F3061M**.

3.2.2 *continued safe flight and landing, n*—continued safe flight and landing as applicable to this specification is defined in Specification **F3061/F3061M**.

3.2.3 *Battery Management System (BMS)*—a battery management system is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it or balancing it, or both.

3.2.4 *Electric Propulsion Unit (EPU)*—a minimum EPU is comprised of the electric motor, associated electronic controllers, disconnects, wiring, and sensors.

3.2.4.1 *Discussion*—See Specification **F3338** for additional information.

3.2.5 *Energy Storage System (ESS)*—a source (component or system) that stores and provides energy that can be drawn upon for propulsion.

3.2.5.1 *Discussion*—See Specification **F3239** for additional information.

3.3 Abbreviations:

3.3.1 *BMS*—Battery Management System

3.3.2 *EPS*—Electric Propulsion System

3.3.3 *EPU*—Electric Propulsion Unit

3.3.4 *ESS*—Energy Storage System

4. Electrical Systems for Electric Propulsion

NOTE 1—**Table 1** provides correlation between various Aircraft Type Codes and the individual requirements contained within this section; refer to **3.2.1**. For each subsection, an indicator can be found under each ATC character field; three indicators are used:

An empty cell () in all applicable ATC character field columns indicates that an aircraft shall meet the requirements of that subsection.

A white circle (○) in multiple columns indicates that the requirements of that subsection are not applicable to an aircraft *only* if all such ATC character fields are applicable.

A mark-out (×) in any of the applicable ATC character field columns indicates that the requirements of that subsection are not applicable to an aircraft if that ATC character field is applicable.

Example—An aircraft with an ATC of 1SRLLDLN is being considered. Since all applicable columns are empty for **4.2.1**, that subsection is applicable to the aircraft. Since both the “L” stall speed column and the “D” meteorological column for **4.1.1.2** contain white circles, then that subsection is not applicable; however, for an aircraft with an ATC of 1SRMLDLN, **4.1.1.2** would be applicable since the “M” stall speed column does not contain a white circle.

4.1 Power Source Capacity and Distribution:

4.1.1 Each installation whose functioning is required for type certification or under operating rules and that requires a power supply is an “essential load” on the power supply. The power sources and the system shall be able to supply the power loads specified in **4.1.1.1 – 4.1.1.3** in probable operating combinations and for probable durations. The power loads may

be assumed to be reduced under a monitoring procedure consistent with safety in the kinds of operation authorized.

4.1.1.1 The power sources and the electrical distribution system, when functioning normally, shall be able to support all connected loads.

4.1.1.2 The power sources and the electrical distribution system shall be able to support all essential loads after the failure of any one ESS or primary electrical power source. An EPU designed to be connected to only one ESS is excluded from this requirement.

4.1.1.3 The power sources and the electrical distribution system shall be able to support all essential loads for which an alternate source of power is required, after any failure or malfunction in any one ESS, any one power supply system, any one distribution system, or any other utilization system. An EPU designed to be connected to only one ESS is excluded from this requirement.

4.1.2 The power source and the electrical distribution system used to satisfy the probable duration requirement of **4.1.1** is required to provide electrical power to those loads that are essential to continued safe flight and landing including non-continuous essential loads with enough capacity to meet the requirements of either **4.1.2.1**, **4.1.2.2**, or **4.1.2.3** as appropriate per **Table 1**.

4.1.2.1 The time needed to complete the function required, for continued safe flight and landing.

4.1.2.2 A time period of at least 30 minutes which includes the time to recognize the loss of primary power and to take appropriate load shedding action.

4.1.2.3 A time period of at least 60 minutes which includes the time to recognize the loss of primary power and to take appropriate load shedding action.

4.1.3 The electrical capacity duration requirement of **4.1.2** shall be demonstrated by test or analysis including all loads essential for continued safe flight and landing.

4.2 Electrical Systems and Equipment:

4.2.1 Electric power sources, their transmission cables, and their associated control and protective devices, shall be able to furnish the required power at the proper voltage and frequency, if applicable to each load circuit essential for safe operation and maintained within the limits for which the equipment is designed during any probable operating conditions.

4.2.2 Compliance with **4.2.1** shall be shown by an electrical load analysis or by electrical measurements that account for the electrical loads applied to the electrical system in probable combinations and for probable durations.

NOTE 2—Guide **F2490** provides information and methodology for an electrical load analysis.

4.2.3 Each electrical system, when installed, shall be free from hazards in itself, in its method of operation, and in its effects on other parts of the aeroplane.

4.2.4 Each electrical system, when installed, shall be protected from fuel, oil, water, other detrimental substances, and mechanical damage.

4.2.5 Each electrical system, when installed, shall be designed so that the risk of electrical shock to crew, passengers, and ground personnel is reduced to a minimum.