



Designation: F3338 – 21

Standard Specification for Design of Electric Engines for General Aviation Aircraft¹

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1. Scope

1.1 This specification covers minimum requirements for the design of electric engines.

1.2 Distributed propulsion is not excluded; however, additional requirements will be needed to address the additional issues that distributed propulsion can create. Some of those issues may include: use of a common motor controller/inverter, segregated electric harnesses, cooling systems, electric power supplies, and others.

1.3 This specification does not address all of the requirements that may be necessary for possible hybrid configurations where an electric engine and a combustion engine drive a common thruster. This specification may be used for the electric engine aspects with supplemental requirements for the thruster and the combustion engine.

1.4 Although this specification does not include specific requirements for electric engines that include gearboxes, thrusters, or any energy storage systems, it also does not preclude such capabilities. This specification may be used for the base electric engine aspects of the design, with supplemental requirements for any additional features prepared by the manufacturer and submitted to the Civil Airworthiness Authority for acceptance. This version of this ASTM specification also does not address all of the requirements necessary for configurations of motor driven ducted-fans. It is anticipated that the fan would be subject to parts of 14 CFR 33 or CS-E and/or 14 CFR 35 or CS-P, or equivalent, in particular blade-off and bird strike. These would be conducted on the fan as a unit (including motor) rather than on motor or fan alone.

1.5 The applicant for a design approval should seek the individual guidance of their respective civil aviation authority (CAA) body concerning the use of this specification as part of a certification plan. For information on which CAA regulatory bodies have accepted this specification (in whole or in part) as a means of compliance to their general aviation aircraft airworthiness regulations (hereinafter referred to as “the

Rules”), refer to ASTM Committee F39 webpage (www.ASTM.org/COMITTEE/F39.htm), which includes CAA website links.

1.6 When applicable, this specification may be used for electric engines with a fixed-pitch propeller or fan. These configurations may be type-certificated as an electric engine including a thruster. There may be additional requirements not currently included in this specification for this type configuration. In addition, 5.25 is included as a test requirement for the electric engine. That section recognizes that when the electric engine does not have an integral thruster it will need to be tested with a representative load on the drive shaft to ensure the engine’s ability to operate properly with static and dynamic loads.

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *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.*

1.9 *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 Standard:

F3060 Terminology for Aircraft

2.2 Code of Federal Regulations:²

14 CFR 33 Airworthiness Standards: Aircraft Engines

14 CFR 35 Airworthiness Standards: Propellers

2.3 EASA Standards:³

CS-E Engines

CS-P Propellers

¹ This specification is under the jurisdiction of ASTM Committee F39 on Aircraft Systems and is the direct responsibility of Subcommittee F39.05 on Design, Alteration, and Certification of Electric Propulsion Systems.

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² Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, <http://www.gpo.gov>.

³ Available from European Aviation Safety Agency (EASA), Postfach 10 12 53, D-50452 Cologne, Germany, <http://www.easa.europa.eu>.

2.4 IEC Standards:⁴

IEC 60034-1 Rotating electrical machines – Part 1 Rating and performance

IEC 60349-4 Electric traction – Rotating electric machines for rail and road vehicles – Part 4: Permanent magnet synchronous electrical machines connected to an electronic converter

2.5 SAE Standard:⁵

SAE J245 Engine-Rating Code~Spark Ignition

3. Terminology

3.1 Terminology specific to this specification is provided below. For general terminology, refer to ASTM F3060, Standard Terminology for Aircraft.

3.2 Definitions:

3.2.1 *duty types, n*—

3.2.1.1 *non-periodic duty, n*—in which generally load and speed vary within the permissible operating range.

3.2.1.2 *periodic duty, n*—comprising one or more loads remaining constant for the duration specified.

3.2.2 *electric engine, n*—A type of aircraft engine that converts electric power into mechanical power or thrust used for propulsion, including those components necessary for proper control and functioning.

3.2.2.1 *Discussion*—In the context of this specification, the minimum essential components of an electric engine are an electric motor and its associated motor controller(s), disconnect(s), wiring, and sensor(s). Other components and accessories necessary for proper control and function are typically considered part of the engine; for example: inverters, liquid cooling components, liquid lubrication components, thrusters, etc.

3.2.3 *energize, v*—the act of connecting the electric engine to the electrical power source such that the engine enters a ready state where throttle input results in shaft rotation. De-energize is the opposite of energize.

3.2.4 *hazardous electric engine effects, n*—the following effects are regarded as hazardous electric engine effects:

- (1) Non-containment of high-energy debris;
- (2) Significant brake power in the opposite direction to that commanded by the pilot;
- (3) Uncontrolled fire;
- (4) Failure of the engine mount system leading to inadvertent engine separation;
- (5) Release of the propeller or fan or any major portion of the propeller or fan by the engine, if applicable;
- (6) Complete inability to shut the engine down; and
- (7) The serious or fatal injury to flight crew, passengers, or ground-handling personnel arising from electric shock.

3.2.5 *inverter, n*—a power electronic device or circuitry that changes direct current (DC) to alternating current (AC). The motor controller is often integrated with the inverter.

3.2.6 *motor, n*—a machine that converts electrical power into rotational mechanical power.

3.2.7 *motor controller, n*—a device or devices that serves to manage the operation of an electric motor.

3.2.7.1 *Discussion*—It could include a manual or automatic means for energizing, starting or stopping the motor, selecting direction of rotation, selecting and regulating motor speeds, regulating or limiting the torque, and protecting against overloads and faults. The inverter is often integrated with the motor controller.

3.2.8 *rated maximum continuous power, n*—with respect to an electric engine, the approved brake power that is developed statically or in flight, in standard atmosphere at a specified altitude, within the engine operating limitations established under CAA requirements, and approved for unrestricted periods of use.

3.2.8.1 *Discussion*—Brake power is defined in SAE J245 as the power available at the flywheel or other output member(s) for doing useful work.

3.2.9 *rated takeoff power, n*—with respect to electric engine type certification, the approved brake horsepower that is developed statically under standard sea level conditions, within the engine operating limitations established under CAA requirements, and limited in use to periods of not over 5 min for takeoff operation.

3.2.10 *shaft power, n*—the brake power delivered at an engine's drive shaft.

3.2.10.1 *Discussion*—References to electrical power are called out as such.

3.2.11 *thrust, n*—The propulsive force generated by the aircraft engine that is used to move an aircraft through the air.

3.2.11.1 *Discussion*—As used in this specification, applies to endurance, durability, and systems tests.

3.2.12 *thruster, n*—as used in this specification, a device such as propeller, rotor, or fan for translating mechanical/rotational energy to thrust.

3.3 Abbreviations:

3.3.1 *EMI*—electromagnetic interference

3.3.2 *HIRF*—high-intensity radiated field

4. Significance and Use

4.1 This specification provides designers and manufacturers of electric propulsion for General Aviation aircraft references and criteria to use in designing and developing electric engines with the intent of gaining approval from a civil aviation authority.

4.2 **Appendix X1** provides additional (but not necessarily all) information and guidance to meet certification or airworthiness requirements, or both, for a particular country or area under the jurisdiction of a civil aviation authority.

5. Requirements in Support of Certification or Approval

5.1 Instructions for Continued Airworthiness:

5.1.1 Instructions for the continued airworthiness of the electric engine must be prepared. The instructions may be incomplete at the time of certification or approval:

⁴ Available from International Electrotechnical Commission (IEC), 3, rue de Varembe, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, <http://www.iec.ch>.

⁵ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.