



Designation: F2689 – 08

Standard Practice for Design and Manufacture of Reciprocating Spark Ignition Engines for Unmanned Aircraft Systems¹

This standard is issued under the fixed designation F2689; 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 practice covers *minimum* requirements for the design and manufacture of reciprocating spark ignition engines for unmanned aircraft systems.

1.2 *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 *RTCA Standard:*²

RTCA DO-178B Software Considerations in Airborne Systems and Equipment Certification

3. Significance and Use

3.1 This practice provides designers and manufacturers of engines for unmanned aircraft systems design requirements and criteria to use in designing and manufacturing engines.

3.2 Declaration of compliance is based on testing and documentation during the design and testing or flight testing of the engine type by the manufacturer or under the manufacturers' guidance.

3.3 Compliance with this specification is intended to demonstrate an adequate level of reliability in accordance with the UAS safety objectives.

4. Engine Model Designation

4.1 *Engine Parts List*—A parts list is required for each engine model qualified in accordance with this specification.

4.2 *New Engine Model Designations:*

4.2.1 Each new engine model must be qualified in accordance with this practice.

4.2.2 Design or configuration changes that impact the installation interface, performance, or operability of the engine require a new engine model designation.

4.3 *Design Changes of Parts*—Each design change of a part or component of an engine model qualified to this specification should be to comply with the requirements of this specification.

5. Data Requirements

5.1 *Retained Data*—The following data and information should be retained on file at the manufacturer's facility for a minimum of 18 years after production is discontinued.

5.1.1 Drawings that define the engine configuration.

5.1.2 Material and process specifications referenced in the parts drawings.

5.1.3 Engineering analyses and test data prepared for qualification with this specification.

5.2 *Delivered Data*—The following data should be delivered to the airplane manufacturer to support design and operation of the applicable airplane.

5.2.1 An engine performance specification that defines the engine performance under all anticipated operating environments.

5.2.2 An installation manual that defines all functional and physical interface requirements of the engine. This should include an engine outline/installation drawing.

5.2.3 An operating manual that defines normal and abnormal operating procedures and any applicable operating limitations.

5.2.4 A maintenance manual that defines periodic installed maintenance, major inspection, overhaul intervals, and any other maintenance limitations.

5.2.5 An overhaul manual that provides instructions for disassembling the engine to replace or repair, or both, parts as required to return the engine to a condition that is safe for operation until the next major overhaul. A manufacturer may withhold an overhaul manual if they feels that a major overhaul cannot be done in the field with reasonable assurance that it can result in an safe for flight condition.

6. Design Criteria

6.1 *Materials*—The materials used in the engine must be adequate for the intended design conditions of the engine.

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² Available from RTCA, Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, www.rtca.org.

6.2 Fire Prevention—The design and construction of the engine and the materials used must minimize the probability of the occurrence and spread of fire by:

6.2.1 Using fire-resistant lines, fittings, and other components that contain a flammable liquid when supplied with the engine; and

6.2.2 Shielding or locating components to safeguard against the ignition of leaking flammable fluid.

6.3 Engine Cooling—The engine design must include provisions for cooling; and the installation manual required in **5.2.1** must specify engine and component temperature limitations.

6.4 Engine Mounting—The mounting point, fittings, and fasteners must meet or exceed the design load limits and that data must be retained.

6.5 Mechanical Ignition Systems—Each mechanical ignition system, must have a demonstrated reliability consistent with the application, or have redundancy with separate sources of electrical energy and an ignition system of equivalent in-flight reliability. System maintenance must be specified in the maintenance manual supplied by the manufacturer, in accordance with **5.2.4**.

6.6 Electronic Engine Controls (EEC)—Each engine which incorporates an Electronic Engine Control for control of the ignition, fuel flow or other critical engine parameters, must have a demonstrated reliability consistent with the application, must have maintenance specified in the maintenance manual supplied by the manufacturer, in accordance with **5.2.4**, and shall demonstrate compliance with the following criteria:

6.6.1 **Single Fault Tolerance**—The EEC shall be designed to mitigate single failures of the electrical circuits. Failure of any single electrical component shall not cause the loss of a critical function and shall not result in a significant power reduction, engine shut down or any unsafe condition.

6.6.2 **Environmental Effects**—The functioning of EECs must not be adversely affected by the environmental conditions of operation specified by the manufacturer, including temperature and moisture. The limits to which the system has been qualified shall be documented in the installation manual. For protection against radiated Electromagnetic Interference/High Intensity Radiated Fields (EMI/HIRF), the harness or cables should be shielded from each sensor to each end point and electrically bonded to the engine. All connections to the controller should be filtered to ground at the controller casing to attenuate both unwanted RF emissions and interference from external sources. These filters should not interfere with other electronic systems on-board the UAS.

6.7 Software and Programmable Logic Devices—Any system, component or sub-assembly which utilizes software, or firmware, shall demonstrate that the software or firmware has been developed in accordance with best industry practices generally accepted by the aviation industry. RTCA DO-178B would be an acceptable standard for use.

6.8 Complex Electronic Hardware—Any system, component or sub-assembly which utilizes complex electronic hardware shall demonstrate that the hardware has been developed

in accordance with best industry practices generally accepted by the aviation industry.

6.9 Fuel and Induction System:

6.9.1 **Induction System Icing**—The fuel and air intake passages must be designed to minimize the accretion of ice.

6.9.2 **Filtering**—The type and degree of fuel and air filtering necessary to prevent obstruction of air or fuel flow must be specified in the installation manual as required by **5.2.2**.

6.9.3 **Liquid Lock**—Each passage in the induction system that conducts a mixture of fuel and air must be self-draining or demonstrated to not cause damage from hydraulic lock on starting.

6.10 Lubrication System:

6.10.1 The lubrication system of the engine must be designed and constructed so that it will function properly in all flight attitudes and atmospheric conditions in which the engine is expected to operate. In wet sump engines, this requirement must be met when only one-half of the maximum lubricant supply is in the engine.

6.10.2 The lubrication system of the engine must be designed and constructed to allow installing a means of cooling the lubricant if required.

6.10.3 The crankcase on four-stroke engines must be vented to the atmosphere to preclude leakage of oil from excessive pressure in the crankcase. This venting must have a means to prevent the blockage of the vent by ice.

6.11 Vibration General—The engine must be designed and constructed to function throughout its normal operating range of crankshaft rotational speeds and engine powers without inducing excessive stress in any of the engine parts.

6.11.1 The engine design must consider the effects of the installed environment with a representative propeller or in helicopter applications allow the use of a flywheel or a cooling fan, or both. The engine design limitations must not be exceeded when a representative appliance is installed.

7. Qualification Tests

7.1 Calibration Test—Each engine design must be tested to such that the characteristics of engine rated power, speeds, and fuel consumption can be determined.

7.2 Detonation Test—Each engine can be tested to confirm that the engine will not detonate throughout its range of intended conditions of operation using the fuel which the designer/manufacturer has specified for the engine.

7.3 Durability Testing—Each engine model must be subjected to an engine test that will verify durability by one of the following methods.

7.3.1 **Accelerated Overhaul Test**—This test simulates an engine overhaul interval. A protocol for this test shall be proposed by the manufacturer and must be representative of the mission of the application for which the engine is intended.

7.3.2 **Endurance Testing**—In place of the accelerated overhaul test in **7.3.1**, the engine may complete endurance flight testing.