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Standard Specification for Design and Performance of a Light Sport Glider[1]

This standard is issued under the fixed designation F2564; 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 airworthiness requirements for the design of a powered or non-powered fixed wing light sport aircraft, a "glider."

1.2 This specification is applicable to the design of a light sport aircraft glider as defined by regulations and limited to day VFR flight.

1.3 A glider for the purposes of this specification is defined as a heavier than air aircraft that remains airborne through the dynamic reaction of the air with a fixed wing and in which the ability to remain aloft in free flight does not depend on the propulsion from a power plant. A powered glider is defined for the purposes of this specification as a glider equipped with a power plant in which the flight characteristics are those of a glider when the power plant is not in operation.

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

1.5 *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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2295 Practice for Continued Operational Safety Monitoring of a Light Sport Aircraft

F2316 Specification for Airframe Emergency Parachutes

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

F2840 Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft

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

2.2 *Other Standards:*

CS-22 Subpart H Certification Specifications for Sailplanes and Powered Sailplanes[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *electric propulsion unit, EPU*—any electric motor and all associated devices used to provide thrust for an electric aircraft.

3.1.2 *energy storage device, ESD*—used to store energy as part of a Electric Propulsion Unit (EPU). Typical energy storage devices include but are not limited to batteries, fuel cells or capacitors.

3.1.3 *feathering*—a single action from the cockpit that repositions the propeller blades to low drag configuration when the engine is not operating.

3.1.4 *flaps*—any movable high lift device.

3.1.5 *maximum empty weight, W_E (kg)* —largest empty weight of the glider, including all operational equipment that is installed in the glider: weight of the airframe, powerplant, excluding energy storage device (ESD) for electric propulsion unit when removable, required equipment, optional and specific equipment, fixed ballast, full engine coolant and oil, hydraulic fluid, and the unusable fuel. Hence, the maximum empty weight equals maximum takeoff weight minus minimum useful load: $W_E = W - W_U$.

3.1.6 *minimum useful load, W_U (kg)* —where $W_U = W - W_E$.

3.1.7 The terms "engine" referring to internal combustion engines and "motor" referring to electric motors for propulsion are used interchangeably within this standard.

3.1.8 The term "engine idle" or "throttle closed" when in reference to electric propulsion units shall mean the minimum power or propeller rotational speed condition for the electric motor as defined without electronic braking of the propeller rotational speed.

3.2 *Abbreviations:*

3.2.1 *AOI*—Aircraft Operating Instructions

3.2.2 *AR*—Aspect Ratio = b^2/S

[1] This specification is under the jurisdiction of ASTM Committee F37 on Light Sport Aircraft and is the direct responsibility of Subcommittee F37.10 on Glider.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from European Aviation Safety Agency (EASA), Postfach 10 12 53, D-50452 Koeln, Germany, http://www.easa.eu.int/home.php.

3.2.3 *b*—wing span (m)

3.2.4 *c*—chord (m)

3.2.5 *CAS*—calibrated air speed (m/s, kts)

3.2.6 C_L—lift coefficient of the aircraft

3.2.7 C_D—drag coefficient of the aircraft

3.2.8 *CG*—center of gravity

3.2.9 C_m—moment coefficient (C_m is with respect to *c*/4 point, positive nose up)

3.2.10 C_{MO}—zero lift moment coefficient

3.2.11 C_n—normal coefficient

3.2.12 *g*—acceleration as a result of gravity = 9.81 m/s^2

3.2.13 *IAS*—indicated air speed (m/s, kts)

3.2.14 *ICAO*—International Civil Aviation Organization

3.2.15 *LSA*—light sport aircraft

3.2.16 *n*—load factor

3.2.17 n_1—glider positive maneuvering limit load factor at V_A

3.2.18 n_2—glider positive maneuvering limit load factor at V_D

3.2.19 n_3—glider negative maneuvering limit load factor at V_A

3.2.20 n_4—glider negative maneuvering limit load factor at V_D

3.2.21 *q*—dynamic pressure = 0.004823 V^2 kg/m^2, when *V* is in km/h

3.2.22 *S*—wing area (m^2)

3.2.23 *V*—airspeed (m/s, kts)

3.2.24 V_A—design maneuvering speed

3.2.25 V_C—design cruising speed

3.2.26 V_D—design diving speed

3.2.27 V_{DF}—demonstrated flight diving speed

3.2.28 V_F—design flap speed

3.2.29 V_{FE}—maximum flap extended speed

3.2.30 V_H—maximum speed in level flight with maximum continuous power (corrected for sea level standard conditions)

3.2.31 V_{LO}—maximum speed for landing gear extended

3.2.32 V_{NE}—never exceed speed

3.2.33 V_S—stalling speed or minimum steady flight speed at which the aircraft is controllable (flaps retracted)

3.2.34 V_{S1}—stalling speed, or minimum steady flight speed in a specific configuration

3.2.35 V_{S0}—stalling speed or minimum steady flight speed at which the aircraft is controllable in the landing configuration

3.2.36 V_R—ground gust speed

3.2.37 V_T—maximum aerotow speed

3.2.38 V_W—maximum winch tow speed

3.2.39 V_Y—speed for best rate of climb

3.2.40 *W*—maximum takeoff or maximum design weight (kg)

3.2.41 W_E—maximum empty aircraft weight (kg)

3.2.42 W_U—minimum useful load (kg)

3.2.43 *w*—average design surface load (N/m^2)

4. Flight

4.1 *Proof of Compliance:*

4.1.1 Each of the following requirements shall be met at the most critical weight and CG configuration. Unless otherwise specified, the speed range from stall to V_{DF} or the maximum allowable speed for the configuration being investigated shall be considered.

4.1.1.1 V_{DF} shall be less than or equal to V_D.

4.1.1.2 If V_{DF} chosen is less than V_D, V_{NE} must be less than or equal to 0.9 V_{DF} and greater than or equal to 1.1 V_C.

4.1.2 The following tolerances are acceptable during flight testing:

Weight	+5 %, −10 %
Weight, when critical	+5 %, −1 %
CG	±7 % of total travel

4.2 Compliance must be established for all configurations except as otherwise noted. In demonstrating compliance, the powerplant or propeller, if retractable, must be retracted, except as otherwise noted.

4.3 *Load Distribution Limits:*

4.3.1 The maximum weight shall be determined so that it is:

4.3.1.1 Not more than:

(1) The highest weight selected by the applicant, and

(2) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition and all requirements for flight characteristics is shown.

4.3.1.2 Not less than:

(1) For a single-place glider not less than the empty weight of the glider, plus a weight of the occupant of 80 kg, plus the required minimum equipment, plus, for a powered glider, sufficient energy (fuel or other energy storage) for at least 30 min of flight at maximum continuous power.

(2) For a two-place glider not less than the empty weight of the glider, plus a weight of the occupants of 160 kg, plus the required minimum equipment, plus, for a powered glider, sufficient energy (fuel or other energy storage) for at least 30 min of flight at maximum continuous power.

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

4.3.3 *Empty Weight and Center of Gravity Range:*

4.3.3.1 The CG range within which the glider can be safely operated must be specified by the manufacturer.

4.3.3.2 The empty weight, corresponding CG, most forward, and most rearward CG shall be determined with fixed ballast and required minimum equipment.

4.3.3.3 The CG range must not be less than that which corresponds to that of a sole pilot weight of 65 kg up to the maximum weight, always considering the most unfavorable placing of luggage.

4.3.3.4 Fixed or removable ballast, or both, may be used if properly installed and placarded.

4.3.3.5 Multiple ESDs may be used if properly installed and placarded.

4.4 *Propeller Speed and Pitch Limits for a Powered Glider*—The operating limitations shall not allow the engine to exceed safe operating limits established by the engine manufacturer under normal conditions.

4.4.1 Maximum RPM shall not be exceeded with full throttle during takeoff, climb, or flight at 0.9 V_H, and 110 % maximum continuous RPM shall not be exceeded during a glide at V_{NE} with throttle closed.

4.5 *Performance, General*—All performance requirements apply in standard ICAO atmosphere in still air conditions and at sea level. Speeds shall be given in indicated (IAS) and calibrated (CAS) airspeeds.

4.5.1 *Stalling Speeds:*

4.5.1.1 Wing level stalling speeds V_{S0} and V_S shall be determined by flight test at a rate of speed decrease of 1 knot/s or less, throttle closed, with maximum takeoff weight, and most unfavorable CG.

4.5.1.2 For powered gliders, wing level stalling speeds V_{S0} and V_S shall also be determined with the engine idling, propeller in the takeoff position, and the cowl flaps closed.

4.5.1.3 For powered gliders, wings level, level flight top speed V_H shall be determined by flight test at maximum continuous rated RPM or with full throttle, if unable to reach max continuous RPM, at maximum takeoff weight, in cruise configuration.

4.5.2 *Takeoff for a Powered Glider:*

4.5.2.1 With the glider at maximum takeoff weight and full throttle, the distance to clear a 15-m (50-ft) obstacle shall not exceed 600 m (2000 ft).

4.5.2.2 Takeoff must be demonstrated with crosswind components not less than 0.2 V_{S0}.

NOTE 1—The procedure used for normal takeoff, including flap position, shall be specified within the AOI.

4.5.3 *Climb*—At maximum takeoff weight, flaps in the position specified for climb within the AOI, landing gear retracted, and full throttle, the minimum rate of climb shall exceed 1.0 m/s (200 ft/min).

4.5.4 *High Speed Descent*—If so equipped, the glider must not exceed V_{NE} in a dive at a 30° angle to the horizon with airbrakes extended.

4.5.5 *Descent*—If so equipped, the glider must have a glide slope not flatter than one in seven at a speed of 1.3 V_{S0} at maximum weight and with airbrakes extended.

4.5.6 *Landing*—The following shall be determined:

4.5.6.1 Landing distance from 15 m (50 ft) above ground when speed at 15 m (50 ft) is 1.3 V_{S0}.

4.5.6.2 Ground roll distance with braking if so equipped.

4.6 *Controllability and Maneuverability:*

4.6.1 *General:*

4.6.1.1 The glider shall be safely controllable and maneuverable during takeoff, climb, level flight, dive to V_{DF} or the maximum allowable speed for the configuration being investigated, engine extension and retraction, and approach and landing through the normal use of primary controls.

4.6.1.2 Smooth transition between all flight conditions shall be possible without exceeding pilot force as shown in Table 1.

TABLE 1 Pilot Force

Pilot force as applied to the controls	Pitch, N	Roll, N	Yaw, N	Wing flaps, landing gear, air brakes, retraction or extension of engine, two cable release, N
For temporary application: (less than 2 min) Stick	200	150	300	150
For prolonged application:	20	15	100	Not determined

4.6.1.3 Full control shall be maintained when retracting and extending flaps within their normal operating speed range (V_{S0} to V_{FE}).

4.6.1.4 Lateral, directional, and longitudinal control shall be possible down to V_{S0}.

4.6.2 *Longitudinal Control:*

4.6.2.1 At steady flight, or if so equipped, with the aircraft trimmed as closely as possible for steady flight at 1.3 V_{S1}, it must be possible at any speed below 1.3 V_{S1} to pitch the nose downward so that a speed not less than 1.3 V_{S1} can be reached promptly. This must be shown with the aircraft in all possible configurations.

4.6.2.2 Longitudinal control forces shall increase with increasing load factor.

4.6.2.3 Longitudinal control must be maintained:

(1) In towed flight, while extending or retracting flaps.

(2) When retraction or extension of the airbrakes is made at speeds between 1.1 V_{S0} and 1.5 V_{S0}.

(3) For powered gliders, when a change of the wing flap configuration is made during steady horizontal flight at 1.1 V_{S1} with simultaneous application of maximum continuous power.

(4) For powered gliders, when the engine is extended or retracted.

4.6.3 *Directional and Lateral Control:*

4.6.3.1 It must be possible, without significant slip or skid, to reverse the direction of a turn with a 45° bank to the opposite direction within *b*/3 or 4 s, whichever is longer (where *b* is the span of the glider in meters), when the turn is made at a speed of 1.4 V_{S1}, with where applicable, wing flaps, air brakes, and landing gear retracted.

4.6.3.2 With and without flaps deployed, rapid entry into or recovery from a maximum cross-controlled slip shall not result in uncontrollable flight characteristics.

4.6.3.3 Lateral and directional control forces shall not reverse with increased deflection.

4.6.4 *Aerotowing:*

4.6.4.1 If the glider is equipped for aerotowing, aerotows must be demonstrated at speeds up to V_T without:

(1) Difficulty in regaining the normal towing position after the glider has been displaced laterally or vertically.

(2) The released tow cable contacting any part of the glider.

4.6.4.2 Aerotowing must be demonstrated with crosswind components not less than 0.2 V_{S0}.

4.6.4.3 A suitable range of tow cables must be established.

4.6.4.4 Tests must be repeated for each location of the towing release mechanism.

4.6.5 *Winch Launching:*

4.6.5.1 If the glider is equipped for winch launching or auto-tow launching, such launches must be demonstrated up to V_W without:

(1) Uncontrolled roll after leaving the ground and upon a release,

(2) Uncontrolled pitching oscillations, and

(3) Control forces in excess of those listed in Table 1 and excessive deflections of the controls.

4.6.5.2 Winch launching must be demonstrated with cross-wind components not less than 0.2 V_{S0}.

4.6.5.3 If a trimming device is fitted, the position used during the climb must be listed in the AOI.

4.6.6 *Approach and Landing:*

4.6.6.1 Normal approaches and landings until the glider comes to a complete halt must be demonstrated with crosswind components not less than 0.2 V_{S0}.

4.6.6.2 The use of air brakes during approach will not cause control forces in excess of those listed in Table 1 or excessive control displacements, nor affect the controllability of the glider.

4.6.6.3 After touchdown, there must not be a tendency to ground loop, for pitching oscillation or to nose over.

4.6.7 *Static Longitudinal Stability:*

4.6.7.1 The glider shall demonstrate the ability to trim for steady flight at speeds appropriate to the launch, flight, and landing approach configurations for gliders, and climb and cruise for powered gliders; at minimum and maximum weight; and forward and aft CG limits. If the glider has no in-flight adjustable longitudinal trimming device, the trim speed must be between 1.2 V_{S1} and 2.0 V_{S1} for all CG positions.

4.6.7.2 The glider shall exhibit positive longitudinal stability characteristics at any speed above V_{S1} , up to the maximum allowable speed for the configuration being investigated, and at the most critical power setting and CG combination.

4.6.7.3 Stability shall be shown by a tendency for the glider to return toward steady flight after: *(1)* a "push" from steady flight that results in a speed increase, followed by a non-abrupt release of the pitch control; and *(2)* a "pull" from steady flight that results in a speed decrease, followed by a non-abrupt release of the pitch control.

4.6.7.4 The glider shall demonstrate compliance with this section for the conditions listed in Table 2.

4.6.7.5 While returning toward steady flight, the aircraft shall:

(1) Not decelerate below stalling speed V_{S1},

(2) Not exceed V_{NE} or the maximum allowable speed for the configuration being investigated, and

(3) Exhibit decreasing amplitude for any long-period oscillations.

4.6.8 *Static Directional and Lateral Stability:*

4.6.8.1 There can be no tendency for the glider when in straight flight at 1.4 V_{S1} with wing-flaps in all en-route positions, air brakes, and where applicable, landing gear retracted to:

(1) Turn or bank when the aileron control is released and the rudder control held fixed in the neutral position, and

(2) Yaw when the rudder control is released and the aileron control held fixed in the neutral position.

TABLE 2 Static Longitudinal Stability Requirements

Cruising Configuration
At all speeds between 1.1 V_{S1} and V_{NE}
Wing flaps in the position for cruising and for circling
Landing gear retracted
Glider trimmed at 1.4 V_{S1} and 2 V_{S1} (if equipped with a trimming device)
Air brakes retracted
Approach
At all speeds between 1.1 V_{S1} and V_{FE}
Wing flaps in the landing position
Landing gear extended
Glider trimmed at 1.4 V_{S0} (if equipped with a trimming device)
Air brakes retracted and extended
Climb for Powered Glider
At all speeds between 0.85 V_Y or 1.05 V_Y
Wing flaps in the position for climb
Landing gear retracted
Glider trimmed at V_Y (if equipped with a trimming device)
Maximum weight
Maximum continuous power
Cruise for Powered Glider
At all speeds between 1.3 V_{S1} and V_{NE}
Wing flaps retracted or in the case of flaps approved for use in cruise flight in all appropriate positions
Landing gear retracted
Glider trimmed for level flight (if equipped with a trimming device)
Maximum weight
Power set for horizontal flight at 0.9 V_H
Approach for Powered Glider
At all speeds between 1.1 V_{S1} and V_{NE}
Wing flaps in the landing position
Landing gear extended
Glider trimmed at 1.5 V_{S1} (if equipped with a trimming device)
Maximum weight
Air brakes retracted and extended
Power set at idle

4.6.8.2 The glider shall exhibit positive directional and lateral stability characteristics at any speed above V_{S1}, up to the maximum allowable speed for the configuration being investigated, and at the most critical CG combination.

4.6.8.3 Powered glider must demonstrate:

(1) Retraction and extension of the power plant or propeller must not produce excessive trim changes,

(2) A climb at maximum continuous power at V_Y with landing gear retracted and wing flaps in the takeoff position is achievable with trimmed pitch controls, and

(3) Level flight at all speeds between V_Y and V_H, with the landing gear retracted and wing flaps in a position appropriate to each speed is achievable with trimmed pitch controls.

4.6.8.4 With the glider in straight and steady flight, and when the aileron and rudder controls are gradually applied in opposite directions, any increase in slideslip angle must correspond to an increased deflection of the lateral control. This behavior need not follow a linear law.

4.6.9 *Dynamic Stability*—Any short period oscillations shall be heavily damped within the appropriate speed range (V_{S0} to V_{FE} flaps extended and V_S to V_{DF} flaps retracted) for primary controls fixed and free. In the case of a powered glider, this requirement must be met with the engine running at all allowable powers.

4.6.10 *Wings Level Stall:*

4.6.10.1 It shall be possible to prevent more than 30° of roll or yaw by normal use of the controls during the stall and the recovery at all weight and CG combinations.

4.6.10.2 The loss of altitude from a stall must be determined and listed in the AOI.

4.6.10.3 Minor yaw (up to 5°) shall not have a significant influence on the stall characteristics.

4.6.10.4 Compliance with this section must be demonstrated under the following conditions:

(1) Wing flaps in any condition,

(2) Air brakes retracted and extended,

(3) Landing gear retracted and extended,

(4) Glider trimmed to 1.4 V_{S1} (if equipped with a trimming device),

(5) Additionally, for powered gliders, cowl flaps must be in the appropriate configuration with the engine at idle and 90 % of maximum continuous power, and

(6) During winch takeoff with the glider pitch 30° above the horizontal.

4.6.11 *Turning Flight Stalls:*

4.6.11.1 When stalled during a coordinated 45° banked turn, it must be possible to regain normal level flight without encountering uncontrollable rolling or spinning tendencies. Compliance with this requirement must be shown under the conditions of 4.6.10.4 that result in the most critical stall behavior of the glider. The landing configuration, with air-brakes retracted and extended, must be investigated.

4.6.11.2 The loss of altitude from beginning of the stall until regaining wings level flight and a speed of 1.4 V_{S1} must be determined.

4.6.12 *Stall Warning:*

4.6.12.1 There must be a clear and distinctive stall warning with airbrakes, wing flaps, and landing gear in any normal position, both in straight and turning flight. In the case of a powered glider, compliance with this requirement must also be shown with the engine running in the conditions prescribed in 4.6.10.4*(5)*.

4.6.12.2 The stall warning may be furnished either through the inherent aerodynamic qualities of the glider (that is, buffeting) or by a device that will give clearly distinguishable indications. A visual only stall warning is not acceptable.

4.6.12.3 The stall warning must begin:

(1) In the speed rand of 1.05 V_{S1} to 1.1 V_{S1}, or

(2) 2 to 5 s before the stall occurs while the speed is decreasing at 1 knot/s.

4.6.13 *Spinning:*

4.6.13.1 For gliders placarded "no intentional spins," the glider must be able to recover from a one-turn spin or a 3-s spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery.

4.6.13.2 For gliders in which intentional spinning is allowed, the glider must be able to recover from a three-turn spin in not more than one and one-half additional turn.

4.6.13.3 In addition, for either 4.6.13.1 or 4.6.13.2:

(1) The applicable airspeed limit and limit maneuvering load factor shall not be exceeded,

(2) Control forces during the spin or recovery shall not exceed those listed in Table 1, and

(3) It must be impossible to obtain unrecoverable spins with any use of the controls.

4.6.14 *Spiral Dive Characteristics*—If there is any tendency for a spin to turn into a spiral dive, the glider must be able to recover from this condition without exceeding either the limiting air speed or the limiting maneuvering factor for the glider.

4.7 *Vibrations*—Flight testing shall not reveal by pilot observation heavy buffeting (except as associated with a stall), excessive airframe or control vibrations, flutter (with proper attempts to induce it), or control divergence at any speed from V_{S0} to V_{DF}.

4.8 *Ground Control and Stability*—There must not be any uncontrollable ground loop tendency at any speed at which a powered glider will operate on the ground up to the maximum crosswind component specified in 4.5.2.2.

5. Structure

5.1 *General:*

5.1.1 *Loads:*

5.1.1.1 Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

5.1.1.2 Unless otherwise provided, the air and ground loads must be placed in equilibrium with inertia forces, considering each item of mass in the aircraft. These loads must be distributed to conservatively approximate or closely represent actual conditions.

5.1.1.3 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:*

5.1.2.1 Unless otherwise provided in 5.1.2.2, an ultimate load factor of safety of 1.5 must be used.

5.1.2.2 Special ultimate load factors of safety shall be applied according to Table 3.

5.1.3 *Strength and Deformation:*

5.1.3.1 The structure must be able to support limit loads without permanent deformation. At any load up to limit loads, the deformation shall 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. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3-s limit does not apply.

5.1.4 *Proof of Structure*—Each design requirement must be verified by means of conservative analysis or test (static, component, or flight), or both.

TABLE 3 Ultimate Load Factors

2.0 × 1.5 = 3.0	on castings
1.2 × 1.5 = 1.8	on fittings
2.0 × 1.5 = 3.0	on bearings at bolted or pinned joints subject to rotation
4.45 × 1.5 = 6.67	on control surface hinge-bearing loads except ball and roller bearing hinges
2.2 × 1.5 = 3.3	on push-pull control system joints
1.33 × 1.5 = 2	on cable control system joints, seat belt/harness fittings (including the seat if belt/harness is attached to it)

5.1.4.1 Compliance with the strength and deformation requirements of 5.1.3 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated. Substantiating load tests should normally be taken to ultimate design load.

5.1.4.2 Certain parts of the structure must be tested as specified in 6.11.

5.2 *Flight Loads:*

5.2.1 *General:*

5.2.1.1 *Flight Load Factors, n,* represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the aircraft) to the weight of the aircraft. A positive flight load factor is one in which the aerodynamic force acts upward with respect to the glider.

5.2.1.2 Compliance with the flight load requirements of this section must be shown at each practicable combination of weight and disposable load within the operating limitations specified in the AOI.

5.2.2 *Symmetrical Flight Conditions:*

5.2.2.1 The appropriate balancing horizontal tail loads must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the symmetrical flight conditions specified in 5.2.2 – 5.2.6.

5.2.2.2 The incremental horizontal tail loads due to maneuvering and gusts must be reacted by the angular inertia of the glider in a rational or conservative manner.

5.2.2.3 In computing the loads arising in the conditions prescribed above, the angle of attack is assumed to be changed suddenly without loss of air speed until the prescribed load factor is attained. Angular accelerations may be disregarded.

5.2.2.4 The aerodynamic data required for establishing the loading conditions must be verified by tests, calculations, or by conservative estimation. In the absence of better information, the maximum negative lift coefficient for rigid lifting surfaces shall be assumed to be equal to −0.80. If the pitching moment coefficient, C_{mo}, is less than ±0.025, a coefficient of at least ±0.025 must be used.

5.2.3 *Flight Envelope*—Compliance shall be shown at any combination of airspeed and load factor on the boundaries of the flight envelope. The flight envelope represents the envelope of the flight loading conditions specified by the criteria of 5.2.4 and 5.2.5 (see Fig. 1).

5.2.3.1 *General*—Compliance with the strength requirements of this subpart must be shown at any combination of airspeed and load factor on and within the boundaries of the flight envelopes specified by the maneuvering and gust criteria of 5.2.3.2 and 5.2.3.3, respectively.

5.2.3.2 *Maneuvering Envelope*—Wing flaps are in the en-route setting and air brakes are closed (see Fig. 1).

5.2.3.3 *Gust Envelope*—Wing flaps in the en-route setting (see Fig. 2). At the design maximum speed V_D, the glider must be capable of withstanding positive (up) and negative (down) gusts of 7.5 m/s acting normal to the flight path.

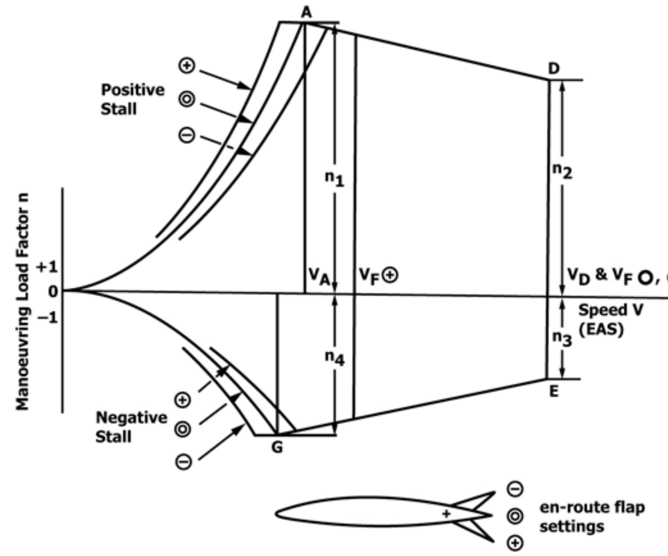

FIG. 1 Maneuvering Envelope

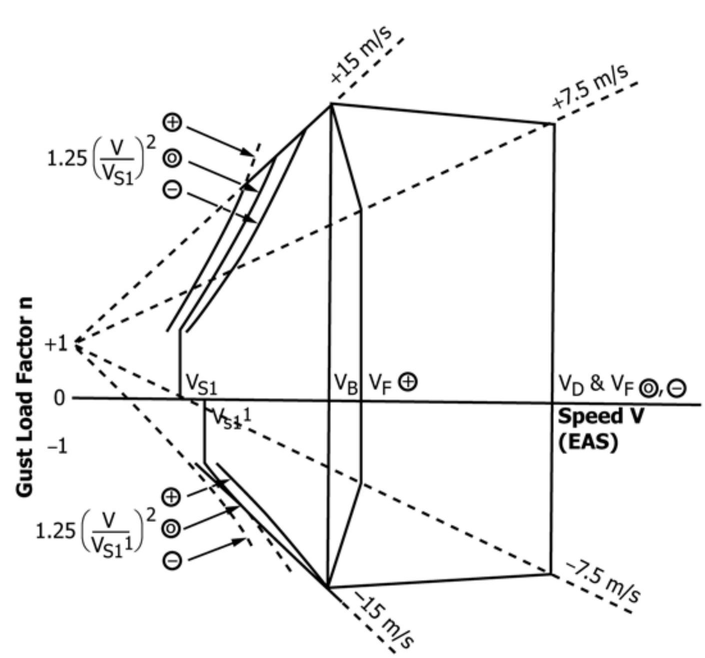

FIG. 2 Gust Envelope

5.2.4 *Design Airspeeds:*

5.2.4.1 *Design Maneuvering Speed, V_A:*

$$V_A = V_{S1}\sqrt{n_1} \quad (1)$$

where:

V_{S1} = estimated stalling speed at design maximum weight with wing-flaps and air brakes retracted, and

n_1 = positive limit maneuvering load factor used in design.

5.2.4.2 *Design Flap Speed, V_F* —For each landing setting, V_F must not be less than the greater of: *(1)* 1.4 V_S, where V_S is the computed stalling speed with the wing flaps retracted at the maximum weight; and *(2)* 2.0 V_{SF} , where V_{SF} is the computed stalling speed with wing flaps fully extended at the maximum weight.

5.2.4.3 *Design Aerotow Speed,* V_T, must not be less than 1.5 V_{S1} according to 5.2.4.1.

5.2.4.4 *Design Dive Speed,* V_D*:*

$$V_D = 18\sqrt[3]{\left(\frac{m}{S}\right)\left(\frac{1}{Cd_{min}}\right)}\ \text{(km/h) but not} \leq V_A \tag{2}$$

where:

m/S = wing loading (kg/m^2) at design maximum weight, and

Cd_{min} = the lowest possible drag coefficient of the glider.

5.2.5 *Limit Maneuvering Load Factors:*

5.2.5.1 The positive limit maneuvering load factor n_1 shall not be less than 4.0 while n_2 shall not be less than 3.0.

5.2.5.2 The negative limit maneuvering load factor n_3 shall not be less than −1.5, while n_4 shall not be less than –2.0.

5.2.6 *Gust Load Factors*—In the absence of a more rational analysis, the gust load factors must be computed as follows:

$$n = 1 \pm \left[\frac{\left(\frac{k}{2}\right)\rho_o\,U\,V\,a}{\left(\frac{mg}{S}\right)}\right] \tag{3}$$

where:

ρ_o = density of air at sea-level (1225 kg/m^3),
U = gust velocity (m/s),
V = equivalent air speed (m/s),
a = slope of wing lift curve (1/rad),
m = mass of the glider (kg),
g = acceleration due to gravity (m/s^2),
S = wing area (m^2), and
k = gust alleviation factor calculated from the following formula:

$$k = \frac{0.88\mu}{5.3+\mu} \tag{4}$$

where:

$$\mu = \frac{2\frac{m}{S}}{\rho Ca}\ \text{(non − dimensional glider mass ration)} \tag{5}$$

where:

ρ = density of air (kg/m^3) at the sea level, and
C = mean geometric chord of wing (m).

The value of n calculated from the expression given above need not exceed:

$$n = \left(\frac{V}{V_{S1}}\right)^2 \tag{6}$$

5.2.7 *Unsymmetrical Flight Conditions*—The glider is assumed to be subjected to the unsymmetrical flight conditions of 5.2.7.1 and 5.2.7.2. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principle masses furnishing the reacting inertia forces.

5.2.7.1 *Rolling Conditions*—The glider shall be designed for the loads resulting from the roll control deflections and speeds specified in 5.7.1 in combination with a load factor of at least two thirds of the positive maneuvering load factor prescribed in 5.2.5.1.

5.2.7.2 *Yawing Conditions*—The glider must be designed for the yawing loads resulting from the vertical surface loads specified in 5.5.

5.2.8 *Loads with Air Brakes and Wing Flaps Extended:*

5.2.8.1 *Loads with Air Brakes Extended:*

(1) The glider structure must be capable of withstanding the most unfavorable combination of the following parameters: equivalent air speed at V_D, air brakes extended, and a load factor from 0 to 2.0.

(2) The horizontal tail load corresponds to the static condition of equilibrium.

(3) In determining the spanwise load distribution, changes in this distribution due to the presence of the air brakes must be accounted for.

5.2.8.2 If wing-flaps are installed, positive limit factor 3,0 must be assumed while positions of the flaps from retracted up to positive deflection and up to speed V_F are considered.

5.2.8.3 It must be considered that the glider at positions of the flaps from retracted up to maximum negative deflection must comply with the requirements of 5.2.3.2 and 5.2.3.3.

5.2.9 *Engine Torque*—The engine mount and its supporting structure must be designed for the effects of:

5.2.9.1 The limit torque corresponding to takeoff power and propeller speed acting simultaneously with 75 % of the limit loads from flight condition of 5.2.5.1.

5.2.9.2 The limit torque corresponding to maximum continuous power and propeller speed acting simultaneously with the limit loads from the flight condition of 5.2.5.1.

5.2.9.3 For conventional reciprocating engines with positive drive to the propeller, the limit torque to be accounted for in 5.2.9.1 and 5.2.9.2 is obtained by multiplying the mean torque by one of the following factors:

(1) 2 for engines with 4 cylinders,
(2) 3 for engines with 3 cylinders,
(3) 4 for engines with 2 cylinders, and
(4) 8 for an engine with one cylinder.

5.2.9.4 For conventional electric motors with positive drive to the propeller, the limit torque to be accounted for in 5.2.9.1 and 5.2.9.2 is obtained by multiplying the mean torque by 1.33.

5.2.10 *Side Load on Engine Mount:*

5.2.10.1 The engine mount and its supporting structure must be designed for a limit load factor in a lateral direction, for the side load on the engine mount, of not less than one third of the limit load factor for flight condition A of Fig. 1 (⅓ n_1).

5.2.10.2 The side load prescribed in 5.2.10.1 shall be assumed to be independent of other flight conditions.

5.3 *Control Surface and System Loads:*

5.3.1 *Control Surface Loads*—The control surface loads specified in 5.3.3 through 5.3.7 are assumed to occur in the conditions described in 5.2.2 through 5.2.6.

5.3.2 *Control System Loads*—Each part of the primary control system situated between the stops and the control surfaces must be designed for the loads corresponding to at least 125 % of the of the computed hinge moments of the movable control surfaces resulting from the loads in the conditions prescribed in 5.3.1 through 5.7.3. In computing the hinge moments, reliable aerodynamic data must be used. In no case shall the load in any part of the system be less than those resulting from the application of 60 % of the pilot forces described in 5.3.3. In addition, the system limit loads need not exceed the loads that can be produced by the pilot. Pilot forces used for design need not exceed the maximum pilot forces prescribed in 5.3.3.

5.3.3 *Loads Resulting from Limit Pilot Forces:*

5.3.3.1 The main control systems for the direct control of the aircraft about its longitudinal, lateral, or yaw axis, including the supporting points and stops, must be designed for the limit loads resulting from the limit pilot forces given in Table 1.

5.3.3.2 The rudder control system must be designed to a load of 600 N per pedal acting simultaneously on both pedals in the forward direction.

5.3.4 *Dual-Control Systems*—Dual-control systems must be designed for the loads resulting from each pilot applying 0.75 times the load specified in 5.3.3 with the pilots acting in opposition.

5.3.5 *Secondary Control Systems*—Secondary control systems, such as those for landing gear retraction or extension, wheel brake, trim control, and so forth must be designed for the maximum forces that a pilot is likely to apply.

5.3.6 *Control System Stiffness and Stretch*—The amount of control surface or tab movement available to the pilot shall not be dangerously reduced by elastic stretch or shortening of the system in any condition.

5.3.7 *Ground Gust Conditions*—In the absence of a more rational analysis, the control system from the control surfaces to the stops or control locks, when installed, must be designed for limit loads due to gusts corresponding to the following hinge moments:

$$M_S = k \cdot C_S \cdot S_S \cdot q \tag{7}$$

where:

M_S = limit hinge moment,
C_S = mean chord of the control surface aft of the hinge line,
S_S = area of the control surface aft of the hinge line,
Q = dynamic pressure corresponding to an airspeed of 38 knots, and
K = limit hinge moment coefficient due to ground gust = 0.75.

5.3.8 *Control Surface Mass Balance Weights*—If applicable, shall be designed for the following forces to be applied to the mass balance weight:

5.3.8.1 A force equal to 24 times the mass balance weight applied normal to the surface, and

5.3.8.2 A force equal to 12 times the weight applied fore and aft and parallel to the hinge line.

5.3.9 The motion of wing flaps on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection unless the aircraft has safe flight characteristics with the wing flaps retracted on one side and extended on the other.

5.3.10 All primary controls shall have stops within the system to withstand the greater of pilot force, 125 % of surface loads, or ground gust loads (see 5.3.7).

5.4 *Horizontal Stabilizing and Balancing Surfaces:*

5.4.1 *Balancing Loads:*

5.4.1.1 A horizontal stabilizing surface balancing load if the load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

5.4.1.2 Horizontal stabilizing surfaces must be designed for the balancing loads occurring at any point on the limit maneuvering envelope and in the air-brake and wing-flap positions specified in 5.2.3.

5.4.2 *Maneuvering Loads*—Horizontal stabilizing surfaces must be designed for pilot-induced pitching maneuvers imposed by the following conditions:

5.4.2.1 At speed V_A, maximum upward deflection of pitch control surface,

5.4.2.2 At speed V_A, maximum downward deflection of pitch control surface,

5.4.2.3 At speed V_D, one-third maximum upward deflection of pitch control surface, and

5.4.2.4 At speed V_D, one-third maximum downward deflection of pitch control surface.

NOTE 2—In 5.4.2, the following assumptions should be made: the glider is initially in level flight, and its altitude and airspeed do not change. The loads are balanced by inertia forces.

5.4.3 *Gust Loads*—In the absence of a more rational analysis, the horizontal tail loads must be computed as follows:

$$F_{VOP} = F_o + \frac{\rho_o}{2} S_{VOP}\, a_{VOP}\, U\, kH_{VOP} \left(1 - \frac{d\varepsilon}{d\alpha}\right) V \tag{8}$$

where:

F_o = horizontal tail balancing load acting on the horizontal tail before the appearance of the gust (N),
ρ_o = density of air at sea-level (1225 kg/m^3),
S_{VOP} = area of horizontal tail (m^2),
a_{VOP} = slope of horizontal tail lift curve per radian,
U = gust speed (m/s),
kH_{VOP} = gust factor. In the absence of a rational analysis, the same value shall be taken as for the wing,
V = speed of flight (m/s), and
$d\varepsilon/d\alpha$ = rate of change of downwash angle with wing angle of attack.

5.5 *Vertical Stabilizing Surfaces:*

5.5.1 *Maneuvering Loads*—The vertical stabilizing surfaces must be designed for maneuvering loads imposed by the following conditions:

5.5.1.1 At a speed, the greater of V_A and V_T, full deflection of the rudder.

5.5.1.2 At speed V_D, one-third full deflection of the rudder.

5.5.2 *Gust Loads:*

5.5.2.1 The vertical stabilizing surfaces must be designed to withstand lateral gusts of the values prescribed in 5.2.3.3.

5.5.2.2 In the absence of a more rational analysis, the vertical surfaces gust loads shall be computed as follows:

$$F_{SOP} = a_{SOP} S_{SOP} \frac{\rho_o}{2} UkV \tag{9}$$

where:

F_{SOP} = gust load (N),
a_v = slope of vertical tail lift curve per radian,
S_{SOP} = area of vertical tail (m^2),
ρ_o = density of air at sea-level (1.225 kg/m^3),

V = speed of flight (m/s),
U = gust speed (m/s), and
k = gust factor, could be taken as 1.2.

5.5.3 *Outboard Fins or Winglets:*

5.5.3.1 If outboard fins or winglets are on the horizontal surfaces or wings, the horizontal surfaces or wings must be designed for their maximum load in combination with loads induced by the fins or winglets and moments or forces exerted on the horizontal surfaces or wings by the fins or winglets.

5.5.3.2 If outboard fins or winglets extend above and below the horizontal surface, the critical vertical surface loading (the load per unit area determined in accordance with 5.5.1 and 5.5.2) must be applied to:

(1) The part of the vertical surface above the horizontal surface with 80 % of that loading applied to the part below the horizontal surface or wing, and

(2) The part of the vertical surface below the horizontal surface or wing with 80 % of that loading applied to the part above the horizontal surface or wing.

5.5.3.3 The end plate effects of outboard fins or winglets must be taken into account in applying the yawing conditions of 5.5.1 and 5.5.2 to the vertical surfaces in 5.5.3.2.

5.5.3.4 When rational methods are used for computing loads, the maneuvering loads of 5.5.1 on the vertical surfaces and the n = 1 horizontal surface or wing load, including induced loads on the horizontal surface, or wing and moments or forces exerted on the horizontal surfaces or wing, must be applied simultaneously for the structural loading condition.

5.6 *Supplementary Conditions for Stabilizing Surfaces:*

5.6.1 *Combined Loads on Stabilizing Surfaces:*

5.6.1.1 With the aircraft in a loading condition corresponding to A or D in Fig. 1 (whichever condition leads to the higher balance load) the loads on the horizontal surface must be combined with those on the vertical surface as specified in 5.5.1. It must be assumed that 75 % of the loads according to 5.4.2 for the horizontal stabilizing surface and 5.5.1 for the vertical stabilizing surface are acting simultaneously.

5.6.1.2 The stabilizing surfaces and fuselage must be designed for asymmetric loads on the stabilizing surfaces which would result from application of the highest symmetric maneuver loads of 5.5.1 so that 100 % of the horizontal stabilizer surface loading is applied to one side of the plane symmetry and 70 % on the opposite side.

5.6.2 *Additional Loads Applying to V-Tails*—A glider with a V-tail must be designed for a gust acting perpendicular to one of the surfaces at speed higher than V_A. This condition is supplemental to the equivalent horizontal and vertical cases previously specified.

5.7 *Ailerons, Wing Flaps, and Special Devices:*

5.7.1 *Ailerons*—The ailerons must be designed for control loads corresponding to the following conditions:

5.7.1.1 At speed V_A, the full deflection of the roll control.

5.7.1.2 At speed V_T, one-third of the full deflection of the roll control.

5.7.2 *Flaps*—Wing flaps, their operating mechanisms, and supporting structure must be designed for the critical loads occurring in the flaps-extended operating range with the flaps in any position.

5.7.3 *Special Devices*—The loadings for special devices using aerodynamic surfaces, such as air brakes, must be determined from test data or reliable aerodynamic data that allows close estimates.

5.8 *Ground Load Conditions:*

5.8.1 *Basic Landing Conditions*—The limits of the ground loads specified in this subpart are considered to be external loads and inertial forces that act upon a glider structure. In each specified ground load condition, the external reactions must be placed in equilibrium with the linear and angular inertial forces in a rational or conservative manner. At the design maximum weight, the selected limit of the vertical inertia load factor at the CG of the glider for the ground load conditions shall not be less than that which would be obtained when landing with a descent velocity of 1.5 m/s. Wing lift balancing the weight of the glider shall be assumed to act through the CG. The ground reaction load factor shall be equal to the inertia load factor minus one.

5.8.2 Subsections 5.8.3 through 5.8.8 apply to a glider with conventional arrangements of landing gear. For unconventional types, it may be necessary to investigate additional landing conditions, depending on the arrangement and design of the landing gear units.

5.8.3 *Level Landing Conditions:*

5.8.3.1 For a level landing, the glider is assumed to be in the following attitudes:

(1) For gliders with a tail skid or wheel, or both, a normal level flight attitude.

(2) For gliders with nose wheels, attitudes in which the nose and main wheels contact the ground simultaneously; and the main wheels contact the ground and the nose wheel is just clear of the ground.

5.8.3.2 The main gear vertical load component F_V must be determined to the conditions in 6.12.3.

5.8.3.3 The main gear vertical load component F_V must be combined with a rearward acting horizontal component F_H so that the resultant load acts at an angle at 30° with the vertical.

5.8.3.4 For gliders with nose wheels, the vertical load component F_V on the nose wheel in the attitude of 5.8.3.1*(2)* must be computed as follows and must be combined with a rearward acting horizontal component according to 5.8.3.3 taking into account 6.12.3.1:

$$F_V = 0.8\,mg \tag{10}$$

where:

m = mass of the glider (kg), and
g = acceleration of gravity (m/s^2).

5.8.4 *Tail Down Landing Conditions*—For design of tail skid and affected structure and empennage, including balancing weight attachment, the tail skid load in a tail down landing (main landing gear close to the ground) must be calculated as follows:

$$F = 4\,mg\left(\frac{i_y^2}{i_y^2 + L^2}\right) \tag{11}$$

where:

F = tail skid load (N),

m = mass of the glider (kg),
g = acceleration of gravity (m/s^2),
i_y = radius of gyration of the glider (m), and
L = distance between tail skid and glider CG (m).

5.8.5 *One Wheel Landing Conditions*—If the two wheels of a main landing gear arrangement are laterally separated (see 5.8.2) the conditions under 5.8.3.1 – 5.8.3.3 must be applied also to each wheel separately, taking into account limiting effects of bank. In the absence of a more rational analysis, the limit kinetic energy must be computed as follows:

$$E = \frac{1}{2} m_{red} w^2 \quad (12)$$

where:

$$m_{red} = m \frac{1}{1+\frac{a^2}{i_x^2}} \quad (13)$$

where:

w = rate of descent = 1.5 (m/s),
m = mass of the glider (kg),
a = half the track (m), and
i_x = radius of gyration of the glider (m).

5.8.6 *Side Load Conditions*—A side load acting where the wheel touches the ground is assumed. The applied load is equal to 0.3 F_V and must be combined with a vertical load of 0.5 F_V, where F_V is the vertical load determined in accordance with 5.8.1.

5.8.7 *Tail Skid Impact:*

5.8.7.1 If the CG of the unloaded glider is situated behind the ground contact area of the main landing gear, the rear portion of the fuselage, the tail skid, and the empennage must be designed to withstand the loads arising when the tail landing gear is raised to its highest possible position, consistent with the main wheel remaining on the ground, and is then released and allowed to fall freely.

5.8.7.2 If the CG in all loading conditions is situated behind the ground contact area of the main landing gear, 5.8.7.1 need not be applied.

5.8.8 *Wing Tip Impact*—A limit load 200 N must be assumed to act rearward at the point of contact of one wing-tip with the ground, in a direction parallel to the longitudinal axis of the glider, the yawing moment so generated must be balanced by side load R at the tail skid/wheel or nose skid/wheel (see Fig. 3).

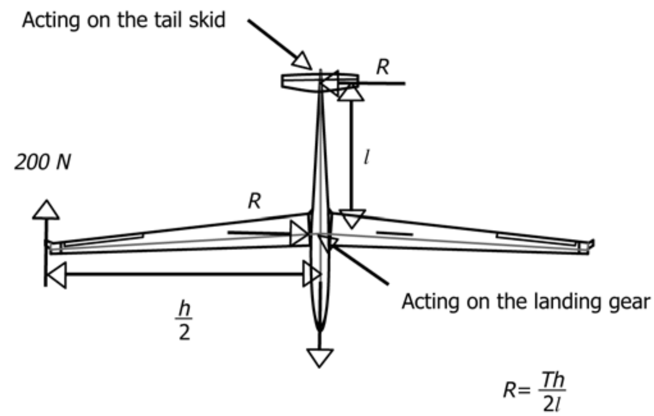

FIG. 3 Wing-Tip Landing

5.9 *Emergency Landing Conditions:*

5.9.1 The structure must be designed to protect each occupant during emergency landing conditions when occupants (through seat belts or harnesses, or both) as well as any concentrated weight located behind or above the occupant (such as engine, baggage, fuel, ESD, ballast, and so forth), experience the static inertia loads corresponding to the following ultimate load factors (these are three independent conditions):

5.9.1.1 n = 4.5 up,

5.9.1.2 n = 9.0 (n = 15.0 for engines or ESD(s) on powered gliders with engines located behind and above the pilot's seat) forward,

5.9.1.3 n = 3.0 lateral, and

5.9.1.4 n = 4.5 down.

5.9.2 A glider with a retractable landing gear must be designed to protect each occupant in a landing with wheel(s) retracted under the following conditions:

5.9.2.1 A downward ultimate inertial force corresponding to an acceleration of n = 3.0.

5.9.2.2 A coefficient of friction of 0.5 at the ground.

5.9.3 Except as provided in 6.13.6, the supporting structure must be designed to restrain, under loads up to those specified in 5.9.1.1 – 5.9.1.4 each item of mass that could injure an occupant if it came loose in a minor crash landing.

5.10 *Aerotowing Loads:*

5.10.1 The glider must be initially assumed to be in stabilized level flight at speed V_T, with a cable load acting at the launching hook in the following directions:

5.10.1.1 Forwards and upwards at an angle of 20°,

5.10.1.2 Forwards and downwards at an angle of 40° with the horizontal, and

5.10.1.3 Horizontally forward and to the sideward at an angle of 30°.

5.10.2 With the glider initially assumed to be subjected to the same conditions as specified in 5.10.1, the cable load due to surging suddenly increases to 1.2 Q_{nom}.

5.10.2.1 The resulting cable load increment must be balanced by inertia forces. These additional loads must be superimposed on those arising from the conditions of 5.10.1.

5.10.2.2 Rated ultimate strength of the towing cable or weak must not be less than 1.3 times the glider maximum weight G (N).

5.11 *Winch Launching Loads:*

5.11.1 The glider will be in level flight at speed V_W with a cable load acting at the launching hook in a forward and downward direction at an angle ranging from 0 to 75° with the horizontal.

5.11.2 The cable load must be determined as the lesser of the following two values:

5.11.2.1 F_{nom} as defined in 5.10.2, or

5.11.2.2 The loads at which equilibrium is achieved, with either:

(1) The elevator fully deflected in upward direction, or

(2) The wing at its maximum lift.

NOTE 3—A horizontal inertia force shall be assumed to complete the equilibrium of horizontal forces.

5.11.3 In the conditions of 5.11.1, a sudden increase of the cable load to the value of 1.2 F_{nom} as defined in 5.10.2 is assumed. The resulting incremental loads must be balanced by inertia forces.

5.12 *Tow Hook Loads:*

5.12.1 The launching hook attachment must be designed to carry a limit load of 1.5 F_{nom}, as defined in 5.10.2, acting in the directions specified in 5.10 and 5.11.

5.12.2 The launching hook attachment must be designed to carry a limit load equal to the maximum weight of the glider, acting at an angle of 90° to the plane of symmetry.

5.13 *Other Loads:*

5.13.1 *Rigging and Derigging Loads*—A rigging limit load of plus and minus twice the wing-tip reaction, determined when either a semi-span wing is simply supported at root and tip or when the complete wing is simply supported at the tips, where this would be representative of the rigging procedure, must be assumed to be applied at the wing tip and reacted by the wing when supported by a reaction and moment at the wing root.

5.13.2 *Hand Forces at the Horizontal Tail Surfaces*—A limit hand force of 5 % of the design maximum weight of the glider but not less than 100 N must be assumed to act on either tip of the horizontal tail surface:

5.13.2.1 In the vertical direction, and

5.13.2.2 In the horizontal direction, parallel to the longitudinal axis.

5.13.3 *Tie-Down Points*—Tie-down points shall be designed for the maximum wind at which the aircraft shall be tied down in the open. V_R = 38 kts minimum in accordance with 5.3.7 shall be used.

5.13.4 *Parachute System Loads*—If the aircraft is to be equipped with an airframe emergency parachute, the attachment point(s) to the airframe must be designed in accordance with Specification F2316.

5.13.5 *Loads from Single Masses*—The attachment means for all single masses that are part of the equipment for the aircraft 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 5.9.

6. Design and Construction

6.1 *General*—The suitability of each structural design detail and part having an important bearing on safety shall be established by test.

6.2 *Materials*—Materials shall be suitable and durable for the intended use. Design values (strength) must be chosen so that no structural part is under strength as a result of material variations or load concentration, or both. Temperatures up to 54°C are considered to correspond to normal operating conditions.

6.3 *Fabrication Methods*—The methods of fabrication used must produce safe structures, especially to ensure strength throughout all conditions of operation. If a fabrication process requires close control to reach this objective, the process must be performed under an approved process specification. Manufactured parts, assemblies, and completed aircrafts shall be produced in accordance with the manufacturer's quality assurance and production acceptance test procedures.

6.4 *Locking of Connections*—An approved 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 glider. No self-locking nut shall be used on any bolt subject to rotation in operation, unless a nonfriction locking device is used in addition to the self-locking device.

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

6.6 *Accessibility*—Accessibility for critical structural elements and control system inspection, adjustment, maintenance, and repair shall be provided.

6.7 *Rigging and Derigging*—Unless specified otherwise, rigging and de-rigging must be able to be performed by persons having no more than average skill. It must be possible to inspect the glider easily for correct rigging and installation of locking devices.

6.8 *Proof of Design*—Fulfillment of the design requirements for the aircraft shall be determined by conservative analysis or tests, or a combination of both. Structural analysis alone shall be used for validation of the structural requirements only if the structure conforms to those for which experience has shown this method to be reliable. Flight tests to limit load factors at maximum takeoff weight and at speeds from V_A to the maximum allowable speed for the configuration being investigated are an acceptable proof (see 5.1.3 and 5.1.4).

6.9 *Flutter:*

6.9.1 The glider must be free from flutter, airfoil divergence, and control reversal at each appropriate speed up to at least V_D. Sufficient damping must be available at any appropriate speed so that aeroelastic vibration dies away rapidly.

6.9.2 Compliance with 6.9.1 must be shown by:

6.9.2.1 A qualified comprehensive review of the frequency characteristics of the structure, influencing the resistance against flutter, like rigidity, mass balancing of the control areas, clearances in the system of the aerodynamic surfaces, distribution of the isolated masses, etc. The judgement must be provided by:

(1) An analytical method, that is able to determine any critical speed in the range up to 1.2 V_D, or

(2) Any other approved method.

6.9.2.2 Systematic flight tests to induce flutter at speeds up to V_{DF}. These tests must show that a suitable margin of damping is available and that there is no rapid reduction of damping as V_{DF} is approached.

6.9.2.3 Flight tests to show that when approaching V_{DF}:

(1) Control effectiveness around all three axes is not decreasing in an unusually rapid manner, and

(2) No signs of approaching airfoil divergence of wings, tailplane, and fuselage result from the trend of the static stabilities and trim conditions.

6.10 *Control Surfaces:*

6.10.1 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:

6.10.1.1 Under limit load (positive or negative) conditions for all control surfaces through their full angular range; and

6.10.1.2 Under limit load on the glider structure other than control surfaces.

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

6.11 *Control System*—Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

6.11.1 *Stops:*

6.11.1.1 Each control system must have stops that positively limit the range of motion of each movable aerodynamic surface controlled by the system.

6.11.1.2 Stops must be located so that wear, slackness, or take-up adjustments will not adversely affect the control characteristics of the glider because of a change in the range of surface travel.

6.11.1.3 Stops must be able to withstand any loads corresponding to the design conditions for the control system.

6.11.2 *Trim System:*

6.11.2.1 Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation. There must be means near the trim control to indicate to the pilot the direction of trim control movement relative to glider motion. In addition, there must be means to indicate to the pilot the position of the trim device with respect to the range of adjustment. This means must be visible to the pilot and must be located and designed to prevent confusion.

6.11.2.2 Tab controls must be irreversible, unless the tab is properly balanced and it is not proved that it has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the glider structure.

6.11.3 *Control System Locks*—If there is a device to lock the control system on the ground, there must be a means to:

6.11.3.1 Give unmistakable warning to the pilot when the lock is engaged, and

6.11.3.2 Prevent the lock from engaging in flight.

6.11.4 *Operation Test*—It must be shown by functional tests that the control system installed on the aircraft is free from interference, jamming, excessive friction, and excessive deflection when the control system design loads (see 5.3) are applied to the controls and the surfaces. The control system stops must withstand those loads.

6.11.5 *Control System Details:*

6.11.5.1 Each detail of the control system must be designed and installed to prevent jamming, chafing, and interference from various objects or the freezing of moisture.

6.11.5.2 There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system.

6.11.5.3 There must be means to prevent the slapping of cables or rods against other parts (min. clearance 5 mm).

6.11.5.4 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.

6.11.6 *Springs*—The reliability of any spring device used in the control system must be established by tests simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.

6.11.7 *Cables and Cable Systems:*

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

(1) 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 and humidity variations; and

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

6.11.7.2 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.

6.11.7.3 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.

6.11.7.4 Turnbuckles must be attached to parts having angular motion in a manner that will enable free movement throughout the range of travel.

6.11.8 *Joints*—Control system joints (in push-pull systems) must have safety factors given in 5.1.2.2.

6.11.9 *Wing Flap and Airbrake Controls:*

6.11.9.1 Each wing-flap control must be designed so that, when the wing-flap has been placed in any position upon which compliance with the performance requirements, the wing-flap will not move from that position if the control is secured or if it is not proved, that such a movement is not dangerous.

6.11.9.2 Wing-flap and air brake controls must be designed to prevent inadvertent extension or movement. The pilot forces and the rate of movement at any approved flight speed must not be such as to impair the operating safety of the glider.

6.11.9.3 The air brake or other drag increasing device must comply with the following:

(1) Where the device is divided into several parts, all parts must be operated by a single control;

(2) It must be possible to extend the device at any speed up to 1.05 V_{NE} without causing structural damage and to retract the device at any speed up to V_A, with a hand force not exceeding 200 N; and

(3) The time required for extension as well as retraction of the device shall not exceed 2 s.

6.11.10 *Wing Flap Position Indicator*—There must be means to indicate to the pilot the actual position of the wing-flaps.

6.11.11 *Wing Flap Interconnection*—The motion of wing-flaps on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection unless the glider has safe flight characteristics with the wing-flaps retracted on one side and extended on the other.

6.11.12 *Release Mechanisms:*

6.11.12.1 Release mechanisms to be used for winch launching must be so designed and installed as to release the towing cable automatically (that is, to back-release) if the glider overruns the cable while it is carrying any appreciable load.

6.11.12.2 It must be impossible for bolts or other projections on the release mechanism itself or the structure surrounding the mechanism, including the landing gear, to damage the towing cable or its parachute.

6.11.12.3 It must be shown that the release force will not exceed that prescribed in 4.6.1.2 when a cable load F_{nom} is applied in any direction (see 5.1.2), and that the release mechanism functions properly under any operating condition.

6.11.12.4 The release lever in the cockpit must be arranged and designed so that the pilot force as defined in 4.6.1.2 can be easily applied.

6.12 *Landing Gear:*

6.12.1 *General:*

6.12.1.1 The glider must be so designed that it can land on unprepared soft ground without endangering its occupants.

6.12.1.2 The design of wheels, skids, and tail skid must be designed to minimize the possibility of fouling by the towing cable.

6.12.2 *Shock Absorption Test*—The proof of sufficient capacity to absorb landing forces must be determined by test.

6.12.3 *Level Landing:*

6.12.3.1 The structure of the glider designed to absorb the landing forces (including tires) must be capable of absorbing the kinetic energy developed in a landing without being fully depressed.

6.12.3.2 The value of kinetic energy to be determined under the assumption that the weight of the glider corresponds to design maximum weight with a rate of descent of 1.5 m/s, wing lift balancing the weight of the glider.

6.12.3.3 Under the assumption of 6.12.3.2, the CG acceleration must not exceed 4 g.

6.12.4 *Retraction Mechanism:*

6.12.4.1 Each landing gear retracting mechanism must be designed for the maximum flight load factors occurring with the gear retracted.

6.12.4.2 For retractable landing gears, it must be shown that extension and retraction of the landing gear are possible without difficulty up to V_{LO}.

6.12.4.3 A glider equipped with a non-manually operated landing gear must have an auxiliary means of extending the gear.

6.12.5 *Wheels and Tires*—The carrying capacity of each wheel and tire must not be exceeded.

6.13 *Pilot Compartment:*

6.13.1 *Cockpit View:*

6.13.1.1 Each cockpit must be designed so that:

(1) The pilot's vision is sufficiently extensive, clear, and undistorted for safe operation; and

(2) Rain shall not unduly impair pilot's view along the flight path in normal flight and during landing.

6.13.1.2 *Windshields and Windows*—Windshields and windows must be constructed of a material that will not darken or result in serious injuries due to splintering.

6.13.2 *Cockpit Controls:*

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

6.13.2.2 The controls must be located and arranged so that the pilot, when strapped in his seat, has full and unrestricted movement of each control without interference from either his clothing (including winter clothing) or from the cockpit structure.

6.13.3 *Motion and Effect of Cockpit Controls*—Cockpit controls must be designed so that they operate as shown in Table 4.

6.13.4 *Seats and Safety Harnesses:*

6.13.4.1 Each seat and its fixing to its supporting structure must be designed for an occupant weight of 90 kg and for the maximum load factors corresponding to the specified flight and ground conditions, including the emergency landing conditions prescribed in 5.9.

6.13.4.2 Seats, including cushions, shall not deform to such an extent that the pilot, when subjected to loads corresponding to 5.10 and 5.11, is unable to reach the controls safely, or that wrong controls are operated.

6.13.4.3 Each seat in a glider must be designed so that an occupant is comfortably seated, whether he wears a parachute or not. The seat design must allow the accommodation of a parachute worn by an occupant.

6.13.4.4 The strength of the safety harness must not be less than that following from the ultimate loads for the flight and ground load conditions and for the emergency landing conditions, taking into account the geometry of the harness and seat arrangement.

6.13.4.5 Each safety harness must be attached so that the pilot is safely retained in his initial sitting or reclining position under any acceleration occurring during the flight or emergency landing.

6.13.5 *Protection from Injury*—Rigid structural members or rigidly mounted items of equipment, must be padded where necessary to protect the occupant(s) from injury during minor emergency landing.

6.13.6 *Baggage Compartment:*

TABLE 4 Motion and Effect of Cockpit Controls

Controls	Motion and effect
Aileron	Right (clockwise) for right wing down
Elevator	Pull for nose up
Rudder	Right pedal forward for nose right
Trim	Corresponding to sense of motion of the controls
Air brakes	Pull for extension
Wing flaps	Pull for wing-flaps down or extended
Towing cable release	Pull to release
Switches	Down or forward: switched off

6.13.6.1 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.

6.13.6.2 Means must be provided to protect occupants from injuries by movement of the contents of baggage compartments under an ultimate forward acceleration of 9.0 g.

6.13.7 *Emergency Exit:*

6.13.7.1 The cockpit must be so designed that unimpeded and rapid escape in emergency situations is possible.

6.13.7.2 On closed canopies, 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 seat and also from outside the cockpit.

6.13.8 *Rescue System*—If an airframe emergency parachute is installed in the aircraft, it shall conform to Specification F2316.

6.13.9 *Ventilation*—On closed cockpits, the cockpit must be designed so as to afford suitable ventilation under normal flying conditions.

6.13.10 *Electrical Bonding*—The pilot shall be protected against electrical potential differences and discharges.

6.13.11 *Ground Clearance:*

6.13.11.1 With the wing-tip touching the ground, the tailplane must not be in contact with the ground.

6.13.11.2 With the wing-tip touching the ground, the associated aileron must not touch the ground when deflected fully down.

6.14 *Gliders with EPU:*

6.14.1 Potential risk of local or overall high temperature, toxic or chemically aggressive emission or other likely threat resulting from the ESD installation and operation must be identified.

6.14.2 Potentially affected structure, systems, other components of the aircraft or occupant(s) shall be identified. Protection against the identified risks shall be provided. This may include, but is not limited to firewalls, heat shielding, electrical isolation, ventilation or drainage.

6.14.3 Adequacy of firewalls used to shield ESD must be verified for the individual risk case.

6.14.4 To supplement isolation barriers or firewalls, fire suppression-abatement methods may be considered and utilized if demonstrated by actual testing, or, fire proof vents may be incorporated into the design to discharge combustion products clear of the aircraft.

7. Powerplant

7.1 *General*—Each combination of engine, exhaust, cooling and fuel system or EPU and ESD on a powered glider must be compatible with the glider, and function in a safe and satisfactory manner within the operational limits of the glider and powerplant.

7.2 *Installation:*

7.2.1 Powerplant installation includes each component that is necessary for propulsion and that affects the safety of the propulsion unit.

7.2.2 The powerplant installation shall ensure safe operation and be easily accessible for inspection and maintenance. The powerplant attachment to the airframe is part of the structure and shall withstand the applicable load factors.

7.2.3 Electrical interconnection must be provided to prevent the existence of potential differences between components of the powerplant and other parts of the glider that are electrically conductive.

7.3 *Engines*—The suitability of installed engines must be verified by test or meet Practice F2339, CS-22 Subpart H, or Practice F2840. Type and production certified engines are also allowable.

NOTE 4—Type certified engines may be subject to additional regulatory maintenance requirements.

7.4 *Gliders with Retractable Powerplants or Propellers*—Powered gliders with retractable powerplants or propellers must comply with the following:

7.4.1 Retraction and extension must be possible without risk of damage and without the use of exceptional skill or effort or excessive time.

7.4.2 It must be possible to secure the retraction (extension) mechanism in the extreme positions.

7.4.3 Any doors associated with extension and retraction must not impair extension and retraction and they must be restrained against spontaneous opening.

7.5 *Gliders with Feathering Propellers*—Powered gliders with feathering propellers must comply with the following:

7.5.1 Feathering and unfeathering must be possible without risk of damage and without the use of exceptional skill or effort or excessive time.

7.5.2 There must be no way for the propeller to be held or arrested permanently in position where power could be applied between the feathered or unfeathered position. A means to provide smooth transition, either by friction, manual or automatic control may be approved and shall be specified in the aircraft operating instructions.

7.5.3 There must be a positive lock of the propeller in either position.

7.6 *Propeller Clearance*—If an unshrouded propeller is to be installed, propeller clearances with the powered glider at maximum weight, with the most adverse CG and with the propeller in the most adverse pitch position, shall not be less than the following:

7.6.1 *Ground Clearance*—There must be a sufficient clearance between the propeller and the ground, with the landing gear statically deflected and in the level attitude, normal takeoff attitude or taxiing attitude, whichever is most critical to ensure that there will be no ground contact of the propeller during normal ground operations. In addition, there must be safe clearance between the propeller and the ground in the level takeoff attitude, with:

7.6.1.1 The critical tire completely deflated and the corresponding landing gear strut statically deflected; and

7.6.1.2 The critical landing gear strut bottomed and the corresponding tire inflated at prescribed pressure statically deflected.

7.6.2 *Structural Clearance*—There must be:

7.6.2.1 A sufficient radial clearance between the blade tips and the glider structure to ensure that the blade cannot come into contact with the structure, plus any additional radial clearance necessary to dampen harmful vibration;

7.6.2.2 A sufficient longitudinal clearance between the propeller blades or cuffs and stationary parts of the glider to ensure that the blades cannot come into contact with stationary parts of the glider; and

7.6.2.3 Positive clearance between other rotating parts of the propeller or spinner and stationary parts of the glider must be kept under all operational conditions.

7.6.3 *Clearance from Crew*—A safe clearance must be maintained between the propeller (propellers) and the crew members—the pilots fixed by duly used harness must not be able to touch the propeller (propellers).

7.7 *Fuel System*—If the glider is provided with a fuel system then:

7.7.1 *General:*

7.7.1.1 Each 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 Each fuel system must be arranged so that fuel feeding the engine can be taken from only one tank, unless the air spaces are interconnected in a manner to ensure that all interconnected tanks feed equally.

7.7.1.3 Fuel system must be arranged so that it cannot be blocked by fuel vapors.

7.7.2 *Fuel Flow:*

7.7.2.1 *Gravity Systems*—The fuel flow rate for gravity systems (main and reserve supply) must be 150 % of the takeoff fuel consumption of the engine at the maximum power established for takeoff.

7.7.2.2 *Pump Systems*—The fuel flow rate for each pump system (main and reserve supply) must be 125 % of the takeoff fuel consumption of the engine at the maximum power established for takeoff.

7.7.3 The unusable fuel quantity for each tank must be established by tests and shall not be less than the quantity at which the first evidence of engine fuel starvation occurs under each intended flight operation and maneuver.

7.7.4 Tanks must be protected against wear from vibrations and their installation shall be able to withstand the applicable inertia loads.

7.7.5 Fuel tanks shall be designed to withstand a positive pressure of 10 kPa without failure or leakage.

7.7.6 The filler must be located outside the passenger compartment and spilled fuel must be prevented from entering or accumulating in any enclosed part of the powered glider.

7.7.7 Each tank must be vented. The vent must discharge clear of the powered glider. In addition:

7.7.7.1 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.

7.7.7.2 Each vent must be constructed to prevent siphoning of fuel during normal operation.

7.7.7.3 Each vent must discharge to the free area clear of the powered glider.

7.7.8 There must be at least one drain to allow safe drainage. A drainable sediment bowl located at the lowest point in the fuel system may be used instead of the drainable sump in the fuel tank.

7.7.9 A fuel strainer or filter accessible for cleaning and replacement must be included in the system.

7.7.10 *Fuel System Lines and Fittings:*

7.7.10.1 The fuel lines must be properly supported to prevent excessive vibration and withstand loads due to fuel pressure and inertial forces during flight.

7.7.10.2 Fuel lines connected to components of the glider, between which relative motion could exist, must have provisions for flexibility.

7.7.10.3 Flexible fuel hose must be shown to be suitable for the particular application.

7.7.10.4 Fuel leaking from any system lines or fittings must not either directly hit hot surfaces or equipment so that a fire risk occurs, or directly hit the occupants.

7.7.11 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 There must be a means of fuel shutoff accessible to the pilot while wearing a seat belt or harness.

7.8 *Oil System*—If an engine is provided with an oil system, it must be:

7.8.1 Capable of supplying the engine with an adequate quantity of oil at a temperature not exceeding the maximum established by the engine manufacturer.

7.8.2 Each oil system must have a usable capacity adequate for the maximum endurance of the powered glider at 75 % of the maximum power of the engine.

7.8.3 *Oil Tanks:*

7.8.3.1 The oil tank or radiator, or both, must be installed to withstand the applicable inertia loads and vibrations, and the oil breather (vent) must be resistant to blockage caused by icing.

7.8.3.2 It must be possible to check the oil level without having to use any tools.

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

7.8.4 Oil tanks must withstand a pressure of 25 kPa without damage or leakage.

7.9 *Cooling*—The powerplant cooling provisions must be able to maintain the temperature of powerplant components, including ESD, if any, and engine fluids within the temperature limits established as safe by the engine manufacturer during all likely operating conditions.

7.10 *Induction System*—If the glider is provided with an induction system, the air induction system must secure the induction of the necessary amount of air into the engine under all expected operational conditions. Penetration of extraneous objects (grass, soil, etc.) must be prevented by a suitable strainer or filter. The engine air induction system shall be designed to minimize the potential of carburetor icing.

7.11 *Exhaust System*—If the glider is provided with an exhaust system then:

7.11.1 The exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

7.11.2 Each exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluids or vapors on any part of the exhaust system, including shields for the exhaust system.

7.11.3 Each exhaust system component must be designed so that to minimize the risk of fire.

7.11.4 No exhaust gases shall discharge dangerously near any oil or fuel system drain.

7.11.5 Each exhaust system component must be ventilated to prevent points of excessively high temperature.

7.11.6 *Exhaust Manifold:*

7.11.6.1 The exhaust manifold must be fireproof and must be designed so that to prevent failure due to expansion by operating temperature.

7.11.6.2 The exhaust and dampening manifold must be supported to withstand the vibration and inertia loads to which it will be subjected in normal operation.

7.11.6.3 Parts of the manifold connected to components between which relative motion could exist must have means for flexibility.

7.12 *EPU Wiring*—If the glider is provided with an EPU then:

7.12.1 Wiring must be properly supported to prevent excessive vibration and withstand loads due to inertial forces during flight.

7.12.2 Wiring carrying the power consumed by the electric motor must be supported such that any possibility for wire chafing, shorting, or adverse contact with the airframe is eliminated.

7.12.3 Wiring connected to components of the glider, between which relative motion could exist, must have provisions for flexibility.

8. Required Equipment

8.1 The aircraft shall be designed with the following minimum instrumentation and equipment:

8.2 *Flight and Navigation Instruments:*

8.2.1 Airspeed indicator, and

8.2.2 Altimeter.

8.3 *For a Powered Glider, the Following Powerplant Instruments:*

8.3.1 Fuel quantity indicator (or equivalent for EPU),

8.3.2 Tachometer (RPM),

8.3.3 Engine "kill" switch (or equivalent for EPU), and

8.3.4 Engine instruments as required by the engine manufacturer.

8.4 *Miscellaneous Equipment—Other Than EPU:*

8.4.1 If installed, an electrical system shall include a master switch and overload protection devices (fuses or circuit breakers).

8.4.2 The electric wiring shall be sized according to the load of each circuit.

8.4.3 The battery installation shall withstand all applicable inertia loads.

8.4.4 Batteries or battery containers that may release gases shall be vented outside of the aircraft (see 6.5).

8.5 *Safety Belts and Harnesses*—A safety harness must be available to each occupant. It must be able to arrest the user at the inertia forces generated at the conditions of emergency landings in accordance with 5.9.

9. Alterations

9.1 *Major Repair, Alteration or Maintenance*—Any repair, alteration, or maintenance for which instructions to complete the task are excluded from the maintenance manual(s) supplied to the consumer are considered major.

9.1.1 All alterations made to an aircraft subsequent to its initial design and production acceptance testing must be proven to comply with this specification and Specification F2972.

9.1.2 The manufacturer or other entity that performs the evaluation of alterations shall provide written documentation equivalent to that documentation used to demonstrate that aircraft's original compliance with the standards of this specification. Such documentation will provide evidence that said aircraft still meets the requirements of this specification subsequent to an alteration.

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

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

9.1.5 The manufacturer or other entity that performs the evaluation of alterations shall provide documentation that demonstrates compliance with Practice F2295.

9.1.6 The manufacturer or other entity that performs the evaluation of alterations shall provide information to the owner/operator of the aircraft regarding required written entries to be made into the aircraft maintenance records or operations limitations documentation, or both, as deemed appropriate.

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

10. Aircraft Operating Instructions

10.1 Each aircraft shall include Aircraft Operating Instructions (AOI). The AOI shall contain at least the following section headings and related information, when applicable, to a specific aircraft and shall be listed in the following order. All flight speeds shall be presented as calibrated airspeeds (CAS) and all specifications and limitations shall be those determined from the preceding relative design criteria. For aircraft sold in the United States of America, all units reported in the AOI shall list their equivalent in US standard units.

10.2 *General Information:*

10.3 *Aircraft and Systems Descriptions:*

10.3.1 Operating weights and loading (occupants, baggage, fuel, ESD(s), batteries, ballast),

10.3.2 Propeller,

10.3.3 Fuel and fuel capacity (or equivalent for aircraft with EPU),

10.3.4 Oil, and

10.3.5 Engine.

10.4 *Operating Limitations:*

10.4.1 Stalling speeds at maximum takeoff weight (V_S, V_{S0}, and V_{S1}),

10.4.2 Flap extended speed range (V_{S0} to V_{FE}),

10.4.3 Maximum maneuvering speed (V_A),

10.4.4 Never exceed speed (V_{NE}),

10.4.5 Maximum aerotow speed (V_T),

10.4.6 Maximum winch tow speed (V_W),

10.4.7 Maximum landing gear extended operating speed (V_{LO}),

10.4.8 Never exceed speed (V_{NE}),

10.4.9 Crosswind and wind limitations for takeoff and landing,

10.4.10 Load factors, and

10.4.11 Prohibited maneuvers.

10.5 *Weight And Balance Information:*

10.5.1 Installed equipment list, and

10.5.2 Center of gravity (CG) range and determination.

10.6 *Performance:*

10.6.1 *Gliders:*

10.6.1.1 Crosswind and wind limitations for takeoff and landing.

10.6.2 *Powered Gliders:*

10.6.2.1 Takeoff distances,

10.6.2.2 Rate of climb,

10.6.2.3 Climbing speeds,

10.6.2.4 Maximum RPM,

10.6.2.5 Time limit for the use of takeoff power,

10.6.2.6 Fuel consumption and total usable fuel volume (or equivalent for aircraft with EPU),

10.6.2.7 Crosswind and wind limitations for takeoff and landing, and

10.6.2.8 Speeds for extracting and retracting powerplant.

10.7 *Emergency Procedures.*

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

10.8.1 Preflight check,

10.8.2 If Powered:

10.8.2.1 Ground engine starting,

10.8.2.2 Taxiing,

10.8.2.3 Normal takeoff,

10.8.2.4 Engine extraction and retraction,

10.8.2.5 Best rate of climb speed (V_Y),

10.8.2.6 In-flight starting of engine,

10.8.2.7 In-flight shutdown of engine, and

10.8.2.8 Ground shutdown of engine;

10.8.3 Cruise,

10.8.4 Approach,

10.8.5 Normal landing, and

10.8.6 Information on stalls, spins, and any other useful pilot information.

10.9 *Aircraft Ground Handling and Servicing:*

10.9.1 Servicing fuel, ESD(s), oil, coolant, and

10.9.2 Towing and tie-down instructions.

10.10 *Required Placards and Markings:*

10.10.1 Airspeed indicator range markings,

10.10.2 Operating limitations on instrument panel, if applicable,

10.10.3 *Passenger Warning*—"This aircraft was manufactured in accordance with Light Sport Aircraft airworthiness standards and does not conform to standard category airworthiness requirements,"

10.10.4 "NO INTENTIONAL SPINS," if applicable,

10.10.5 Empty weight,

10.10.6 Maximum takeoff weight,

10.10.7 Maximum and minimum weight of crew,

10.10.8 Allowable weight of the load in any luggage area, and

10.10.9 Seat for solo operations of two seated gliders.

10.11 *Supplementary Information:*

10.11.1 Familiarization flight procedures, and

10.11.2 Pilot operating advisories, if any.

10.12 *Maintenance Manual*—A maintenance manual containing routine inspection and repair maintenance procedures for the aircraft and, if so equipped, the engine, EPU, and propeller must be provided.

11. Keywords

11.1 glider; light sport aircraft; motor glider; motorized glider; powered glider; self-launching glider; sustainer

ANNEX

(Mandatory Information)

A1. ADDITIONAL REQUIREMENTS FOR LIGHT SPORT GLIDERS USED TO TOW GLIDERS

A1.1 *Applicability*—This annex is applicable to light sport gliders that are to be used to tow gliders.

A1.2 *Minimum Climb Performance While Towing*:

A1.2.1 The aircraft must be capable of achieving a gradient of climb while towing of at least 1⁄18 while not exceeding the maximum placarded towing speed of the towing aircraft, or the maximum safe towing speed of the aircraft being towed.

A1.2.2 The aircraft must be capable of achieving a rate of climb while towing of at least 0.75 m/s (150 ft/min), while not exceeding the maximum placarded towing speed of the towing aircraft, or the maximum safe towing speed of the aircraft being towed.

NOTE A1.1—Compliance with this section must take into account the performance and control capabilities of both the towing aircraft and the aircraft being towed. In order to account for varying performance and control capabilities on the part of the towed aircraft, the manufacturer of the towing aircraft shall specify a maximum weight and maximum drag for the towed aircraft at each speed for which the towing aircraft is approved for tow operations, such that the required climb performances can be achieved. Compliance with this section is then shown when the towed aircraft is safely controllable under tow at a speed for which its drag and weight are within these prescribed maximum weight and drag limits.

A1.3 *Controllability and Maneuverability*—The tow aircraft shall be safely controllable and maneuverable during all ground and flight operations applicable to normal towing operations, including both deliberate and inadvertent release of the glider being towed.

A1.4 *Stability*—It shall be possible to conduct normal towing operations, including both deliberate and inadvertent release of the glider being towed, without incurring any dangerous reduction in the stability of the aircraft.

A1.5 *Structure and Strength Requirements*—Strength requirements for the aircraft structure shall take into account the effects of loads arising from towing equipment that is installed on the aircraft in accordance with A1.6.

A1.6 *Design and Construction* :

A1.6.1 *Glider Towing Equipment Installations:*

A1.6.1.1 The maximum all up takeoff weight of the glider to be towed, including pilot and all equipment, shall be selected by the manufacturer.

A1.6.1.2 The maximum glider towing speed (V_T), shall be selected by the manufacturer. The V_T shall be at least 1.3 V_S, where V_S is the computed stalling speed of the aircraft in the cruise configuration without a glider in tow.

A1.6.1.3 Tow equipment attach points on the airframe shall have limit and ultimate factors of safety of not less than 1.0 and 1.5 respectively, when loads equal to 1.2 of the nominal strength of the weak link (see A1.6.1.5) are applied through the towing hook installation for the following conditions, simultaneously with the loads arising from the most critical normal accelerations (as defined in the normally applicable requirements for structure and strength) at the speed V_T. The applicable conditions are as follows:

(1) The speed is assumed to be at the maximum glider towing speed V_T, and

(2) The load at the towing hook installation is assumed to be acting in each of the following directions, relative to the longitudinal centerline of the aircraft: horizontally backwards; backwards and upwards at 40° to the horizontal; backwards and downwards at 20° to the horizontal; and horizontally backwards and 25° sideways in both directions.

A1.6.1.4 The towing hook shall be of a quick release type. It shall be established by test that when the release control is operated simultaneously with loads equal to 10 and 180 % of the nominal strength of the weak link (see A1.6.1.5) applied to the towing hook in each of the directions prescribed in A1.6.1.3*(2)*: *(1)* the tow cable will be released; *(2)* the released cable will be unlikely to cause damage to or become entangled with any part of the aircraft; and *(3)* the pilot effort required shall not be less than 20 N (4.5 lbf) nor greater than 100 N (22.5 lbf).

A1.6.1.5 The release control shall be located so that the pilot can operate it without having to release any other primary flight control.

A1.6.1.6 The maximum strength of any weak link that shall be interposed in the towing cable shall be established. For the determination of loads to be applied for the purpose of this section, the strength of the weak link shall not be less than 900 N (202.3 lbf).

A1.6.2 *Engines*—The suitability of installed engines must meet Practice F2339, LSA engine design and production standards. Type and production certified engines are also allowable.

A1.7 *Operating Limitations*:

A1.7.1 Operating limitations applicable to towing operations must be established and included in the Aircraft Operating Instructions, to include at a minimum:

A1.7.1.1 The maximum permissible towing speed (V_T).

A1.7.1.2 The maximum weak link strength (may be specified in terms of the weight of the glider to be towed).

A1.7.1.3 The maximum permissible all up weight of the glider to be towed.

APPENDIXES

(Nonmandatory Information)

X1. IMPERIAL AND METRIC UNITS

X1.1 Only those units relevant to this specification are listed as follows, with a conversion accuracy adequate for the intended use.

Force	1 lbf = 4.448 N
Length	1 ft = 12 in. = 0.305 m
	1 in. = 2.54 cm
	1 m = 100 cm = 1000 mm = 39.37 in. = 3.28 ft
Surface	1 ft^2 = 0.093 m^2
	1 m^2 = 10.76 ft^2
	1 mm^2 = 0.001 55 $in.^2$ = 1550 mil^2
Volume	1 U.S. gal = 3.78 L
	1 L = 0.264 U.S. gal
	(1 British gal = 1.2 U.S. gal = 4.5 L)
Weight	1 lb = 0.454 kg
	1 kg = 2.205 lb
Pressure	1 PSF = 4.88 kg/m^2
	1 kg/m^2 = 0.205 PSF
	1 psi = 2.3-ft water column = 0.000 703 kg/m^2
	1 ksi = 1000 psi = 0.703 kg/m^2
	1 kg/mm^2 = 1.43 ksi = 1430 psi
Dynamic pressure in standard atmosphere, at sea level	$q = V^2/391$ in lb/ft^2 when V in mph
	$q = (V/14.4)^2$ in kg/m^2 when V in km/h
Speeds	1 mph = 1.61 km/h
	1 knot = 1.15 mph = 1.85 km/h
	1 km/h = 0.62 mph = 0.54 knots
Earth acceleration	g = 32.2 ft/s^2 = 9.81 m/s^2
Fuel density	6 lb/U.S. gal
	0.72 kg/L

X2. COLOR CODING FOR COCKPIT CONTROLS

X2.1 *Color Marking of Cockpit Controls*—Cockpit control handles should be marked as shown in Table X2.1.

TABLE X2.1 Color Marking of Cockpit Controls

Towing cable release	Yellow
Air brakes	Blue
Trim	Green
Canopy operating handle	White
Canopy jettison handle	Red
For other controls in the cockpit the above colors should not be used.	