INTERNATIONAL

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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 stated in SI units are to be regarded as standard. The values given 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, health, and environmental 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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1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM 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

[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), Aviation House, Beehive Ringroad, Crawley, West Sussex RH6 0YR, https://www.caa.co.uk/.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, https://www.faa.gov.

[5] Available from IHS Market, 15 Inverness Way East, Englewood, CO 80112, https://www.global.ihs.com.

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 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 s 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 s 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.