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Standard Specification for Design and Testing of Light Sport Aircraft Propellers[1]

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1. Scope

1.1 This specification covers the establishment of the minimum requirements for the design, testing, and quality assurance of fixed-pitch or ground adjustable propellers for light sport aircraft. These propellers are used on light aircraft, and could be used with engines conforming to Practice F2339.

1.1.1 When applying the additions provided in Appendix X1, this specification also covers the establishment of the minimum requirements for the design, testing and quality assurance of in-flight adjustable propellers for light-sport aircraft.

1.2 This specification is intended for use by manufacturers of propellers for light sport aircraft.

1.3 This specification does not address the airframe installation requirements for propellers.

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 and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2339 Practice for Design and Manufacture of Reciprocating Spark Ignition Engines for Light Sport Aircraft

3. Terminology

3.1 *Definitions:*

3.1.1 *blade, n*—the aerodynamic portion of a propeller which is rotated through and acts on the air.

3.1.2 *blade root, n*—the portion of the blade that interfaces with the hub and provides retention.

3.1.3 *conventional fixed pitch propeller, n*—a one-piece fixed pitch propeller that is constructed of material such as wood or metal that has no abrupt changes in material properties as the blades transition through the hub area.

3.1.3.1 *Discussion*—A propeller with wooden blades bonded to a metallic hub would not be conventional.

3.1.4 *fixed pitch propeller, n*—a propeller with no capacity for pitch setting adjustment.

3.1.5 *ground adjustable propeller, n*—a propeller whose pitch setting is adjustable only when the aircraft is on the ground and the propeller is not rotating.

3.1.6 *hub, n*—any device that retains the blades of a propeller assembly.

3.1.7 *pitch setting, n*—the propeller blade setting as determined by the blade angle measured in a manner, and at a radius, specified by the instruction manual for the propeller.

3.1.8 *propeller, n*—a device for propelling an aircraft that has blades on an engine-driven shaft and that, when rotated, produces by its action on the air, a thrust approximately perpendicular to its plane of rotation.

4. General

4.1 Each manufacturer who claims compliance to this specification must be able to show compliance with the applicable requirements of this specification.

4.2 Manufacturers must prepare and make available a list of acceptable engine-propeller combinations.

4.3 Manufacturers must prepare and make available an operating manual or manuals containing, at minimum, the following information:

4.3.1 An overall description of the propeller and its features.

4.3.2 The mass moment of inertia of the propeller about its rotational axis.

4.3.3 Instructions for installation of the propeller.

4.3.4 Instructions for operation of the propeller.

4.3.5 The maximum allowable engine power and rotational speed and any other propeller operating limitations found necessary by the manufacturer for the safe operation of the propeller.

4.3.6 For ground adjustable propellers, instructions for pitch adjustment and the minimum and maximum pitch settings allowed during operation.

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[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.

4.3.7 Instructions for removal of the propeller.

4.4 Each manufacturer must prepare and make available a maintenance manual. The maintenance manual is intended to provide for continued safe and proper operation of the propeller throughout its life cycle and contains, at minimum, the following content:

4.4.1 A maintenance schedule that provides the recommended periods at which the propeller should be cleaned, adjusted, inspected, and tested.

4.4.2 The applicable damage and wear allowances.

4.4.3 Any applicable maintenance and overhaul instructions, which include the following:

4.4.3.1 A list of tools needed.

4.4.3.2 Skills or training required for personnel performing the work.

4.4.3.3 Inspections required.

4.4.3.4 Details of repair and overhaul sequence and methods.

4.4.3.5 Applicable testing requirements.

4.4.4 If a manufacturer deems it necessary to set mandatory replacement intervals of propellers or propeller components, the details of this requirement shall be stated in a separate, clearly distinguishable section entitled Life Limitations.

5. Design and Construction

5.1 *Design Features*—The propeller may not have design features that have been shown to be hazardous or unreliable unless the suitability of each questionable design detail or part can be established by tests.

5.2 *Materials*—The suitability and durability of materials used in the propeller must:

5.2.1 be established on the basis of in-service experience or tests; and

5.2.2 conform to documented specifications that ensure that strength and other material properties consistently meet or exceed those used in the initial design and qualification testing.

5.3 *Durability*—Each part of the propeller must be designed and constructed with consideration of likely in-service damage and wear. The propeller must be able to operate normally between inspection and overhaul periods at the maximum damage and wear limits published in the maintenance manual.

5.4 *Ground-Adjustable Propellers*—The adjustment system of a ground-adjustable propeller must be designed such that no single failure or malfunction in that system during normal or emergency operation will result in unacceptable changes in propeller blade pitch setting. Failure of structural elements need not be considered if the occurrence of such a failure is expected to be extremely remote.

5.5 *Propeller Strength and Endurance*—Propellers must be shown to have satisfactory endurance as well as stresses that do not exceed values shown to be safe for continuous operation in accordance with the applicable requirements of Section 6, Tests and Inspections.

6. Tests and Inspections

6.1 *General:*

6.1.1 Each manufacturer must be able to show that the propeller concerned can complete the applicable tests and inspections of this section without evidence of failure or malfunction.

6.1.2 The minimum applicable testing and inspection requirements are outlined in Table 1 according to propeller material type.

6.2 *Strength Testing:*

6.2.1 Proof of strength must be shown for all propellers except conventional fixed pitch propellers.

6.2.2 On all other propellers, the blade root and blade retention system must be tested for 1 h at a load level equal to two times the centrifugal load that would be generated by the blade weight at maximum rated rotational speed. This may be done by either a whirl test or a static pull test. The required pull load for each blade must be carried by at least the inner 20 % of its span.

6.3 *Stress Measurement, Fatigue Strength, and Fatigue Analysis*—Vibration testing may be performed to allow reduced endurance test hours. This section does not apply to conventional fixed pitch wooden propellers.

6.3.1 The magnitude of the propeller vibration stresses, including any stress peaks and resonant conditions, throughout the operational envelope of the propeller shall be determined:

6.3.1.1 By direct measurement of stresses on a vibrationally representative engine, or

6.3.1.2 Comparison of the propeller to similar propellers installed on similar airplane installations for which these measurements have been made.

6.3.2 Through testing or analysis, the fatigue allowable for root, mid-blade and tip regions of the propeller blade shall be determined. This testing shall also account for normal in-service damage and wear.

6.3.3 Using the measured stresses and root, mid-blade, and tip fatigue allowables, a fatigue assessment shall be conducted to show that failure of the propeller will not occur between the declared propeller inspection intervals when using the declared inspection techniques.

6.4 *Endurance Testing*—The propeller shall undergo an endurance test on the intended engine or a vibrationally representative engine that is capable of providing the maximum rated power at the maximum rated propeller rotational speed and diameter. The propeller pitch may be adjusted as necessary to achieve maximum rated takeoff power at maximum rated takeoff RPM. Propeller pitch need not be readjusted for the remainder of the test unless necessary to avoid declared operational speed placards. During the test, it is acceptable to stop the test as needed, but the test should be restarted and continued from the point in the test schedule where it was

TABLE 1 Applicable Section 6 Paragraphs for Testing and Inspection Requirements

Propeller Blade Material Type	Strength Testing	Fatigue (Vibration) Testing	Endurance Testing	Inspection/ Maintenance
Wood	6.2	6.3 optional	6.4	6.5 and 6.6
Composite	6.2	6.3 optional	6.4	6.5 and 6.6
Metal	6.2	6.3 required	6.4.1 or 6.4.3	6.5 and 6.6

stopped. The entire endurance test shall be completed by a single propeller and hardware. All propellers must be subjected to one of the following tests:

6.4.1 Conventional fixed pitch wooden propellers or propellers with a vibration stress survey must be subjected to one of the following tests:

6.4.1.1 A 50-h flight test in level flight or in climb. At least 5 h of this flight must be with the propeller operated at the rated rotational speed, and the remainder of the 50 h must be with the propeller operated at not less than 90 % of the rated rotational speed.

6.4.1.2 A 50-h ground test on an engine at the power and propeller rotational speed for which a rating is sought.

6.4.2 Propellers without a vibration stress survey must be subjected to one of the following tests:

6.4.2.1 The endurance test shall be conducted according to the schedule, and in the order, shown in Fig. 1.

6.4.2.2 Compliance with 6.4.2.1 may be accomplished by providing documented service experience for the duration, power and speeds for the conditions shown in Fig. 1. The 10-h segment at maximum declared takeoff power and rpm shall be the final segment of testing after all other power and speed segments are completed.

6.4.3 An analysis based on tests of propellers of similar design may be used in place of the tests 6.4.1 and 6.4.2.

6.5 *Teardown Inspection:*

6.5.1 After completion of each test prescribed in Section 6 of this specification, the propeller must be completely disassembled and a detailed inspection must be made of the propeller parts for cracks, wear, distortion, and any other unusual conditions.

6.5.2 Any unsatisfactory findings during the teardown inspection must be resolved through design changes and additional testing as necessary to establish the compliance of the propeller to this specification.

6.6 *Propeller Adjustments and Parts Replacements*—The manufacturer may service and make repairs to the propeller during the tests. Any service or repairs completed must be allowed by the maintenance manual. If repairs or replacement of parts that are beyond the scope of the maintenance manual are found necessary during the tests or in the teardown inspection, the parts in question must be subjected to additional testing or design changes, or both, as necessary to establish the compliance of the propeller to this specification.

7. Identification Marking

7.1 Each manufacturer of a propeller, propeller blade, or propeller hub shall identify each by means of a plate, stamping, engraving, etching, or other method of permanent identification.

7.2 The identification shall be placed on a non-critical surface that will not likely be defaced or removed during normal service or lost or destroyed in an accident.

7.3 The identification marking(s) shall contain the following information. Propeller diameter, pitch (for fixed-pitch propellers), and manufacturer's identification must be obvious from the marking(s). The other required information can be encoded or abbreviated as necessary to limit the space required for the marking(s):

7.3.1 Manufacturer's identification.
7.3.2 Propeller model designation.
7.3.3 Propeller serial number.
7.3.4 Part number (or equivalent).
7.3.5 Propeller diameter.
7.3.6 Propeller pitch (for fixed-pitch propellers).

8. Design Control

8.1 The design of a propeller consists of at least the following:

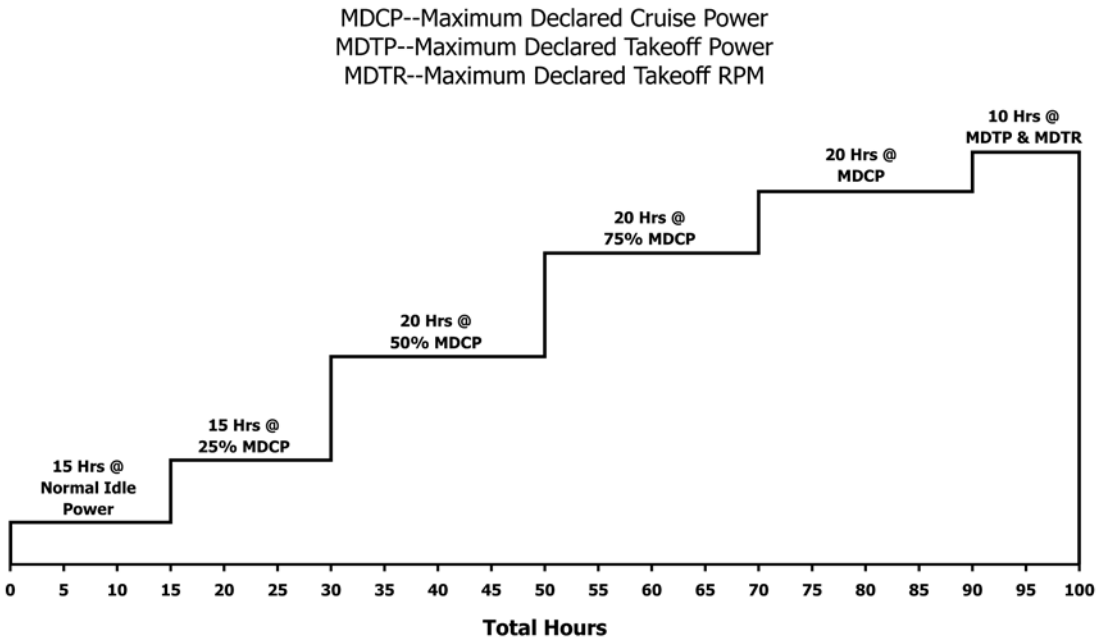

FIG. 1 Propeller Endurance Test Schedule

8.1.1 The drawings and specifications, and a listing of those drawings and specifications necessary to define the configuration and the design features of the propeller shown to comply with this specification.

8.1.2 Information on dimensions, materials, and processes necessary to define the structural strength of the propeller.

8.1.3 Any other data necessary to allow, by comparison, the determination that later propellers of the same or similar design meet the requirements of this specification.

9. Quality Assurance

9.1 The propeller manufacturer shall have a quality assurance system that ensures manufactured propellers maintain conformity to the established design.

10. Keywords

10.1 light sport aircraft; propeller

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL REQUIREMENTS FOR IN-FLIGHT ADJUSTABLE PROPELLERS

X1.1 Definitions

X1.1.1 *In-Flight Adjustable Propeller*—Any propeller that allows for in-flight propeller rotational speed adjustment via pitch change of the propeller blades, including manually controlled variable pitch propellers and automatic controlled (constant speed) propellers, regardless if adjusted by direct pilot interaction, (constant speed) controller, or combination of both.

X1.2 Applicability

X1.2.1 This Appendix defines design and performance requirements applicable to in-flight adjustable propellers. This appendix complements, and does not replace, the requirements imposed by the main section of this standard.

X1.2.2 Requirements in this standard applicable to the ground adjustment capability of a ground-adjustable propeller also apply to the adjustment capability of an in-flight adjustable propeller.

X1.2.3 The requirements in this appendix do not cover propellers that allow for reverse thrust operation, regardless if permitted for inflight operation, or limited to on-ground operation.

X1.3 Pitch Control

X1.3.1 Failure of the propeller pitch control on an in-flight adjustable propeller may not cause hazardous overspeeding under intended operation conditions.

X1.3.2 If the propeller can be feathered, the control system must be designed to minimize *(1)* consequential hazards, such as a propeller runaway resulting from malfunction or failure of the control system, and *(2)* the possibility of an unintentional operation.

X1.4 Testing

X1.4.1 For in-flight adjustable propellers, when conducting the tests as per 6.4, the full applicable range of pitch shall be considered and tested, matching with the relevant speed and power settings.

X1.4.2 For in-flight adjustable propellers where the hub includes critical metal components, when applying 6.3, the stress measurement and fatigue assessment shall be expanded to the critical sections of the metal components of the propeller hub.

X1.4.3 Each in-flight adjustable propeller must be subjected to all applicable functional tests of this paragraph.

X1.4.3.1 The same propeller used in the endurance test as per 6.4 must be used in the functional test.

X1.4.3.2 The propeller and all associated system components enabling its full intended function must either be operated on the intended engine, or on a representative engine with the same power and vibration characteristic, on a test stand in a manner representative to the installation on an airplane, or on a representative airplane.

X1.4.3.3 The functional test shall be conducted prior to the teardown inspection, or shall be followed by a second teardown inspection, as per 6.5.

X1.4.3.4 Manually controlled in-flight adjustable propellers shall complete 500 complete cycles of control throughout the pitch and rotational speed ranges. The feathering range is excluded when limited to unpowered use.

X1.4.3.5 In-flight adjustable propellers controlled by a (constant speed) controller shall complete 1500 complete cycles of control throughout the pitch and rotational speed ranges. The feathering range is excluded when limited to unpowered use.

X1.4.3.6 Feathering propellers shall complete 50 cycles of feather and un-feather operation.