Designation: F 2538 – 07a

Standard Practice for Design and Manufacture of Reciprocating Compression Ignition Engines for Light Sport Aircraft[1]

This standard is issued under the fixed designation F 2538; 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 compression ignition engines for light sport aircraft, Visual Flight Rules (VFR) use.

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 Documents:*[2]

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

RTCA DO-254 Design Assurance Guidance for Airborne Electronic Hardware

2.2 *FAA Documents:*[3]

FAA AC 33.28–2 Guidance Material 14 CFR 33.28 Reciprocation Engines, Electrical and Electronic Control Systems

3. Significance and Use

3.1 This practice provides designers and manufacturers of engines for light sport aircraft design references 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 manufacturer's guidance.

4. Engine Model Designation

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

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 practice should be evaluated relative to the requirements of this practice.

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, and

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

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; this manual shall include instructions for use of appropriate engine monitoring gauges, electronic or otherwise.

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

5.2.5 If applicable (or if overhauls are authorized by the manufacturer), an overhaul manual that provides instruction for disassembling the engine to replace or repair, or both, parts as required to return the engine to airworthy condition that is safe for operation until the next major overhaul.

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[1] This practice is under the jurisdiction of ASTM Committee F37 on Light Sport Aircraft and is the direct responsibility of Subcommittee F37.70 on Cross Cutting.

Current edition approved May 1, 2007. Published June 2007. Originally approved in 2007. Last previous edition approved in 2007 as F 2538 – 07.

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

[3] Available from U.S. Department of Transportation, Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591. www.faa.gov

6. Design Criteria

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

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; the installation manual must specify engine and component temperature limitations.

6.4 *Engine Mounting*—Attach points on the engine must have data for the correct design of mounting structures to the airframe. The maximum allowable limit and ultimate loads for the engine mounting attachments and related structure must be specified.

6.5 *Ignition*—Reliable combustion must be achieved in all flight and atmospheric conditions in which the engine is expected to operate.

6.5.1 Limitations on restart at altitude must be established and documented in the operating manual.

6.5.2 The use of "glow plugs" or other starting aids must be established (if applicable) and documented in the operating manual.

6.6 *Electronic Engine Controllers (EEC)*:

6.6.1 *Essentially Single Fault Tolerance*—The EEC should be designed to accommodate single failures of the electrical circuit. Loss of any single EEC should not cause significant power reduction or engine stoppage.

6.6.2 The functioning of EECs must not be adversely affected by the declared environmental conditions of operation 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 EMI/HIRF, the harnesses or cables should be shielded from each sensor to each end point and electrically bonded to the engine. Filter pin connectors should be located at the controller housing interface and shunted to ground on the case. Filter pin connectors should have 40 dB attenuation, minimum. For EMI emissions, powerline filters suppress emissions from the controller on outgoing signals.

6.7 *Fuel and Induction System*:

6.7.1 *Fuel Lubricity*—If fuel system components rely on fuel as a lubricant, their proper function and service life must be established for the lowest lubricity fuel that will be encountered in service. This may be demonstrated during the qualification tests in Section 7 or by other means such as fuel system/component bench tests.

6.7.2 *Filtering*—The type and degree of fuel and air filtering necessary to prevent obstruction of air or fuel flow must be specified.

6.7.3 *Air Lock*—The degree of susceptibility to air in the fuel supply lines must be established. If return flow or purge lines are required, their provision must be documented in the installation manual.

6.8 *Lubrication System*:

6.8.1 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.

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

6.8.3 The crankcase 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.

6.9 *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.

6.9.1 The engine must have a crankshaft vibration survey to determine torsional and bending characteristics from idle speed up to maximum desired takeoff speed. This survey should be done with a representative propeller and no hazardous conditions would be allowed.

7. Qualification Tests

7.1 *Calibration Test*—Each engine design shall be tested and the characteristics of engine rated power, speeds, and fuel consumption shall be determined.

7.2 *Knocking/Misfire Test*—Each engine shall be tested on the lowest cetane number fuel likely to be encountered in service. Lack of off-load misfiring or excessive cylinder pressure due to delayed combustion (knocking), or both, must be demonstrated.

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 incorporate, as a minimum, the following elements:

7.3.1.1 At least 100 % of the time at maximum power that would occur over the overhaul interval.

NOTE 1—For calculation, each hour of normal flight would have 5 min of full power.

7.3.1.2 At least 10 % of the time at cruise power that would occur over the overhaul interval.

7.3.1.3 At least one cycle per hour of test from maximum power to cruise power and back.

7.3.1.4 At least one engine start for each 5 h of testing.

7.3.1.5 *For Air Cooled Engines*—During operation at maximum power, one cylinder must be maintained within 10°F of the limiting cylinder head temperature, the other cylinders must be operated at a temperature not lower than 50°F below the limiting temperature, and the oil inlet temperature must be maintained within 10°F of the limiting temperature.

7.3.1.6 The engine must be fitted with a propeller that thrust-loads the engine to the maximum thrust that the engine is designed to resist at each applicable operating condition specified in this section.