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Standard Specification for Design and Performance of Light Sport Gyroplane Aircraft[1]

This standard is issued under the fixed designation F2352; 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 manufacture of gyroplanes. This specification includes design and performance requirements for light sport gyroplane aircraft.

1.2 This specification applies to light gyroplane aircraft seeking civil aviation authority approval in the form of flight certificates, flight permits, or other like documentation.

1.3 A gyroplane for the purposes of this specification is defined as a rotorcraft to be used for day VFR only, with rotor blades that are not engine-driven in flight and are supported in flight by the reaction of the air on a single rotor that rotates freely on a substantially vertical axis when the aircraft is in horizontal flight.

1.4 These requirements apply to light gyroplanes of orthodox design. Aircraft having the following basic features will be so regarded:

1.4.1 Rotors of either fixed collective pitch or collective pitch control that are not adjustable in flight,

1.4.2 Single engine with fixed or ground adjustable pitch propeller,

1.4.3 No more than two occupant seats, and

1.4.4 A maximum gross weight (MGW) of 725 kg (1600 lb) or less.

1.5 Where it can be shown that a particular feature is similar in all significant respects to a feature that has historically demonstrated compliance with this specification and can be considered a separate entity in terms of its operation, that feature shall be deemed to be applicable and in compliance with this specification.

1.6 Where these requirements are inappropriate to particular design and construction features, it will be necessary to submit an appropriate amendment of this specification to ASTM Committee F37 on Light Sport Aircraft for consideration and approval.

1.7 The values in SI units are to be regarded as the standard. The values in parentheses are for information only.

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

1.9 *Table of Contents:*

[1] This specification is under the jurisdiction of ASTM Committee F37 on Light Sport Aircraft and is the direct responsibility of Subcommittee F37.50 on Gyroplane.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

F2483 Practice for Maintenance and the Development of Maintenance Manuals for Light Sport Aircraft

F2972 Specification for Light Sport Aircraft Manufacturer's Quality Assurance System

2.2 *CAA Standard:*[3]

CAP 643 British Light Gyroplane Airworthiness Requirements, Section T

2.3 *Federal Aviation Regulations:*[4]

FAR-33 Airworthiness Standards: Aircraft Engines

2.4 *Joint Aviation Regulations:*[5]

CS-E EASA Certification Standard—Engines

CS-22 EASA Certification Standard—Sailplanes and Powered Sailplanes

JAR-E Joint Aviation Requirements for Engines

JAR-22 Sailplanes and Powered Sailplanes

3. Terminology

3.1 *Definitions:*

3.1.1 *factor of safety, n*—multiplier of limit load to determine design ultimate load.

3.1.2 *fire proof, adj*—capable of withstanding for a period of at least 15 min the application of heat by the standard flame.

3.1.3 *fire resistant, adj*—capable of withstanding for a period of at least 5 min of heat by standard flame.

3.1.4 *limit load, n*—maximum expected static load on a component.

3.1.5 *power off, n*—for testing purposes, engine at idle.

3.1.6 *primary structure, n*—those parts of the structure the failure of which would endanger the gyroplane.

3.1.7 *ultimate load, n*—limit load multiplied by the factor of safety.

3.2 *Acronyms:*

3.2.1 *ASTM*—American Society for Testing and Materials

3.2.2 *CAS*—calibrated airspeed

3.2.3 *CG*—center of gravity

3.2.4 *CN*—normal force coefficient

3.2.5 *IAS*—indicated airspeed

3.2.6 *ICAO*—International Aviation Organization

3.2.7 *LSA*—light sport aircraft

3.2.8 *MGW*—maximum gross weight

3.2.9 *MPRS*—minimum power required airspeed

3.2.10 *POH*—Pilot Operating Handbook

3.2.11 *VFR*—Visual Flight Rules

3.2.12 V_H—straight and level airspeed at full power

3.2.13 V_{MIN}—minimum controllable level flight airspeed, IAS

3.2.14 V_{NE}—never exceed airspeed, IAS

3.2.15 V_Y—best rate of climb airspeed, IAS

4. Flight

4.1 *General:*

4.1.1 *Conditions of Compliance:*

4.1.1.1 Unless otherwise specified, each requirement of this section must be met for the most adverse combinations of weight and balance loading conditions within which the gyroplane will be operated.

4.1.1.2 Unless otherwise stipulated, performance requirements are at standard atmospheric conditions (15°C (59°F)) and sea level pressure altitude).

4.1.1.3 Each requirement of this section must be met for all configurations at which the gyroplane will be operated except as otherwise stated. (If, for example, a gyroplane is equipped with a canopy or doors and it is intended that the gyroplane may be operated with the canopy or doors removed, then the gyroplane must meet the requirements both with and without the canopy or doors installed.)

4.1.2 *Load Distribution Limits*—A method must be specified to determine the range of weight and balance of the pilot, passenger, and fuel (and ballast if required) that ensures satisfactory control and safety margins. The range of balance is

[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 Civil Aviation Authority (CAA), http://www.caa.co.uk/.

[4] Available from Federal Aviation Administration, 800 Independence Ave., SW, Washington, DC 20591.

[5] Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704

normally determined by a "hang test" with specified angular limits between a fixed airframe component and a horizontal reference.

NOTE 1—The method of determination of proper weight and balance must be specified in the POH.

4.1.3 *Weight Limits*—The MGW, which is the highest weight that complies with each applicable structural loading condition and each applicable flight requirement, must be established. The MGW must be specified in the POH.

4.1.4 *Empty Weight:*

4.1.4.1 The design empty weight shall be specified by the manufacturer.

NOTE 2—The design empty weight must be included in the POH.

4.1.4.2 The actual empty weight shall be established by weighing the gyroplane with fixed ballast, required minimum equipment, and unusable fuel and, where appropriate, maximum oil, engine coolant, and hydraulic fluid, and excluding usable fuel, weight of occupant(s), and other readily removable items of load.

4.1.4.3 The condition of the gyroplane at the time of determining actual empty weight must be one that is well defined and easily repeated.

4.1.5 *Removable Ballast*—Removable ballast may be used in compliance with the flight requirements of this section.

4.1.6 *Rotor Speed Limits:*

4.1.6.1 At the critical combinations of weight, altitude, and airspeed, the rotor speed must be stable and remain within the established safe range that would permit any expected maneuver to be performed safely. The established safe rotor speed range must be identified in the POH. The established safe range must be established by the rotor blade manufacture or acceptable history of safe operation.

4.1.6.2 The established safe range must be speed in consideration of spanwise and chordwise flexure cycles on the rotor at the worst combination of load and rotor speed, and rotor stiffness that assures the in-plane vibration natural frequency is higher than the maximum rotor RPM by a minimum factor of 1.2.

4.1.6.3 Compliance may also be established by use of acceptable aircraft manufacturing practices, correct use of materials of known design strength and fatigue properties, and performance testing at the extremes of the established safe range rotor speed.

4.2 *Performance:*

4.2.1 *General*—The performance in accordance with Section 4 applies:

4.2.1.1 With normal piloting skill under average conditions;

4.2.1.2 In and shall be corrected to International Civil Aviation Organization (ICAO) defined standard atmosphere in still air conditions at sea level;

4.2.1.3 Speeds shall be given in indicated (IAS) and calibrated (CAS) airspeeds;

4.2.1.4 At the most critical weight and CG combination;

4.2.1.5 At the most unfavorable center of gravity for each condition; and

4.2.1.6 Using engine power not in excess of the maximum declared for the engine type and without exceeding power plant and propeller limitations in accordance with 9.4.

4.2.2 *Takeoff*—The distance(s) required from rest, to takeoff and climb to 15 m (50 ft) above the takeoff surface, with zero wind, with normally accepted flight technique(s) must be established (with and without pre-rotator if it is intended that the gyroplane is to be operated both ways).

NOTE 3—These established takeoff distances must be identified in the POH.

4.2.3 *Climb*—The time for climb from leaving the ground up to 300 m (1000 ft) above the field must be established and must be less than 4 min.

NOTE 4—The established climb must be identified in the POH.

4.2.4 *Glide:*

4.2.4.1 The minimum achievable power off rate of descent and the associated airspeed must be established by test at the maximum gross weight with the gyroplane trimmed at the minimum rate of descent airspeed.

NOTE 5—The minimum power off rate of descent must be identified in the POH.

4.2.4.2 The maximum achievable power off glide ratio must be established by test at maximum gross weight with the gyroplane trimmed at the best glide ratio airspeed.

NOTE 6—The best glide ratio airspeed must be identified in the POH.

4.2.5 *Never Exceed Airspeed (V_{NE})*—The maximum safe operating airspeed, considering the controllability, maneuverability, and stability requirements (4.3.1 – 4.5.7) must be established. This airspeed must be established for the worst-case power condition between idle and full power.

NOTE 7—The established V_{NE} must be identified in the POH.

4.2.6 *Minimum Controllable Airspeed for Level Flight, V_{MIN}*—The minimum speed for level flight at maximum takeoff power must be established.

NOTE 8—The established V_{MIN} must be identified in the POH.

4.2.7 *Best Rate of Climb Airspeed (V_Y)*—The airspeed at which the maximum rate of climb is achieved must be established.

NOTE 9—The established V_Y must be identified in the POH.

4.2.8 *Minimum Power Required Airspeed (MPRS)*—The airspeed at which minimum power is required for steady level flight must be established.

NOTE 10—The established MPRS must be identified in the POH.

4.2.9 *Landing Distance*—The distance required to land and come to rest from a point 15 m (50 ft) above the landing surface, with zero wind, must be established. The approach airspeed to achieve this performance must be established.

NOTE 11—This landing distance and the approach speed to achieve this landing distance must be identified in the POH.

4.2.10 *Maximum Operating Altitude*—The maximum safe operating altitude considering the controllability, maneuverability, and stability requirements (4.3.1 – 4.5.7) must be established, except that demonstrating safe operating pressure altitudes in excess of 3000 m (10 000 ft) is not required.

NOTE 12—The maximum operating altitude must be identified in the POH.

4.2.11 *Height/Velocity Envelope*—The combinations of height and forward airspeed from which a safe landing cannot be made following engine failure must be established as a limiting height-speed envelope (graph).

NOTE 13—The height-speed envelope graph must be included in the POH.

4.3 *Controllability and Maneuverability:*

4.3.1 *General*—The gyroplane must be safely controllable and maneuverable with sufficient margin of control movement and blade freedom to correct for atmospheric turbulence and permit control of the attitude of the gyroplane at all power settings at the critical weight and balance at sea level and at the maximum operating altitude:

4.3.1.1 During steady flight at all operable airspeeds up to V_{NE},

4.3.1.2 During airspeed changes,

4.3.1.3 During changes of engine power (including rapid or sudden application or loss of engine power), and

4.3.1.4 During any maneuver appropriate to the type, including:

(1) Takeoff,

(2) Climb,

(3) Turning flight,

(4) Descent (power on and off), including vertical and spiral descents,

(5) Landing (power on and off),

(6) Recovery to full power climbing flight from an aborted landing, and

(7) Dynamic maneuvers including steep turns, straight pullouts, and roll reversals.

4.3.2 It must be possible to maintain any required flight condition and make a smooth transition from one flight condition to another (including turns and slips) without exceptional piloting skill, alertness, or strength, and without danger of exceeding the limit maneuvering load factor, under any operating condition probable for the type, with the engine operating at all possible associated power settings within the allowable range, including the effect of power changes and sudden engine failure. Normal variations in pilot techniques must not cause unsafe flight conditions.

4.3.3 *Controls*—The controls must not exhibit excessive breakout force, friction, lag, or freeplay.

4.3.4 A technique must be established for landing the gyroplane at maximum gross weight, with the engine at idle, without hazard to the occupants.

NOTE 14—This procedure for landing at engine idle must be included in the POH.

4.3.5 The gyroplane shall not require unusual attention to prevent or stop any pitch oscillation at any and all power settings at the most critical weight and CG combination at both sea level and at the maximum operating altitude:

4.3.5.1 During steady flight at speeds up to V_{NE},

4.3.5.2 During airspeed changes, including:

4.3.5.3 During changes of engine power (including sudden loss of engine power), and

4.3.5.4 During any maneuver appropriate to the type, including:

(1) Takeoff,

(2) Climb,

(3) Turning flight,

(4) Descent (power on and off),

(5) Landing (power on and off),

(6) Recovery to power-on flight from an aborted landing, and

(7) Dynamic maneuvers including steep turns, straight pullouts, and roll reversals.

4.3.6 Any unusual flying characteristics or reactions under the conditions stated in this section must be identified. The appropriate avoidance and remedy actions must be identified.

4.4 *Longitudinal Lateral and Directional Control:*

4.4.1 It must be possible at any speed including vertical descents, and at any power settings including power off, to lower the rotor disk angle of attack so that a speed equal to 1.3 V_{MIN} can be reached promptly.

4.4.2 It must be possible to raise the rotor disk angle of attack at V_{NE} at all permitted weight limitations and engine power settings so that 1.3 V_{MIN} can be reached promptly.

4.4.3 The control forces must not exceed those prescribed in 5.4.2. This requirement applies with all allowable engine power settings including power off.

4.4.4 A maximum wind speed, maximum crosswind, and maximum tailwind must be established in which the gyroplane can be operated without loss of control near the ground in any maneuver appropriate to the type (such as crosswind takeoffs and landings) without undue piloting skills and with:

4.4.4.1 Most critical weight, and

4.4.4.2 Most critical center of gravity.

NOTE 15—These wind velocities must be identified in the POH.

4.5 *Stability:*

4.5.1 *General:*

4.5.1.1 The gyroplane stability characteristics must satisfy all of the stability criteria of 4.5.

4.5.1.2 The gyroplane must be able to be flown without undue piloting skill, alertness, or strength in any normal maneuver for a period of time as long as that expected in normal operation.

4.5.1.3 Each requirement of this section must be met for the most adverse combinations of engine power and airspeed within which the gyroplane will be operated. Unless otherwise specified, all requirements of this section shall be met at engine power settings ranging from idle power to maximum allowed engine power. Unless otherwise specified, all requirements of this section shall be met at airspeeds ranging from MPRS to V_{NE}.

4.5.2 *Longitudinal Power Response:*

4.5.2.1 A power change from trimmed MPRS level flight at MPRS power must result in a steady state trimmed airspeed not to differ by more than 25 % from the initial trimmed MPRS airspeed for the following conditions:

(1) In level flight, MPRS power increased to full power.

(2) In level flight, MPRS power reduced to engine off.

(3) Conducted with a cyclic stick fixed in pitch at the initial MPRS stick position.

(4) Conducted with a the cyclic stick free in pitch at the initial MPRS pitch trim.

4.5.2.2 Without trim adjustment, the cyclic pitch control range must be adequate to reduce airspeed from trimmed V_{NE} to V_{MIN} airspeed without excessive forces on the cyclic control system at the following conditions:

(1) From V_{NE} to V_{MIN} with engine power off.

(2) From V_{NE} to V_{MIN} with engine at full power.

4.5.2.3 A rapid power change from trimmed MPRS level flight at MPRS power must result in an airframe pitch attitude rate of change not to exceed 5° per second for the following conditions.

(1) MPRS power rapidly increased to full power.

(2) MPRS power rapidly reduced to idle power.

(3) Conducted with a cyclic stick fixed in pitch at the initial MPRS stick position.

(4) Conducted with a the cyclic stick free in pitch at the initial MPRS pitch trim.

4.5.3 *Static Longitudinal Airspeed Stability:*

4.5.3.1 The longitudinal control must be such that: (*1*) with constant engine power, an aft force and movement of the cyclic control is necessary to achieve an airspeed less than any available trim airspeed; and (*2*) with constant engine power, a forward force and movement of the control is necessary to achieve an airspeed greater than any available trim airspeed. The control force slope must not reverse during any progressive application of control movement at airspeeds greater than V_{MIN} up to V_{NE}. Static longitudinal airspeed stability must be met at the following power and trimmed airspeed conditions:

(1) Steady altitude at MPRS,

(2) Full power at V_{NE},

(3) Full power at V_{MIN},

(4) Engine idle at MPRS,

(5) Engine idle at 80 % V_{NE}, and

(6) Engine idle at V_{MIN}.

4.5.3.2 The longitudinal control must be such that, with constant engine power and with airspeed temporarily increased at least 20 % above trimmed airspeed, upon release of the cyclic pitch control the airspeed shall not diverge and shall return to within 10 % of the following initially trimmed airspeed condition with the cyclic pitch control free. Initial and return trimmed conditions:

(1) Steady altitude at MPRS,

(2) Full power at 80 % V_{NE},

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % V_{NE}.

4.5.3.3 The longitudinal control must be such that: (*1*) with constant engine power and with airspeed temporarily increased at least 20 % above trimmed airspeed, upon return to the following fixed stick conditions the airspeed shall return to within 10 % of the initial fixed stick steady state airspeed; and (*2*) with constant engine power and with airspeed temporarily decreased at least 20 % below trimmed airspeed, upon return to the following fixed stick conditions the airspeed shall return to within 10 % of the initial fixed stick steady state airspeed. Initial and return fixed stick conditions:

(1) Steady altitude at MPRS,

(2) Full power at 80 % V_{NE},

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % V_{NE}.

4.5.4 *Static Longitudinal Maneuvering (G-Load) Stability:*

4.5.4.1 The pitch control forces during turns or load factor maneuvers greater than 1.0 *g* must be such that an increase in load factor is associated with an increase in aft pilot control force, and a decrease in load factor is associated with a decrease in aft pilot control force for the following initial trimmed conditions:

(1) Steady altitude at MPRS,

(2) Full power at the lesser of V_H or V_{NE},

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % V_{NE}.

4.5.4.2 The airspeed during turns or load factor maneuvers greater than 1.0*g* at a fixed cyclic pitch position must be such that an increase in load factor is associated with an increase in airspeed, and a decrease in load factor is associated with a decrease in airspeed for the following initial fixed stick conditions:

(1) Steady altitude at MPRS,

(2) Full power at the lesser of V_H or of V_{NE},

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % V_{NE}.

4.5.5 *Static Spiral Divergence:*

4.5.5.1 For banked turns up to 1.5 *g* or 30° of bank with the stick fixed, there must be no tendency for the gyroplane to increase the turn rate rapidly at all allowable power settings for the following conditions:

(1) Level 30° banking turn at straight and level MPRS airspeed,

(2) 30° banking turn at full engine power, and

(3) Descending 30° turn at MPRS at engine idle.

4.5.6 *Lateral and Directional Stability:*

4.5.6.1 Following an initial yaw disturbance, with the yaw controls fixed or free and other controls held fixed, the gyroplane shall tend to correct automatically for disturbance in yaw within three cycles.

4.5.6.2 The directional and lateral stability should be sufficient to prevent dangerous flight conditions following abrupt pedal displacements.

4.5.6.3 Positive directional (yaw) static stability shall be demonstrated by the requirement for increasing rudder pedal force and displacement with increasing sideslip.

4.5.6.4 No lateral or directional oscillations with periods less than 5 s shall be exhibited with primary cyclic controls fixed, and with primary cyclic controls free.

4.5.6.5 *Conditions*—Lateral and directional stability must be met at the following power and trimmed airspeed conditions:

(1) Steady altitude at MPRS,

(2) Full power at the lesser of V_H or of V_{NE},

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % V_{NE}.

4.5.7 *Dynamic Longitudinal Stability:*

4.5.7.1 The gyroplane under moderately turbulent air conditions must exhibit no dangerous or divergent behavior with cyclic pitch control fixed or with cyclic pitch control free for the following conditions:

(1) Steady altitude at MPRS,

(2) Full power at V_{NE},

(3) Engine idle at MPRS,

(4) Engine idle at 80 % V_{NE}, and

(5) Engine idle at V_{MIN}.

4.5.7.2 *Longitudinal Oscillation Damping:*

(1) Any excitable longitudinal oscillations with periods less than 5 s must damp to one half amplitude in not more than one cycle with cyclic pitch control fixed or with cyclic pitch control free. There should be no tendency for undamped small amplitude oscillations to persist for more than 2 cycles with cyclic pitch control fixed or with cyclic pitch control free.

(2) Any excitable longitudinal oscillations with periods between 5 and 10 s should damp to one half amplitude in not more than two cycles. There should be no tendency for detectable undamped small oscillations to persist for longer than 20 s.

(3) Any excitable longitudinal oscillations with periods between 10 and 20 s should be damped, and in no circumstances should a longitudinal oscillation having a period longer than 20 s achieve more than double amplitude in less than 20 s.Conditions:

(a) Steady altitude at MPRS,

(b) Full power at V_{NE},

(c) Engine idle at MPRS,

(d) Engine idle at 80 % V_{NE}, and

(e) Engine idle at V_{MIN}.

4.6 *Ground-Handling Characteristics:*

4.6.1 *Directional Stability and Control*—The gyroplane must have satisfactory ground-handling characteristics, including freedom from uncontrolled tendencies in any condition expected in operation, particularly in all takeoff conditions.

4.6.2 *Taxiing Condition:*

4.6.2.1 The gyroplane must be safely controllable and maneuverable when it is taxied over the roughest ground that may reasonably be expected in normal operation.

4.6.2.2 The ground speeds up to which it is safe to taxi, takeoff, and touch down must be established.

NOTE 16—The established maximum ground speeds must be identified in the POH.

4.6.2.3 The gyroplane should at least be suitable for operation from surfaces with short grass.

4.7 *Miscellaneous Flight Requirements:*

4.7.1 *Vibration*—Each part of the gyroplane must be free from excessive vibration under each appropriate combination of airspeed and engine power in all normal flight and ground operations.

5. Structure

5.1 *General*—Evidence of compliance with the Structures Sub-Section C of CAP 643 shall be accepted in lieu of compliance with Section 5 of this specification.

5.1.1 *Loads:*

5.1.1.1 Strength requirements are stated as limit loads (the maximum static load to be expected in service) and ultimate loads (limit loads multiplied by factors of safety). Unless otherwise stated, loads given are limit loads.

5.1.1.2 If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

5.1.2 *Factor of Safety*—The strength of any safety critical part must have a safety factor of 1.5 for the application.

5.1.3 *Strength and Deformation:*

5.1.3.1 The structure and control systems must be able to support limit loads for at least 3 s without detrimental or permanent deformation. At any load up to limit loads, the deformation must not interfere with safe operation.

5.1.3.2 The structure must be able to support ultimate loads without failure for at least 3 s.

5.1.4 *Design Conditions*—The structural requirements of 5.1 must be met for all allowable combinations of:

5.1.4.1 The maximum gross weight,

5.1.4.2 Airspeeds up to V_{NE},

5.1.4.3 The balance limitations, and

5.1.4.4 The positive limit maneuvering load factor.

5.2 *Flight Loads:*

5.2.1 *General:*

5.2.1.1 Airframe flight load factors represent the ratio of the rotor aerodynamic thrust (acting at the rotor attach point on the airframe) to the weight of the airframe. A positive flight load factor on the airframe is one in which the rotor thrust acts upward with respect to the gyroplane.

5.2.1.2 Rotor flight load factors represent the ratio of the rotor aerodynamic thrust (acting at the rotor attach point on the airframe) to the axial load presented by the airframe in flight. A positive flight load factor on the rotor is one in which the axial load presented by the airframe acts generally downward, with respect to the rotor. The flight load requirements apply at each practicable combination of weight and disposable load.

5.2.2 *Limit Maneuvering Load Factors:*

5.2.2.1 The gyroplane's rotor must be designed for positive limit maneuvering load factor of 3.0 at all forward airspeeds from zero to the never exceed airspeed, V_{NE}.

5.2.2.2 The rest of the gyroplane must be designed for positive and negative limit maneuvering load factors of +3.0 and –0.5, respectively, at all forward speeds from zero to the never exceed airspeed, V_{NE}.

5.2.3 *Resulting Limit Maneuvering Loads*—The loads resulting from the application of limit maneuvering load factors are assumed to act at the center of the rotor hub and to act in directions so as to represent each critical maneuvering condition.

5.2.4 *Yawing Conditions:*

5.2.4.1 The gyroplane must be designed for yawing loads on the vertical tail surface at the maximum achievable yaw rate.

5.2.4.2 The engine mount and its supporting structure must be designed for precession yawing loads at maximum achievable yaw rates.

5.3 *Engine Torque:*

5.3.1 The engine mount and its supporting structure must be designed for the effects of the limit torque corresponding to the maximum continuous power and propeller speed, acting simultaneously in accordance with the limit loads of 5.2.2.

5.3.2 *Engine Mount Torque Pulse Factor*—For conventional reciprocating engines, the limit torque to be accounted for is obtained by multiplying the engine mean torque by the propeller speed reduction factor and by one of the following factors.

5.3.2.1 For four-stroke engines:

(1) 1.33 for engines with five or more cylinders;

(2) 2, 3, 4, or 8 for engines with four, three, two, or one cylinders, respectively.

5.3.2.2 For two-stroke engines:

(1) 2 for engines with three or more cylinders; or

(2) 3 or 6 for engines with two or one cylinders, respectively.

5.4 *Control System Loads:*

5.4.1 *Primary Control System:*

5.4.1.1 The part of each control system from the pilot's controls to the control stops must be designed to withstand pilot forces of not less than the forces specified in 5.4.2.

5.4.1.2 The part of each control system from the control stops to the attachment to the rotor hub (or control areas) must be designed to at least:

(1) From pilot input forces, withstand the maximum pilot forces obtainable in normal operation;

(2) Without yielding, the cyclic or rudder control mechanical limits shall support 1.6× the equivalent 5.4.2 limit pilot forces presented on those control limits by any control surface or by the rotor from ground gusts or control inertia.

5.4.2 *Limit Pilot Forces*—For primary flight controls, the limit pilot forces are as follows:

5.4.2.1 For foot controls, 59-kg (130-lb) force, and

5.4.2.2 For stick controls, 45-kg (100-lb) force fore and aft and 18-kg (40-lb) force laterally.

5.4.3 *Dual Control Systems*—Dual control systems must be designed to withstand the loads that result when each pilot applies 0.75 times the load specified in 5.4.2 with:

5.4.3.1 The pilots acting together in the same direction, and

5.4.3.2 The pilots acting in opposition.

5.4.4 *Secondary Control Systems*—Secondary control systems such as those for brakes, throttles, trim controls, and so forth must be designed for supporting the maximum forces that a pilot is likely to apply to those controls.

5.5 *Stabilizing and Control Surfaces:*

5.5.1 *Control and Stabilizing Surface Loads*—The maximum limit loads for each stabilizing and control surface (other than the rotor blades), and its supporting structure, must be determined by testing or other rational analysis for the following loads:

5.5.1.1 Gust loads of 15 lb/ft^2 distributed over surface area,

5.5.1.2 Stabilizing static loads,

5.5.1.3 Propwash turbulence loads, and

5.5.1.4 Air loads shall be distributed chordwise and centered at the:

(1) 25 % chord line for symmetrical airfoils,

(2) Hinge line for flapped airfoils, and

(3) Chord line determined by rational calculation or test for cambered airfoils.

5.6 *Ground Loads:*

5.6.1 *General*—The limit ground loads specified in this section are considered to be external loads and inertia forces that act upon a gyroplane structure.

5.6.2 *Main Landing Gear—Shock Absorption*—To minimize pilot injury, the landing gear shall be capable of withstanding, without permanent deformation or flight critical damage, an impact with the ground under the following conditions:

5.6.2.1 On a flat solid surface,

5.6.2.2 At MGW,

5.6.2.3 With rotor installed or with a simulated rotor weight at the rotor attach point,

5.6.2.4 With initial impact on the main wheels in a normal landing attitude, and

5.6.2.5 Impact with the ground at a vertical velocity equaling that achieved in a free fall:

(1) From a normal landing attitude, and

(2) From a height at which the main wheels are 16.5 cm (6.5 in.) above the ground when in the normal position for landing and bearing no weight.

5.7 *Main Component Requirements:*

5.7.1 *Rotor Structure:*

5.7.1.1 Each rotor assembly (including the rotor hub and blades) must be designed as in accordance with 5.7.1.

5.7.1.2 The rotor structure must be designed to withstand the critical flight loads in accordance with 5.2.2 and 5.2.3.

5.7.1.3 The rotor structure must be designed to withstand loads simulating, for the rotor blades and hub bar, any normal expected impact forces of each blade against its teetering stops during ground operation.

5.7.1.4 The rotors and rotor head structure must be designed to withstand the maximum limit torque likely to be transmitted by any rotor spin-up device or rotor brake at all speeds from zero to maximum at which the device is designed to be engaged.

5.7.2 *Fuselage, Landing Gear, and Rotor Pylon Structures:*

5.7.2.1 Each fuselage, landing gear, and mast structure must be designed as prescribed in this section. Resultant rotor forces may be represented as a single force applied at the rotor hub bar attachment point (teeter bolt).

5.7.2.2 Each structure must be designed to withstand:

(1) The critical loads prescribed in 5.2.2 and 5.2.3,

(2) The applicable ground loads in accordance with 5.6.1 and 5.2.2, and

(3) The loads prescribed in 5.7.1.3 and 5.7.1.4.

5.8 *Emergency Landing Conditions:*

5.8.1 *General:*

5.8.1.1 The gyroplane, although it may be damaged in emergency landing conditions, must be designed in accordance with 5.8.1 to protect each occupant under those conditions.

5.8.1.2 The gyroplane should be capable, in an emergency landing, to reduce its forward airspeed to near zero and subsequently contact the ground in a near vertical direction in a near level attitude, thereby minimizing load factors in the forward direction.

5.8.1.3 The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a landing incident, when proper use is made of belts and harnesses provided for in the design, in the following conditions:

(1) Each occupant experiences ultimate inertial forces corresponding to the load factors in Table 1.

(2) These forces are independent of each other and are relative to the surrounding structure.

5.8.1.4 The supporting structure must be designed to restrain, under loads up to those specified in 5.7.2.2, each item of mass that could injure an occupant if it came loose in a minor crash landing.

5.8.1.5 For a gyroplane with the engine located behind an occupant's seat, the engine mounting structure must be able to restrain the engine, propeller, and any other items supported by the engine mounting structure, when they experience the forward inertial force above with a load factor of five.

5.8.1.6 Fuel tanks, fuel lines, oil tanks, and oil lines must be capable of retaining their contents under the inertial forces above without rupture.

5.9 *Other Loads:*

5.9.1 *Loads from Single Masses*—The attachment means that all single masses, which are part of the equipment of the gyroplane, including ballast, must be designed to withstand loads corresponding to the maximum design load factors to be expected from the established flight and ground loads, including the emergency landing conditions of 5.8.1.

6. Design and Construction

6.1 *General*—Evidence of compliance with the Design and Construction Sub-Section D of CAP 643 shall be accepted in lieu of compliance with Section 6, Design and Construction, of this specification.

6.1.1 The strength of any part must have a safety factor of 1.5 for the application.

6.2 *Materials*—Materials shall be suitable and durable for the intended use, and design values (strength) must be chosen so that structural deficiency because of material variations is extremely remote as shown by test, analysis, service history, or manufacturer certification.

6.3 *Fabrication Methods:*

6.3.1 Workmanship of manufactured parts, assemblies, and aircraft shall be of high standard.

6.3.2 Methods of fabrication shall produce consistently sound structures.

6.3.3 Process specifications shall be followed where required.

6.4 *Locking of Connections*—An acceptable means of locking must be provided on all connecting elements in the primary structure and in control and other mechanical systems that are essential to safe operation of the gyroplane. In particular, self-locking nuts must not be used on any bolt subject to rotation in operation unless a positive locking device is used in addition to the self-locking device.

TABLE 1 Load Factors

Direction	Load Factor
Upward	1.5
Forward	3.0
Sideward	3.0
Downward	4.5

6.5 *Protection of Structure*—Protection of the structure against weathering, corrosion, and abrasion, as well as suitable ventilation and drainage, shall be provided.

6.6 *Inspection*—Means must be provided to allow inspection (including inspection of principal fixed and rotating structural elements and control systems), close examination, repair, and replacement of each part requiring periodic inspection, maintenance, adjustments for proper alignment and function, lubrication, or servicing.

6.7 *Provisions for Rigging and Derigging*—The design must be such that where any rigging and derigging may be expected to be carried out on a routine basis, the probability of damage or incorrect assembly is eliminated. It must be possible to inspect the gyroplane easily for correct assembly.

6.8 *Material Strength Properties and Design Values*—Materials must meet design strength values at ambient air temperatures between –5 and 54°C.

6.9 *Fatigue Strength:*

6.9.1 The detail design of the blade and hub bar of the gyroplane should be such that as far as reasonably practicable features that cause high stresses are avoided, especially if it cannot be shown that features of a similar design have accumulated considerable satisfactory service experience in a similar application.

6.9.2 The primary structures of the airframe or rotor shall be designed in consideration of the spanwise and chordwise flexure cycles on the rotor at the worst combination of load, rotor speed and airspeed. All parts of the primary structure shall be easily accessible for inspection.

6.10 *Special Factors of Safety*—The factor of safety prescribed in 5.1.2 must be increased to the special factors prescribed in this paragraph.

6.10.1 *Casting Factors*—For castings, the strength of which is substantiated by at least one static test and which are inspected by visual methods, a casting factor of safety of 3.0 must be applied. This factor may be reduced to 1.25, providing the reduction is substantiated by tests on not less than three sample castings, and if these and all production castings are subjected to an approved visual and radiographic inspection or an accepted equivalent nondestructive inspection method.

6.10.2 *Bearing Factors:*

6.10.2.1 The factor of safety for bearing loads at bolted or pinned joints must be multiplied by a special factor of safety of 3.0 to provide for:

(1) Relative motion in operation, and

(2) Joints with clearance (free fit) subject to pounding or vibration, or both.

6.10.2.2 For control surface hinges and control system joints, comply with the factors prescribed in 6.14 and 6.18.8, respectively.

6.10.3 *Fitting Factors*—For each fitting (a part or terminal used to join one structural member to another), the following apply:

6.10.3.1 For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of safety of at least 1.8 must be applied to each part of:

(1) The fitting,

(2) The means of attachment, and

(3) The bearing on the joined members.

6.10.3.2 No fitting factor need be used for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood).

6.10.3.3 For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.

6.10.3.4 Local attachments in the load path between the safety belt or harness and the main gyroplane structure must be shown by analysis, test, or both to be not less strong than the strength necessary for 3.0 times the loads corresponding to the emergency landing inertia loads of 5.8.1.

6.10.3.5 When using only two hinges at each control surface, the safety factor for these hinges and the attached parts of the primary structure must be multiplied by a factor of 1.5.

6.10.4 *Cable Factor*—A factor of safety of 2.0 on nominal cable strength must be applied to cables used for structural applications and for all primary control systems.

6.10.5 *Rotor Components Factor:*

6.10.5.1 The rotor head, rotor hub bar, and blade spar structure shall have a factor of safety of two for centripetal tension loads acting alone under the critical flight loads in accordance with 5.2.2 and 5.2.3.

6.10.5.2 The supporting structure and the attachment of rotor blade mass balance weights must have a factor of safety in excess of 1.5 when subjected to the combined loads resulting from:

(1) Accelerations of plus or minus 20*g* in the flap plane of the rotor,

(2) Accelerations of plus or minus 20*g* in the lag plane of the rotor, and

(3) The centripetal force at the maximum rotor speed.

6.11 *Flutter Prevention and Structural Stiffness*—Each major part of the gyroplane must be free from flutter and resonance, in both the free and fixed control mode at all airspeed and power conditions at speeds up to V_{NE}.

6.12 *Control Surfaces and Rotors:*

6.12.1 *Drainage*—For each rotor blade:

6.12.1.1 Internal air pressure must be either vented if necessary to prevent deformation or structural compromise, or

6.12.1.2 The blade must be designed to prevent water from becoming trapped in it.

6.12.1.3 Sections 6.12.1.1 and 6.12.1.2 do not apply to sealed blades capable of withstanding the maximum pressure differentials expected in service.

6.13 *Control Surface Installations (Other Than Rotor Blades):*

6.13.1 Movable control surfaces must be installed so that there is no interference between any surfaces or their bracings when one surface is held in any position and the others are operated through their full angular movement. This requirement must be met:

6.13.1.1 Under limit load conditions for all control surfaces through their full angular range, and

6.13.1.2 Under limit load on the gyroplane structure other than the control surfaces.

6.13.1.3 If a ground adjustable stabilizer is used, it must have stops that will limit its range of travel to that allowing safe flight and landing.

6.14 *Control Surface Hinges (Other Than Rotor Blades):*

6.14.1 Control surface hinges, except ball, roller, and spherical bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing.

6.14.2 For ball, roller, or spherical bearing hinges, the approved rating of the bearing must not be exceeded.

6.14.2.1 Mechanical limits of rod-end spherical ball bearing hinges must not exceed the mechanical design limits of the joint in accordance with the requirements of 6.18.8.

6.15 *Rotor Mass Balance:*

6.15.1 The spanwise balance of the rotor blades must be such that excessive out-of-balance vibration is prevented.

6.15.2 The chordwise balance of the blades must be such that the blades cannot be induced to flutter or weave in all flying conditions. The chordwise balance of each blade in a pair must be the same. The aerodynamic center should be at or very close to the 25 % chord.

6.16 *Rotor Blade Clearance*—There must be enough clearance between the rotor blades and other parts of the structure to prevent the blades from striking the propeller or any part of the structure or passing through any area likely to cause injury to occupants during any normal operating condition.

6.17 *Rotor Head Bearings*—All rotor head bearings:

6.17.1 Must have specifications that ensure that they have the strength and other properties assumed by the gyroplane designer, and

6.17.2 Must have their suitability established by experience or tests.

6.18 *Control Systems:*

6.18.1 *General*—Each control shall operate easily, smoothly, and positively enough to allow proper performance of its functions.

6.18.2 *Stops:*

6.18.2.1 Each control system must have stops that positively limit the range of motion of the pilot's controls.

6.18.2.2 Each control system must have stops or other mechanical limitations to prevent positively possible interference with other control systems or moving components (that is, rudder stops to prevent interference with propeller).

6.18.2.3 Each stop must be located so that wear, slackness, or take-up adjustments will not adversely effect the control characteristics of the gyroplane because of a change in the range of travel of the control.

6.18.2.4 Each stop must be able to withstand any loads corresponding to the design conditions for that control.

6.18.2.5 Joystick stops must be arranged so as to avoid excessive or possibly damaging control rod and joystick loads.

6.18.2.6 *Rotor System Stops:*

(1) For precession stall avoidance, the cyclic control shall have a maximum total rotor disk (spindle angle) travel of 20° fore to aft and side to side.

(2) For precession stall avoidance, the rotor teeter stops shall allow no more than 24° total flap of a rotor blade.

(3) The cyclic control shall have a minimum total rotor disk (spindle angle) travel fore to aft and side to side adequate to maneuver the gyroplane as intended by the design but shall not be less than 16° total.

(4) The teeter rotor stops shall allow adequate rotor blade flap to accommodate the airspeeds and maneuvers as intended by the design.

6.18.3 *Trim System*—If a trim system is fitted which is operable in flight, proper precautions must be taken to prevent inadvertent, improper, or abrupt trim operation. In addition, trimmed range must be limited so that stick force cannot exceed 9 kg (20 lb) on takeoff or during level flight.

6.18.4 *Operation*—When operating the controls from the cockpit, the control system, designed to the loads specified in 5.4.2, must be free from:

6.18.4.1 Jamming or binding,

6.18.4.2 Excessive friction, and

6.18.4.3 Excessive deformation under control load forces specified in 5.4.2.

6.18.5 *Control System Details:*

6.18.5.1 Each detail of each control system must be designed and installed to prevent jamming, binding, chafing, or interference from baggage, passengers, loose objects, or the freezing of moisture.

6.18.5.2 There must be means in an enclosed or semi-enclosed cockpit to prevent the entry of foreign objects into places in which they would jam the system.

6.18.5.3 There must be means to prevent the slapping or abrasion of cables, tubes, or rods against other parts.

6.18.5.4 Each element of the flight control system must have design features, or must be distinctively and permanently marked, to minimize the possibility of incorrect assembly that could result in malfunctioning of the control system.

6.18.5.5 Where bellcranks are used in any control system, they must be so designed that their range of travel is limited to a maximum of 45° each side of the mean position in respect to any movement measured at that bellcrank. The mean position is when the center line between the bellcrank pivot and the bellcrank push/pull rod mount is at right angles to the push/pull rod.

6.18.6 *Spring Devices*—The failure of any spring device used in the control system must not cause unsafe flight characteristics including:

6.18.6.1 Abrupt attitude change that would result in loss of control, and

6.18.6.2 Possibility of failed spring device to interfere with other flight or propulsion systems.

6.18.7 *Cable Systems:*

6.18.7.1 Each cable, cable fitting, turnbuckle, splice, and pulley used must meet stated specifications. In addition:

(1) No cable smaller than 2.3-mm (3⁄32-in.) diameter may be used in primary control systems;

(2) Aircraft grade, 7 by 7 strand or more, flexible control cable shall be used in primary control systems;

(3) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations; and

(4) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle.

6.18.7.2 Each kind and size of pulley must correspond to the cable with which it is used. Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

6.18.7.3 Fairleads must be installed so that they do not cause a change in cable direction of more than 3°, except where tests or experience indicate that a higher value would be satisfactory. The radius of curvature of fairleads must not be smaller than the radius of a pulley for the same cable.

6.18.7.4 Turnbuckles attached to parts having angular motion must be done so in a manner that will positively prevent binding throughout the range of travel.

6.18.7.5 Use of bridle cables clamped directly to rudder cables to affect nose or tail wheel steering is prohibited.

6.18.8 *Joints:*

6.18.8.1 Control system joints (in push-pull systems) that are subject to angular motion, except those in ball, roller, and spherical bearing systems, must have a factor of safety of not less than 3.3 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball, roller, or spherical bearings, the approved ratings must not be exceeded.

6.18.8.2 Rod end bearing spherical ball attachment (in push-pull systems):

(1) Double Shear—The bolt through the spherical ball in rod end bearings (in push-pull systems) is preferred to be rigidly captured on both sides of the ball (double shear) so as not to put cantilever forces on the bolt.

(2) Single Shear—Cantilevered bolt arrangement is permissible if bolt and the structure can be demonstrated to be appropriately robust to prevent flexure or fatigue, or both, of the structure or bolt, and the bolt is installed with its threaded portion inside the arm such that there is no significant bending on the threaded portion of the bolt.

6.18.8.3 The rod end bearing threads must use a locknut to prevent the threaded joint from turning on its threads.

6.18.8.4 Special care shall be made that the spherical ball in the rod end bearings does not limit travel of the controls and that undue bending forces are not put on the rod end bearings. Push-pull rods using rod end bearings on both ends should have freedom to twist at all extremes of the control inputs.

6.19 *Cockpit Design:*

6.19.1 *General*—The cockpit and its equipment must allow each pilot to perform his/her duties without unreasonable concentration or fatigue.

6.19.2 *Cockpit View*—Each cockpit must be designed so that:

6.19.2.1 The pilot's field of view is sufficiently extensive, clear, and undistorted for safe operation.

6.19.2.2 If a windscreen is provided, and unless otherwise placarded against flying in rain, rain or mist must not unduly impair the pilot's view along the flight path in normal flight and during landing. A canopy opening or other means shall be provided for adequate pilot's view under such conditions.

6.19.2.3 The pilot is easily able to establish a pitch attitude by reference to a fixed point on the airframe (or a device attached to the airframe) that appears near the horizon in the pilot's view when looking forward in level flight.

6.19.3 *Windshields, Windows, and Doors:*

6.19.3.1 Windshields and windows, if fitted, must be constructed of a material that will not break into dangerous fragments or become opaque when damaged.

6.19.3.2 Doors, windows compartment covers, and inspection covers, if fitted, shall be designed so that, in the event of a malfunction of their latching mechanisms, they will not be forced open by the action of the slipstream.

6.19.4 *Cockpit Controls:*

6.19.4.1 Each cockpit control must be located to provide convenient operation and prevent confusion and inadvertent operation.

6.19.4.2 The controls must be located and arranged so that each pilot, when properly secured by his safety harness, has full and unrestricted movement of all essential controls from each of the two pilot seats (including allowance for bulky winter clothing).

6.19.4.3 Secondary controls must maintain any desired position without requiring constant attention by the pilot(s) and must not tend to creep under loads or vibration. Controls must have adequate strength to withstand operating loads without failure or excessive deflection.

6.19.5 *Flight Controls:*

6.19.5.1 Cyclic forward for rotor tilt forward, backward for rotor tilt backward, right for right lateral roll, and left for left lateral roll.

6.19.5.2 Rudder-right foot pedal forward for nose-right yaw rotation, left foot pedal forward for nose-left yaw rotation.

6.19.6 *Seats:*

6.19.6.1 Each seat and its supporting structure must be designed for an occupant weight in accordance with 4.1.3 and for the maximum load factors corresponding to the specified flight and ground conditions including the emergency landing conditions prescribed in 5.8.1.

6.19.6.2 Seats, including cushions, must not deform under flight loads to such an extent that the pilot is unable to operate the controls safely or that the pilot is likely to operate the wrong controls.

6.19.7 *Safety Belts and Harnesses:*

6.19.7.1 A safety lap belt must be available to each occupant, capable of restraining the wearer against the forces resulting from the accelerations prescribed for emergency landing conditions in 5.8.1.

6.19.7.2 Unless a suitably safe attach point is not practical in that application, a shoulder harness must be available to each occupant, capable of restraining the wearer against the forces resulting from the accelerations prescribed for emergency landing conditions in 5.8.1.

6.19.7.3 Shoulder harness, if installed, should attach at a point on the airframe that would not be likely to depart the airframe forcibly upon a crash (that is, motor mounts or mast upon a blade strike) or result in ancillary occupant injury such as spinal compression.

6.19.7.4 Each safety harness must be attached so that the wearer is safely restrained in the seat under flight and emergency landing accelerations.

6.19.8 Where the occupants and engine are housed within an enclosed fuselage or where the occupants are within an enclosed fuselage, the occupants and engine must be separated by a sealed firewall.

6.19.9 Where an engine is housed in a separate compartment, the fuel tank will not be located in that compartment unless the tank and all of its associated components are fireproof.

6.19.10 *Protection from Injury*—Rigid structural members or rigidly mounted items of equipment must be padded where necessary to avoid occupant injury during minor crash conditions.

6.19.11 *Baggage Compartment:*

6.19.11.1 Each baggage compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the flight and ground load conditions of Section 6.

6.19.11.2 Means must be provided to protect occupants from injuries by movement of the contents of baggage compartments under the forward load factor specified in 5.8.1.

6.19.12 *Emergency Exit:*

6.19.12.1 The cockpit must be so designed as to provide occupants with unimpeded and rapid escape in an emergency.

6.19.12.2 Where the cockpit is enclosed, the opening system must be designed for simple and easy operation. It must function rapidly and be designed so that it can be operated by each occupant strapped in his/her seat and also from outside the cockpit.

6.19.13 *Ventilation*—When there is an enclosed cockpit, it must be designed so as to afford suitable ventilation under normal flying conditions.

7. Powerplant

7.1 *General*—Except for 7.2, engine criteria which is additionally required, evidence of compliance with the Powerplant Sub-Section E of CAP 643 shall be accepted in lieu of compliance with Section 7, Powerplant, of this specification.

7.1.1 *Installation*—Powerplant installation includes the engine, propeller, and each component that:

7.1.1.1 Is necessary for propulsion,

7.1.1.2 Affects the safety of the propulsion unit between normal inspections and overhauls, or

7.1.1.3 Affects the control of the propulsion unit.

7.1.2 The powerplant must be constructed, arranged, and installed to:

7.1.2.1 Ensure safe operation between normal inspection and overhaul, and

7.1.2.2 Be accessible for necessary inspections and maintenance.

7.1.3 Components of the powerplant, including fuel tanks and other parts of the gyroplane that are electrically conductive, must be grounded to the main frame.

7.2 *Engine*—Installed engines shall meet one of the following criteria:

7.2.1 Installed engines shall meet Practice F2339, or

7.2.2 Installed engines shall be type and production certified under FAR-33, JAR-E, CS-E, JAR-22 Subpart H, or CS-22 Subpart H design and production standards.

NOTE 17—Type certified engines may be subject to additional regulatory maintenance requirements.

7.3 *Engine and Propeller Compatibility:*

7.3.1 The combination of engine and propeller must be compatible with the gyroplane, function in a satisfactory manner, and be operated safely within any limitations set under 9.2 and 9.4.

7.3.2 Safe and satisfactory operation of the engine and propeller combination in the make and model gyroplane for a period of 100 h flying without significant problems is acceptable evidence of compliance. Note that if significant changes are made to the engine, additional flying hours may be necessary to ensure that a complete period of 100 h is achieved with the final standard of engine in combination with the propeller.

7.4 *Rotor Spin-Up and Brake Systems:*

7.4.1 If a rotor spin-up or brake system is installed and would be detrimental to flight safety, it must be designed to prevent:

7.4.1.1 It remaining engaged on takeoff, and

7.4.1.2 It becoming engaged in flight.

7.4.2 Any abnormal limitation(s) on the use of any rotor spin-up or brake systems must be specified.

NOTE 18—Such limitation(s) must be identified in the POH.

7.5 *Powerplant and Rotor System Compatibility:*

7.5.1 The combination of powerplant and rotor system must be compatible with the gyroplane, function in a satisfactory manner, and be operated safely over the range of operating conditions and flight envelope.

7.5.2 Safe and satisfactory operation of the engine and propeller combination in the make and model gyroplane for a period of 100 h of flight which is representative of operational use, without significant problems, is acceptable evidence of compatibility of the powerplant and rotor combination. Note that if significant changes are made to the powerplant or rotor system, additional flying hours may be necessary to ensure that a complete period of 25 h is achieved with the final standard of powerplant in combination with the rotor system.

7.6 *Propeller Clearance*—If an unshrouded propeller is installed, propeller clearances at maximum gross weight with the most adverse balance with the propeller in the most adverse pitch position and taking account of likely engine mount and airframe flexibility must not be less than the following:

7.6.1 *Ground Clearance*—There must be a clearance of at least 175 mm (7 in.) between the propeller and the ground, with the landing gear statically deflected and in the level normal takeoff or taxiing attitude, whichever is most critical. In addition, there must be positive clearance between the propeller and the ground in the level takeoff attitude, with the most adverse combination of:

7.6.1.1 Undercarriage deflection, and

7.6.1.2 One tire fully deflated.

7.6.2 *Clearance from Other Parts of the Gyroplane*—There must be:

7.6.2.1 There must be adequate longitudinal clearance between the propeller blades or cuffs and other parts of the gyroplane or engine to allow for engine movement and the flexibility of the propeller and airframe.

7.6.2.2 Positive clearance between all rotating parts of the propeller and spinner and other parts of the gyroplane under all operating conditions.

7.6.3 *Clearance from Occupant(s)*—There must be adequate clearance between the occupant(s) and the propeller so that it is not possible for the occupant(s), when seated and strapped in, to contact the propeller inadvertently. (This is not intended to cover the case where an occupant deliberately stretched to try to touch the propeller).

7.7 *Fuel System:*

7.7.1 *General:*

7.7.1.1 The fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine functioning under any normal operating condition.

7.7.1.2 Fuel feed systems may not supply fuel to the engine from more than one tank at a time, unless both tanks are interconnected in such a manner to ensure that all interconnected tanks feed to the last of the useable fuel (see 7.7.3).

7.7.1.3 The fuel system must be arranged to minimize the occurrence of vapor locks and to prevent introducing air into the system.

7.7.1.4 The fuel system and its components must be resistant to detrimental effects from exposure to, or use of gasoline which contains up to 25 % ethyl alcohol (ethanol fuels). Detrimental effects shall include, among others, leakage, swelling, cracking, internal shredding, or other conditions that could lead to an engine failure or engine power loss.

7.7.1.5 The fuel system and its components must be resistant to detrimental effects from exposure to or use of alternate fuels approved for use by the aircraft and engine producer. Alternate fuels shall include but not be limited to diesel or bio fuels. Detrimental effects shall include, but not be limited to: leakage, swelling, cracking, internal flaking, or other conditions that could lead to an engine failure or engine power loss.

7.7.2 *Fuel Flow:*

7.7.2.1 *Gravity Systems*—The fuel flow rate for each gravity system (main and reserve supply) must be at least 150 % of the actual takeoff fuel consumption of the engine.

7.7.2.2 *Pump Systems*—The fuel flow rate for the pump system (and reserve supply if dual pump systems are provided) must be at least 125 % of the actual takeoff fuel consumption of the engine at the maximum power established for takeoff.

NOTE 19—Fuel flow is measured after the float valve(s) in carburetor engines and at the inlet to the injectors in injected engines.

7.7.3 *Fuel Quantity:*

7.7.3.1 The useable fuel quantity for each tank must be established as not less than that quantity at which the first evidence of engine fuel starvation occurs under the most adverse fuel feed conditions occurring during takeoff, climb, approach, and landing involving that tank.

7.7.3.2 The unusable fuel quantity must be established and identified on the fuel level indicator or indicating device and should be included in the gyroplane empty weight in 4.1.4.

NOTE 20—Unusable fuel quantity must be included specified in the POH.

7.7.4 *Fuel Tanks—General:*

7.7.4.1 Each fuel tank must be able to withstand, without failure, inertia, fluid, and structural loads that it may be subjected to in normal operation.

7.7.4.2 Where surging of fuel within the tank could cause significant changes in the center of gravity of the gyroplane, means must be provided to reduce the surging to within acceptable limits.

7.7.4.3 Each fuel tank must be immune to detrimental effects from long-term exposure to, or use of, fuels which contain up to 25 % ethyl alcohol (ethanol fuels). Such detrimental effects shall include, among others, softening, hardening, leakage, shrinkage, or other effects which could lead to failure of the fuel tank or failure of the fuel tank to meet the requirements of this standard.

7.7.5 *Fuel Tank Pressure:*

7.7.5.1 Each fuel tank must be able to withstand pressure of 0.1 bar (1.5 psig) (above atmospheric pressure) without failure or leakage.

7.7.6 *Fuel Tank Installation:*

7.7.6.1 Each fuel tank must be supported so that the loads resulting from the weight of the fuel are distributed to multiple support points on the airframe and on the fuel tank. In addition:

(1) Provisions must be made, if necessary, to prevent chafing between each tank and its supports or any part of the frame or structure, and

(2) Materials used for supporting the tank or padding the supporting members must be nonabsorbent or treated to prevent the absorption of fuel.

7.7.6.2 Any compartment containing a fuel tank must be ventilated and drained to prevent accumulation of flammable fluids and vapors.

7.7.6.3 Structural damage that may result from a heavy landing in excess of the ultimate capability of the landing gear but within the emergency landing conditions of 5.8.1 must not result in rupture of the fuel tank or fuel lines.

7.7.7 *Fuel Tank Sump:*

7.7.7.1 Each fuel tank, if permanently installed, must have a drainable sump which is effective in all normal ground and flight attitudes and with a capacity of 0.10 % of the tank capacity, or 120 mL (0.03 gal), whichever is the greater. Alternatively:

(1) A fuel system sediment bowl or chamber that is accessible for drainage and has a capacity of at least 120 mL (0.03 gal) must be fitted, and

(2) Each fuel tank outlet must be located so that, in the normal ground attitude, water draining from any part of the tank will accumulate in the sediment bowl or chamber.

7.7.7.2 The fuel drainage system must be readily accessible and easy to drain.

7.7.7.3 Each fuel system drain must have manual or automatic means for positive locking of the closed position.

7.7.8 *Fuel Tank Filler Connection:*

7.7.8.1 Fuel tank filler connections must be located outside the cockpit, or must be located so that overflowed or spilled fuel runs overboard, and so that fuel or fuel vapors cannot enter any closed compartment of the gyroplane.

7.7.9 *Fuel Tank Vents:*

7.7.9.1 Each fuel tank must be vented from the top of the tank.

7.7.9.2 Each vent outlet must be located and constructed in a manner that minimizes the possibility of its being obstructed by ice or other foreign matter.

7.7.9.3 Each vent must be constructed to prevent siphoning of fuel during normal operation nor should it create a partial vacuum.

7.7.9.4 Each vent must discharge clear of the gyroplane and clear of any electrical or exhaust components.

7.7.10 *Fuel Strainer or Filter:*

7.7.10.1 There must be a replaceable or drainable fuel filter or strainer between the fuel tank outlet and the fuel pump inlet (or carburetor inlet on gravity feed systems).

7.7.11 *Fuel System Lines and Fittings:*

7.7.11.1 Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads caused by fuel pressure and accelerated flight conditions.

7.7.11.2 Each fuel line connected to components between which relative motion could exist must have provisions for flexibility.

7.7.11.3 Each flexible hose must be shown to be suitable for the particular application.

7.7.11.4 Where possible, fuel lines must be located so that leakage from any fuel line or connection must not impinge on hot surfaces or equipment which could cause a fire nor fall directly onto any occupant.

7.7.11.5 Fuel lines must be located or insulated with respect to hot surfaces or equipment so as to minimize the risk of fire or vapor lock.

7.7.11.6 Fuel lines located in an area subject to high heat (engine compartment) must be fire resistant or protected with a fire-resistant covering.

7.7.12 *Fuel Valves and Controls:*

7.7.12.1 The portion of fuel line between any fuel line stop valve and the carburetor must be as short as practically possible.

7.7.12.2 Each fuel line stop valve, if installed, must be at least fire resistant and must have either positive stops or effective detents in the ON and OFF positions.

7.7.12.3 Each fuel line stop valve, if installed, must be at least fire resistant and must have readily identifiable ON and OFF positions.

7.8 *Oil System:*

7.8.1 *General:*

7.8.1.1 If an engine is provided with an oil system, it must be capable of supplying the engine with an appropriate quantity of oil at a temperature not exceeding the maximum established as safe for continuous operation.

7.8.1.2 Each oil system must have a useable capacity adequate for the endurance of the gyroplane.

7.8.2 *Oil Tanks:*

7.8.2.1 Where an oil tank is fitted, it must be installed:

(1) Meet the requirements of 7.7.6, and

(2) Withstand any vibration, inertia and fluid loads expected in normal operation. Evidence of compliance may be accumulated under 7.5.

7.8.2.2 The oil level must be easy to check without having to use any tools.

7.8.2.3 If the oil tank is installed in the engine compartment, it must be made of fireproof material.

7.8.3 *Oil Tank Pressure*—Each oil tank must be able to withstand a pressure of 3500 Kgf/cm^2 (5 psig) (above atmospheric pressure) without failure or leakage.

7.8.4 *Oil Lines and Fittings:*

7.8.4.1 Oil lines must comply with 7.7.11 and accommodate a flow of oil at a rate and pressure adequate for proper engine functioning under any normal operating conditions.

7.8.4.2 Oil lines must be so routed and, if necessary, supported so as to prevent chafing of any part of the engine or frame.

7.8.4.3 Breather lines must be arranged so that:

(1) Condensed water vapor or oil that might freeze and obstruct the line cannot accumulate at any point;

(2) The breather discharge will not constitute a fire hazard if foaming occurs or cause emitted oil to strike the occupant(s) or the pilot's windshields; and

(3) The breather does not discharge into the engine air induction system unless the engine is correctly fitted with a positive crankcase ventilation valve.

7.9 *Cooling:*

7.9.1 *General*—The cooling provisions must be able to maintain the temperatures of powerplant components and engine fluids within acceptable temperature limits during all likely operating conditions.

7.9.1.1 Any coolant hoses must be so routed and if necessary supported as to prevent chafing on any part of the engine or frame.

7.9.1.2 Any coolant hoses that could burst and cause hot water or steam to strike the occupant(s) must be suitably lagged or shielded.

7.10 *Induction System:*

7.10.1 *Air Induction*—The air induction system for the engine must supply the air required by the engine under all intended operating conditions. Evidence of compliance may be accumulated under 7.5.

7.11 *Exhaust System:*

7.11.1 *General:*

7.11.1.1 The exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in the cockpit.

7.11.1.2 Each exhaust system component must be separated from adjacent flammable parts of the gyroplane.

7.11.1.3 No exhaust gases may discharge dangerously near any oil or fuel system drain.

7.11.1.4 Each exhaust system compartment must have adequate ventilation or airflow to prevent points of detrimental high temperature.

7.11.2 *Exhaust Manifold:*

7.11.2.1 The exhaust system must be fireproof and must have means to prevent failure due to vibration and expansion by operating temperature.

7.11.2.2 The exhaust and silencing system must be supported to withstand the inertia loads to which it may be subjected in normal operation.

7.11.2.3 If the design of the exhaust system is such that after a failure in the exhaust system it can interfere with the propeller, additional restraint must be provided to ensure a degree of redundancy in the exhaust system mounting.

7.11.2.4 Parts of the exhaust system connected to components between which relative motion could exist must have means for flexibility.

7.12 *Powerplant Controls and Accessories:*

7.12.1 *General*—The portion of each powerplant control located in an engine compartment that is required to be operated in the event of fire must be at least fire resistant.

7.12.2 *Engine Ignition System:*

7.12.2.1 A switch, readily accessible to the pilot, must be provided to enable each ignition circuit to be rendered inoperative.

7.12.2.2 The ignition switch(s) must be arranged and designed to prevent inadvertent operation.

7.12.2.3 Each battery ignition system must be supplemented by a charging system that is capable of sustaining normal flight engine operation should the battery fail.

7.12.3 *Propeller Speed*—During takeoff and climb at the recommended best rate-of-climb speed, the propeller must limit the engine rotational speed at full throttle to a value not greater than the maximum allowable rotational speed.

7.13 *Cowling and Nacelle*—When an engine installation is cowled:

7.13.1 Each cowling must be constructed and supported so that it can resist any vibration, inertia, and air loads to which it may be subjected in operation.

7.13.2 There must be a means for rapid and complete drainage of each part of the cowling in the normal ground and flight attitudes. No drain may discharge where it will cause a fire hazard.

7.13.3 For tractor engines, the cowling must be at least fire resistant.

7.13.4 For tractor engines, each part behind an opening in the engine compartment cowling must be at least fire resistant for a distance of at least 0.6 m (23 in.) aft of the opening.

7.13.5 Each part of the cowling subjected to possible detrimental high temperatures because of its nearness to exhaust system ports or exhaust gas impingement must be fireproof and protected from detrimental heat damage.

8. Equipment

8.1 *General:*

8.1.1 *Function and Installation:*

8.1.1.1 Each item of required equipment must:

(1) Be of a kind and design appropriate to its intended function,

(2) Be installed according to limitations specified for that equipment, and

(3) Function properly when installed.

8.1.1.2 Instruments and other equipment must not in themselves, or by their effect upon the gyroplane, constitute a hazard to safe operation.

8.1.2 *Flight and Navigation Instruments*—The following are required flight and navigational instruments:

8.1.2.1 Air speed indicator,

8.1.2.2 Altimeter, and

8.1.2.3 Compass.

8.1.3 *Powerplant Instruments*—The following are the required powerplant instruments:

8.1.3.1 Such pressure, temperature, and rpm indicators as are necessary to operate the engine within its limitations;

8.1.3.2 A fuel quantity indicator for each fuel tank; and

8.1.3.3 An oil quantity indicator for each tank, for example, dipstick.

8.1.4 *Miscellaneous Equipment*—Reserved.

8.2 *Instruments—Installation:*

8.2.1 *Arrangement and Visibility*—Flight and navigation instruments and powerplant instruments, in accordance with 8.1.2 and 8.1.3, must be clearly arranged and plainly visible.

8.2.2 *Pitot and Static Pressure Systems*—The design and installation of pitot and static pressure systems must be such that:

8.2.2.1 Positive drainage of moisture is provided,

8.2.2.2 Chafing of tubing, and excessive distortion or restriction at bends in the tubing, is avoided, and

8.2.2.3 The materials used are durable, suitable for the purpose intended, and protected against corrosion.

8.2.3 *Powerplant Instruments:*

8.2.3.1 *Instruments and Instrument Lines:*

(1) Each powerplant instrument line carrying flammable fluids under pressure must meet the requirements of 7.7.11.

(2) Each line carrying flammable fluids under pressure must have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails.

8.2.3.2 Each exposed sight gage used as a liquid quantity indicator must be protected against damage. The low level indication range of the indicator must be plainly visible to the pilot.

8.3 *Electrical Systems and Equipment:*

8.3.1 *Battery Design and Installation*—Each battery must be installed so that:

8.3.1.1 No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the gyroplane.

8.3.1.2 No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent essential equipment.

8.3.2 *Electric Cables and Equipment:*

8.3.2.1 Each electric connecting cable must be of adequate capacity and correctly routed, attached, and connected so as to minimize the probability of chafing, short circuits, and fire hazards.

8.3.2.2 Overload protection of sufficient current-carrying capacity must be provided for each electrical circuit.

8.3.2.3 Electric cables must not be attached to fuel lines.

8.4 *Miscellaneous Equipment:*

8.4.1 *Airborne Radio and Radio Navigation Equipment*—Any fixed item of airborne radio equipment must comply with the following:

8.4.1.1 The equipment and its antenna may neither in themselves, nor by their mode of operation or by their effect upon the operating characteristics of the gyroplane and its equipment, constitute a hazard to safe operation.

8.4.1.2 The equipment and its control and monitoring devices must be arranged so as to be easily controllable. Their installation must be such that they are sufficiently ventilated to prevent overheating.

9. Operating Limitations and Information

9.1 *General:*

9.1.1 Each operating limitation specified in 9.4 and other limitations and information necessary for safe operation must be established.

NOTE 21—The established limitations must be identified in the POH.

9.1.2 The operating limitations and other information necessary for safe operation must be made available to the pilot in accordance with 9.7.1 – 9.7.5.

9.2 *Airspeed Limitations*—All flight speeds must be stated in terms of indicated airspeed (IAS).

9.3 *Weight and Balance*—Limitations essential to proper loading and balance of the gyroplane must be documented and carried in the aircraft. A method to develop this weight and balance or hang test documentation must establish the following:

9.3.1 The MGW determined under 4.1.3 must be established as an operating limitation.

9.3.2 The balance limitations determined under 4.1.2 must be established as operating limitations.

9.3.3 The empty weight and the corresponding balance limitations must be determined in accordance with 4.1.4.

9.3.4 A method must be provided or described to conduct the hang test or weight and balance without structurally endangering or overstressing critical components from which the gyroplane may be hung or supported.

NOTE 22—The method of conducting the hang test and the determination of these critical weights and balance must be provided in the POH.

9.4 *Powerplant and Propeller Limitations*—The powerplant and propeller limitations must be established.

NOTE 23—The powerplant and propeller limitations must be identified in the POH.

9.5 *Pilot Operating Handbook, POH*—Pilot Operating Handbook containing system descriptions, operating procedures and limitations, engine and aircraft performance, critical airspeeds and altitudes, a height versus velocity curve, emergency procedures, preflight inspections, and any other information critical to safe operation of the gyroplane must be provided. The POH shall contain at least the following section headings and related information when applicable to a specific aircraft model and configuration and shall be listed in the order shown as follows. All specializations and limitations shall be those determined from the preceding relative design criteria.

9.5.1 *Operating Limitations:*

9.5.1.1 Never exceed speed, V_{ne} (see 4.2.5),

9.5.1.2 Crosswind and wind limitations (see 4.4.4),

9.5.1.3 Service ceiling (see 4.2.10),

9.5.1.4 Established safe rotor speed range (see 4.1.6.1),

9.5.1.5 Rotor spin-up and brake limitations (see 7.4.2),

9.5.1.6 Load factors if achievable, and

9.5.1.7 Prohibited maneuvers.

9.5.2 *Emergency Procedures:*

9.5.2.1 Emergency landing (see 4.3.1.4).

9.5.3 *Normal Procedures*—The following operating procedures and handling information shall be provided:

9.5.3.1 Pre-flight check,

9.5.3.2 Engine starting,

9.5.3.3 Taxiing,

9.5.3.4 Normal takeoff,

9.5.3.5 Best rate of climb speed (V_Y),

9.5.3.6 Cruise,

9.5.3.7 Approach,

9.5.3.8 Normal landing,

9.5.3.9 Short field takeoff and landing procedures, if any,

9.5.3.10 Balked landing procedures,

9.5.3.11 Slow speed sink, vertical descents, and recovery, and

9.5.3.12 Other useful pilot information.

9.5.4 *Performance:*

9.5.4.1 Takeoff and landing distances (see 4.2.2 and 4.2.9),

9.5.4.2 Rate of climb (see 4.2.3),

9.5.4.3 Best glide airspeed and rate of descent (see 4.2.4),

9.5.4.4 Minimum controllable airspeed for level flight, $V_{\min}$ (see 4.2.6),

9.5.4.5 Best rate of climb airspeed, V_y (see 4.2.7),

9.5.4.6 Minimum power required airspeed, MPRS (see 4.2.8),

9.5.4.7 Height/velocity envelope (see 4.2.11),

9.5.4.8 Engine RPM (see 9.3), and

9.5.4.9 Fuel consumption.

9.5.5 *Weight And Balance Information:*

9.5.5.1 Installed equipment list,

9.5.5.2 Maximum gross weight (see 4.1.3),

9.5.5.3 Design empty weight (see 4.1.4), and

9.5.5.4 Hang test or center of gravity (CG) range and determination (see 4.1.2 and 9.3.2).

9.5.6 *Aircraft and Systems Descriptions:*

9.5.6.1 Engine,

9.5.6.2 Propeller,

9.5.6.3 Rotor,

9.5.6.4 Fuel, fuel specifications, fuel capacity, and unusable fuel (see 7.7.3.2),

9.5.6.5 Electrical,

9.5.6.6 Oil, and

9.5.6.7 Operating weights and loading (occupants, baggage, fuel, ballast).

9.5.7 *Aircraft Ground Handling and Servicing:*

9.5.7.1 Servicing fuel, oil, coolant, and

9.5.7.2 Towing and tie-down instructions.

9.5.8 *Supplementary Information:*

9.5.8.1 Familiarization flight procedures and techniques, if any,

9.5.8.2 Flight instruction information and materials, if any, and

9.5.8.3 Pilot operating advisories, if any.

9.5.9 *Required Placards and Markings:*

9.5.9.1 Airspeed indicator range markings,

9.5.9.2 Operating limitations on instrument panel, if applicable, and

9.5.9.3 *Passenger Warning*—This aircraft was manufactured in accordance with light sport aircraft airworthiness standards and does not conform to standard category airworthiness requirements.

9.6 *Maintenance Manual*—A maintenance manual containing routine, inspection, and repair maintenance procedures for the aircraft and engine must be provided.

9.7 *Markings and Placards:*

9.7.1 *General*—The gyroplane must be marked with:

9.7.1.1 The markings and placards specified in 9.7.2 – 9.7.5, and

9.7.1.2 Any additional information, instrument markings, and placards required for the safe operation of the gyroplane.

9.7.1.3 Each marking and placard prescribed in 9.7.1.1

(1) Must be displayed in a conspicuous place, and

(2) May not be easily erased, disfigured, or obscured.

9.7.1.4 The units of measurement used to indicate air speed on placards must be the same as those used on the air-speed indicator.

9.7.2 *Operating Limitations, Placards, and Instrument Markings*—Airspeed and powerplant limitations essential to the safe operation of the gyroplane must be plainly visible to the pilot. Where this cannot be achieved by instrument markings, a placard must be provided. Where these limitations are shown by instrument markings, each maximum and minimum safe operating limit, if applicable, must be marked by a red line.

9.7.3 *Fuel Quantity Indicator*—Each fuel quantity indicator shall be calibrated to read zero during level flight when the quantity of fuel remaining in the tank is equal to the unusable quantity determined in accordance with 7.7.3.

9.7.4 *Control Markings:*

9.7.4.1 Each cockpit control, other than primary flight controls, must be clearly marked as to its function and method of operation.

9.7.4.2 Emergency controls must be colored red.

9.7.4.3 For powerplant fuel controls:

(1) The fuel tank selector control (if fitted) must be marked to indicate the position corresponding to each tank, and

(2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on or near the selector for those tanks.

9.7.5 *Miscellaneous Markings and Placards:*

9.7.5.1 *Baggage Compartment*—Each baggage compartment must have a placard stating the loading limitations.

9.7.5.2 Fuel filler opening(s) must be marked at or near the filler cover(s) with the minimum fuel grade and if applicable the fuel/oil ratio.

9.7.5.3 *Fuel Tanks*—The usable fuel capacity of each tank must be marked either at the selector or the gauge or on the tank if the tank is translucent and visible to the pilot in flight.

9.7.5.4 *Loading*—If removable ballast is used, the place for carrying ballast must have a placard stating instructions for the proper placement and securing of the removable ballast under each loading condition for which each removable ballast is necessary.

9.7.5.5 *Occupant Warning*—A placard showing an occupant warning must be plainly visible to all occupants when occupying the control seats, as follows: "This aircraft was manufactured in accordance with light sport aircraft airworthiness standards and does not conform to standard category airworthiness requirements."

9.7.5.6 Where alternate flight configurations are allowed, such as with or without canopies or doors, any significantly different flight limitations for any particular configuration must be clearly marked in view of all occupants.

10. Propellers

10.1 *Design and Construction:*

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

10.1.1.1 Be established on the basis of experience or tests, and

10.1.1.2 Conform to specifications that ensure that they have the strength and other properties assumed in the design data.

10.1.2 *Durability*—Propeller design and construction must minimize the possibility of the occurrence of an unsafe condition of the propeller between overhauls.

11. Alterations

11.1 Major alterations applicable to this section are those alterations not included in the aircraft's maintenance manual as provided according to Practice F2483.

11.2 All major alterations made to aircraft subsequent to its initial design and production acceptance testing must be evaluated as to comply with the standards of this specification.

11.2.1 The manufacturer or other entity that performs the evaluation of a major alteration shall provide written documentation that the aircraft being altered will still meet the requirements of this specification subsequent to the alteration.

11.2.1.1 The manufacturer or other entity that performs the evaluation of major alterations shall provide information to the owner of the aircraft for documentation of the alteration in the aircraft records

11.2.2 The manufacturer or other entity that performs the evaluation of major alterations shall provide written instructions and diagrams on how the alteration is to be implemented and define who may perform the alteration.

11.2.2.1 The instructions must include ground and flight testing procedures, as appropriate, to verify that a major alteration was performed in accordance with the written instructions and the aircraft is in a safe condition for return to flight.

11.2.3 Material substitutions or design changes made by the original manufacturer prior to delivery to the end user shall be proven to comply with the standards of this specification and Specification F2972, and are not considered major alterations, as defined in this section, and need not comply with the provisions of this section.

12. Keywords

12.1 gyroplane; light sport aircraft