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Standard Specification for Design and Performance Requirements for Lighter-Than-Air Light Sport Aircraft[1]

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1. Scope

1.1 This specification covers design and performance requirements that apply for the manufacture of lighter-than-air light sport aircraft.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2353 Specification for Manufacturer Quality Assurance Program for Lighter-Than-Air Light Sport Aircraft
F2354 Specification for Continued Airworthiness System for Lighter-Than-Air Light Sport Aircraft
F2356 Specification for Production Acceptance Testing System for Lighter-Than-Air Light Sport Aircraft
F2427 Specification for Required Product Information to be Provided with Lighter-Than-Air Light Sport Aircraft

3. Terminology

3.1 *Definitions:*

3.1.1 *airship*—engine-driven lighter-than-air aircraft that can be steered.

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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.

3.1.1.1 *Discussion*—

This definition can include "and that sustains flight through the use of either gas buoyancy or an airborne heater, or both."

3.1.2 *balloon*—lighter-than-air aircraft that is not engine-driven, and that sustains flight through the use of either gas buoyancy or an airborne heater, or both.

3.1.3 *design useful load*—load (other than structure, engine, enclosure, and systems) that a lighter-than-air aircraft can carry while achieving the design defining performance requirements.

3.1.4 *gross weight*—~~total~~total aircraft system weight(s) at takeoff. T~~he weight limits must be established so that it is: (1) the designed maximum weight at which compliance with each applicable structural loading condition is demonstrated, or (2) the highest weight at which compliance at each applicable flight requirement is demonstrated.~~

3.1.5 *lighter-than-air aircraft*—aircraft that can rise and remain suspended by using contained gas weighing less than the air that is displaced by the gas.

3.1.5.1 *Discussion*—

Airships may include dynamic lift that derive as much as 30 % lift from other than buoyancy.

3.1.6 *maximum takeoff weight*—gross weight limit as defined by the manufacturer, proven through compliance with this specification and placarded on the aircraft as the not-to-exceed gross weight.

3.1.7 *thermal airship*—~~craft with~~ airship using heated air for a portion of its lift, incorporating design features to prevent nose collapse due to ~~forward motion for which buoyancy is created or enhanced by heating of the gas in an otherwise unpressurized envelope.~~dynamic pressure and exempt from specific pressurized envelope requirements.

3.1.8 *vectored thrust balloon*—~~craft that can move laterally, but is limited to lateral speed by its lack of~~ thermal balloon with thrust capability that does not have design features to prevent forward envelope collapse due to ~~forward motion.~~dynamic pressure and is therefore limited in its lateral speed capability.

3.1.9 *weight limitations*—operational weight restrictions (maximum/minimum) as defined by the manufacturer and proven through compliance with this specification to demonstrate controllability.

4. Flight Requirements

4.1 *Performance Requirements for Airships and Thermal Airships, except as noted:*

4.1.1 *Proof of Compliance*—Each of the following requirements shall be met at the maximum takeoff weight and most critical center of gravity (CG) position. To the extent that CG adjustment devices may be adjusted for flight, these components will be evaluated in the least favorable recommended position as it affects either performance or structural strength.

4.1.2 *General Performance*—All performance requirements apply in and shall be corrected to International Civil Aviation Organization (ICAO) defined standard atmosphere in still air conditions at sea level. Speeds shall be given in indicated (IAS) and calibrated (CAS) airspeeds in knots.

4.1.3 *Flight Performance*—For all flight operations it shall be shown that control sufficient to safely maneuver or land the airship, or both, can be maintained.

4.1.4 *Climb*—The following shall be measured:

4.1.4.1 Distance to clear a 15-m (50-ft) obstacle not to exceed 213 m (700 ft) from point of lift-off. Compliance with the requirements of this section must be shown at each extreme of altitude and ambient temperature for which approval is sought.

4.1.4.2 Climb rates of 1.5 m/s (300 fpm) and 0.5 m/s (100 fpm) with one engine inoperable for multi-engine configurations.

4.1.5 *Controllability and Maneuverability*—The aircraft shall be safely controllable and maneuverable during takeoff, climb, level flight (cruise), approach, and landing.

4.1.5.1 Demonstrate a smooth transition between all flight conditions shall be possible without excessive pilot skills nor exceeding pilot forces of 59.1 kg (130 lb) for the foot-operated control, 9.1 kg (20 lb) prolonged application, or 29.5-kg (65-lb) hand controls, 4.5 kg (10 lb) prolonged operation.

4.1.6 *Descent*—The following shall be measured.

4.1.6.1 It must be shown that in the event of the most critical uncontrolled descent from either: (*1*) an engine or propeller failure, (*2*) burner failure for thermal airship, (*3*) valve leak for either hot air or captive gas airship, or (*4*) the maximum permitted envelope failure as specified in 5.1.2.

NOTE 1—Procedures must be established for landing at the maximum vertical velocity attained and procedures must be established for arresting the maximum descent rate within the manufacturer's specified altitude.

4.1.7 *Landing*—It must be shown that a pilot of normal skill can achieve landing sink rates of no more than 0.77 m/s (2 ft/s).

4.1.8 *Stability and Control:*

4.1.8.1 *Vertical Stability and Control*—Stability and control of the airship shall be determined at maximum gross weight, with minimum in-flight turbulence/wind for:

(1) Maximum duration of envelope valve operation (if equipped), during which the airship must not enter into a dangerous descent.

(2) Minimum burner fuel pressures (if equipped), which will arrest the maximum descent rate as determined in 4.1.6 and climb as determined in 4.1.4.

4.1.8.2 *Longitudinal Stability*—Longitudinal stability of the aircraft will be demonstrated by performing 2 min of flight without control input for three conditions. In each case, the aircraft must not enter into dangerous or unusual altitudes. A test must be conducted at maximum gross weight, with a minimum of in-flight turbulence. The three conditions are ascent, descent, and level flight.

4.1.8.3 *Longitudinal Control*—With all engines operating at maximum power, the airship must be capable of:

(1) A nose-down pitch from a stabilized climb with a 30° nose-up deck angle,

(2) A nose-up pitch from a stabilized descent with a 30° nose-down deck angle, and

(3) Longitudinal upset response shall be evaluated by analysis or test, or both, to show that it does not result in unsafe conditions.

4.1.8.4 *Lateral and Directional Stability:*

(1) Lateral stability will be demonstrated by maintaining the surface controls in a fixed position, which will initially give an unaccelerated level flight condition. The aircraft must not enter into a dangerous altitude during the 2 min that the flight control surfaces are fixed. A test must be conducted at maximum operating weight, with minimum in-flight turbulence.

(2) Directional stability will be demonstrated by a separate and full deflection of each directional flight control surfaces for three full turns of 360° without the aircraft entering any dangerous flight altitude during the maneuver. A test must be conducted at minimum flight weight, with minimum in-flight turbulence. The demonstrated turn rate shall not be less than 6°/s (60 s for a 360° turn) in either direction.

4.2 *Performance Requirements for Balloons:*

4.2.1 *Proof of Compliance*—Each of the following requirements shall be met at the maximum takeoff weight.

4.2.2 *General Performance*—All performance requirements apply and shall be corrected to International Civil Aviation Association Organization (ICAO) defined standard atmosphere in still air conditions at sea level.

4.2.3 *Flight Performance*—For level flight, climbs, descents, and landing, it shall be shown that control sufficient to safely land the balloon can be maintained.

4.2.3.1 *Climb*—Each balloon must be capable of climbing at least 300 ft in the first minute after takeoff with a steady rate of climb. Compliance with the requirements of this section must be shown at each altitude and ambient temperature for which approval is sought.

4.2.3.2 *Controllability*—The balloon shall be controllable during takeoff, climb, level flight, approach, and landing.

4.2.3.3 *Descent*—The following shall be measured. It must be shown that in the event of the most critical uncontrolled descent from either: (*1*) burner failure for hot air balloon, (*2*) valve leak for either hot air or captive gas, and (*3*) the maximum permitted envelope failure as specified in 5.2.2. Procedures must be established for landing at the maximum vertical velocity attained and procedures must be established for arresting the maximum descent rate within the manufacturer's specified altitude.

4.2.3.4 *Landing*—It must be shown that the pilot can achieve a landing sink rate of not more than 1 m/s.

4.2.4 *Stability and Control*—Stability and control of the balloon shall be determined at maximum gross weight, with minimum in flight turbulence/wind for:

4.2.4.1 Maximum duration of envelope valve operation, during which the balloon must not enter into a dangerous descent.

4.2.4.2 Minimum burner fuel pressures that will arrest the maximum descent rate as determined in 4.2.3.3 and climb as determined in section 4.2.3.1.

5. Structure Requirements

5.1 *Structure for Airships and Thermal Airships (except as noted):*

5.1.1 *Loads*—Unless otherwise specified, all requirements are specified in terms of limit load.

5.1.1.1 Ultimate loads are limit loads multiplied by the factor of safety defined below. Loads shall be redistributed if the deformations affect them significantly.

5.1.2 *Factors of Safety*—The factor of safety is 1.5, except as shown in the following:

5.1.2.1 3.0 on castings,

5.1.2.2 1.8 on fittings,

5.1.2.3 6.67 on control surface hinges,

5.1.2.4 3.3 on push-pull control systems,

5.1.2.5 2.0 on cable control systems, and

5.1.2.6 5.0 on envelope structures (fibrous or non-metallic parts) and rigging.

5.1.2.7 In applying factors of safety, the effect of temperature and other operating characteristics, or both, that may affect strength of the balloon must be accounted for.

5.1.2.8 For design purposes, an occupant weight of at least 170 lb must be assumed.

5.1.3 *Strength and Deformation:*

5.1.3.1 The structure must be able to support limit loads without permanent deformation of the structure.

5.1.3.2 The structure must be shown by analysis, test, or analysis supported by test to be able to withstand ultimate loads without failure.

5.1.3.3 The structure shall be able to withstand ultimate loads for 3 s without failure when proof is by static test. When dynamic tests are used to demonstrate strength, the 3-s requirement does not apply. Local failures or structural instabilities between limit load and ultimate load are acceptable if the structure can sustain the required ultimate load for 3 s.

5.1.4 *Proof of Structure*—Each critical load requirement shall be investigated either by conservative analysis or tests, or a combination of both.

5.1.5 *Proof of Strength*—Envelope material, attachments, and car frame shall all be demonstrated by test to meet the load factor requirement with the required factor of safety. This evaluation shall include suitable tear resistance testing for the envelope.

5.1.6 *Load Factor:*

5.1.6.1 *Positive*— $n = 1.5$ (comprised of a maneuvering load multiplied by a gust load factor).

5.1.6.2 *Negative*— $n = 0$.

5.1.6.3 Additional load considerations shall be evaluated for selected design airspeeds and resultant dynamic pressures.

5.1.7 *Design Airspeeds*—The selected design airspeeds are equivalent airspeeds (EAS) except as provided in specific requirements.

5.1.7.1 *Design Stall Speed, V(SI)*—shall be calculated based on area, lift coefficient estimates, and maximum negative boyance.