



Designation: F3316/F3316M – 18

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 material was developed through open consensus of international experts in general aviation. This material was created by focusing on Normal Category Airplanes. 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 must 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 may not be exact equivalents. Each system shall be used independently of the other; combining values from the two systems may result in nonconformance with the standard.

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.*

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.

Current edition approved May 15, 2018. Published June 2018. DOI: 10.1520/F3316_F3316M-18.

2. Referenced Documents

2.1 *ASTM Standards*:²

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

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Small Aircraft

F3066/F3066M Specification for Aircraft Powerplant Installation Hazard Mitigation

F3235 Specification for Aircraft Storage Batteries

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.

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 System (EPS)*—installation that includes at least one EPU and hardware required to produce

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>.

propulsive thrust. Multiple EPU's may be in different arrangements such as serial or parallel or a combination of the two.

3.2.5 Electric Propulsion Unit (EPU)—the EPU shall as a minimum consist of the electric motor, associated controllers disconnects and wiring, motor generator, and monitoring gauges and meters.

3.2.6 Energy Storage System (ESS)—any manner that stores some form of energy that can be drawn upon at a later time to provide energy for propulsion. Typical energy storage devices include but are not limited to: batteries, fuel cells, or capacitors.

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 must 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** contain white circles, then that subsection is not applicable; however, for an aircraft with an ATC of 1SRMLDLN, **4.1.1** 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 must 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, must be able to support all connected loads.

4.1.1.2 The power sources and the electrical distribution system must 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 must 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 to continued safe flight.

4.2 Electrical Systems and Equipment:

4.2.1 Electric power sources, their transmission cables, and their associated control and protective devices, must 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** must 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, must 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, must be protected from fuel, oil, water, other detrimental substances, and mechanical damage.

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

4.2.6 Electric power sources must function properly when connected in combination or independently.

4.2.7 No failure or malfunction of any electric power source may impair the ability of any remaining source to supply load circuits essential for safe operation.

4.2.8 Each electrical system must be designed so that essential load circuits can be supplied in the event of reasonably probable faults or open circuits including faults in heavy current carrying cables.

4.2.9 A means must be accessible in flight to the appropriate flight crewmembers for the individual and rapid disconnection of the electrical power sources from the distribution system which includes the distribution busses, their associated feeders, each control device, and each protective device.